ZITHOLELE CONSULTING

Professional Registrations:

- (SACNASP) South African Council for Natural Scientific Professions
- (IAIAsa) International Association for Impact Assessment – South Africa

Occupation:

- Senior Environmental Scientist

Specialisation:

- Environmental and Social Impact Assessments
- Strategic Environmental Assessments
- Estuarine Ecological Assessments
- Project Management and GIS

Education:

- Ph.D., Zoology, 2012 Nelson Mandela Metropolitan University
- M.Sc., Zoology, 2003 University of Port Elizabeth
- B.Sc. Hons, Zoology, 2001 University of Port Elizabeth
- B.Sc., Zoology and Botany, 2000 University of PE

Dr. Mathys Vosloo

KEY EXPERIENCE

Dr. Mathys Vosloo is a well-qualified and technically proficient environmental and natural scientist with more than 12 years environmental management experience. His experience include Environmental Impact Assessments (EIAs) and the development of Environmental Management Programmes during environmental assessments of construction projects, environmental compliance monitoring and reporting, and Environmental Control Officer (ECO) services for construction projects. Recent experience includes project management and execution of large waste related projects, such as the application for development of Ash Disposal Facilities, and large linear projects such as the management EIA process for the implementation of extensive power lines for renewable projects. Mathys also has substantial experience in Geographical Information Systems (GIS), creating and analysing digital terrain models, runoff and stream flow analysis, stormwater design and map-making for projects in Africa. Further experience include the development and completion of State Of the Environment Reporting (SOER), Strategic Environmental Assessments (SEA) and feasibility studies. Mathys' experience in natural science include aquatic ecological assessments, project management and sample collection in several west, south and east coast estuaries, including ecosystem analysis of estuaries in the Eastern Cape and former Transkei area.

PROJECT EXPERIENCE

2017 PPP and WOP for Kusile PS 60year ADF R 2.8m

Public participation process for Wetland Offset Strategy and implementation of Wetland Offset Plan for the Kusile Power Station 60year Ash Disposal Facility.

2017 BA for KEMJV slimes pipeline R 230 000

Basic Assessment for construction of slimes pipeline for Kimberley Ekapa Mine Joint Venture, Northern Cape.

2016 - 2017 Asbestos Mine Rehabilitation Programme R 1.3 million

Undertaking environmental site investigations and project scoping for the rehabilitation of 10 derelict and abandoned asbestos mines in Limpopo and Mpumalanga Provinces.

PROJECT EXPERIENCE (continued)

2016 Walkdown & WULA for Kuruman Powerline upgrade R 355 000
Specialist walkdown of approved 132 kV powerline servitude between Kuruman and Kathu, Northern Cape.

2016 - 2017 EA Amendment for Kuruman Powerline Upgrade R 60 000
EA Amendment application i.t.o. EIA 2014 regulations for amendment to the approved 132 kV powerline corridor between Hotazel, Kuruman and Kathu, Northern Cape.

2016 Breede-Gourits CMS: Estuarine component R 81 000
Estuary Situation Assessment to inform the Breede-Gourits Catchment Management Strategy for Breede-Gourits Water Management Area.

2016 - 2017 BA for Tshepisong Extension 4 development R 198 000
Basic Assessment for Mixed Business and Residential Development within Portion 64 of Farm Vlakfontein 238 IQ, Tshepisong Extension 4, Johannesburg West, Gauteng Province.

2016 - 2017 BA for Patensie Housing Development R 283 000
Basic Assessment for the Patensie Housing Development, Eastern Cape.

2016 Specialist Walkdown for Kuruman Powerline upgrade R 355 000
Specialist walkdown of approved 132 kV powerline servitude between Hotazel and Kuruman, Northern Cape.

2016 Solar Park EA Amendment R 248 000
Environmental Authorisation (EA) Amendment application i.t.o. EIA 2014 regulations for amendments to the Solar Park to Nieuwehoop 400 kV power line corridor near Upington, Northern Cape.

2015 - 2016 Solar Park WULA R 547 000
WULA for Solar Park to Nieuwehoop 400 kV powerline development near Upington, Northern Cape.

2015 - 2016 BA Clanwilliam Weirs R 409 000
Proposed Re-alignment of the Bulshoek Dam and Doring River Weirs near Clanwilliam, Western Cape.

2015 - 2016 BA Klipspruit Valley R 244 000
BA and WULA for the Klipspruit Valley Road Upgrade.

2014 - 2016 EIA Koffiefontein Slimes Dam R1 million
EIA for the new Koffiefontein Slimes Dam Development, Kimberley.

2014 - 2015 BA and WULA Kuruman Upgrade R1.3 million
BA and WULA for 132kV power line upgrade from Hotazel to Kuruman and Kathu, Northern Cape.

2013 - 2016 EIA Kendal 30 year Ash Disposal Facility R6 million
EIA, WMLA and WULA for a new Ash Disposal Facility for Kendal Power Station near Ogies in Mpumalanga.

2013 - 2014 Design of 3 canals R 700 000
3 x BAs for the proposed prevention of water ingress into previously mined out areas in the Witwatersrand Mining Basin (canalisation of 3 streams), Gauteng.

2013 - 2014 BA for Vaalbank Switching Station R 380 000
Basic Assessment for Vaalbank Switching Station and 2 x 88 kV Powerlines, Free State.

PROJECT EXPERIENCE (continued)

2012 - 2015 EIA Solar Park **R5 million**
EIA, EMP &WULA for the Solar Park 132/400 kV Sub Station and Associated lines, Northern Cape.

2012 - 2015 Kusile 60 year Ash Disposal Facility **R11 million**
EIA, WML and WULA for the 60 year Ash Disposal Project near Balmoral in Mpumalanga.

2012 - 2015 WULA Wilge Pipeline **R 900 000**
WULA for the sewage and water pipeline from Wilge Township to Phola, Mpumalanga.

2012 BA Kouga Dam Wall **R 250 000**
The rehabilitation of the Kouga Dam wall and associated mining activities.

2012 EMP City of Cape Town Stormwater **R1.5 million**
Maintenance and management interventions undertaken by the City of Cape Town in its surface stormwater systems.

2012 BA Melkhout Powerlines **R 100 000**
The installation of 132kV transmission lines from Melkhout to Dieprivier, including the construction of a new substation at Dieprivier, Cacadu District.

2012 BA Diepriver Powerlines **R 100 000**
The installation of 132kV transmission lines from Dieprivier to Kareedouw, including the extension of the existing substation at Kareedouw, Cacadu District.

2012 BA Patensie Powerlines **R 100 000**
The installation of 132kV transmission lines from Melkhout to Patensie, including the construction of a new substation at Patensie, Cacadu District.

2012 Mmnthatha River System
Catchment delineation and stream calculation for the Mnthatha River System, GIBB Durban.

2011 - 2012 PRASA Passenger rail and shunting yard proposed sites
Environmental Screening for the PRASA passenger rail and shunting yard proposed sites in Cape Town, Gauteng and Durban.

2010 - 2012 ATTP Flow Limiters installation
NMBM Assistance to the poor (ATTP) and schools leakages repairs and flow limiters installation.

2010 - 2012 ATTP Database ManagementFlow Limiters installation **R4 million**
NMBM Assistance to the poor (ATTP) and schools leakages repairs and flow limiters installation database management.

2010 - 2011 Nelson Mandela Bay Provincial Department of Housing
Nelson Mandela Bay and Cradock low cost housing rectification audits. Management of incoming and outgoing GIS data and GIS mapping, Provincial Department of Housing.

2010 - 2011 ECO Bulk Stormwater Infrastructure Motherwell
Installation of bulk storm water infrastructure in Motherwell NU29 and 30 and Implementation of an artificial wetland at the Motherwell stormwater canal outlet structure.

PROJECT EXPERIENCE (continued)

2010 **BA McAdam Street Upgrade** **R 60 000**
The extension of McAdam Street from Worraker to Mangold Street, NMBM.

2009 - 2011 **EIA Motherwell Housing Development** **R 270 000**
Motherwell NU 31 housing development, NMBM.

2009 - 2011 **Coega Integrated Stormwater Management Plan**
Coega IDZ Eastern Sector Integrated Stormwater Management Plan, Coega Development Corporation.

2009 - 2011 **EIA KougaWind Farm** **R 350 000**
Kouga 300 MW wind farm, Kouga Local Municipality.

2009 - 2010 **ECO Swartkops River Artificial Wetland**
Swartkops River, NMBM.

2009 - 2010 **ECO Humewood Road Upgrade**
Realignment of the S-bend section of Humewood Road in Humewood.

2009 - 2010 **ECO Paapenkuils Sewer Augmentation**
Paapenkuils Main Sewer Augmentation in Port Elizabeth NMBM.

2009 - 2010 **SOER State of the Environment Report** **R 350 000**
NMBM State of the Environment Report.

2009 - 2010 **ISWMP Coega IDZ** **R 350 000**
Coega IDZ Eastern Sector Integrated Stormwater Management Plan, CDC.

2009 - 2010 **SOER Flood Plain and Spatial Analysis**
Nelson Mandela Metropolitan Municipality SOER flood plain and spatial analysis, NMBM.

2009 - 2010 **EIA – Red Cap Developments**
Kouga Local Municipality wind farm development EIA, RedCap Developments.

2008 - 2009 **Port Harcourt City Open Space System Plan**
Port Harcourt City Open Space System Plan, Government of Nigeria.

2008 - 2009 **ECO Kwazakhele stormwater infrastructure**
Construction of stormwater detention ponds and upgrading of stormwater infrastructure in Kwazakhele, Phase 3.

2008 **ECO Sherwood Road Upgrade**
Upgrading of Devon and Fairley Roads in Port Elizabeth, NMBM.

2008 **OR Tambo District Municipality water conservation and demand management**
OR Tambo District Municipality water conservation and demand management.

2008 **SOER Eden District Municipality**
Eden District Municipality SOER, Eden District Municipality.

2008 **Kouga Local Municipality catchment and flood attenuation analysis**
Jeffreys Bay Marina Martinique catchment and flood attenuation analysis, Kouga Local Municipality.

2008 **EIA Bethelsdorp Housing Development** **R 230 000**
Bethelsdorp Phase 3 social housing development, NMBM.

PROJECT EXPERIENCE (continued)

2008 BA Beacon Maritime Navigational Structure Upgrade R 60 000
Beacon maritime navigational structure upgrading, NMBM.

2008 BA Moffet Dam Rehabilitation R 60 000
Moffet Dam breach remedial works, Kouga Local Municipality.

2008 BA Pollok Beach light mast installation R 50 000
Pollok Beach light mast installation, NMBM.

2008 BA Humewood Road Re-alignment R 60 000
Humewood Road re-alignment along the S-bend section, NMBM.

2008 SOER Hessequa Local Municipality R 200 000
Hessequa Local Municipality State of the Environment Summary Report.

2008 SEA Coastline redevelopment R 250 000
North End Coastline redevelopment SEA, NMBM.

2008 Mzimkhulu River catchment and flood attenuation analysis
Mzimkhulu River catchment and flood attenuation analysis, Umzimkhulu Municipality.

2008 PE Paapenkuils River catchment and flood attenuation analysis
Port Elizabeth Paapenkuils River catchment and flood attenuation analysis, NMBM.

2007 - 2008 ECO Mavuso Road Upgrade
Construction of Mavuso Road in Kwazakhele, NMBM.

2007 BA Jagersfontein Chicken Farm R 40 000
Jagersfontein farm 432 commercial production of chicken and operation of an abattoir, Kouga Local Municipality.

2007 BA Zwide Roads Upgrade R 55 000
Tarring of roads in Zwide, NMBM.

2007 BA McAdam Street Construction R 40 000
Construction and extension of McAdam Street, NMBM.

2007 BA Tygerbay Reconstructiontion R 60 000
Repair and reconstruction of water retaining structures at Tyger Bay EIA NMBM.

2007 BA Lorraine Infill development R 40 000
Erf 306 Lorraine Infill development, NMBM.

2007 BA Sherwood Roads Upgrade R 40 000
Tarring of roads in Sherwood, NMBM.

2007 BA Zwide Roads Upgrade R 40 000
Tarring of Ntsele, Mkutuka, Nanto and Vabaza Streets in Zwide, NMBM.

2007 BA Pollok Beach Parking Lot R 50 000
Pollok Beach, Summerstrand, parking lot relocation, NMBM.

2007 BA Uitenhage Roads Upgrade R 40 000
Tarring of Dube, Grootboom and Luzipho Streets in Uitenhage, NMBM.

PROJECT EXPERIENCE (continued)

2007 BA PE ICC Site Assessment **R 150 000**
Port Elizabeth International Convention Centre Rapid site assessment, NMBM.

2007 EIA Exemptions Applications Motherwell
Motherwell/Coega outfall canal upgrade.

2007 EIA Exemptions Applications Lorraine Infill Development
Erf 17, Lorraine, infill development.

2007 EIA Exemptions Applications Korsten Upgrade
Korsten Modal Interchange Upgrade.

2007 GIS SANRAL outdoor advertising opportunities
SANRAL outdoor advertising opportunities in the Eastern Cape, SANRAL.

2007 Coega Integrated Stormwater Plan
Coega Integrated Stormwater Plan, Coega Development Corporation.

2007 Uitenhage Stormwater Master Plan
Uitenhage Stormwater Master Plan, NMBM.

2006 Nelson Mandela Metropolitan University exchange programme
Analyses and identification of nematode collected samples from the Mngazi Estuary in the Eastern Cape (former Transkei), South Africa, University of Ghent, Belgium – Nelson Mandela Metropolitan University exchange programme.

2005 - 2006 Berg River Reserve Determination Study **R 150 000**
Hyperbenthos and zooplankton field assessment in Berg River estuary.

2005 Olifants River Reserve Determination Study, Western Cape **R 300 000**
Specialised field ecologist - Field assessment: subtidal macrozoobenthos, hyperbenthos and zooplankton in Olifants River estuary for the Olifants River Reserve Determination study, Western Cape., Contracted sampling for CSIR Stellenbosch (Environmentek).

2004- 2005 DWAF - Kromme and Seekoei Estuary Reserve Determination Study **R 200 000**
Specialised field ecologist - Kromme and Seekoei Estuary Catchment Reserve Study. Contracted sampling for Department of Water Affairs and Forestry (DWAF).

2003 - 2004 Berg River Baseline Monitoring Program (UCT) **R 350 000**
Berg River Baseline Monitoring Program (UCT). Collecting subtidal macrozoobenthos.

2002 - 2006 University of Port Elizabeth Ecological analysis **R4 million**
Specialised field ecologist - Field assessment: subtidal macrozoobenthic and hyperbenthic invertebrates, zooplankton, microzooplankton, meiofauna at Mngazi and Mngazana River estuaries.

2002 - 2003 University of Port Elizabeth Ecological analysis
Ecological analysis of the functioning Sundays, Swartkops, Kromme, and Gamtoos estuaries using Ecopath with Ecosim, and assessment of the impact of recreational fishing on these ecosystems. MSc dissertation, University of Port Elizabeth.

PROJECT EXPERIENCE (continued)

2002 Sylt Ecosystem, Germany R 250 000

Assistant ecosystem modeller - Assisting in preparation and balancing of ecosystem carbon flow models of the Sylt Ecosystem, Germany.

2002 Field assessment: subtidal macrozoobenthos, hyperbenthos and zooplankton in Rooiels R 400 000

Specialised field ecologist - Field assessment: subtidal macrozoobenthos, hyperbenthos and zooplankton in Rooiels, Palmiet, Heuningnes, Breede, Klein Brak and Kaaimans River estuaries, Western Cape.

2002 Field Assessment - intertidal invertebrates Eastern Cape R 150 000

Specialised field ecologist - Field assessment: intertidal invertebrates in Kabeljous, Gamtoos, Swartkops, Sundays and Kariga River estuaries, Eastern Cape.

PAPERS, PUBLICATIONS, PRESENTATIONS AND PROFESSIONAL SOCIETIES

PAPERS, PUBLICATIONS

1. Vosloo, M C and Hendricks, M G J. 2017. Marine and estuarine nematodes in South Africa, Book Chapter. In *Nematology in South Africa: A view from the 21st Century*. Fourie, Spaull, Jones, Daneel, De Waele (Eds).
2. Vosloo, M.C. 2012. Network analysis of trophic linkages in two sub-tropical estuaries along the south-east coast of South Africa. PhD thesis, Nelson Mandela Metropolitan University.
3. Vosloo, M.C. 2009. Marine and estuarine meiofauna: Contribution to the National Marine Ecosystem Diagnostic Analysis. Agulhas and Somali Current Large Marine Ecosystems.
4. Vosloo, M.C. 2004. A comparative assessment of the impact of recreational and subsistence fishing on selected Eastern Cape estuarine ecosystems using the Ecopath modelling approach. MSc Dissertation, University of Port Elizabeth, Port Elizabeth.

PROFESSIONAL SOCIETIES

1. Member of International Association for Impact Assessment – South Africa (IAIAsa)
2. Registered member of South African Council for Natural Scientific Professions, (SACNASP)

EMPLOYMENT RECORD

2013 - Present	Zitholele Consulting	Manager: Licencing and Permitting, Senior Environmental Consultant
2012	GIBB Engineering and Science	Senior Environmental Scientist
2007 – 2011	GIBB Engineering and Science	Environmental Scientist

2008 – 2011	Nelson Mandela Metropolitan University	Postgraduate (part-time) Student
2005 – 2007	Nelson Mandela Metropolitan University	Full time Postgraduate (PhD) Student
2001 - 2003	University of Port Elizabeth	Full time postgraduate (MSc) Student
2006	University of Ghent, Belgium	Exchange Ecologist

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	René von Gruenewaldt (*nee* Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 15 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

René von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over fifteen (15) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and three (3) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise.

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Malawi, Kenya, Angola, Democratic Republic of Congo, Namibia, Madagascar and Egypt) René has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

RELEVANT EXPERIENCE

Mining and Ore Handling

René has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. René was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

Apart from Eskom projects, power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Paratus Power Plant).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rauntenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications, and my experience.

_______________________ 22/11/2017 _______________________

Signature of staff member

Date (Day / Month / Year)

Full name of staff member: René Georgeinna von Gruenewaldt

Education

MSc Hydrogeology, University of Free State - IGS, 2011

2 Year Certificate in Business Administration, University of South Africa, 2002

BSc (Hons) Geography, University of South Africa, 1991

BSc Geography, University of South Africa, 1991

National Diploma-Geology , Technicon Pretoria , South Africa, 1988

Languages

Afrikaans – Fluent

English – Fluent

Golder Associates Africa (Pty) Ltd. – Pretoria

Senior Hydrogeologist

Responsible for various groundwater pollution studies at mining environments. Geophysical surveys for placement of monitoring networks. Groundwater resources investigation; comprising of project management, management of geophysical surveys, boreholes sitting, supervision of drilling and test pumping programmes and management of field contractors on site. Aquifer assessment to estimate the hydraulic parameters, hydrogeological characterization & mapping, water quality assessment, client liaison, data processing and report writing. Groundwater sampling programmes, data interpretations and slug testing.

Employment History

Golder Associates Africa (Pty) Ltd – Pretoria

Hydrogeologist (2007 to Present)

Responsible for various groundwater pollution studies at mining environments. Geophysical surveys for placement of monitoring networks. Groundwater resources investigation; comprising of management of geophysical surveys, boreholes sitting, supervision of drilling and test pumping programmes and management of field contractors on site. Aquifer assessment to estimate the hydraulic parameters, hydrogeological characterization & mapping, water quality assessment, client liaison, data processing and report writing. Groundwater sampling programmes, data interpretations and slug testing.

VSA Geo Consultants (Pty) Ltd – Pretoria, South Africa

Senior Hydrogeologist (2002 to 2007)

Responsible for various groundwater supply projects, which include desk studies, geophysical surveys, drilling site selection, supervision of drilling and construction of production and exploration boreholes. Test pumping of successful production boreholes. Chemical and bacteriological sampling of production boreholes for fitness of groundwater for human consumption. Progress and project reports. Detailed Hydrocensus surveys of boreholes and springs for updating of groundwater databases and hydro geological investigations.

Groundwater Project Management (Pty) Ltd – Pretoria, South Africa

Project manager (1998 to 2002)

Part of specialist team responsible for data management and compilation of strategic groundwater planning maps for the South African Department of Water Affairs and Forestry by means of Aquabase (database) and Arcview (GIS).

Department of Water Affairs (DWAF), Directorate Geohydrology – Pretoria, South Africa

Student to First Geohydrological Technician (1985 to 1998)

Geophysical Exploration – 13 years' experience in the application of various geophysical methods for groundwater exploration projects on a National level in South Africa in primary, secondary and karst aquifers. Scientific borehole siting and supervision of exploration drilling and test pumping.
Regional dolomite borehole hydro censuses for updating of DWAF database.

PROJECT EXPERIENCE – HYDROGEOLOGY

Geophysical survey and supply projects
Various, South Africa

As Learner Geohydrological Technician was involved in various Geohydrological Projects. Ad hock borehole siting for various government departments in South Africa. Hydrocensus and groundwater sampling along the Nile river groundwater control area. Hydrocensus on the Dolomites of the Transvaal Sequence over the Grootfontein dolomitic Compartment. Discharge and recharge volumes were measured from irrigation dams as well borehole water level monitoring. Experience was gained in geological logging and pump testing of boreholes in the dolomites

Geophysical survey
Walvisbay, Namibia

Member of the investigation team to determine the volume of saturated sediments South of Walvisbay, along the Kuiseb River in Namibia which was estimated by modelling gravity and time-domain electromagnetic data, and calibrated by means of exploratory drilling, The position of the saline wedge due to seawater intrusion was mapped using the EM-34 electromagnetic method.

Geophysical survey and supply projects
Various, South Africa

Member of the investigation team to conduct a gravity survey for possible groundwater supply to Zeerust from fault zones extending into the underlying dolomites (North West Province).

Member of gravity and electromagnetic survey team at Polfontein to identified potential groundwater resources.

Member of investigation team to determine the thickness of alluvium in the Limpopo River at Greefswald. EM-34 electromagnetic soundings were conducted and modelled to compile alluvial aquifer thickness contour maps. This investigation was for water supply to the Venicia diamond mine in the Northern Province.

Geophysical survey and supply projects
Various, South Africa

Part of geophysical team comprising out of gravitation and electromagnetic geophysical methods survey at Pomfret (North Western Cape) to identified potential groundwater resources for area and regional water supply.

Member of an investigation team who conducted a geophysical study at St Lucia and Richards bay (KwaZulu Natal Province), to map salt-water intrusions into the fresh water lakes.

Cape Fold Belt (Southern Cape) research project for faulting and joint zones. Survey comprises out of Very Low Frequency (VLF) electromagnetic, EM-34 and magnetic survey.

Project leader of groundwater pollution study at Clayville - gravity survey (Gauteng) in the East Rand.

Member of the investigation team for Municipal groundwater supply projects for the following towns; Stella, Mareetsane, Amsterdam, Botriver, Francshoek, Ceres, Jefferysbay, Van Wyks Vlei, Williston and Groblersdal. Responsibilities included managing a drilling and test pumping programme that included drilling and test pumping supervision, borehole construction and groundwater sampling.

Part of investigation team conducting a combined gravity and seismic reflection survey at Bray (Northern Cape) to locate a graben structure beneath the Kalahari sediments.

Member of the investigation team to conduct an aquifer study at Witsand (Northern Cape). Geophysical survey comprises out of gravity, electromagnetic soundings and magnetic method. Borehole drilling was conducted to confirm aquifer yield.

Part of the drought relief program in Kwazulu Natal for community water supply projects. Involvement included borehole siting, drilling and testing supervision and geological borehole logging. Geophysical training of learner and junior technicians was also conducted as part of the programme.

Geophysical survey and supply projects
Various, South Africa

Member of the investigation team to conduct a groundwater pollution study at Dundee (KwaZulu Natal) for proposed sludge irrigation site.

Member of the investigation team to conduct a groundwater pollution study at Paul Pietersburg (KwaZulu Natal) to determine groundwater contamination from coal mining activities.

Project leader of geophysical team conducting a characterisation study on the Transvaal Sequence Dolomite in the Nelspruit (Mpumalanga Province) area.

Municipal groundwater supply projects at Mara, Bandelierskop (Limpopo Province), Rietfontein, Mareetsane and Danielskuil (Northern Cape Province). Responsibilities included managing a drilling and test pumping programme that included drilling and test pumping supervision, borehole construction and groundwater sampling.

Member of the geophysical investigation team for kimberlite intrusions at Rietfontein (Northern Cape Province).

Part of Ghaapplato LANDSAT research project - gravity, electromagnetic and magnetic survey.

Project leader of drought relief program for community water supply in Seshego, Mokerong 2 and Zebediela (Limpopo Province). Responsibilities included geophysical borehole siting, managing a drilling and test pumping programme, drilling and test pumping supervision, borehole construction and groundwater sampling.

Project leader of IFR (In Stream Flow Requirements) studies in the Mogalakwena Sabie and Sand rivers (Mpumalanga Province). Determination of sand thickness through selected river profiles using gravity, resistivity and electromagnetic soundings methods.

Team member of geophysical LANDSAT research project at Adelaide (Eastern Cape).

Part of research and characterisation project in the Wolkberg (Limpopo Province) area to determine the extent of the karstification in these dolomites. Responsibilities included gravity survey, borehole siting, managing of drilling and test pumping programme, drilling and test pumping supervision, borehole construction and groundwater sampling.

Member of the investigation team of a research project at Calitzdorp (Southern Cape) to investigate the Cape Fold Belt underneath cretaceous sediments (Karoo sediments) - Gravity survey.

Member of the investigation team of a research project across the Matlala and Moletsi Batholiths in the Limpopo Province for the possibility of groundwater occurrence on batholith contact zones at depth. Responsibilities included electromagnetic survey managing of drilling and test pumping programme, drilling and test pumping supervision, borehole construction and groundwater sampling.

Geophysical survey and supply projects
Various, South Africa

KwaZulu Natal Groundwater perspective - Compilation maps on Arc view.

El Nino mitigation program- study report for DWAF.
Part of geophysical mineral exploration team for gold deposits near Barberton (Mpumalanga Province) - Electromagnetic survey.

Electromagnetic survey for mineral exploration for ISCOR, Iron deposits - Limpopo Province.

Part of the DWAF Refurbishment programme for community groundwater supply in Mokerong 1(Limpopo Province) - Involvement includes hydrocensus, crisis identification, geophysical surveys, borehole siting, geological logging, pump test and drilling supervision.

Part of pollution control study's at Koornfontein and Douglas collieries near Witbank (Mpumalanga Province) - borehole logging and drilling supervision, slug testing, EC measuring and water sampling of pollution inflows into boreholes.

Groundwater Strategic Planning and groundwater data management
Various, South Africa

KwaZulu Natal Groundwater perspective - Compilation maps on Arc view.

El Nino mitigation program- study report for DWAF.

The possible utilization of governmental drilling rigs of the Northern Province under the water services program - study report

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Borehole data management of Northern Province Refurbishment programme - Aquabase groundwater database.

Borehole data management of the Limpopo Province - Aquabase. Compilation of user maps - ArcView.

Assisting with groundwater statistics and First Order Strategy maps of Limpopo, North West Eastern Cape, Free State, Mpumalanga, Northern Cape and KwaZulu Natal Provinces.

Compiling of Limpopo, Eastern Cape and KwaZulu Natal provinces Groundwater Development Strategic planning maps - ArcView.

Hydrocensus, Groundwater Supply and Geophysical surveys projects
Gauteng, South Africa

Bothithong (Northern Cape), responsible for hydrocensus and borehole verification.
Conduct Stratagem survey at Manthatayaneng (groundwater supply project), and processing of data.

Project team leader for Kgalagadi community water supply project. Responsibilities included borehole verification, geophysical borehole sitting, managing of drilling and test pumping programmes, drilling and test pumping supervision, borehole construction and groundwater sampling. Pump test analyses and management recommendations of boreholes for KGALAGADI water supply program and Lily Farms (Zambia project) with FC interpretation software.

Groundwater supply project for irrigation farmers at Kookfotein and Jagersfontein in North West Province. Responsibilities included geophysical survey, drilling and test pumping supervision, borehole construction and groundwater sampling.

Member of investigation team at Coligny verification project for the possible groundwater resource potential of granite aquifer for water supply augmentation. Responsible for detailed hydrocensus survey and resource assessment.

Responsible for drilling and testing supervision at Bapong community water supply project. Responsible for data processing and management recommendations with FC interpretation software.

Part of Moshaweng village sanitation project, which include borehole verification, water quality sampling, identification of aquifer and source protection zones and potential pollution sources.

School sanitation project (Gill and Ass.), which include borehole verification, village baseline water quality, identification of aquifer and source protection zones and potential pollution sources. Assist in report compiling.

Pump testing of existing boreholes at Lanseria Polo Estates development, Water quality analyse and management recommendation - Report.

Geophysical groundwater investigation at Pollack Park Golf Course in Springs - Gauteng Province. Data analysis and report writing.

Geophysical survey
Orapa, Botswana

Conduct a Stratagem survey to outline kimberlite intrusions at Orapa and Lethlakane kimberlite diamond mines in Botswana.

Hydrocensus, Groundwater Supply and Geophysical surveys projects
Various, South Africa

Grootpan Dolomite Survey. Detailed Hydrocensus surveys of boreholes and springs for updating of groundwater databases and hydrogeological investigations.

Willodene (Free State Province), groundwater supply project. Responsible for electromagnetic (EM) and magnetic geophysical investigation for groundwater and report writing.

Part of Source development programme for drought relief villages in the Limpopo Province. Responsible for geophysical survey comprising out of electromagnetic and magnetic methods for groundwater and report writing.

Crocodile Creek Polo Estate. Prepare relevant documentation for borehole licensing procedures and Water service provider contract.

Vryburg South, groundwater supply project for low cost residential development. Responsible for geophysical survey.

Hyde Park High School. Geophysical survey comprising out of electromagnetic and magnetic methods.

Mabeskraal sanitation survey. Responsibilities include borehole verification, water quality sampling, identification of aquifer and source protection zones and potential pollution sources.

Laxey Gravity groundwater supply Project. Responsible for geophysical survey comprising out of gravity and magnetic methods.

Project team leader of Uitvalgrond (North West Province) groundwater supply project. Management of extensive gravity survey and data manipulation.

Fullgro gravity survey in North West Province for manganese deposits Responsible for drilling and test pumping supervision, groundwater sampling of exploration boreholes.

Camden and Wyksfontein ward 8, community groundwater supply projects. Responsible for geophysical survey.

Burnstone groundwater project at Balfour in Mpumalanga Province. Responsible for test pumping supervision. Data analyses of test results with FC interpretation software and report writing.

Mabula Lodge groundwater supply project (Limpopo Province). Responsibilities included managing of drilling and test pumping programme including drilling and test pumping supervision, borehole construction and groundwater sampling. Interpretation and management recommendations of test pumping results with FC interpretation software.

Groundwater Supply and Geophysical surveys projects
Various, South Africa

Magalies Water Round 7, community supply programme (Ruigtesloot, Transactie and Tweelaagte; 36 Boreholes drilled). Responsibilities included managing of drilling and test pumping programme which include drilling and test pumping supervision, borehole construction and groundwater sampling. Pump test data interpretation and management recommendations (FC software).

Drought Relief project at Derby in North West Province (13 Boreholes drilled). Responsibilities included managing of drilling and test pumping programme which include drilling and test pumping supervision, borehole construction and groundwater sampling. Pump test data interpretation and management recommendations (FC interpretation software).

Magalies Water round 7, on-going community supply programmes. Managing drilling and testing programme, drilling and pump testing supervision at 9 villages as part of a drought relief program. 11 Boreholes were drilled and 10 boreholes pump tested. Pump test analyses of test results with FC interpretation software.

Mabula Lodge groundwater supply project, Mokai Kai area (Limpopo Province). Extension of previous survey to Mokai Kai area. Responsibilities included managing of drilling and test pumping programme, drilling and test pumping supervision, borehole construction and groundwater sampling. Interpretation and management recommendations of test pumping results with FC interpretation software.

Well field development for Magalies Water at Shakung/Jericho, community groundwater supply project. Responsible for management of drilling programme of advance borehole drilling techniques in loose Karoo sediments with Johnson screen constructions (4 boreholes) and double casing constructions with perforated steel outside and PVC inside (2 boreholes).

Groundwater Supply and Geophysical surveys projects
Various, South Africa

Drought Relief programme at Koster in North West Province (South Africa). Responsibilities included hydrocensus, managing of drilling and test pumping programme including drilling and test pumping supervision, borehole construction and groundwater sampling. Interpretation and management recommendations of test pumping results with FC interpretation software.

Swartruggens Drought relief programme (North West Province), Magalies Water Round 7. Responsibilities included managing of drilling and test pumping programme including drilling and test pumping supervision, borehole construction and groundwater sampling. Interpretation and management recommendations of test pumping results with FC interpretation software.

Groundwater supply project
Nacala, Mozambique

Drilling supervision and borehole construction at Nacala in Mozambique for Murray and Roberts for water supply to new planned coal terminal.

Groundwater Baseline study, Hydrocensus, Groundwater Supply and Geophysical surveys projects
Various, South Africa

Responsible for drilling supervision of monitoring boreholes at Bravo Eskom project near Ogies.

Member of geophysical team conducting a geophysical investigation for monitor boreholes at Cullinan Diamond Mine (CDM) in Cullinan, Gauteng Province. Managing geophysical survey, data interpretation and borehole siting.

Conduct a hydrocensus at Dawn Park for new residential development. Responsible for pump testing programme and supervision of groundwater monitoring boreholes at Heidelberg as part of planned underground Coal mining project.

Manganese Metal Company, characterisation and baseline assessment. Responsible for drilling supervision, groundwater sampling and slug testing of monitoring boreholes. Slug test data interpretation.

Part of groundwater sampling team of monitoring boreholes at Shisen Iron Mine (South Africa).

Eskom Underground Coal Gasification project - Amersfoort. Responsible for magnetic survey, borehole siting, drilling supervision, groundwater sampling and slug testing of boreholes. Slug test data interpretation.

Kloof Gold mine (South Africa), Groundwater contamination study. Responsible for geophysical survey, managing of drilling and test pumping programme including drilling and test pumping supervision.

Proposed tailings facility at Geluksdal site - Rand Uranium. Responsible for managing of drilling and test pumping programme including drilling and test pumping supervision and report writing.

Groundwater Baseline study
Bakouma, Central African Republic

Bakouma Groundwater Assessment. A Geohydrological investigation that formed part of an environmental feasibility study with the aim of developing pit dewatering strategies as well as groundwater impacts. Responsibilities included managing of test pumping programme, data interpretation and installation of water level loggers.

Groundwater Impact Assessment (contamination) and groundwater baseline studies
Various, South Africa

Conduct a groundwater impact assessment for Foskor (PTY) LTD near Phalaborwa, as part of their EIA for their proposed pyroxenite expansion project (PEP). Involvement includes managing geophysical survey, drilling and test pumping programme including drilling and test pumping supervision, borehole construction and groundwater sampling. Data interpretation, groundwater conceptual model and report writing.

Conduct a hydrogeological investigation at the Norcros, Olifantsfontein site, near Irene. The study involved hydrogeological site assessment, groundwater quality and vulnerability, identify possible pollution sources and access impact on groundwater system and nearby wetland. Responsible for field survey, data interpretation and groundwater report writing.

Involved in the on-going hydrogeological consultancy services to Eskom’s Underground Coal Gasification (UCG) project team at the Majuba trial site in south-eastern Mpumalanga Province. Responsible for geophysical survey, borehole siting for relocated community, installation of level loggers and monitoring of water level of shallow aquifer and six monthly groundwater hydrochemistry monitoring report and technical memos.

Conduct a phase I hydrogeological investigation for Foskor (PTY) LTD at their North Pyroxenite Mine (NPM). Foskor (Pty) Ltd is currently operating two open pit mines in Phalaborwa. The study comprises out of a hydrocensus, groundwater sampling, quality analyses, GAP analyses and inception report.

Responsible for drilling supervision for monitor boreholes for Unitrans Fuel and Chemicals (Pty) Ltd (Unitrans), at the Tulisa Park Truck Depot. Write technical memo on drilling results.

Conduct a groundwater study at Xstrata Atcom for two adjacent projects. Responsible for geophysical survey, the drilling supervision, slug testing and groundwater sampling. Data interpretation and report writing.

Conduct a phase II hydrogeological investigation for Foskor (PTY) LTD at their North Pyroxenite Mine (NPM). Foskor (Pty) Ltd is currently operating two open pit mines in Phalaborwa. Responsible for managing of geophysical survey, drilling and test pumping programme including drilling and test pumping supervision, borehole construction, slug testing and groundwater sampling. Data interpretation, groundwater conceptual model and report writing.

Groundwater Impact Assessment (contamination) and groundwater baseline studies
Various, South Africa

Ruighoek Chrome Mine in the North West province, Groundwater and geochemical investigation as part of basic assessment. Responsible for drilling supervision of two new monitoring boreholes adjacent to TSF, hydrocensus, groundwater and geochemical sampling and report.

Integrated Water and Waste management Plan for Koornfontein Mines (Pty) Ltd. The mine forms part of the Optimum Coal Holdings Group and operates underground and planned open pit mining operations, as well as a coal beneficiation plant near Komati Power Station in Mpumalanga Province Responsible for groundwater specialist reporting.

Groundwater Impact Assessment (contamination) and groundwater baseline studies
Various, South Africa

Conduct a hydrogeological assessment at the AngloGold Ashanti Iduapriem (AAIL) mine which is located in the south west of Ghana close to the town of Tarkwa. The assessment of the hydrogeology of the mining and surrounding area was undertaken to identify sources of groundwater contamination (arsenic was reported), the extent of any associated groundwater pollution plumes and the construction of a preliminary conceptual hydrogeological model. Responsible for site assessment, hydrogeology data evaluation, drilling supervision of monitoring boreholes, water sampling, hydrocensus, GAP analyses and assessment report.

Groundwater Impact Assessment (contamination) and groundwater baseline studies
Various, South Africa

Responsible for baseline groundwater assessment report for Lonmin Platinum mines in North West Province.

Responsible for groundwater sampling and characterising at Sappi Usutu - Swaziland. Data interpretation and technical reporting.

Conducted a groundwater baseline assessment at Enviroil's site at Wadeville, Germiston. The groundwater assessment form part of the specialist studies of the Environmental Impact Assessment (EIA) at the new Enviroil site. Responsible for drilling supervision, slug testing, groundwater sampling, data interpretation and reporting.

Groundwater specialist report to inform the EIA in support of the application for an Integrated Waste Management Licence Application for Evraz Highveld Limited (Mpumalanga Province).

Part of investigating team at Platreef mine in Mokopane. Responsible for geophysical survey, drilling supervision and test pumping at proposed decline portal.

Drilling of additional groundwater monitoring boreholes at Evraz Highveld steel and Vanadium steel works to characterise the groundwater quality outside the site boundary and map pollution plume. Responsible for drilling supervision and groundwater report writing.

Drilling of additional groundwater monitoring boreholes at Evraz Highveld steel Mapoch's mine to characterise and monitor groundwater quality down gradient of paddocks. Responsible for drilling supervision and groundwater report writing.

Conduct groundwater study at Sasol Secunda Halve pan site. Responsible for geophysical survey, data interpretation and drilling site selection, drilling and test supervision, sampling and reporting.

Involved in the Vaal Gamagara Groundwater water scheme. Responsible for hydrocensus in two Source development areas Danielskuil and Postmasburg. Supervision of geophysical survey.

Groundwater baseline study
Nyanzaga, Tanzania

Involved in to assessment of the potential impacts that the proposed Nyanzaga mine in Tanzania will have on the receiving surface and groundwater regimes.

Groundwater Impact Assessment (contamination), baseline and supply studies
Various, South Africa

Responsible for groundwater baseline report for Exxaro Resources (Pty) Ltd at their Zincor facility located in the Springs district of Gauteng.

Part of groundwater specialist study at Impala Platinum Refinery as part of the Environmental Impact Assessment (EIA) and for a Water Use Licence application (WULA).

Conduct a hydrogeological assessment at the proposed passive water treatment plant at Anglo Coal Vryheid Coronation Colliery (VCC) in KwaZulu Natal Province. The hydrogeological assessment is part of the Environmental Impact Assessment (EIA) and Water Use Licence application (WUL) for the proposed passive water treatment plant. Responsible fieldwork and reporting.

Conduct a groundwater baseline report for Zitholele Consulting (Pty) Ltd to provide a specialist groundwater input in support of the Waste License process at Kendal Power Station. This process involves an Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) - as part of the Integrated Water Use License (IWUL) for the extension of the existing dry ashing facility and a Waste Management Licence (WML) for the existing ash dump to continue disposal of ash for the next 7 years whereupon a new ash dump will be commissioned. Project manager, responsible for task management and reporting.

Part of the team who conducted groundwater assessment at the Dimbaza Foundry site located close to King Williams Town (Buffalo City Municipality) in Eastern Cape. Responsible for reporting on the groundwater status following the site visit and to inform the DEA of the proposed monitoring boreholes which will support the groundwater specialist study for the closure of the Dimbaza Foundry site.

Involved in the Vaal Gamagara Groundwater Resource Assessments and possible augmentation of the Vaal-Gamagara pipeline water scheme. Responsible for supervision of drilling of large diameter boreholes in the Dolomite Karst formation at Danielskuil area. Test pumping supervision and interpretation of high yielding boreholes. Responsible for groundwater reports of two source development areas (SD1 and SD2).

Conduct a groundwater baseline report for Zitholele Consulting (Pty) Ltd to provide a specialist groundwater input in support of the Waste License process at Kendal Power Station and for the waste management licencing for the 30 year extension of ash disposal upon a new ash dump. Project manager, responsible for task management and reporting.

Project manager of geophysical survey at Samancor Lannex operations near Steelpoort. Objective was to map the pollution plume, Identify zones of deeper weathering and fracturing of the bedrock which could act as preferential groundwater flow paths. Responsible for task management and reporting.

Conduct geophysical survey at Sasol Secunda Halvepan site to optimize installation of scavenger borehole positions. Responsible for data interpretation, drilling site selection and reporting.

Project manager of a geophysical survey and drilling programme at Sasol Secunda Halvepan, to optimize installation of scavenger boreholes. Responsibility includes data interpretation, drilling site selection and groundwater report writing.

Responsible for compiling of three groundwater source development reports namely, Ga Magatle, Thamoyanche and Klein Eiffel in Northern Cape Province.

Project manager of a geophysical survey at Impala Platinum operations near Rustenburg – North West Province. Objective was to map the sub surface to identify zones of deep weathering and fracturing of the bedrock which could act as preferential groundwater flow paths. The geophysical survey was part of an assessment to locate suitable geological targets to install exploration/scavenger boreholes for remediation purposes as part of the rehabilitation programme. Responsibility includes task management and groundwater report writing.

Tubatse Chrome ground and surface water monitoring programme – 2015.

Groundwater task manager of specialist study at Exxaro's Grootegeluk Coal mine in Limpopo Province. Grootegeluk Coal Mine (Grootegeluk) is an existing open-pit mine situated 25 km from Lephalale (Ellisras). The groundwater specialist study is part of the revising of their Integrated Water Use License Application (IWULA) and their Integrated Water and Waste Management Plan (IWWMP) for the Grootegeluk Coal Mine and Reductants Plant.

Project manager of a groundwater feasibility study to assess the viability and sustainability of potable groundwater as a source to supply the villages around the Mathanjana Magisterial District in the Dr JS Moroka Local Municipality.

Task manager of ongoing hydrogeological consultancy services to Eskom's Underground Coal Gasification (UCG team at the Majuba trial site in south-eastern Mpumalanga Province. As part of the ongoing Hydrogeological services a geophysical survey was conducted during March 2015 to assist with the selection of drill sites for the installation of shallow monitoring boreholes in the compliance zone around Gasifier 1 and 2 (existing production boreholes).

Project manager of groundwater investigation to undertake the Environmental Impact Assessment (EIA) and Waste Management Licence (WML) application, including a water use licence application (WULA) for Eskom at their proposed Flue Gas Desulphurisation (FGD) retrofit to Medupi Power Station.

Project manager of groundwater specialist study for Khongoni Coal as part of their Mining Right Applications (MRA). Writing of the scoping report, conduct groundwater Impact assessment to determine the impact of the proposed opencast coal mine on the groundwater.

Part of investigation team for Midal Cables International LDA to do a hydrogeological and geophysical Investigation at their water treatment plant (WTP). The water quality of groundwater abstracted do not confirm to the specifications for which the plant was originally for.

Project manager of source verification and development projects for Oppel Consulting & Construction Management (OCCM) who appointed Golder Associates (Pty) Ltd to verify and assess the existing groundwater potential at Disake, Mokgalwaneng and Pella, Silwerkrans in the North West Province.

Conduct groundwater specialist investigation for Anglo American Inyosi Coal (Pty) Ltd (AAIC) for their Heidelberg South Rand Underground Mining Project, Gauteng Province. It comprises an area of 75 square kilometres, and is located ~ 35 km to the northwest of Eskom's Grootvlei Power Station. Compile Scoping report and conduct groundwater impact assessment.

Conduct aquifer testing of existing boreholes and an Earth Resistivity Image (ERI) profile for Exarro at Pegasus South at their Inyanda Colliery – Mpumalanga Province.

Project manager of a a geophysical survey for Delta H at Commissiekraal to determine optimal drilling sites for the groundwater impact investigation for the proposed underground coal mine in the Kwazulu Natal Province.

Project manager of groundwater specialist study for Zitholele Consulting (Pty) Ltd to undertake the Environmental Impact Assessment (EIA) and Waste Management Licence (WML) application, including a water use licence application (WULA) for the proposed Flue Gas Desulphurisation (FGD) retrofit to Medupi Power Station. Responsible for Groundwater task management and reporting.

Project manager of Aquifer testing programme for Exxaro at Inyanda Colliery – Mpumalanga Province. Responsible for Groundwater task management and reporting.

Project manager of drilling project of scavenger boreholes for Sasol Synfuels at Secunda - Mpumalanga Province and the update the groundwater numerical model of Sasol Synfuels Halvepan.

Project manager of a groundwater specialist study for Glencore's IMpunzi Office and Phoenix pit, Mpumalanga Province. The groundwater specialist study is part of an EIA and WULA application for Impunzi for the proposed extension of their opencast operations at the Office and Phoenix area. Responsible for Groundwater task management and reporting.

Project manager of Aquifer testing programme for at Anglo American's Umlalazi Minipit, and Kromdraai Colliery near Witbank– Mpumalanga Province. Responsible for Groundwater task management and reporting.

Project manager of an Earth Resistivity Image (ERI) survey for Kimopax (PTY) Ltd at Tshandama – Limpopo Province. Involvement, task management and reporting.

Part of investigation team for Khumani Iron Ore Mine (KIOM) to develop groundwater resources on the farms Bruce and King to augment the total shortfall in water supply. Accountable for drilling and aquifer testing programmes and reporting.

Project manager of a geophysical survey for Delta H at Standerton in the Mpumalanga Province. The geophysical survey is to locate suitable geological targets and deep weathering zones to optimize drilling targets. Responsible for Groundwater task management and reporting.

Part of investigation team to conduct a groundwater specialist study for Ukwazi's copper project near Musina, Limpopo Province. The groundwater specialist study is part of a scoping level of confidence mining study to compile a Mining Works Programme (MWP) as part of the Mining Right Application (MRA). Responsible for Groundwater task management and reporting.

Project manager of Aquifer testing programme for KMSD Consulting Engineers, to test two existing boreholes, one each at Madibeng and Perth Primary Schools. Responsible for Groundwater task management and reporting.

Project manager of a groundwater investigation for Onno Fortuin Consulting, to install additional groundwater supply and monitoring boreholes at Vryburg's new Waste Water Treatment Works (WWTW). Responsible for Groundwater task management and reporting. Task involved geophysical survey, drilling and aquifer testing.

Project manager of a hydrogeological investigation for Sedibeng Water and the Department of Water and Sanitation to verify the status and use of existing production boreholes and to augment shortfalls in water demand at three villages (Atamelang, Khunwana and Vrischgewaagd) within the Tswaing Local Municipality as part of emergency supply services. ADI Engineering (ADI) was appointed by Sedibeng Water as Professional Service Provider for the above stated Project and Poloko Trading 634 CC the appointed contractor. Responsible for Groundwater task management and reporting. Task involved geophysical survey, drilling and aquifer testing.

Project manager of a hydrogeological investigation for Sedibeng Water and the Department of Water and Sanitation is upgrading water sources of villages within the Tswaing Local Municipality as part of emergency water supply services. B2B Consultants (PTY) Ltd (B2B) appointed Golder Associates to conduct a hydrogeological investigation at Mofufutse 1 as part of the emergency water supply service. Responsible for Groundwater task management and reporting. Task involved geophysical survey, drilling and aquifer testing.

Project manager of groundwater verification and source development projects for Oppel Consulting & Construction Management (OCCM) who appointed Golder Associates (Pty) Ltd to verify and assess the existing groundwater potential at Magong, Kameelboom and Madikwe in the North West Province. Responsible for Groundwater task management and reporting. Task involved geophysical survey, drilling, aquifer testing, borehole registration and reporting.

Project manager of a groundwater feasibility study for McCain Springs Plant site. Study include desk study, hydrocensus groundwater quality analyses and reporting.

Conduct a groundwater baseline study for a proposed new open cast copper mine close to Musina. The hydrogeological investigation was based on available information as input into a scoping report that includes a gap analysis and scope of work required to support IRL environmental permitting process.

Project manager for a geophysical survey at Sasol Synfuels at their Sasol Nitro Fertilizer (Nitro) plant, to investigate the sub-surface for geological structures namely; dolerite dyke intrusions, deep weathering and fracture zones which could act as preferential groundwater pathways. Responsible for Groundwater task management and reporting. Task involved geophysical survey (ERI and magnetic methods) and reporting.

Conduct hydrogeological support services as part of the Dr Ruth S Mompati Rural Water Supply Programme (2016-2019) at Broederspút, Schweizer Reneke, Reivilo and Lykso. Responsible for groundwater project management and reporting. Tasks involved geophysical survey, drilling and aquifer testing.

Conduct a hydrogeological phase I investigation at Phola Coal Processing Plant (PTY) Ltd near Ogies, Mpumalanga Province. The objective of the groundwater investigation is to establish a comprehensive and site wide groundwater monitoring programme. Responsible for Groundwater project management and reporting.

Conduct a groundwater baseline investigation and Environmental Impact Assessment (EIA) for Exxaro at Turfvlakte adjacent to Grootegeluk Mine, Limpopo Province. Responsible for groundwater task management and reporting. Tasks involved geophysical survey, drilling support, aquifer testing and impact scenarios and mitigation measures.

Conduct a groundwater source verification and development investigation at Campbell in the Northern Cape Province. The objective of the hydrogeological investigation is the verification of the status of exiting boreholes, fountains, groundwater quality and long term safe yields of production boreholes. Responsible for groundwater project management and reporting. Tasks involved geophysical survey, drilling, aquifer testing and borehole management recommendations.

Installation of new background monitoring boreholes at Tubatse Chrome at Steelpoort. Responsible for groundwater project management and reporting.

PROFESSIONAL AFFILIATIONS

SACNSP (South African Council for Natural Scientific Professions, Pr. Sci. Nat) Reg. no. 400027/11

COURSES

Mine Water Course, University of the Free State, 2008

Acid Mine Drainage Introduction, sampling and monitoring activities in waste disposal sites with emphasis to Mining environment, introduction to WISH programme and introduction to groundwater in the Mining industry.

***Technical Writing Course, GAA In-house**,*

November 2008

***Project Management Course, GAA In-house (PM24)**,*

July 2008

Report Writing Course, wordsm;ths-Barbara English,

July 2010

Exploration Drill Rig Safety Training Course, DICASA,

June 2011

Project Management Fundamentals Course, GAA In-house,

October 2012

Microsoft Excel – Advanced, Front Foot Strategic Consulting,

May 2014

CURRICULUM VITAE

1. Name and Surname: Nkosinathi Tomose

2. Proposed Role in the Team: Principal Heritage Consultant

3. Biop: Nkosinathi (affectionately known as Nathi by his peers) is an experienced consultant with 11 years' experience in the predevelopment and development sector. He specialises in environmental and sustainability matters and is an accredited archaeologist and heritage resources management resources management specialist. In his 11 years' involvement in the predevelopment and development sector, he has managed environmental and sustainability projects relating to turnkey linear development such as water augmentation, Eskom power transmission and distribution, as well as urban development and sustainability projects.

Nathi holds a Masters in Science (MSc) from the Wits University and is currently enrolled for **Master of Architecture in Sustainable Cities** (Wits) (**2018 to 2019**).

Nathi began his career in the predevelopment and development sector facilitating stakeholder relations for mine development programme in KwaNongoma, KwaZulu-Natal for **Synergistics Environmental Services** (2004). He was later appointed by Sumo Coal (a Turkish mining company in SA) and its Turkish associates as the lead **Public Participation and Community Liaison Officer** in the **Environmental Impact Assessment** for the construction of Nizamiye Turkish Masjid in Midrand (2005). Among other private companies that he has worked for are: Nzumbululo Holdings (Pty) Ltd (**Division Manager: Environment and Sustainability Department);** PGS Heritage (Lead Heritage Consultant and Community Liaison); Kanya College (**Associated Researcher**). He has worked on projects such as Environmental and Heritage Impact Assessments, Namoya SALR – Gold Mine, Maniema Province in the eastern Democratic Republic of Congo.

Within the public sector Nathi has worked for the South African Heritage Resources Agency (SAHRA) in various capacities and as a lead project manager for the Cradle of Humankind World Heritage Site (COWHS), and for the University of the Witwatersrand in the School of Geography, Archaeology & Environmental Studies.

4. Major Projects Involved in 2015 – 2017

A) Basic Assessment Report (BAR), Environmental Management Programme, Environmenta Audit for the Proposed Bela-Bela 132kV Substation, Bela-Bela, Waterberg District, Limpopo Province. Status: Approved – Environmental Authorisation (EA) Issued in April 2017 (**Annexure A**) (**Power and Energy**)

Role: Lead Consultant and Author:

Client: GKB Design and Associates (Pty) Ltd on Behalf of Bela-Bela Local Municipality

Referee: Mr Gaylord Mupona (gmupona@gkbgroup.co.za/ 0825276969)

Project Proponent: Bela-Bela Local Municipality

B) Integrated Heritage Resources Management report for the Proposed Elim District Hospital Redevelopment, Limpopo Province Inclusive of Baseline Social Impact Assessment and Biodiversity Study (**Built Environment**)

Role: Lead Consultant and Author:

Client: Ngonyama Okpanum and Associates (Pty) Ltd

Referee: Mr Hammond Dendere, Project Architect & Development Planner

Project Proponent: Limpopo Department of Health

Role: Lead Consultant and Co-Author:

Client: Moditi Consulting (Pty) Ltd and Ngonyama Okpanum and Associates (Pty) Ltd

Referee: Mr Hammond Dendere (hammond@noact.co.za / tshepom@moditi.co.za)

Project Proponent: National Department of Health

C) Integrated Heritage Resources Management Report and Social Impact Assessment Study for the Proposed Medupi Power Station Flue Gas Desulpherisation (FGD) Project, Limpopo Province, South Africa (**Power and Energy**).

Role: Lead Consultant and Author:

Client: Zithole Consulting (Pty) Ltd

Referee: Mrs. Sharon Meyer-Douglas (sharonm@zitholele.co.za / +27 11 207 2073)

Project Proponent: Eskom Holdings

Referee: Mrs. Sharon Meyer-Douglas, Head of Environmental service

Project Proponent: Eskom Holdings

D) Heritage and Social Impact Assessment and Social Impact Assessment Study for Study for the Proposed Ariadne-Eros 400kv/132kV Multi-Circuit Power Transmission Line, KwaZulu-Natal Province, South Africa (**Power and Energy)**.

Role: Lead Consultant and Author:

Client: Mokgope Consulting CC, Director

Referee: Dr Mpho Nenweli (mphonenweli@gmail.com /082 256 73099)

Project Proponent: Eskom Holdings and African Development Bank

E) Heritage and Socio-Economic Studies for the Proposed Passenger Rail Agency South Africa (PRASA) for the following Stations (**Built Environment**):

- HIA and SIA for Wonderboom PRASA Station, Pretoria Gauteng Province, South Africa
- HIA and SIA for and SIA for Lellara PRASA Station, Tembisa, Gauteng Province, South Africa
- HIA and SIA for Limindlela PRASA, Tembisa, Gauteng Province, South Africa
- HIA and SIA for Kempton Park PRASA Station, Kempton Park, Gauteng Province, South Africa
- HIA and SIA for for Germiston Junction PRASA Station, Germiston, Gauteng Province, South Africa
- HIA and SIA for Roodepoort PRASA Station, Roodepoort, Gauteng Province, South Africa
- HIA and SIA for Vereeniging PRASA Station, Vereening, Gauteng Province, South Africa
- HIA and SIA for Duffs Road PRASA Station, KwaMashu, KwaZulu-Natal Province, South Africa
- HIA and SIA for Merebank PRASA Station, Durban South, KwaZulu-Natal Province, South Africa
- HIA and SIA for Rossburgh PRASA Station, Durban South, KwaZulu-Natal Province, South Africa

Role: Lead Consultant and Author:

Client: Ecosolve Environmental Consulting (Pty) Ltd

Referee: Mr Tsepo Lepono, Managing Director (tsepo@ecosolve.co.za / 083 339 9103)

Project Proponent: Passenger Rail Agency South Africa

F. Scoping, Environmental Impact Assessment, Environmental Management Programme for Mathanjane Bulk Water Augmentation, Limpopo and Mpumalanga Province (**Water Infrastructure**)

Role: Lead Consultant and Author:

Client: GKB Design and Associates (Pty) Ltd

Referee: Mr Gaylord Mupona (gmupona@gkbgroup.co.za/ 0825276969)

Project Proponent: Rand Water on behalf of National Department of Water Affairs.

5. **Demographic** Black Youth
6. **Gender** Male
7. **Nationality** South African
8. **Date of Birth** 05 May 1983

9. Education

Name of Institution	Degree Obtained	Dates Attended
University of Witwatersrand	M.Sc. Degree	2007 – 2008
University of Witwatersrand	B.S.C Honours (Landscape and GIS)	2006
University of Witwatersrand	BA Geography & Archaeology	2003 – 2005

10. Other Qualifications (Further Education and Skills Improvement)

Name of Institution	Training Details	Dates Obtained
University of Witwatersrand	Master of Architecture in Sustainable Cities	Current - 2019

11. Professional Registration/Licensure *(do not include memberships of industry associations)*

Registration/Licensing Body	Type of Registration	Date Obtained
ASAPA	Cultural Resources Management: Industrial Archaeology, Built Environment, Iron Age, Rock Art and Burial Grounds and Graves	2006 to date
Amafa KwaZulu-Natal	General Heritage Consultant (Archaeology, Rock Art, Built Environment and Landscape, Burial Grounds and Graves)	2010 to date
Eastern Cape PHRA	General Heritage Consultant (Archaeology, Rock Art, Built Environment and Landscape, Burial Grounds and Graves)	2010 to date
SACNASP	Currently Applied for Environmental Management	2018

12. Countries of Work Experience

Country	Start and End Date
South Africa	2008- to present (BAR, EMPrs, Environmental Audits, Social Impact Assessment Studies, Community Participation, Relocation Action Plan and ICRMs, Public Participation and Social Consultation)
Democratic Republic of Congo	2012 -2012 (HIA, Namoya SALR – Gold Mine, Maniema Province
Peoples Republic of China	2010-2010 (Cultural Resources Management)
United States (Smithsonian Institute)	2007-2007 (Operational Models, Funding and Marketing of Cultural Heritage Institutions in South Africa)
France (*Centre National de la Recherché Scientifique*)	2004-2004 (Recording, documentation and dating of rock art)

13. Languages (Scale of 1 – 5: Poor; 5 and above: Excellent)			
Language	Speaking	Reading	Writing
IsiXhosa	5	4	4
English	5	5	5
Afrikaans	3	3	3
SeSotho	4	4	4
SeTswana	3	3	3
IsiZulu	5	5	5

14. Employment Record *Starting with current position, list in reverse order every employment held by the candidate since graduation, giving dates of employment, name of employing organisation, positions and responsibilities held.*

Employer	**Date:**
A) NGT Holdings (Pty) Ltd:	**September 2012 to date**
Position Held:	Founder and Director
Location:	Victory Park, Johannesburg
Responsibilities:	• Strategic Leadership • Governance • Financial Accounting • Risk Management **Professional Technical Work** • Basic Assessment Reports, EMPrs, Environmental Scoping and EIRs • Water Use License Applications (WULA); • Waster License Application (WLA); • Social and Socio-Economic Impacts Consulting • Integrated Cultural Resources Management • Development of Community Participation Strategies in Developmental Projects • Project Management and Administration
B) Freelancer	**May to September 2012**
Responsibilities:	BAR, Consulting Project Manager, Heritage and Social Impact Specialist
C) Nzumbululo Holdings (Pty) Ltd	**April to May 2012**
Position Held:	Division Manager: Environment and Sustainability Department
Location:	Midrand, Johannesburg, South Africa
Responsibilities:	• Business development (marketing, tendering and responding to RFQs) • Managing department budget and team specialist • Coordination and management of Basic Assessments and EMPr for road development for Limpopo Road Agency • Coordination and management of heritage projects - including grave relocation projects • Coordination and management of social impact projects

issues the management of heritage and social issues in environment and engineering projects - processes and legislation

- Management of document pathway with authorities.

Employer	**Dates:**
D) PGS Heritage (Pty) Ltd	**October 2010 to February 2012**
Position Held:	Heritage Consultant and Community Liaison Officer
Location:	Waverley, Pretoria, South Africa
Responsibilities:	• Management of heritage and grave relocation projects • Community Liaison – consulting and facilitating multi-stakeholder relations in projects that involve community and grave relocation in Mpumalanga Province i.e. clients included **Eskom Kusile Power Station (clearing ground for Kusile Power Station), Xstrata, Glencoe, Anglo, BHP Billiton and Anglo Coal**. • Management of document pathway with authorities.

E) Khanya College (NPO)	**April to October 2010**
Position Held	Associate Researcher and History Programs Facilitator
Location	Johannesburg, South Africa
Responsibilities	• This job formed part of Khanya College and Workers Museum History Programme; it involved researching socio-cultural and socio-economic issues affecting previously disadvantage communities in South Africa with a particular focus on Migrant Labour (ML) issues; their forms of social organization, resistance, their socio-cultural and economic dynamics e.g. disruption of their pattern of life and livelihoods as the result of migration and political system in South Africa. • Assisting Khanya College with capacity building in community empowerment workshops. • Assisted Khanya College with the development and administration of a Monitoring and Evaluation Programme (MEP) for its Annual Winter School (NGO conference & workshops). Assisting with field research/interviews in socio-cultural and economic programmes as part of Khanya College and the Workers Museum History Programme aimed at conserving and promoting histories and heritage of migrant labour in South Africa.

F) South Africa Heritage Resources Agency (SAHRA)	March 2009 to March 2010
Position Held	Cultural Heritage Officer (**Built Environment**)
Location	Johannesburg (80%) and Cape Town (20%)
Responsibilities	• Adjudication of heritage Impact assessment (HIAs), archaeological impact assessments (AIAs), palaeontological impact assessments (PIAs) and environmental impact assessments (EIAs) studies submitted to the SAHRA. • Adjudication of heritage permits and grave relocation permits. • Fostering relations between SAHRA, developers and Civic organisations on the management of cultural resources in South Africa. • Advising developers to strategically incorporate heritage resources into their projects as a form of conservation measure e.g. development of integrated heritage management plans and/or conservation management plans. • Managing the Cradle of Humankind World Heritage Site (COHWHS) in association with the Management Authority, the Gauteng Department of Economic Development and the Gauteng Department Agriculture and Rural Development.

Employer	Date:
G) School of Geography, Archaeology & Environmental Studies	**April 2008 to February 2009**
Position Held	Collections Manager
Location	Johannesburg, South Africa
Responsibilities	• Development and management of archaeology collections database/repository using Vernon Collection Management System. • Development of Archaeology Department collections management policies • Establishment and implementation of safety and security measures for the protection and conservation of Wits archaeology collections by liaising with different stakeholders. • Preparation of collection for education and research purposes.

H) Synergistics Environmental Services (Pty) ltd	**2004 to 2006 (Part-time basis)**
Position Held	Community Liaison Officer
Location	Johannesburg, South Africa
Responsibilities	• Management of multi-stakeholder relations in application of mining rights, environmental impact assessments and public participation in kwaNongoma, South Africa.

I) Sumo Coal (Pty) ltd	**2006 to 2006 (Part-time basis)**
Position Held	Public Participation and Community Liaison Officer
Location	Johannesburg, South Africa
Responsibilities	• Management of multi-stakeholder relations in the environmental management process for the development of application of mining rights, environmental impact assessments and public participation in Midrand, South Africa.

15. Conference Papers Presented And Manuscripts Published:

Nkosinathi, G. Tomose, 2010. Challenges and Opportunities in Managing Multi-Stakeholder Interests in World Heritage Site: *A Case of the Cradle of Humankind World Heritage, South Africa*. Conference Presentation in Beijing, Peoples Republic of China.

15. Certification

- I, the undersigned, certify that to the best of my knowledge and belief, this CV correctly describes my qualifications and my experience. Furthermore, I understand that any willful misstatement described herein may lead to my disqualification or dismissal, if engaged on projects with the client.
- Finally, I hereby confirm my availability to commence work on any of your projects, from **08/January/2018**

Signature

Education

BSc. Eng (Civil) , University of Cape Town, Cape Town , 1996

Languages

English – Fluent

Afrikaans – Fluent

Golder Associates Africa (Pty.) Ltd. – Johannesburg

Surface Water Group - Civil Engineer

Conduct storm water planning and modelling, provide civil engineering input to storm water designs, provide technical support to junior staff, mentoring and supervision, provide review capacity, project management and administration, provide linkage between engineering team and water resources group.

Water Engineering Division - Civil Design Engineer

Civil Engineer in the Water Engineering Division. Tasks and responsibilities include civil engineering design and review, feasibility studies, project management, construction supervision, tender preparation, mentoring and administration.

Mining Infrastructure and Waste Division – Civil Design Engineer

Civil Engineer in the Mining Infrastructure and Waste Division. Tasks and responsibilities include civil engineering design, feasibility studies, project management, construction supervision, tender preparation, mentoring and administration.

Surface Water and Closure Division - Civil Design Engineer

Civil Engineer in the Surface Water and Closure Division. Tasks and responsibilities included mine closure cost estimates and mine rehabilitation planning and project management.

Water Engineering Division - Civil Design Engineer

Civil Engineer in the Water Engineering Division. Tasks and responsibilities included civil and hydraulic design (pipe and pump), project management, involvement in tender and construction, project cost estimation, feasibility studies, development and administration.

Employment History

Golder Associates Africa (Pty) Ltd – Midrand and Pretoria, Gauteng, South Africa

Civil Design Engineer (September 2002 to Present)

Civil Engineer in the Water Engineering Division. Tasks and Responsibilities include Civil Engineering Design, Project Management, Involvement in Tender and Construction, Project Cost Estimation, Business Development, Marketing, Site Supervision, and Administration.

Wates, Meiring and Barnard Consulting Engineers (Pty) Ltd – Midrand, Gauteng, South Africa

Civil Design Engineer (September 2001 to August 2002)

Civil Engineer in the Water Engineering Division. Tasks and Responsibilities included Civil and Hydraulic Design (pump and pipe), Project Management, Involvement in Tender and Construction, Site Supervision, Project Cost Estimation, Development and Administration

National Department of Water Affairs and Forestry – Pretoria, Gauteng, South Africa

Engineer (2000 to August 2001)

Civil Engineer in the Sub-Directorate: Structural Studies. Tasks and Responsibilities included Structural Analysis of bulk water facilities using the Finite Element Method, compilation of Design and Analysis Reports, Development and Administration.

National Department of Water Affairs and Forestry – Gauteng, South Africa

Assistant Engineer (April 1998 to 1999)

Civil Engineer in the Sub-Directorate: Structural Studies. Tasks and Responsibilities included Structural Analysis of bulk water facilities using the Finite Element Method, compilation of Design and Analysis Reports, Development and Administration

National Department of Transport – Gauteng, South Africa

Assistant Engineer (January 1997 to March 1998)

Civil Engineer in the Sub-Directorate: Pavement Management Systems and member of the Department of Transport Engineer in Training Design Team. Responsibilities included Civil Design, Feasibility Studies, Review, Compilation of Reports, Development and Administration.

PROJECT EXPERIENCE – INFRASTRUCTURE

McCain Foods - Storm water management plan Mpumalanga, South Africa	Prepare tender designs for conveyance of water discharged from plant areas. Includes runoff modelling, hydraulic calculations and civil engineering design.
Yanfolila TSF - conceptual design Yanfolila, Mali	Conduct runoff caclulations and sizing of storm water interception / diversion works and flood peak for Phase 1 and Phase 2 TSF spillway.
Vanchem Vanadium Products - Detail Design of Calcine Disposal Facility Extension Mpumalanga, South Africa	Detail civil engineering design of extensions to lined calcine disposal facilities and storm water pond. Included role of project manager and design lead. also presentation to Department of Water and Sanitation. Tender process and technical tender evaluation.
McCain Foods Delmas - Conceptual Storm Water Management Mpumalanga, South Africa	Upgrades and improvements to Oil Offloading Area to keep oil spills out of storm water, and general surfacewater management interventions
Steyn City Estate Development Gauteng, South Africa	Develop concepts for the construction of a weir across the Jukskei River, for water use licence and environmental approval.

PROJECT EXPERIENCE – MINING

Acacia Bulyanhulu Mine - Conceptual Design and Costing: - dam lining Bulyanhulu, Tanzania	Conceptuak engineering for dam liners, including technical memo and costing.
Vale Moatize Coal Tete, Mozambique	Conduct design of in-pit disposal of coarse rejects and waste rock mine waste streams.
Vanchem Vanadium Products - Options Analysis for Next Phase Development Ferrobank, Mpumalanga, South Africa	Conduct an options analysis for determining the optimal extension of the calcine dump, based on the conceptual design. Project elements included PCD sizind for 3 options, capacity analysis and cost estimate for development (capital).
Vanchem Vanadium Products - Remaining Capacity Analysis Ferrobank, Mpumalanga, South Africa	Determination of remaining airspace volume and life of facility, using aerial survey and by estimating average deposition rates.

Vale Moatize Coal - Product Stockpile, Run of Mine Stockpile and Waste Dump Tete, Mozambique	Provide professional review capacity for engineering development of dumps.
Msobo Coal - pollution control dam - Integrated Water Use Licence Application Mpumalanga, South Africa	Prepare conceptual details of pollution control dam for support of IWULA. Present to Inkomati Catchment Management Agency.
Anglogold Ashanti West Wits Mponeng Shaft PCD Upgrade Gauteng, South Africa	Design of new PCD including upgrade of surface water collection system, earthworks, liners, ancillary works etc. To tender level. Includes engineering drawings, specifications, schedule of quantities and cost estimate.
Vale Moatize Coal - Conceptual and Detail Design Phases Tete, Mozambique	Detail design of all aspects relating directly to the waste and product stockpiles including platform design, dranage design, consideration of spontaneous combustion, modelling, leachate management.
Vanchem Mpumalanga, South Africa	Design of infrastucture for a new calcine disposal and slimes disposal facility for Vanchem, various infrastructure including earthworks, liners and PCD works.
Waterval Domestic Waste Facility Rustenburg/Limpopo, South Africa	Design of all aspects of waste domestic waste disposal facility for Rustenburg Local Municipality including services, earthworks, liners and water management.
Anglo American Thermal Coal Waterberg Degassing Project, South Africa	Conceptual Engineering Design of infrastructure related to the energ yfrom gas project including earthworks, storm water and separation, services and ancillary works.
SAPPI Ngodwana Design of Macrodump Extension, South Africa	Prepare detail design of the macrodump extension at SAPPI Kraft Mill in Ngodwana, Mpumalanga, South Africa. Included earthworks, storm water, cell liners, access, separation systems and ancillary works. Lead in design team.
BHP Billiton Energy Coal SA Limited Middelburg Mines - Mine Water Reclamation Facility, South Africa	Conceptual Engineering Design for the Waste Disposal Facilities (sludge and brine) and ancillary works.
BHP Billiton Energy Coal SA Limited Rietspruit Mine Rehabilitation	Member of design team responsible for ongoing desing, site assessments, designer input to quality assurance and ongoing construction team support. An EPC type project.
Amoma Mine Ghana, Ghana	Detail design of storm water management and ancillary works, remote site support and ongoing design and testing input during the construction phase, assistance in materials procurement and manufacturing. Member of design team.

Amoma Mine Ghana, Ghana	Conceptual design and costing assistance for storm water management, and environmental protection measures for proposed Amoma mine in Ghana.
Goldfields Kloof Mine Carletonville, South Africa	Design, tender and site assistance for construction of upgrades to Kloof Plant 1 and Plant 2 return water dams.
Exxaro Coal (Matla) Ogies, South Africa	Remediation design in terms of drainage, involvement also in tender and site assistance aspects.
ASA Metals South Africa	Design, tender and site assistance relating to the construction of infrastructure for ASA Metals mine and smelter including storm water, sewer and water supply.
Africon Tete, Mozambique	Design and tender aspects relating to infrastructure for new coal mining development in Tete, Mozambique, Golder as sub-consultant to Africon.
Exxaro Coal (Matla) Ogies, South Africa	Design, tender and site supervision for construction of river diversion of the Rietspruit River.
Anglo Coal Mpumalanga, South Africa	Design and tender involvement for new return water dams and associated infrastructure at Greenside Colliery.
BHP Billiton Energy Coal SA Limited Middelburg, South Africa	Tender Design Stage: - analysis and design for raw water abstraction works, gravity pipeline to water reclamation plant and intake tower. Construction Design Stage: - design and tender involvement for sludge and brine disposal facility and associated works, as well as part-time site supervision.
BHP Billiton Energy Coal SA Limited Middelburg, South Africa	Conduct system analysis and design for a small floating pump station to transfer raw mine water from an evaporation dam to a passive treatment plant steel reservoir. Prepare drawings, pipe schedules and assist with measurement of tender quantities.
AngloGold Ashanti Limited West Wits and Orkney, South Africa	Conduct rehabilitation planning for eleven sites on the AngloGold Ashanti Limited West Wits and Vaal River operations. This involved extensive site reconnaissance, project management and reporting. The deliverables were eleven rehabilitation planning reports which incorporated situational descriptions of the sites and rehabilitation plan. Detailed cost estimates for implementation were also provided.
Highveld Steel and Vanadium Corporation Mapochs Mine Roossenekal, South Africa	The closure and rehabilitation cost estimate and report were prepared for the plant and opencast mining areas of the mine. This included on-site assessment of closure components and preparation of closure cost in line with regulatory guidelines and requirements.

Goldfields Beatrix Mine Virginia, South Africa	The closure and rehabilitation cost estimate and report were prepared for four shafts and two gold plants of the mine. This included on-site assessment of closure components and preparation of closure cost in line with regulatory guidelines and requirements.
De Beers Finsch Mine Lime Acres, South Africa	The project involved the engineering design, specification and tender process of the mechanical and civil components of the return water system, including a barge pump system, a return water pump station and return water pipeline.
Sappi Ngodwana Mill Ngodwana, South Africa	The project entailed collection of spring ("Eye") water, transfer to treatment facilities, and distribution. Personal involvement included collection system, plant layout and distribution in the disciplines of pumping, piping and civil works. The project was done at the level of preliminary design and cost estimate.
Olifantsvlei Water Treatment Plant Johannesburg, South Africa	Conducted a water hammer analysis for the new sludge pump station and pipeline system.
Sappi Ngodwana Mill Ngodwana, South Africa	As a member of a multi-disciplinary team, conducted Civil and Piping design for the Effluent Reduction Project Phase 1: Distribution System. The work involved upgrading the mill treatment plant, recycling process water to a new reservoir and distributing the water back into the mill process. Personal involvement included industrial site investigation in brown field's conditions, rising main analysis and design, pump selection, reticulation design and water hammer analysis.
Sunderland Ridge Waste Water Works Centurion, South Africa	Initiated layout and design of civil work for the new anaerobic digester facility.
Kimberley Diamond Mine Kimberley, South Africa	Conducted preliminary design of roads and potable water diversion for the new rock dump facility at Kimberely Diamond Mine.
Extensions to Mothotlung WWTP Northwest Province, South Africa	Was appointed Resident Engineer for full time site supervision during the construction phase of the Waste Water Treatment Plant at Mothotlung Township.
Kingston Vale Hazardous Waste Disposal Site Nelspruit, South Africa	Was member of a design team; design of main and secondary access roads, relocation of farm irrigation, dust suppression and water services for farm labourers.
Sadiola Gold Mine Treatment Works Western Mali	Was involved in design review.
King Dinizulu Effluent Treatment Plant Eshowe, South Africa	Was involved in aspects of detailing and design for the plant layout and biological reactor.

Zheng Yong Garment Factory Effluent Treatment Works
Swaziland

Was tasked with drawing and design for the pumping, piping and civil structure for the Sand Filter Installation at the water treatment works for the garment factory.

Ephes Mamkele Primary School
Wattville, South Africa

Was involved in detailing and design for various aspects of the school layout and facilities, including management of storm water.

Kgolagano Primary School
Benoni, South Africa

Was involved in detailing and design for various aspects of the school layout and facilities, including management of storm water.

Luvuvhu River G.W.S.
Luvuvhu WMA, , South Africa

Tasked with reinforcement and detailing for a concrete pipe junction box.

Spring Grove Dam
Mooi River, South Africa

Conducted a 2D stability analysis for earthquake loads using a DOS based analysis package and confirmed results using a commercially available module. The work was conducted for an in-house client for whom a letter was drafted to report on the findings of the analysis.

Finite Element Analysis
Various, South Africa

Conducted Finite Element Analysis and prepared Analysis Reports for the following dams and structures:
Welbedacht Dam
Thabina Dam
Dasbos Tunnel Plug
Lindleyspoort Dam
Pongolapoort Dam
Der Brochen Dam Intake Tower
Oukloof Dam

National Route 1: Hex River Pass
Western Cape, South Africa

Was tasked with the preliminary design and cost estimate for geometric improvements to “Spookdraai” on National Route 1, known for accidents due to “hairpin bend”, particularly amongst heavy vehicles.

National Route 10 Section 3
Cradock, South Africa

A portion of the N10 Section 3 passes by a stretch of rock face immediately adjacent to the roadway. A history of rock falls and increasingly unstable conditions in the rock face required planning and development of remedial measures, preliminary design and costing and selection of alternatives. Formed part of the Design Team involved in this project.

PROFESSIONAL AFFILIATIONS

Professional Engineer (Pr Eng) Engineering Council of South Africa (ECSA)

Geosynthetic Interest Group of South Africa (GIGSA)

South African Institution of Civil Engineers (MSAICE)

Water Institute of South Africa (MWISA)

PUBLICATIONS

Conference Proceedings

JORDAAN, JOHAN and FRANCOIS MARAIS. 2014. *THE VANCHEM WASTE DISPOSAL FACILITY, A PHASED DEVELOPMENT APPROACH OF A VANADIUM HAZARDOUS WASTE SITE*. SAICE 5th INTERNATIONAL MINING AND INDUSTRIAL WASTE MANAGEMENT CONFERENCE, MARCH. RUSTENBURG, SOUTH AFRICA.

Golder Associates Africa (Pty.) Ltd. – Johannesburg

Water Resource Scientist, Water Division

Lee Boyd is a Water Resource Scientist in the Surface Water Team, Water Division of Golder Associates Africa (Pty) Ltd. Lee gained her professional experience in the field of water quality management with particular emphasis on wastewater related issues and nutrient management. Lee has also been the project manager on several catchment management projects including the development of an Integrated Water Quality Management Plan for the Olifants Water Management Area and the development of a Catchment Management Strategy for the Breede-Gouritz Water Management Area. She has worked closely with stakeholders from various sectors in these catchment studies. She is a Water Institute of Southern Africa (WISA) fellow, was on the WISA Board and WISA Water Scientists Committee for several years.

Education

BSc. Biological Sciences, University of the Witwatersrand Johannesburg, 1987

BSc. Honours, University of the Witwatersrand Johannesburg, 1990

MSc. Water Utilisation, University of Pretoria, 1994

Languages

Afrikaans – Fluent

English – Fluent

Employment History

Department: Water Affairs and Forestry – Pretoria, South Africa

Deputy Director, Resource Protection and Waste: Local Government and Water Service Institutions (2005 to 2006)

Overall planning, quality control, and oversight to ensure consistency with the issuing and review of Water Use Authorisations, including co-operative authorisations with DEAT and DME (marine outfall, waste disposal, EMPR), and the implementation of Interventions for non-compliance and the development and consistent implementation and review of Policy and Regulatory Instruments.

Department: Water Affairs and Forestry – Pretoria, South Africa

Assistant Director, Water Quality Management, Urban development and Agriculture (1998 to 2005)

Development of policy, strategies, procedures and guidelines to ensure compliance to the relevant legislation as contained in the relevant sections of the National Water Act.

Cydna Laboratories (Jhb City Council) – Johannesburg, South Africa

Registered Scientist (1996 to 1998)

The post included water pollution control issues including research as required, eg disinfection studies, gas works remediation studies, odour studies.

Northern Works STW (Jhb City Council) – Johannesburg, South Africa

Registered Scientist (1993 to 1996)

The post included routine laboratory analysis, development of new analytical techniques, research activities with respect to plant optimisation for the biological nutrient removal process

Cydna Laboratories (Jhb City Council) – Johannesburg, South Africa

Registered Scientist (1988 to 1992)

This was the first position held after completing studies and involved research projects on viruses in sewage, anaerobic digestion, leachate studies, biological phosphate removal studies and routine lab work.

PROJECT EXPERIENCE – WATER RESOURCES

Golder Associates Africa Gauteng, South Africa	Update of the 1996 Water Quality Guidelines for Domestic Use
Golder Associates Africa Mpumalanga/ Limpopo, South Africa	Development of an Integrated Water Quality Management Plan for the Olifants Water Management Area
Golder Associates Africa Western Cape, South Africa	Development of a Catchment Management Strategy for the Breede-Gouritz Water Management Area
Golder Associates Africa Gauteng/North West/Mpumalanga, South Africa	Implementation of the Waste Discharge Charge System in the Upper Olifants and Upper Vaal catchments
Golder Associates Africa Gauteng/NorthWest/Limpopo, South Africa	Classification of significant water resources in teh Crocodile (West)/Marico WMA and the Mokolo and Matlabas catchments of the Limpopo WMA.
Golder Associates Africa Gauteng and Free State, South Africa	Development of Resource Quality Objectives for the Middle Vaal
Golder Associates Africa Mpumalanga, South Africa	Update on the water resources requirements in the Highveld coalfields
Golder Associates Africa Gauteng, South Africa	A water resources, water supply and water requirements assessment of the Highveld Coalfields area of the Upper Olifants catchment
Golder Associates Africa Gauteng, South Africa	Development of an inspection guideline for wastewater treatment works
Golder Associates Africa Gauteng, South Africa	Technical review of the AngloGold Ashanti Vaal River and West Wits operations wastewater treatment works
Golder Associates Africa Gauteng, South Africa	Implementation of an integrated water quality management model
Golder Associates Africa Gauteng, South Africa	Development of a framework for the integration of water resources and potable water quality

Golder Associates Africa Johannesburg, South Africa	Development of a guideline for package plants for Johannesburg Water

PROJECT EXPERIENCE – VARIOUS

Golder Associates Africa Johannesburg, South Africa	Development of Integrated water and waste management plans and integrated water use licence applications for various mines and industries
Golder Associates Africa Johannesburg, South Africa	The Manual of Guidelines on the Management of EDCs in Water Resources Volume 4: Management Options for EDCs in Catchments
Department of Water Affairs and Forestry Pretoria, South Africa	Development of an intervention and support protocol for non-compliant Local Authorities in the wastewater sector
Department of Water Affairs and Forestry Pretoria, South Africa	Development of an emergency protocol for water related diseases.
Department of Water Affairs and Forestry Pretoria, South Africa	Development of Waterworks regulations in terms of the National Water Act, 1998 and associated qualifications
Department of Water Affairs and Forestry Pretoria, South Africa	Phase 1 of the development of a Nutrient management strategy for South Africa.
Department of Water Affairs and Forestry Pretoria, South Africa	A Strategy to manage the water quality effects from densely populated settlements – the approach used as well as the implementation of the strategy in the informal settlement on the banks of the Klip River as it passes through the wetlands.
Department of Water Affairs and Forestry Pretoria, South Africa	Audit of the Northern Province Water Resources Management with particular reference to sewage works operations.
Department of Water Affairs and Forestry Pretoria, South Africa	Development of Unit Standards for the Wastewater industry
Department of Water Affairs and Forestry Pretoria, South Africa	Development of an Aide Mēmoire for Sewage Works
Cydna Laboratories, Johannesburg City Council Pretoria, South Africa	Rehabilitation studies at an old gas works site in Johannesburg.

Cydna Laboratories, Johannesburg City Council
Pretoria, South Africa

Research into percentage readily biodegradable COD in various industrial effluents discharged to sewer.

PROFESSIONAL AFFILIATIONS

Senior Fellow of the Water Institute of Southern Africa

PUBLICATIONS

Other

Boyd, L. and Tompkins, R.(2011) 'A New Mindset for Integrated Water Quality Management for South Africa', International Journal of Water Resources Development, 27: 1, 203 — 218

Boyd L and Tompkins R. A conceptual model for integrated water quality management in South Africa, Drinking Water Quality Conference, May 2009, South Africa

Mc Donald L.A. and Theron P.F. “Towards a Microbiological Indicator for Leachates” Presented at the International Conference on Waste management in the Nineties, Tenth Conference, 1990, South Africa.

Boyd L.A. and Lötter L.H. “The Effect of Chemical Addition on Biological Phosphate Removal” Presented at the WISA conference, May 1993, South Africa.

Pitman A.R. and Boyd L.A. “Transforming Local Government Wastewater Departments – from Adversary to Industrial Partner”, Presented at the IAWQ Conference Chemical and Process Industries and Environmental Management, Cape Town, 8 to 10 September 1997, South Africa.

Boyd L.A. “Poster Relating to Filamentous Bacteria in Three Johannesburg Wastewater Treatment Works” presented at the first International Specialised Conference on Micro-organisms in Activated Sludge Processes, September 1993, Paris, France.

Boyd L.A. “Poster entitled: Managing the Water Quality Effects from Settlements” presented at the International Symposium Frontiers in Urban Water Management, Deadlock or hope? June 2001, Marseille, France.

Boyd L.A. “Waterworks Regulations” Afriwater 2003, South Africa.

Boyd L.A. “Waterworks Regulations in Terms of the National Water Act” WISA 2004, South Africa.

Boyd L.A. “Diffuse Pollution in an Urban Context and its Management under the National Water Act” IWA/WISA Specialist Conference, August 2005, South Africa.

Kasselman G. and. Boyd L.A. The Integrated Authorisation of Effluent and Residues Emanating from the Treatment of Domestic Wastewater and Potable Water under the National Water Act”, IWA/WISA Specialist Conference, August 2005, South Africa.

Yonanda Martin Pri Sci Nat
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B.Sc Degree in Environmental Science from the University of North West, Potchefstroom Campus (2003). M.Sc Degree in Ecological Remediation and Sustainable Utilization from the University of North West, Potchefstroom Campus (2007). She is currently employed by Newtown Landscape Architects working on the following projects.

EXPERIENCE: ***Associate / Senior Environmental Practitioner*** **- NEWTOWN LANDSCAPE ARCHITECTS CC**

Responsible for the management and writing up of environmental projects, which includes Basic Assessments, Environmental Impact Assessments (Scoping & EIA), Environmental Management Programmes (EMPr), Environmental Monitoring, Water Use Licenses as well as Visual Impact Assessments.

Current Projects:

Environmental Projects

- **Diepsloot East Residential Development,** Diepsloot. Environmental Impact Assessment, Environmental Management Programme, Water Use License and management of specialist.
- **Lindley Waste Water Treatment Works,** Mogale City Local Municipality project located in Lindley / Lanseria. Environmental Screening, Environmental Impact Assessment, Environmental Management Programme and Water Use License Application and management of specialist.
- **African Leadership Academy,** Laser Park, Johannesburg. This project entails the rectification of activities undertaken by ALA as well as the compilation of an overall Environmental Management Programme (EMPr) that addresses current environmental concerns on campus but also future projects such as recycling, rain water harvesting, vegetable gardens and events.
- **Orchards Extension 50-53**, Orchards. The project includes the construction of a residential development. The project includes monitoring of the environmental conditions as well as the appointment of sub-consultants for rehabilitation purposes.
- **Kareekloof Oxidation Ponds, Suikerbosrand.** This project entails the environmental monitoring during construction and rehabilitation of the project.

Visual Impact Assessments

- **Holfontein Integrated Waste Management Facility Project** (SLR Consulting (Pty) Ltd), Holfontein, Gauteng Province

- **Eskom Arnot Ash Dump Project** (Environmental Impact Management Services), Rietkuil, Mpumalanga Province
- **Kalkheuwel Housing Development** (ECO Assessments), Kalkheuvel, North-West Province
- **Kyasand Light Industrial Project** (Terre Pacis Environmental), Kyasand, Gauteng Province

PROFESSIONAL AFFILIATIONS:

Registered Professional Natural Scientist – 400204/09 (September 2009)
Member of IAIAsa
IAIAsa Gauteng Branch Chair 2016/17

EDUCATION:

Environmental Law Training, Business Success Solutions (2016)
Invasive Species Training: Module 1 – Introduction to Legislation, South African Green Industries Council (SAGIC) (2016)
Invasive Species Training: Module 2 – Developing and Implementing Control Plans, South African Green Industries Council (SAGIC) (2016)
Invasive Species Identification Training Workshop, South African Green Industries Council (SAGIC) (2015)
Sharpening the Tool: New techniques and methods in Environmental Impact Assessment, SE Solutions (2014)
First Aid Level 1, Action Training Academy (2014)
Supervisory Management, ISIMBI (2011)
Public Participation Course, International Association for Public Participation, Golder Midrand (2009)
Wetland Training Course on Delineation, Legislation and Rehabilitation, University of Pretoria (2008)
Environmental Impact Assessment: NEMA Regulations – A practical approach, Centre for Environmental Management: University of North West (2008)
Effective Business Writing Skills, ISIMBI (2008)
Short course in Geographic Information Systems (GIS), Planet GIS (2007)
M.Sc Degree in Ecological Remediation and Sustainable Utilization, University of North West, Potchefstroom Campus (2007)
Thesis: Tree vitality along the urbanization gradient in Potchefstroom, South Africa.
B.Sc Degree in Environmental Science, University of Potchefstroom (2003)

CURRICULUM VITAE

18 January 2017
vanzyl_generalcv_jan2017

MARIUS VAN ZYL

Profession:	Environmental Management
Date of Birth:	4 July 1955
Position in firm:	Technical Director
Years with the firm:	8
Nationality:	South African
Education / Qualifications:	B.Sc. Honours (Biochemistry & Environmental Management)
Languages:	English, Afrikaans
Employers:	
AECI (Pty) Ltd	1980
Rand Afrikaans University	1981 - 1984
Department of Water Affairs and Forestry	1984 - 1994
Jarrod Ball & Associates cc	1994 - 2005
Golder Associates Africa (Pty) Ltd	2005 - 2010
Jones & Wagener Consulting Civil Engineers (Pty) Ltd	2010 -

Areas of Expertise:

Integrated environmental authorisation processes, Environmental Impact Assessments and Environmental Management Programmes (EMPr's), Water Use Licence applications; Integrated Water and Waste Management Plans (IWWMPs); licensing of waste management facilities, identification and evaluation of candidate waste disposal sites; waste and residue characterisation, classification and assessments; waste and water management facility monitoring, interpretation of results and auditing; integrated environmental management solutions, public participation.

Professional Affiliations:

Registered Professional Natural Scientist (Pr.Sci.Nat.)

Member of the Institute of Waste Management of Southern Africa (IWMSA)

Member the International Association of Impact Assessors (South African Branch) (IAIAsa)

Relevant Experience:

Integrated Environmental Authorisation Processes, Impact Assessments, EMPr's, Water Use Licence Applications and IWWMPs:

Kuyasa Mining: KiPower IPP Project, Delmas, South Africa: Project director of the multi-disciplinary team responsible for the integrated environmental authorisation, waste management licence and atmospheric emissions licence processes for the development of an Independent Power Producer (IPP) power plant and associated ash disposal facility. The project also involved the compilation of the Integrated Water Use Licence Application (IWULA) and the required Integrated Water and Waste Management Plan (IWWMP). In addition, assistance is being given for the preparation of the BID to be submitted to the Department of Energy (2010 – current).

BHP Billiton Energy Coal South Africa, Middelburg Mines: Project manager for the integrated environmental authorisation process for the Middelburg Water Reclamation Project (2010 – 2012).

BHP Billiton Energy Coal South Africa, Wolvekrans Colliery: Project manager of the multi-disciplinary team responsible for the environmental authorisation process for the expansion of the Boschmanskrans Section of the colliery. The project also involved the drafting of an Integrate Water and Waste Management Plan (IWWMP), as well as the Integrated Water Use Licence Application (IWULA) (2011 – 2014).

Lonmin Platinum, PMR Refinery, Brakpan, South Africa: Project director of the team responsible for the environmental authorisation process for the development of a new waste incinerator for Lonmin's PMR Refinery. The project also involves the drafting of the required Waste Management Facility Licence Application Report and EMPr. (2012 – current).

Kynoch Fertilizers, Potchefstroom, South Africa: Project leader for the environmental scoping and feasibility study of a storm water containment dam for Kynoch's Potchefstroom Factory. The project was carried out in association with AEMS and Hobbs Consulting. Project leader for site remediation investigation projects at Kynoch Fertilizer's Potchefstroom Factory and fertilizer depots in various locations in South Africa.

Waste Disposal Facility Licensing, Remediation and Upgrading:

Sappi Kraft Ltd – Enstra Mill, Springs, South Africa: Project leader for the drafting of the motivation for the extension of the Sappi Enstra Landfill Site. The project involved the development of a revised landform by the Jones & Wagener's engineers, as well as input by Kobus Otto and Associates (2011).

Manganese Metal Company (MMC), Nelspruit, South Africa: Project manager for the remediation and closure of the informal Pappas Quarry hazardous waste disposal site. Tasks involved the upgrading of the groundwater model, interim capping of the site, Basic Assessment for the site and compilation of the licence application report for closure (2008 – 2009).

Sappi Kraft Ltd - Ngodwana Mill, Nelspruit, South Africa: Developed the final landform and closure design for the Macrodump waste disposal facility in 1994/5 (Jarrod Ball & Associates). A motivation for the permitting of the site was compiled as part of the final landform design. Whilst employed by Golder Associates, fulfilled the role as project manager for the multi-disciplinary team involved in the extension of the Macrodump (2009 – 2010).

Vanchem Vanadium Products (Pty) Ltd (VVP), eMalahleni (Witbank), South Africa: Project manager for the identification and evaluation of candidate landfill sites, environmental impact assessment, preliminary and detailed design, and authorisation of the new calcine hazardous waste disposal facility for VVP. In order to evaluate the long-term performance of the liner system, source-pathway-receptor (SPR) modelling was undertaken as part of the feasibility study phase of the project (2007 to 2009).

Simunye Sugar Estate, Simunye, Swaziland: Identified, conducted an EIA and permitted a new waste disposal facility for the Simunye Sugar Estate in Swaziland. It involved the initial evaluation of the existing sites with a view to upgrading them. Public consultation was also undertaken as part of this project.

Sappi Novobord Ltd: White River Plant White River, South Africa: Investigated and compiled the permit application report with a view to closure of the Roodewal landfill site in association with other team members of Jarrod Ball & Associates cc.

Lekoa Vaal Metropolitan Council: Boipatong Vanderbijlpark, South Africa: Investigated and developed a remedial design and operating plan for the Boipatong landfill site. The landfill was remediated to minimise the negative public and environmental impacts it had been causing. The landfill operation was upgraded with a view to closure in accordance with acceptable landfill operating practices, while at the same time accommodating the operations of a large number of informal waste salvagers on the site. The needs of the local communities, industries and authorities have been taken into account by means of a Public Consultation Programme. The landfill was also audited on a regular basis after remediation.

Transvaal Sugar Limited: Komati Mill Komatipoort, South Africa: The project entailed the investigation, permitting, development and commissioning of the new Komati Mill landfill site (1994). It included the formulation of an operational and end-use plan. The project involved other members of Jarrod Ball & Associates cc. More recently involved in the auditing of the landfill on a regular basis with other members of Golder Associates Africa and Jones & Wagener (2012).

Kynoch Fertilizer (Pty) Limited Potchefstroom, South Africa: Project manager of the multi-disciplinary team involved in the investigation, environmental impact assessment, public consultation and permitting of Kynoch Fertilizers' hazardous gypsum tailings storage facility in association with Africon, AEMS, Jones & Wagener and Mc Trev Consultancy.

Kynoch Fertilizers (Pty) Ltd, South Africa: Project leader for site remediation investigation projects at Kynoch Fertilizer's Potchefstroom Factory and fertilizer depots at various locations in South Africa.

Impala Platinum Limited Rustenburg, South Africa: Project leader for the investigation, environmental scoping, environmental management plan and permitting of a new landfill site to serve Impala Platinum's Rustenburg Mine complex and the Royal Bafokeng Nation. Work was conducted in association with Mc Trev Consultancy, Groundwater Consulting Services and others.

Thohoyandou Transitional Local Council, Thohoyandou, South Africa: Responsible for the environmental scoping and permitting of the informal Thohoyandou landfill site (in association with Africon and Mc Trev Consultancy).

Delta EMD (Pty) Ltd Nelspruit, South Africa: Responsible for the application for an exemption in terms of Section 20(1) of the Environment Conservation Act for Delta EMD's hazardous waste Residue Treatment Facility. Currently involved in the annual audit of the treatment facility and usage of the treated residue.

<u>Waste Disposal Strategies, Systems and Procedures:</u>

Eskom Holdings SOC, Medupi Power Station, Lephalale: Project leader for the development of an IWMP for the construction phase of the power station. The project is carried out in association with Kobus Otto and Associates (2010 – 2012).

Lonmin Platinum Group, South Africa: Project leader for the development of an IWMP for the mining company's Marikana and Brakpan operations. The project is carried out in association with Kobus Otto and Associates (2011 – 2013).

Optimum Colliery, Hendrina, South Africa: Task manager for the investigations and evaluations into alternative disposal options for mine water treatment plant sludges containing gypsum (2009).

Lekoa Vaal Metropolitan Council Vanderbijlpark, South Africa: Developed a Regional Waste Disposal Strategy for the Lekoa Vaal Region. This included a status quo analysis in which the current and future waste streams were determined and the existing landfill sites were evaluated with a view to determining future disposal needs. The status quo was followed by the identification of candidate landfill sites, the development of a waste disposal strategy and a Feasibility Study and Environmental Scoping of the best candidate landfill site.

Impala Platinum Limited Rustenburg, South Africa: Developed a waste management policy and waste management procedures for various waste types for Impala Platinum's Rustenburg Mine

Complex. This was followed by the drafting of a detailed landfill operating plan for Impala Platinum's new waste disposal facility.

Gauteng Department of Agriculture, Conservation & Environment Johannesburg, South Africa: guideline document was developed for the development of IWMPs for usage by local authorities in Gauteng in association with other members of Jarrod Ball & Associates cc and other sub-consultants.

Bojanala Platinum District Municipality Rustenburg, South Africa: Assisted with the development of a strategic Integrated Waste Management Plan (IWMP) for the district municipality in association with other members of Jarrod Ball & Associates cc.

Rustenburg Local Municipality Rustenburg, South Africa: Assisted with the development of an IWMP for the municipality in association with other members of Jarrod Ball & Associates cc.

Mangaung Municipality, Bloemfontein, South Africa: Service standards for the municipality's waste disposal facilities were developed. The standards are used for the evaluation of contractors operating the waste disposal sites. The project involved the upgrading of waste management and disposal practices for the municipality. The project was carried out in association with other consultants.

<u>Identification and Evaluation of Waste Disposal Sites:</u>

COWI, Viet Tri, Vietnam: Assisted with the evaluation of a candidate landfill site earmarked for the development of a hazardous waste disposal facility in Phu Tho Province, Vietnam in association with COWI (2004). Developed a scope of work for the field investigations and design of the proposed facility.

Sappi Ngodwana Mill Nelspruit, South Africa: Identified and evaluated candidate landfill sites to serve the paper mill, associated infrastructure and residential areas. The project was conducted in association by other members of Jarrod Ball & Associates.

Southern District Council Klerksdorp, South Africa: The project involved the identification and evaluation of candidate landfill sites to serve the greater Klerksdorp, Orkney, Stilfontein area.

Rustenburg Local Municipality Rustenburg, South Africa: The project commenced with a pre-feasibility study of a candidate site identified by other consultants. This was followed by the identification and evaluation of additional candidate landfill sites in order to identify the most favourable site. The most favourable site was subjected to a feasibility study and environmental scoping exercise. The project was conducted in association with other members of Jarrod Ball & Associates and VAPI Consulting. The favoured site was successfully licensed by Golder Associates Africa in 2012.

<u>Auditing and status quo analysis:</u>

Sappi Southern Africa (Pty) Ltd, Enstra Mill: Conducted a due diligence assessment of the solid waste disposal site of the Sappi Enstra Mill (2015).

Lonmin Platinum: Marikana: Compliance audit of hazardous waste storage facility and two sewage works (2013, 2015).

Sasol Synfuels – Secunda: Compliance audit of the Waste Ash Disposal facility with other members of Jones & Wagener (2010 to 2012).

Tauw: Conducted due diligence audits for various clients of Tauw with interests in South Africa (2010 - 2016).

Mondi Kraft Ltd - Piet Retief Mill, Piet Retief, South Africa: The operation of the Mills' new waste disposal facility has been evaluated for a number of years. It included the interpretation of the results obtained from the ground and surface water monitoring system. A groundwater evaluation was carried out in 2012 as part of the motivation for the envisaged expansion of the site.

Northam Platinum Mine Thabazimbi, South Africa: Audited the implementation of the Northam Platinum Mine's Environmental Management Programme (EMPR) on an annual basis with other members of the Golder Associates Africa. Audited the environmental compliance of Northam Platinum Mine's waste disposal facility.

EnviroServ (Pty) Limited Springs & Johannesburg, South Africa: Audited the Margolis and Holfontein hazardous waste disposal facilities for a number of years in association with other members of Jarrod Ball & Associates and Golder Associates Africa in order to verify compliance with legal requirements.

MOZAL Maputo, Mozambique: Conducted an environmental due diligence audit of Metlite, a company that processes dross waste obtained from MOZAL in order to produce material for, inter alia, the explosives industry.

Johnson Matthey Germiston, South Africa: Conducted environmental due diligence audits of the company's waste management contractors in order to establish compliance with legal requirements of these companies.

Hillside Aluminium Smelter (BHP Billiton) Richards Bay, South Africa: Conducted an audit of the smelter's waste management system in order to identify shortfalls in the system. The audit was followed with the development of a waste management training manual. The project was carried out in association with other members of Jarrod Ball & Associates cc.

Chemical and Allied Industries Association (CAIA) Johannesburg, South Africa: Assisted with the development of a uniform hazardous waste management audit protocols for the Chemical and Allied Industries Association (CAIA) in association with Wiechers Environmental.

Municipal Infrastructure Investment Unit (MIIU), Thohoyandou, South Africa: Conducted a status quo analysis of the Thohoyandou Transitional Local Council's sewage water treatment and waste disposal facilities in order to establish remediation requirements, such as upgrading of the works, and organisational and training requirements.

Royal Swaziland Sugar Corporation Simunye, Swaziland: Conducted a status quo analysis of the sugar estate and mills' sewage and effluent water treatment and waste disposal facilities in order to identify environmental impacts and the need for upgrading the facilities.

ESKOM Kriel, South Africa: Conducted an audit of the operating standard of the Kriel Power Station's sewage treatment works to, inter alia, establish compliance with the Water Act's legal requirements.

Gauteng Department of Agriculture, Conservation & Environment Johannesburg South Africa: Developed a landfill evaluation pro-forma for use by government officials when inspecting and evaluating waste disposal facilities.

<u>Contaminated Land, Waste Assessments and Classifications, Geochemical Assessments and Hazard Ratings of Industrial Wastes, and Mine Residues and Deposits</u>

Assmang: Cato Ridge: Project manager for waste classification and application for Basel Convention permission to export waste (2018).

EXM Advisory Services: Conducted waste assessments for Sishen Iron Ore Company's Sishen Mine proposed new beneficiation plant (2017).

Omnia Group: Project manager for assessing various industrial sites in terms of Part 8 of the National Environmental Management: Waste Act (2017).

Eskom Holdings SOC: Majuba Power Station: Conducted waste and geochemical assessments of coal and coal stockpile leachate (2015)**.**

Aquatico: Conducted various waste assessments for Lonmin Platinum (2015).

South32 South Africa Energy Coal Limited: Conducted waste and geochemical assessments of various overburden, coal discard and fine coal stockpiles at the Vandyksdrift operations in Mpumalanga (2014).

Sasol Synfuels, Secunda South Africa: Assessment ash water, ash and seepage in terms of the National Environmental Management: Waste Act waste assessment regulations (2014).

Iliso Consulting (Pty) Ltd, Centurion, South Africa: Conducted a classification of the waste water sludge from Bloemwater's Rustfontein water treatment works in terms of the draft DEA and Minimum Requirements classification procedures, as well as the Water Research Commission's *Guidelines for the Utilisation and Disposal of Wastewater Sludge* (2012).

Sasol Synfuels, Secunda South Africa: Conducted waste classifications of fine and paste ash samples in terms of the draft DEA and Minimum Requirements classification procedures (2012).

Zitholele Consulting (Pty) Ltd, Midrand, South Africa: Conducted the classification of the new ash disposal facility for Eskom's Camden Power Station. The draft DEA and Minimum Requirements classification procedures were used in this project (2011).

Sappi Kraft Ltd – Enstra Mill, Springs, South Africa: Conduct a risk profile of the Sappi Enstra landfill site leachate with a view to reclassifying the landfill site (2011).

Exxaro, Pretoria, South Africa: Conduct a classification of a ferrous metal slag with the view to using the slag in cement based products. Both the Minimum Requirements and the draft Department of Environmental Affairs' waste classification processes were used (2011).

Anglo Platinum: Polokwane Smelter: Conducted a waste risk profile of slag with a view to reclassifying the waste disposal facility of the smelter (2010).

EnviroServ (Pty) Ltd: Commented on draft waste management regulations and waste classifications systems for client and presented comments to the Department of Environmental Affairs (2010).

Sappi Fine Paper, Ngodwana Mill Ngodwana, South Africa: Conducted a number of hazard ratings on various waste stream originating from the paper mill. It was possible to delist a number of these waste streams and obtain permission for down-stream uses thereof.

Technic Services, Luanda, Angola: Hazard rated a number of the waste types to be disposed of on Technic Services' new landfill site with a view to establishing the liner design requirements.

Delta EMD (Pty) Ltd, Nelspruit, South Africa: Investigated the alternative uses and environmental consequences of a treated metallurgical residue from Delta EMD. Project conducted in association with Environmental and Chemical Consultants and Golder Associates Africa. Responsible for the environmental evaluation of the use of a treated residue in road building applications, which led to the authorities granting permission for the use of the treated material in capped road applications

Waste Management Training

Department of Environmental Affairs, South Africa: Developed and presented a one day course on aspects of landfill performance evaluation, environmental monitoring and auditing. The training target group consisted of Control Environmental Officers of the National and Provincial Departments dealing with waste management matters (2011).

Chemical and Allied Industries Association (CAIA) Johannesburg, South Africa: Presented a short training course on the licensing procedure for waste management facilities in terms of the requirements of the National Environmental Management: Waste Act (NEM:WA) and the National Environmental Management Act (NEMA) (2010).

Mondi Forests, Piet Retief, South Africa: Developed and presented a short course in waste management for officials of Mondi Piet Retief's Forestry Division.

Swaziland Environment Authority, Mandini, Swaziland: Developed and presented an integrated waste management training course for the Swaziland Environment Authority. The course included practical excursions and exercises. The course was developed in association with other members of Jarrod Ball & Associates.

North West University's: Potchefstroom Campus, Potchefstroom, South Africa: Developed a five day course in Integrated Waste Management and Planning for the University's Centre for Environmental Management (1996 – 2007).

Basel Convention, Nairobi, Kenya: Lectured on aspects of hazardous waste management to Kenyan Government officials and the private sector in Nairobi. This formed part of the Basel Convention initiative to develop a training centre in hazardous waste management for the English speaking countries in Africa.

COWI, Viet Tri, Vietnam: Lectured on aspects of hazardous waste management to industry employees and government officials in Viet Tri, Vietnam, in association with other members of COWI (2004).

Other:

TSB Komati, Mpumalanga, South Africa: Annual evaluation of the ground water status of the sugar mill's licensed waste disposal facility as part of the annual external audit (2010 – current).

South32, South Africa: Involved in the rehabilitation and closure cost assessment, and residual risk assessment project for the Khutala Colliry as required in terms of the Financial Provision Regulations (2017 – current).

Sappi Fine Papers, Springs, South Africa: Annual evaluation of the ground and surface water status of Sappi Enstra's permitted waste disposal facilities and drafting of the interpretation report (2011, 2012, 2015).

Northam Platinum, Thabazimbi, South Africa: Registered the mine's water uses in terms of the provisions of the National Water Act.

Manganese Metal Company (MMC), Nelspruit, South Africa: Peer reviewed the consulting work carried out for the identification, investigation and permitting of MMC's new hazardous landfill site at Kingston Vale, Nelspruit. Project was carried out in association with others of Jarrod Ball & Associates. As employee of Golder Associates Africa involved in aspects of liner performance monitoring and evaluation at the Kingston Vale landfill site.

Gauteng Department of Agriculture, Conservation & Environment, Johannesburg, South Africa: Developed and conducted performance monitoring of the multi-media bin system deployed at a number of the World Summit on Sustainable Development venues in association with Sue Posnik and Associates and others.

Golder Associates SrL, Italy: Project leader for desktop study on the market potential for landfill gas (LFG) clean development mechanism (CDM) projects in South Africa for Asja Ambiente Italia (Asja). Asja is an Italian based firm with extensive experience in the landfill gas to energy industry. The study was commissioned by Mr F. Belfiore of Golder Europe.

Agresu, Maputo, Mozambique: Co-ordinated the Phase 1 evaluation of landfill gas (LFG) generation at Maputo's Hulene landfill site. The project involved the siting of three gas monitoring wells, subsequent LFG monitoring and data collection. LFG modelling was undertaken by Golder's UK team using the Gassim2 model (2009).

Summary of other Experience / Publications

Author and co-author on a number of papers pertaining to integrated catchment management and landfill remediation

Declaration

I confirm that the above CV is an accurate description of my experience and qualifications.

_______________________________ 23 February 2018

Signature of Staff Member Date

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF EAP AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

Medupi Power Station FGD Retrofit Project EIA

Environmental Assessment Practitioner (EAP):	Zitholele Consulting (Pty) Ltd (Dr. Mathys Vosloo)		
Contact person:	Dr. Mathys Vosloo		
Postal address:	P.O. Box 6002, Halfway House		
Postal code:	1685	Cell:	(084) 748 3018
Telephone:	(011) 270 2079	Fax:	(086) 674 6121
E-mail:	mathysv@zitholele.co.za		
Professional affiliation(s) (if any)	Pr. Sci. Nat. (SACNASP)		

Project Consultant:	Zitholele Consulting (Pty) Ltd (Dr. Mathys Vosloo)		
Contact person:	Dr. Mathys Vosloo		
Postal address:	P.O. Box 6002, Halfway House		
Postal code:	1685	Cell:	(084) 748 3018
Telephone:	(011) 270 2079	Fax:	(086) 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The Environmental Assessment Practitioner

I, Dr. Mathys Vosloo, declare that –

General declaration:

I act as the independent environmental practitioner in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting environmental impact assessments, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I will take into account, to the extent possible, the matters listed in regulation **8** of the Regulations when preparing the application and any report relating to the application;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;
I will keep a register of all interested and affected parties that participated in a public participation process;
I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
all the particulars furnished by me in this form are true and correct;
will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest (delete whichever is not applicable)

I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;

~~I have a vested interest in the proposed activity proceeding, such vested interest being:~~

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Signature of the environmental assessment practitioner:

Zitholele Consulting (Pty) Ltd

Name of company:

23.05.2018

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	
NEAS Reference Number:	
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

ENVIRONMENTAL IMPACT ASSESSMENT:
MEDUPI FLUE GAS DESULPHURISATION (FGD) RETROFIT PROJECT

Specialist:	Noise Specialist		
Contact person:	Reneé von Gruenewaldt		
Postal address:	PO Box 5260, Halfway House		
Postal code:	1685	Cell:	083 222 6916
Telephone:	011 805 1940	Fax:	
E-mail:	renee@airshed.co.za		
Professional affiliation(s) (if any)	The South African Council for Natural Scientific Professionals Reg No.: 400304/07		

Project Consultant:	Zitholele Consulting		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, R von Gruenewaldt, declare that --

General declaration:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Airshed Planning Professionals (Pty) Ltd

Name of company (if applicable):

29 November 2017

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	
NEAS Reference Number:	
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

ENVIRONMENTAL IMPACT ASSESSMENT:
MEDUPI FLUE GAS DESULPHURISATION (FGD) RETROFIT PROJECT

Specialist:	Air Quality Specialist		
Contact person:	Reneé von Gruenewaldt		
Postal address:	PO Box 5260, Halfway House		
Postal code:	1685	Cell:	083 222 6916
Telephone:	011 805 1940	Fax:	
E-mail:	renee@airshed.co.za		
Professional affiliation(s) (if any)	The South African Council for Natural Scientific Professionals Reg No.: 400304/07		

Project Consultant:	Zitholele Consulting		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, R von Gruenewaldt , declare that --

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Airshed Planning Professionals (Pty) Ltd
Name of company (if applicable):

29 November 2017
Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Noise and Air Quality Specialist		
Contact person:	Reneé von Gruenewaldt		
Postal address:	PO Box 5260		
Postal code:	1685	Cell:	083 222 6916
Telephone:	011 805 1940	Fax:	
E-mail:	renee@airshed.co.za		
Professional affiliation(s) (if any)	SACNASP (Reg. no: 400304/07)		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, R von Gruenewaldt, declare that --

General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Airshed Planning Professionals (Pty) Ltd
Name of company (if applicable):

01/12/2017
Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Soils Specialist		
Contact person:	Ian Jones		
Postal address:	P.O. Box 3529, Knysna		
Postal code:	6570	Cell:	0836542473
Telephone:	0836542473	Fax:	
E-mail:	ian@earthscience.co.za		
Professional affiliation(s) (if any)	Pr. Sci. Nat 400040/08 EAPASA Certified		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Ian P. C. Jones ________________________ , declare that --

General declaration:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

____

Signature of the specialist:

Earth Science Solutions (Pty) Ltd

Name of company (if applicable):

27th November 2017

Date:

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2014; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 921, 2013

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Land Capability Specialist		
Contact person:	Ian Jones		
Postal address:	P.O. Box 3529, Knysna		
Postal code:	6570	Cell:	0836542473
Telephone:	0836542473	Fax:	
E-mail:	ian@earthscience.co.za		
Professional affiliation(s) (if any)	Pr. Sci. Nat 400040/08 EAPASA Certified		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Ian P. C. Jones ______________________ , declare that --

General declaration:

I act as the independent specialist in this application;
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, Regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Earth Science Solutions (Pty) Ltd

Name of company (if applicable):

27th November 2017

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

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File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Groundwater		
Contact person:	Danie Brink		
Postal address:	P.O. Box 6001Halfway House		
Postal code:	1685	Cell:	083 379 2666
Telephone:	011 254 4800	Fax:	086 582 1561
E-mail:	dbrink@Golder.co.za		
Professional affiliation(s) (if any)	Hydrogeologist		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Danie Brink , declare that --

General declaration:

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Golder Associates Africa

Name of company (if applicable):

27 November 2017

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

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File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Surface Water Quality		
Contact person:	Lee Boyd		
Postal address:	PO Box 6001, Halfway House		
Postal code:	1685	Cell:	082 885 1799
Telephone:	011 254 4915	Fax:	086 582 1561
E-mail:	lboyd@golder.co.za		
Professional affiliation(s) (if any)	FWISA		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Lee Ann Boyd, declare that – General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

GOLDER ASSOCIATES AFRICA (PTY) LTD

Name of company (if applicable):

27 NOVEMBER 2017

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Waste assessments of FGD generated wastes		
Contact person:	Marius van Zyl, Jones & Wagener (Pty) Ltd		
Postal address:	P.O. Box 1434, Rivonia		
Postal code:	2128		
Telephone:	011 519 0200		
E-mail:	vanzyl@jaws.co.za		
Professional affiliation(s) (if any)	South African Council for Natural Scientific Professions: Registration number: 400171/87		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, Marius van Zyl, declare that --

General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

[signature]
Signature of the specialist:

Jones & Wagener (Pty) Ltd
Name of company (if applicable):

28 November 2017
Date:

Ek sertifiseer dat bostaande verklaring deur my afgeneem is en dat verklaarder erken dat hy/sy vertroud is met die inhoud van hierdie verklaring en dit begryp. Hierdie verklaring is voor my beëdig/bevestig en verklaarder se handtekening/merk/duimafdruk is in my teenwoordigheid daarop aangebring.

I certify that the above statement was taken by me and that the deponent has acknowledged that he/she knows and understands the contents of this statement. This statement was sworn to/affirmed before me and deponent's signature/mark/thumbprint was placed thereon in my presence.

te / at Gallo manor op / on 2017/11/28 om / at 14 : 30

[signature]
(HANDTEKENING) KOMMISSARIS VAN EDE
(SIGNATURE) COMMISSIONER OF OATHS

Lugmo Memmogh
VOLLE VOORNAME EN VAN IN DRUKSKRIF
FULL FIRST NAMES AND SURNAME IN BLOCK LETTERS

Gallo man
BESIGHEIDSADRES (STRAATADRES)
BUSINESS ADDRESS (STREET ADDRESS)

Cw

RANG/RANK

SA POLISIEDIENS
SA POLICE

SOUTH AFRICAN POLICE SERVICE
CLIENT SERVICE CENTRE
GALLO MANOR
28 NOV 2017
KLIENTE DIENSSENTRUM
GALLO MANOR
SUID-AFRIKAANSE POLISIEDIENS

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Heritage Impact Assessment Specialist		
Contact person:	Nkosinathi Tomose		
Postal address:	48 Dale Brook Crescent Victory Park, Randburg		
Postal code:	2195	Cell:	078 163 0657
Telephone:	011 888 0209	Fax:	
E-mail:	Nkosinathi@ngtholdings.co.za		
Professional affiliation(s) (if any)	Association of Southern African Professional Archaeologist		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, **Nkosinathi Tomose**, declare that --

General declaration:

I act as the independent specialist in this application

I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant

I declare that there are no circumstances that may compromise my objectivity in performing such work;

I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;

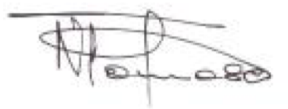
I will comply with the Act, regulations and all other applicable legislation;

I have no, and will not engage in, conflicting interests in the undertaking of the activity;

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

all the particulars furnished by me in this form are true and correct; and

I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.



Signature of the specialist:

NGT Holdings (Pty) Ltd

Name of company (if applicable):

11 May 2018

Date:

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Social Impact Assessment Specialist		
Contact person:	Nkosinathi Tomose		
Postal address:	48 Dale Brook Crescent Victory Park, Randburg		
Postal code:	2195	Cell:	078 163 0657
Telephone:	011 888 0209	Fax:	
E-mail:	Nkosinathi@ngtholdings.co.za		
Professional affiliation(s) (if any)	Association of Southern African Professional Archaeologist		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, **Nkosinathi Tomose** , declare that --

General declaration:

I act as the independent specialist in this application

I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant

I declare that there are no circumstances that may compromise my objectivity in performing such work;

I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;

I will comply with the Act, regulations and all other applicable legislation;

I have no, and will not engage in, conflicting interests in the undertaking of the activity;

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

all the particulars furnished by me in this form are true and correct; and

I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

NGT Holdings (Pty) Ltd

Name of company (if applicable):

11 May 2018

Date:

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	14/12/16/3/3/3/110
NEAS Reference Number:	
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

Proposed retrofitting of a Flue Gas Desulphurisation (FGD) system at the Medupi Power Station, Lephalale in the Limpopo Province

Specialist:	Civil Engineer		
Contact person:	J J Jordaan Pr Eng		
Postal address:	PO Box 6001 Halfway House, 1685		
Postal code:	1685	Cell:	082 614 5770
Telephone:	+27 11 254 4800	Fax:	086 582 1561
E-mail:			
Professional affiliation(s) (if any)	Engineering Council of South Africa		

Project Consultant:	Zitholele Consulting (Pty) Ltd		
Contact person:	Dr. Mathys Vosloo		
Postal address:	PO Box 6002, Halfway House		
Postal code:	1685	Cell:	084 748 3018
Telephone:	011 207 2060	Fax:	086 674 6121
E-mail:	mathysv@zitholele.co.za		

4.2 The specialist appointed in terms of the Regulations_

I, J J Jordaan, declare that --

General declaration:

I act as the independent specialist in this application
I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
I declare that there are no circumstances that may compromise my objectivity in performing such work;
I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
I will comply with the Act, regulations and all other applicable legislation;
I have no, and will not engage in, conflicting interests in the undertaking of the activity;
I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
all the particulars furnished by me in this form are true and correct; and
I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

GOLDER ASSOCIATES AFRICA (PTY) LTD
Name of company (if applicable):

2018/05/10
Date:

Eskom	Report	Technology

Title:	**Medupi Flue Gas Desulphurisation: Technology Selection Study Report**	Unique Identifier:	**474-10175**
		Alternative Reference Number:	**195700.41.0109**
		Area of Applicability:	**Engineering**
		Documentation Type:	**Report**
		Revision:	**2.0**
		Total Pages:	**44**
		Next Review Date:	**NA**
		Disclosure Classification:	**PUBLIC DOMAIN**

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Date: 9 JAN 2018	Date: 11 January 2018	Date: 11 JANUARY 2018

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Eskom Limited is under a government mandate to install and operate flue gas desulphurization (FGD) technology on the Medupi Power Station units. This study includes a technical suitability assessment of commercially available FGD technologies to identify leading FGD technologies for implementation at Medupi Power Station, the cost implications associated with the leading FGD technologies, and the raw resources required for the operation with the leading FGD technologies and their availability at the Medupi Power Station.

Commercially available FGD technologies were considered for the Medupi plant. Based on the outcome of technology studies, the leading FGD technologies evaluated in the report are the Wet FGD and Dry FGD – Circulating Fluidized Bed (CFB) technologies.

The Wet FGD has a long history of application to fossil fuelled power plants in units of all sizes, and remains the predominant process utilized today. It has high removal efficiency on high sulphur coals and only requires a single absorber vessel per boiler. The gypsum created by this process can be used in concrete and wall board manufacturing or be landfilled. There may be a waste water stream created that will require further processing. The amount of water used in Wet FGD is higher than a Dry FGD-CFB, however a flue gas cooler may be installed to reduce this water requirement to that of the Dry FGD-CFB.

The Dry FGD-CFB has been used extensively around the world and mixes lime, water, and fly ash-laden flue gas in a reactor to remove the sulphur dioxides from the boiler flue gas stream. There is no waste water stream created by this process. The fly ash created in the process will need to be landfilled. This process works best with low to medium sulphur coals and has a current reactor size maximum of 450 MW, so two reactors would be required for each boiler for Medupi.

While the implementation of WFGD with flue gas cooling has the potential to reduce the WFGD water consumption the practical challenges cannot be ignored as this is expected to have a significant impact on the maintainability and availability of the power plant and the cost of electricity to the consumer. Furthermore all three power stations from Europe visited by Eskom during a benchmarking exercise advised against the installation of the system due to the problematic operation that it provides. WFGD with flue gas cooling is therefore not considered as a feasible option for Medupi.

The implementation of the WFGD technology has the potential to contribute to the broader socio-economic development of Lephalale and its surrounding areas because the WFGD has the flexibility of using lower quality limestones that can be sourced from areas closer to the power station which is not the case with the DFGD systems. Furthermore the water supply for the WFGD at Medupi is part of the Phase 2A water augmentation project which is being developed to maximise the potential use of the natural water resource in the Crocodile catchment for industrial use in Lephalale and the surrounding areas. The development of Phase 2A therefore creates an opportunity for economic development in the area which cannot take place without it.

The DFGD technology resulted in a 9% higher capital cost for implementation due to modifications required for existing ductwork design and the addition of a new fabric filter system to the existing FFP in order to retrofit this technology. Although the DFGD processes use slightly

less water for the Medupi site, the estimated operating expense for the DFGD is 53% higher than the WFGD system, mostly due to the significantly higher cost of the lime reagent.

It is therefore recommended that Eskom continue with its plan to construct the WFGD technology without the inclusion of a flue gas cooler as this is still the best long term option for SO_2 removal at Medupi Power Station. Based on the information presented in this report it is evident that this is the most efficient, sustainable and broadly (i.e. technical, social, cost) responsible solution for both Eskom and South Africa going forward.

1. INTRODUCTION

1.1 Background

The Medupi Power Station will consist of six 800 Megawatt (MW) coal fired steam electric generating units located in Limpopo Province, approximately 15 kilometres (km) west of the town of Lephalale, South Africa. The Medupi Power Station Flue Gas Desulphurisation (FGD) Project will result in the retrofitting of an FGD system to each of the operating units. The FGD units are planned to enter commercial operation sequentially post the first general overhaul outage of the respective units.

Eskom previously conducted a technology review of FGD technologies [9] available to achieve the level of SO_2 reduction required by law. This was applicable to new as well as existing power stations. The Wet Flue Gas Desulphurisation technology was selected for Kusile and Medupi Power Station based, amongst other reasons, on its technology maturity and high level of commercialised industrial application worldwide.

As a result, the design of Medupi Power Station included considerations and provisions for the future retrofit of a WFGD plant for SO_2 emission abatement. The WFGD plant engineering design for the retrofit therefore commenced in 2011.

Recent questions arose on the applicability of this technology selection based on the maturity that other technologies have gained in the past few years. A reassessment of the technology selection at Medupi was therefore initiated and the findings are reported herein[1].

Eskom traditionally makes project related decisions based on a techno-economic basis. This implies that the chosen technology is cost effective and technically proven. For the Medupi FGD project specifically additional considerations need to be made with regards to raw resource availability. This suggests that there needs to be a strategic look at specifically water and sorbent availability and quality in South Africa.

Furthermore, Eskom recognises the significance of considering the technology selection within the current socio-economic climate of South Africa. In this, the chosen technology for implementation must be efficient, sustainable and a broadly (i.e. cost, social, technical) responsible solution for emission abatement. This required finding the balance between the cost of implementation and the environmental and social impacts relating thereto. These factors are highly interdependent and cannot be evaluated in isolation. The basis for comparison of the technologies were mainly on the legislative requirements, impact to the electricity tariff and the utilisation of the raw resources (i.e. water and sorbent).

1.2 Study Objectives

The study is broken down into three evaluation steps. Firstly the technical suitability of a technology will be assessed and compared for implementation at Medupi Power Station. Secondly the cost associated with each of the technologies respectively will be discussed, and finally the raw resource availability will be evaluated.

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[1] The costs developed in this study should be analysed only on a comparative basis for the respective technologies and should not be taken as absolute values.

The FGD Technology Selection Study Design Basis [3] serves as the basis for all calculations, analysis and estimates.

In particular, the objectives of the study can be summarised as follows:

a) Technical suitability assessment

i) Understand the requirement for SO_2 reduction and the implications of non-compliance.

ii) Identify the technologies available to achieve the level of SO_2 reduction required. Factors for consideration include: degree of commercialisation, unit size, reliability and availability.

iii) Understand the requirements for the magnitude of waste produced in the FGD to serve as input to waste management planning.

iv) Discussion on water reduction strategies that can be employed for each alternative (if applicable) and the degree of implementation for each alternative.

v) Consider the infrastructure requirements in relation to the existing power plant configuration and arrangement.

vi) Short term measures for emission abatement.

b) Cost Implications

i) Determine the capital expenditure requirement for each alternative.

ii) Discussion on the operational expenditure for each alternative.

iii) Evaluation of the implication to the electricity tariff for each alternative.

c) Raw Resource Availability

i) Fundamental raw resource definition.

ii) Understand the requirements for the magnitude of sorbent usage.

iii) Understand the requirements for the magnitude of water usage.

2. SUPPORTING CLAUSES

2.1 Scope

The scope of this document is limited to the study objectives as described in Section 1.2 and is related to Medupi Power Station only. Any technical recommendations are therefore limited to Medupi Power Station.

2.1.1 Purpose

The purpose of this document is to capture the technical position for flue gas desulphurisation at Medupi Power Station and the sharing of the considerations to relevant stakeholders (including the public).

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions with specific reference to the Medupi Power Station.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] Design Base Standard – Doc no: 474-190.

[2] Design Review Procedure – Doc no: 240-5311 3685.

[3] Technology Selection Study Design Basis – Doc no: 348-11281 (B&V file no.: 195700.41.0108).

2.2.2 Informative

[4] Medupi User Requirements (URS) Rev. 4 – Doc no: NC/001.

[5] Medupi FGD Retrofit Project Design Manual (PDM) – Doc no: 200-61989.

[6] Eskom Air Quality Strategy – Doc no: ESG32-1143.

[7] National Environmental Management Act 2004 (Act 39 2004).

[8] Listed Activities and Associated Minimum Emission Standards Identified in Terms of Section 21 of the National Environmental Management: Air Quality Act, 2004 (Act 39 2004).

[9] FGD Technology Review – Doc no: RES/RR/04/24115.

[10] Medupi FGD Retrofit Basic Design Report (BDR) – Doc no: 200-61771 Rev 2.

[11] Pre-screening of flue gas cooling options based on techno-economic assessment for Medupi Power Station WFGD Retrofit Project –Doc no: 200-2211635 (June 2016).

[12] Fleet SOx Project – Majuba Power Station Cost Estimation and Life Cycle Cost Analysis – Doc no: 363-SOx-ACCA-D00160-2 (Steinmueller Doc no: 062104-T-KAL-101).

[13] Fleet SOx Emissions Reduction Report - Majuba Power Station Concept Design Report – Doc no: 363-SOx-BDDD-D00185-7.

[14] Post-combustion Flue Gas Desulphurization (FGD) Plant Technology Strategy.

[15] Dry Sorbent Injection for Medupi Power Station - Doc no:1788771.41.0053.

2.3 Definitions

2.3.1 Classification

Public domain: Published in any public forum without constraints (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviations	Description
BDR	Medupi FGD Retrofit Basic Design Report [10]
BOP	Balance-of-Plant
°C	Centigrade
$CaCO_3$	Calcium Carbonate (limestone)
CaO	Calcium Oxide (lime or quick lime)
$Ca(OH)_2$	Calcium Hydroxide (hydrated lime)
CFB	Circulating Fluidized Bed (FGD)
DFGD	Dry or Semi-Dry Flue Gas Desulphurisation
FFP	Fabric Filter Plant
FGD	Flue Gas Desulphurisation
ID	Induced Draught
Km	Kilometres
kPa	Kilopascal
µm	Micron (micrometre)
LSFO	Limestone Forced Oxidation
m^3	Cubic Metres
Mbar	Millibar
mg/Nm^3	Milligram per Normal Cubic Metre (0º C and 1 atmosphere, dry basis at 6% O_2)
MW	Megawatt
O_2	Oxygen
PDM	Project Design Manual
SDA	Spray Dryer Absorber (semi-dry flue gas desulphurisation)
SO_2	Sulphur Dioxide

Abbreviations	Description
URS	User Requirements Specification
WFGD	Wet (limestone) Flue Gas Desulphurisation
ZLD	Zero Liquid Discharge

2.5 Roles and Responsibilities

This document was compiled under instruction from Eskom with input from three parties; Black and Veatch, Steinmüller Engineering and Eskom.

Individual	Company	Role and Responsibility
Candice Stephen	Eskom Boiler Lead Discipline Engineer	Input
Christian Unger	Steinmüller Project Manager/Lead Process Engineer	Input
Daniel Chang	Black & Veatch Project Manager	Compile
Leon van Wyk	Eskom Boiler Auxiliaries CoE Manager (Acting)	Review
Muhammad Bagus	Eskom Engineering Design Work Lead	Review

2.6 Process for Monitoring

Not Applicable.

2.7 Related Supporting Documents

Not Applicable.

3. TECHNICAL SUITABILITY ASSESSMENT

3.1 Requirement for SO_2 reduction

According to the United States Environmental Protection Agency and also referenced by the World Health Organisation, the leading concern with SO_2 is short-term exposure to airborne SO_2 as this has been associated with various adverse health effects, particularly respiratory health. Secondary other environmental effects include contributions to acidic deposition, reduced visibility and negative impact to vegetation growth.

South Africa has therefore created and issued Minimum Source Emission Standards for Listed Activities published in terms of Section 21 of the National Environmental Management: Air Quality Act (Act No 39 of 2004). This Act stipulates that the SO_2 emission limits for new and existing coal fired power stations shall not exceed 500 mg/Nm^3 and 3500 mg/Nm^3 (10% referenced oxygen content) respectively with an associated compliance timeframe for each.

Medupi Power Station is included in this requirement and will need to operate the power generation facility with a maximum SO_2 outlet emission concentration of 500 mg/Nm^3. This cannot be achieved through any other means than FGD technology.

Typical operating emission levels for Medupi without FGD are approximately 4000mg/Nm^3. The nominal SO_2 removal efficiency required is therefore approximately 87.5%[2]. All technologies considered should therefore be able to at least meet this removal efficiency.

As SO_2 emissions is a function of the coal sulphur content being combusted, the outlet emissions cannot be manipulated with load reductions at the power generation facility. Non-compliance to the emission limit therefore implies a shutdown of the generation facility.

3.2 Identification of the technologies available to achieve the level of SO_2 reduction required

The identification of suitable FGD technology begins with evaluating commercially available and applicable technologies for SO_2 reduction in flue gas from coal power generation activities. SO_2 can be reduced using FGD technologies identified in Figure 1 before combustion, during combustion, and post-combustion of coal.

[2] The quoted removal efficiency is not the designed removal efficiency required for the project as the design includes various transient conditions, fuel dynamics and safety factors. The quoted removal efficiency is only used as a guideline for initial technology screening purposes.

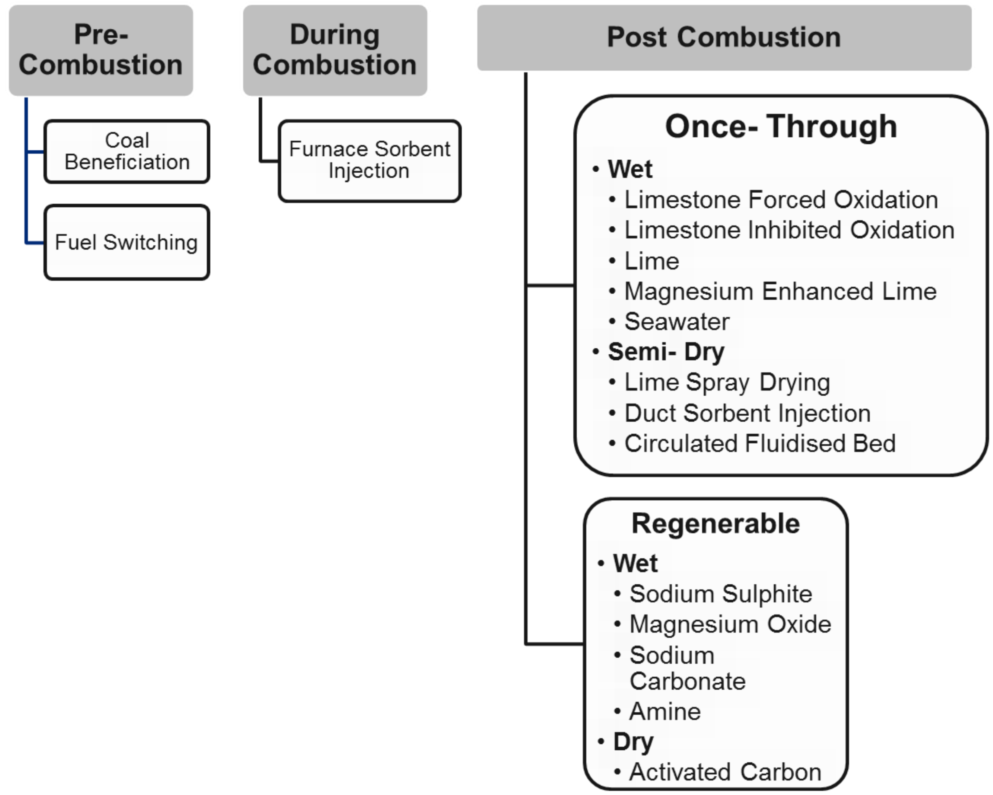

Figure 1: Summary of conventional technologies to reduce SO_2 emissions as a result of the combustion of coal, adapted from (Srivastava, 2000).

The majority of FGD technology alternatives employed for SO_2 reduction from flue gas includes Wet FGD and variants of Dry FGD (spray drying absorber, circulated fluidised bed, and duct injection system). A summary of the worldwide installed capacity and SO_2 and water consumption performance metrics of the Wet and Dry FGD is presented in Table 1.

Table 1: Summary of main FGD technologies installed worldwide and associated performance specification (Carpenter, 2012).

FGD technology	SO_2 removal efficiency achievable (%)	Worldwide installed capacity (%)	Water consumption (l/kWh)
WFGD	98	80	0.21
SDA/CFB	90-95	10	0.14
DSI	30-60	2	Negligible

A study was completed by Eskom that reviewed the commercially available SO_2 control technologies that could be employed to meet the requirements of controlling the SO_2 emissions from the Medupi generating units to the statutory emissions level of 500 mg/Nm3 @ 10% O_2 [14]. The technologies considered are found in Table 2 below.

Table 2: Technology Comparison Overview

	Wet FGD	**Dry FGD**		
Criteria	**Limestone Forced Oxidation**	**Spray Drying Absorber (SDA)**	**Circulated Fluidised Bed (CFB)**	**Duct Injection System**
Coal Sulphur Type	Low, Medium and High (This parameter is critical when selecting the FGD technology)			
SO_2 Removal Efficiency %	>98%	>90%	>95%	30% - 60%
Potential Reagents	Limestone, Lime	Hydrated Lime, Calcium Oxide	Hydrated Lime	Lime, Sodium Base
Ca/S mole ratio	1.1 - 1.3	1.4 - 2.0	1.4 - 2.0	2 - 4
By-product Disposal Alternatives	Landfill, saleable gypsum	Landfill, reclamation	Landfill, reclamation	Landfill, reclamation
Fly Ash Disposal Alternatives	No Effect on Fly Ash Quality	Fly ash co-disposed with by-product or new pre-filter	Fly ash co-disposed with by-product or new pre-filter	Fly ash co-disposed with by-product
Pressure Drop Impact	2-2.5 kPa	1-1.2 kPa (with an additional 1.7-2 kPa due to new fabric filter)	2-2.5 kPa Due to reactor and fabric filter	No impact
Effect on Stack Liner	Potential for corrosion due to acid mist in saturated flue gas	Standard Carbon Steel	Standard Carbon Steel	Standard Carbon Steel
Power consumption of plant utilities	1.2-1.6% increase in auxiliary power consumption	0.5% increase in auxiliary power consumption	0.3-1% energy consumption of the electric capacity of the plant	<1% increase in auxiliary power consumption
Effects on Waste Water Treatment System	To make saleable gypsum, a chloride blow-down is required	None	None	None
Water Usage (% of Base Case)	High water consumption to quench flue gas to saturation (100%)	Hydration of Lime (60 – 65%)	Low Water consumption (60% less than LSFO)	N/A (hydrated lime)

Based on the results of these studies, the Dry FGD (SDA and CFB) and Wet FGD technologies were identified as being capable of meeting the new regulations at the Medupi plant.

3.2.1 Dry FGD Technology

DFGD processes, including the spray dryer absorber (SDA) process and circulating fluidized bed (CFB) process have been extensively used around the world for SO_2 control. The DFGD technology uses less water than typical WFGD systems because the flue gas is not saturated with water and the technology uses hydrated lime instead of limestone as the reagent for SO_2 capture. The system mixes the water, lime, and fly ash-laden flue gas in a reactor, which then passes to a fabric filter to remove all the by-products of desulphurisation and the fly ash from the flue gas stream. This technology is evaluated in this report as representative of all semi-dry FGD technologies.

Utilities have installed numerous dry and semi-dry FGD systems on boilers using low sulphur fuels. These installations generally have DFGD systems designed for a maximum fuel sulphur content of less than 2 percent. The CFB process uses calcium hydroxide [$Ca(OH)_2$] produced from the lime (CaO or "quick lime") reagent, as a dry powder to the flue gas in a reactor designed to provide good gas-reagent contact. SDA systems use $Ca(OH)_2$ injected as a liquid slurry. The SO_2 in the flue gas reacts with the calcium in the reagent to produce primarily a mix $CaSO_3 \bullet 1/2H_2O$ and $CaSO_4 \bullet 2H_2O$.

An evaluation of the SDA, CFB, and other semi-dry modular technologies based on experience, fuel flexibility, SO_2 emissions control, site layout, operability, capital cost, and operating costs indicates that these systems are fairly comparable in most areas as considered in the 2005 FGD Technology Review [9]. Increased utilisation of these technologies and some process developments are now resulting in higher SO_2 removal guarantees with a lower corresponding risk as to lime consumption.

SDA technology has an experience advantage over CFB and modular technologies. SDA systems have been designed for units in excess of 900 MW using multiple absorber vessels, with each vessel handling the flow equivalent to 450 MW. The range of experience for the CFB and modular systems indicates that these technologies have sufficient range of operational and design experience to be considered applicable; however as with the SDA, multiple CFB reactors would be required for each unit.

SO_2 removal efficiency of the SDA technology has been enhanced by hydrated lime injection into the SDA inlet by at least one manufacturer to allow it to now quote 96 to 98 percent SO_2 removal, which is similar to CFB technologies for low to medium sulphur coals.

The main difference between the SDA and CFB processes is the preparation of the lime into calcium hydroxide. Slakers produce a paste with approximately 10 to 13 percent lime mixed with water and are typically used with the SDA technology. This can limit the amount of lime (and, as such, SO_2 removed) added to the process due to the transport water causing the flue gas to approach dew point.

Since one of the features of the CFB is the ability to control the amount of lime independent of water, CFB systems are supplied with lime hydrators that convert the pebble lime to calcium hydroxide. The hydrated lime is stored in a separate hydrated lime silo for application to the scrubbing absorber module, as required. This allows for a spare lime hydrator to be incorporated and the product to be stored to allow for maintenance and redundancy in the reagent preparation systems similar to the operation of the WFGD.

There are DFGD technologies where a group of small flash dry modules are clustered together for parallel operation. Modules are removed from service to facilitate partial load operation. This is in lieu of the recirculation duct used in the CFB to keep adequate gas velocities in the absorber, to keep the CFB absorber bed fluidised.

Another consideration for the DFGD technologies is the elimination of the potential to produce a saleable by-product such as that produced from the WFGD systems. There is no known commercial use for the by-product of the DFGD processes, which is captured as a mixture with the fly ash in the fabric filter downstream of the absorber. This requires the by-product from the DFGD to be disposed of, typically in a landfill.

No wastewater is produced with the DFGD technology as all water is evaporated or contained as waters of hydration in the dry by-product mixture. This eliminates the capital and operating costs of an additional wastewater treatment system when considering the application of this technology. Other water streams at the plant may require treatment for reuse, but they are not associated with the scrubbing process and are, therefore, not included in the cost analysis.

3.2.2 Wet FGD Technologies

WFGD technology has a long history of application to fossil fired generating facilities in units of all sizes. WFGD remains the predominant process utilised today, particularly in retrofit applications, due to its high SO_2 removal capability, high inlet sulphur capability, and retrofit suitability. Wet limestone-based FGD processes are most frequently applied to pulverised coal fired boilers that combust medium-to-high sulphur coals. Typically, the WFGD processes on a coal facility are characterised by high removal efficiency (greater than 98 percent) and high reagent utilisation (95 to 97 percent) when combined with a high sulphur fuel. The ability to realise high removal efficiencies on higher sulphur fuels is a major difference between wet scrubbers and semi-dry/dry FGD processes.

In a WFGD system, the absorber module is located downstream of the ID fans (or booster fans, if required), placing the retrofit WFGD downstream of any existing particulate control device. This location typically eliminates the need for the addition of another particulate control device and the WFGD usually provides some additional particulate control itself. Flue gas exiting the fans enters the module and is contacted with slurry containing reagent and by-product solids. The SO_2 is absorbed into the slurry and reacts with the calcium to form calcium sulphite hemi-hydrate ($CaSO_3 \bullet \frac{1}{2}H_2O$) and calcium sulphate di-hydrate ($CaSO_4 \bullet 2H_2O$, also called "gypsum"). On most new WFGD systems, oxidation air is blown into the absorber tank to push the chemical reactions to create gypsum and very little $CaSO_3 \bullet \frac{1}{2}H_2O$. This helps in the process chemistry to virtually eliminate scaling and plugging of the absorber and can allow for the sale of by-product for wallboard production or other industry purposes, if a suitable market exists in the nearby region. To create a marketable by-product, most times a wastewater stream is necessary to purge impurities such as chlorides from the system. Such a wastewater stream may be avoided if a wetter by-product is sent to waste.

3.3 Understanding the requirements for the magnitude of by-product produced in the FGD

Each FGD technology will create waste by-product streams that will need to be disposed of while the plants are in operation. The by-products created by each technology are shown below in Table 3 below:

Table 3: By Product Quantities Generated

By-product Quantities Generated	Wet FGD	Dry FGD
Gypsum (tonnes/tonne of SO_2)	5.62	

By-product + Ash (tonnes / tonne of SO_2)		7.43
Crystallizer Salts (tonnes / tonne of SO_2)	0.48	0
Pre-treatment Solids (tonnes / tonne of SO_2)	0.92	0

The DFGD waste does not produce a currently marketable product and would require that all the ash and scrubber by-product be disposed of by landfilling. For the purposes of this study, only the differential cost of landfilling the additional by-product has been calculated to allow equal comparison of all technologies.

The WFGD waste will consist of the gypsum produced by the FGD process, pre-treatment solids from the ZLD Pre-treatment plant, and the salt produced by the ZLD Crystallizer plant. As noted previously, the gypsum produced by the FGD process can be a marketable by-product if a good quality limestone is used and, if necessary, the chlorides contained in the gypsum are removed by washing the gypsum during the dewatering process. Otherwise, the gypsum and pre-treatment solids should be able to be landfilled together. The crystallizer salts may require a separate landfill depending on how the South African Department of Environmental Affairs determines to classify this waste.

The ash from the existing FFP plant is currently landfilled on the plant site.

Both the wet and semi-dry technologies produce wastes that must be managed and disposed in compliance with the national legislation. The legislation provides guidelines for the waste classification and corresponding type of waste management applied (i.e. re-use, recycling, recovery, treatment, and disposal). The wastes are classified based on the quantity, physical, chemical and leachability properties depending on laboratory testing of actual samples. The FGD wastes are classified as hazardous and vary in type with Type 0 being the most hazardous and Type 3 being the least hazardous. The disposal of all these wastes require a liner protection with Class A being the most conservative (and most expensive) and Class D being the least conservative (and least expensive). Please see below a summary of the waste management requirements in terms of the legislation.

Table 4: Waste Management Requirements

	Hazardous Classification	**Waste Management Applied**	**Landfill Liner Class**
WFGD Wastes			
Gypsum	Type 3	Re-use, recovery, disposal	Class C
Chemical Sludge from ZLED Plant	Type 1	Disposal	Class A
Chemical Salts from ZLED Plant	Type 1	Disposal	Class A

	Hazardous Classification	Waste Management Applied	Landfill Liner Class
CDS Waste exiting the particulate abatement system.	Type 3	Disposal	Class C

It is also important to note that implementation of CDS implies that the entire mixture of the fly ash and the CDS by-product removed from the particulate abatement system will need to be landfilled. This implies a larger footprint equipped with a Class C liner to cater for the fly ash and CDS by-product mixture. Currently the fly ash is landfilled in a designated area equipped with a Class C liner because fly ash alone is classified as a Type C waste. Implementation of the CDS technologies also eliminates the potential for commercial exploitation of the fly ash since it will be removed as a mixture.

3.4 Water reduction strategies that can be employed

The WFGD technology is the only of the FGD technologies that has the potential for reduction in its water consumption.

Eskom is a strategic water user in the country and based on its commitment to water conservation it has already taken various measures to reduce the plant's water consumption and ensure that water is utilised responsibly within the plant. The implementation of ***dry cooling technology*** and the adoption of the ***zero liquid effluent discharge policy (ZLED)*** are notably Eskom's most significant water-saving initiatives. Once completed Medupi will be the largest dry-cooled power plant in the world. The implementation of dry cooling reduces the water consumption from approximately 2 l/kWh to 0.14 l/kWh and came with an energy penalty of roughly 1.75% on the overall thermal efficiency of the plant. If retrofitted the WFGD plant will be a consumer of water in the power plant however due to the implementation of the various water reduction measures the water requirement of the power plant with WFGD (power plant with WFGD$\approx$ 0.35 l/kWh) is still expected to be lower when compared to the conventional wet-cooled power plants (power plant without WFGD$\approx$ 2 l/kWh) within Eskom's fleet.

The various streams in which water enters and leaves the WFGD process are summarised below.

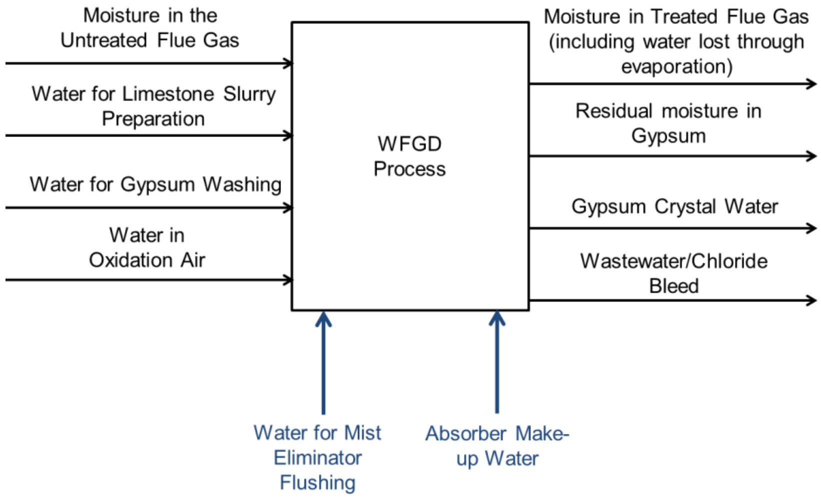

Figure 2: Overview of the water users and losses in the WFGD system.

Water is lost through the treated flue gas, gypsum and wastewater bleed outlet streams.

The biggest water consumption in the WFGD LSFO process is due to the evaporative cooling of the flue gas as it is cooled from the inlet flue gas temperature to the saturation temperature. The higher the flue gas temperature entering the WFGD, more water would be required to reach saturation. Therefore water savings can be realised through the reduction of the flue gas temperature entering the WFGD process.

Several technologies have been developed in order to facilitate temperature reduction prior to a WFGD plant. Two main technologies commonly utilised in the power generation industry include; regenerative rotary type heat exchangers and tubular shell-and-tube cross flow heat exchangers.

Regenerative rotary type heat exchange is not a new technology in the power industry. These types of heat exchangers are traditionally used to heat combustion air through the cooling of flue gas. An adaptation of the traditional use can be employed to further cool down the flue gas to a point closer to saturation temperature. Traditionally the treated flue gas leaving the absorber is used as the cooling medium; in this way the temperature of the untreated flue gas is reduced closer to the saturation temperature before entering the absorber and the treated flue gas is heated before exiting via the stack. The reheat of the treated flue gas before it exits via the stack also reduces the visibility of the plume and improves the buoyancy of both the plume and the residual pollutants. Another benefit of reheating the treated flue gas before it enters the stack is that the stack can be operated in a dry environment negating the need for special liners required for traditional wet stacks. While the implementation of regenerative rotary type heat exchange may result in the benefits described above it is important to consider the practical application with respect to construction, operation and maintenance. These types of heat exchangers require large surface area and are expensive to install and maintain. Advances in the technology have improved the choice of these heat exchangers as leakage rates have now been improved to the point that they no longer pose a risk to non-compliance due to clean flue gas contamination through re-entrainment. The biggest drawback of this technology is the spatial requirements due to the large surface area required.

Indirect flue gas tubular shell-and-tube crossflow heat exchangers have been implemented at several power stations. The advantage of this technology is that the heating and cooling elements can be separated to reduce the overall size. In this technology the cooling media is mostly liquid-gas. The biggest drawback of this technology is the material selection. A plastic perfluoroalkoxy (PFA) material is most commonly used in the cooling section as the flue gas enters at the sulphur dew point. Acid corrosion therefore is a significant consideration. The cooling elements are made up of thousands of small diameter PFA tubes suspended from a tube plate with the cooling liquid (usually water) circulated through them. Several bundles of these PFA tubes are required with some installations having the PFA tube surface area exceeding that of the heating elements within the boiler. In the event that the flue gas needs to be reheated, chloride becomes the main consideration from a material selection perspective. Most installations utilise stainless steel alloys. The PFA bundles need to be cleaned periodically due to ash contamination. Ash contamination causes clogging and reduced heat transfer even with an efficient fabric filter plant or electrostatic precipitator (dust concentration to be less than 20 mg/Nm^3). A water washing system is introduced to facilitate this process. It is recommended to manually clean these systems at least every 15,000 operational hours to maintain efficient functionality of the heat exchanger. Due to the close packed bundle spacing, maintenance provisions outside of the duct are required to ensure proper cleaning and maintenance. Two further considerations are required; firstly PFA tubes undergo diffusion of sulphur and the cooling liquid pH needs to be managed accordingly. Secondly, the PFA tubes leak over time which requires manual intervention to plug the holes of the leaking tubes. The management of the flue gas cooler is critical and poor maintenance can cause significantly increased plant down-time. The PFA bundles are also expensive items and add to the operating cost of the unit. Ducts leading to the WFGD from the cooler further need to be lined with a plastic material (PFA or glass-reinforced (GRP)) in order to withstand the sulphur corrosion. Water can be reclaimed from the washing process by a having duct design recline into the absorber. There is therefore no additional water requirement needed for the washing system over and above the water requirement for the FGD process.

Eskom benchmarked a few flue gas cooler installations in order to establish its feasibility for application within the Eskom fleet. Three power stations in Europe (hereafter referred to as Power Station A, B and C) were selected as example stations utilising the flue gas cooler after the particulate abatement plant and two power stations in China (hereafter referred to as Power Station D and E) for application before the particulate abatement plant.

The three power stations in Europe had varying degrees of success for the application of the flue gas coolers installed. Power Station A utilised PFA tube material. Water washing is introduced 4-6 times per day. The experience of Power Station A suggests that 20% of the tubes are plugged at any given point in time of their operation due to leaking. This would require a design consideration to increase the actual surface area requirement with a significant margin in order to maintain appropriate heat transfer rates. Furthermore, Power Station A has been required to replace all the heat transfer bundles within a 6 year period.

Due to the problems experienced with the PFA tubes, an innovative improvement has been developed in which an increased diameter steel tube arrangement is used. The tube is coated in enamel and jacketed with PFA material. The PFA and enamel is able to protect the steel tube from corrosion and the heat transfer characteristics are not significantly reduced through this improvement.

Power Station B utilised the mild steel, enamel and PFA material-arrangement with increased success (increase in plant availability and reduction in maintenance cost) to Power Station A.

The system also utilises a water washing system which introduces purge air to keep the nozzles of the washing system clean and reduce plugging. Power Station B noted that the handling and cleaning of the enamel based material is critical and the enamel can easily damage; a sentiment which was shared by Power Station C, although not using the same application.

Power Station C utilised an application similar to that of Power Station A, but with a higher degree of maintenance and operating care is able to operate with only 10% of tubes plugged at any given point of operation. Power Station C noted that a few aspects are important to manage to improve the operability of the cooler. The distribution of the washing system needs to be such that more water is available higher in the bundle than lower down. Power Station C furthermore reduced the frequency of washing the cooler to reduce the moisture in the cooler that in their experience contributed to clogging. It is also important to have the flue gas distribution over the cooler equal to ensure proper heat transfer. Power Station C further noted that the cleaning pressure of the system needs to be maintained between 200-300 kPa, but higher pressure manual cleaning is also needed every 15,000 operational hours, which requires the plant to be on outage for approximately 5 days' worth of cleaning time (subject to maintenance provisions being made such as out-of-duct bundle suspension cleaning).

All three power stations in Europe advised against the installation of the system due to the problematic operation that it provides. The installations at these power stations were not due to water conservation considerations, but due to various other reasons that included increased plant efficiencies (through feed-water heating integration) and visible plume reduction out of the stack as legislatively prescribed in their countries. This technology has also mostly been implemented on lignite coal fired power plants where the benefits of the improved power plant efficiency through heat recovery are significant due to the higher back-end flue gas temperatures.

The applications in China for Power Stations D and E were both recent installations and maintenance experience has not been fully established. The installations both have the flue gas cooler installed before the particulate abatement plant (ESP for both applications). The operating fundamental is that the cooler is operating in a finned-tube arrangement with a soot blower rather than a water washing system to clean the heat transfer elements. The application is subject to the ash being able to neutralise the sulphur concentration being formed through the interaction of calcium and magnesium within the ash.

Images taken from reference power plants during the benchmarking exercise are shown below.

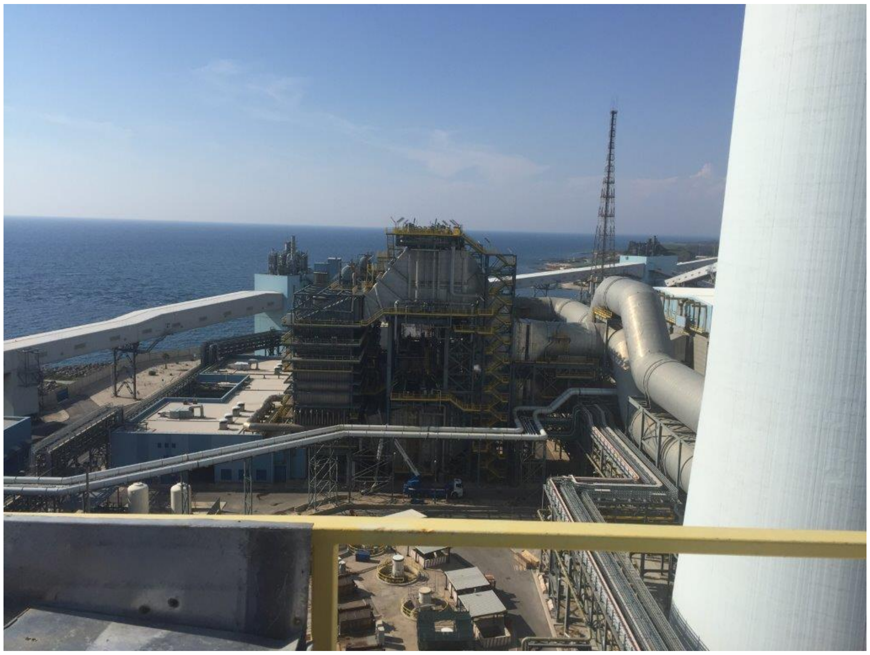

Figure 3: Side view of a tubular flue gas cooler.

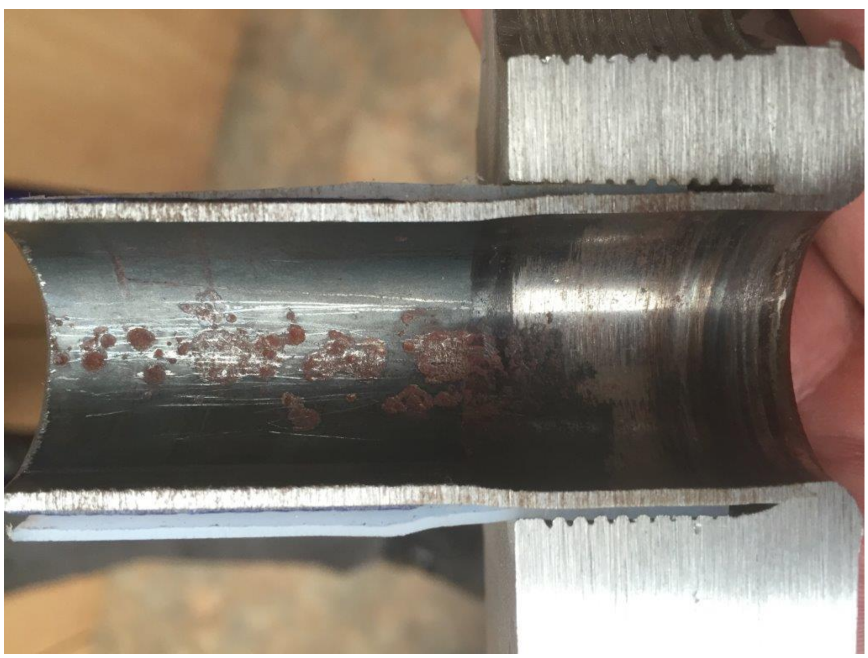

Figure 4: Corrosion of a carbon steel tube.

Figure 5: Water washing system cracking due to corrosion.

Figure 6: Corrosion of carbon steel bolt.

Figure 7: Corrosion of the stainless steel tube sheet.

Figure 8: Fly Ash build-up retrieved from the tubes during maintenance.

Figure 9: Wear damage of carbon steel tube.

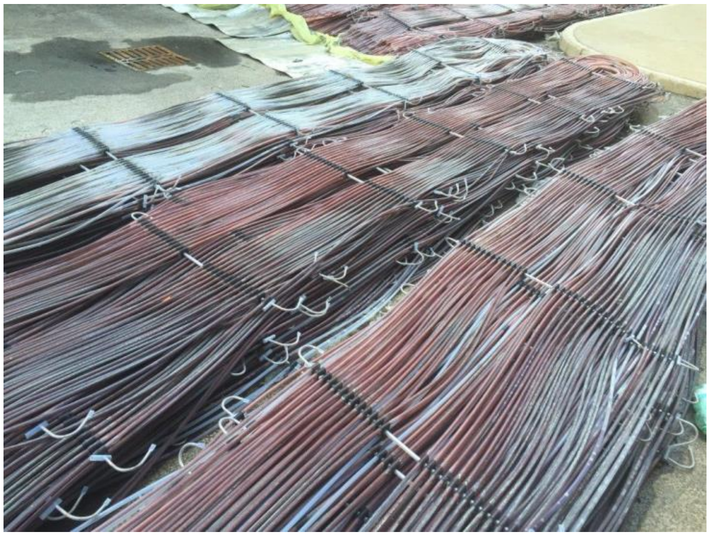

Figure 10: Discolouration of the PFA tubes due to fly ash contamination.

The installation of a regenerative type heat exchanger at Medupi is not possible due to the established layout and space constraints at the plant and is therefore not considered further.

Conclusions on WFGD with flue gas cooling for Medupi

The installation of a regenerative type heat exchanger at Medupi is not possible due to the established layout and space constraints at the plant and is therefore not considered further.

Elements of concern for the installation of the flue gas cooler at Medupi Power Station are the following:

- For applications before the FFP:

A flue gas cooler before the particulate abatement plant is not possible due to the ash characteristics. It has been found through the operation of the FFP that the ash does not have a neutralisation effect to the formed sulphur and therefore will not be successful in reducing the acid corrosion that will take place.

The ash characteristics at Medupi are such that it is highly abrasive. This will erode the finned tube material easily if the velocity is not kept sufficiently low enough. The velocity reduction in a high ash environment although good for wear protection, will incur both dust fall-out and plugging problems. It is therefore not advisable to install a flue gas cooler before the FFP at Medupi.

- For applications after the FFP:

Although the ash loading is low, wear protection should still be considered for ash as aggressive as the Medupi fly ash.

The availability of space on the already established footprint and plant layout will cause a significant constraint to the installation of a flue gas cooler. Although the real estate may be found to install the cooler itself, space is conceptually not available to install all the maintenance provisions that is required to service the plant appropriately. Without the increased maintenance provisions, complexity in maintenance and plant downtime will be experienced.

The cost of the material selection for the flue gas cooler is high. Elements such as the cooler's weight contributes to the overall cost and considerations such as deep piling for founding conditions which may require blasting at Medupi on an already generating unit.

- Use of the recovered heat needs to be considered. Feed-water integration although possible will be complex with increased piping lengths that need to be considered.

Installation of the flue gas cooler will also reduce the power output of the unit due to increased pressure drop and pumping for water recirculation. This will increase the relative CO_2 per megawatt sent out from the generating unit.

- Plant downtime to periodically clean the flue gas cooler will decrease the plant availability which is contradicting to the objective of the plant.

While the implementation of flue gas cooling has the potential to reduce the WFGD water consumption the practical challenges discussed above cannot be ignored as this is expected to have a significant impact on the maintainability and availability of the power plant and the cost of electricity to the consumer. WFGD with flue gas cooling is therefore not considered to be a feasible option at Medupi and was not considered further however the costs associated with this option has been included in this report for the purpose of information only.

3.5 Infrastructure requirements in relation to the existing power plant configuration and arrangement.

The infrastructure additions and changes that are required to the existing power plant arrangement to install each of the technologies are discussed below. The equipment required to implement each technology is reviewed, including the core equipment to treat the flue gas and the balance of plant equipment required to support the core equipment.

3.5.1 WFGD – Limestone Reagent

This technology was recommended in the Medupi FGD Retrofit BDR [10], which is the basis for this technology evaluation. The BDR WFGD system design includes an absorber system with five spray levels in the absorber tower that allows for a design emission rate of 400 mg/Nm^3 at full load on the worst anticipated coal. A bypass arrangement around the existing duct to the stack was designed to allow the untreated flue gas to go to the absorber tower for SO_2 removal, and then return the clean flue gas back to the stack. There is a significant number of balance of plant systems required to support the absorber system, including limestone handling, limestone preparation, makeup water, by-product separation and disposal, liquid recycling, and chemical processing of the process bleed stream that produces a solids by-product to be landfilled and a water stream that can be reused in the plant.

The BDR WFGD system design includes all balance-of-plant (BOP) equipment required for the successful integration of the new equipment into the existing plant.

The process flow diagram for the technology case study design basis is shown on drawing 006265-R-PFD-005.

3.5.2 Dry CFB Technology

The application of a semi-dry CFB technology to the Medupi Power Station would result in significant changes to the equipment as compared to the BDR WFGD design [10]. The limestone handling would be replaced by lime handling systems for receiving pebble lime deliveries and for processing the pebble lime into hydrated lime for use in the DFGD absorbers. This modification to the process design is reflected in process flow diagram 006265-R-PFD-010 (attached).

The makeup water system supply may be marginally impacted with the requirement for filtration of all the water through a 100 µm filter. In addition, there are some limitations for the hardness and chloride content for the makeup water used to hydrate the pebble lime and therefore may require some softening upstream of the slaking process; however, the majority of the water required by the semi-dry absorber process would be directed to a makeup water tank for direct injection into the absorber flue gas stream.

The CFB technology would require relocation of the existing FFP or construction of a new FFP as well as the relocation of the ID fans. An increase in the size, height and location of the flue gas duct work after the CFB and the addition of a recirculation duct for low load operation would also be required. The time requirement for the relocation of the existing FFP into the new elevated CFB configuration is not feasible during the planned outage schedule of 6 weeks. The FFP is elevated so that the captured lime / fly ash / scrubber by-product can be returned to the CFB absorber by gravity and recycled. This requires that the FFP is elevated to have the hopper outlet flanges 20 to 25 metres above grade and in close proximity to the CFB absorber.

The Medupi Plant would be required to have two installed CFB absorbers per 800 MW unit. One CFB absorber per boiler unit may be possible; however, operations at part-load conditions are reduced and no absorber of this size currently exists in operation.

The Process Area Arrangement Dry/CFB Drawings (006265-Z4050-001-00 and 006265-Z4050-002-00), in conjunction with Process Flow Diagram (PFD) Dry/CFB Cluster 1 (attached), reflect the general arrangement requirements of the CFB and FFP combination required for the Medupi Plant. The existing FFP would be abandoned and ducted through, and a new FFP constructed after the CFB absorber. The existing ductwork that feeds directly to the chimneys would be abandoned. The PFD shows the relocated ID fans and a recirculation duct, which is used during periods of low load operation to recirculate clean flue gas back to the inlet of the CFB absorber to keep the bed fluidised with adequate air flow during periods of low-load operation. Standard designs of the dry CFB technology do not include a bypass of the CFB absorber to the FFP. The risk of no bypass is mitigated by the use of two 50 percent absorber vessels that would be installed in parallel. This will allow the plant to remain on line at 50 to 60 percent load if equipment failure occurred on one of the absorbers that required its removal from service for repair or maintenance. The CFB absorber design should address the air flow requirements of the units operating at this reduced load.

The CFB also uses recirculation of the material captured in the FFP back to the inlet to the CFB. Significant portions of hydrated lime are not consumed by the reaction with SO_2 during a single pass through the CFB and are still available in the captured material. This material, with the addition of water that is added at the inlet to the CFB, can enhance the lime for additional SO_2 capture, to minimise the cost of the process sorbent.

The reagent demand for lime and limestone are similar, however, the pebble lime delivered to the site cannot be stored outdoors and will need to be unloaded into silos versus open air piles used for limestone. Based on the design coal specifications, approximately 17,640 tons per week of pebble lime sorbent will be required. The design, as shown in the redundancy sizing criteria, indicates two quicklime silos, which will supply all of the hydrators, and six hydrated lime silos will be required to receive the product from the 18 anticipated quick lime hydrators (two required for each unit with one spare).

An additional ash silo will be required to receive the increased ash from the FFP/FGD system compared with the WFGD. A conveyor will be required to move the ash to the existing ash disposal system. Details of this installation are not included in this study. However, the supply and installation of the new silos and pneumatic conveying system from the FFP product silo to the existing ash silo is included in the estimated costs of the system.

4. COST IMPLICATIONS

Capital and annual operating cost estimates were prepared for the WFGD and CFB technologies that were identified in the FGD Technology Review [9].

The cost estimates for each FGD technology have a conceptual-level accuracy (±30 percent) in 2017 ZAR and were based on information obtained from the following sources:

- Steinmüller in-house database.
- Black & Veatch in-house database.

- Publicly available cost data.

The cost estimates include allowances for auxiliary electric, control system upgrades, and other required BOP system upgrades. The operating cost estimates were based on operation at full-load conditions. The annual operating costs also account for increases in auxiliary power requirements, additional labour requirements, water costs, and additional costs for consumables.

4.1 Capital Cost Estimates

Capital costs were developed for this study for the two FGD retrofit technologies and the one modification to a proposed technology that were identified in the Medupi FGD Retrofit BDR [11] and are shown in Table 5. The capital cost estimates were based on adjustments to the Basic Design cost estimate as noted in this report, and escalated to 2017 cost basis. The cost estimate is developed based on the Technology Selection Study Design Basis [3]. The capital cost estimates include direct and indirect costs as an overnight price, but excludes Owner's costs. The purpose of these estimates is to provide sufficient confidence in the Phase 1 design study to support the selection of a FGD technology.

Table 5: Capital Cost Estimate Summary (1,000,000 ZAR)

Description	**Option 1 Wet FGD**	**Option 2 Wet FGD + Gas Cooler**	**Option 3 Dry FGD**
Environmental Purchase Contracts	2,657,484	2,657,488	1,694,784
Mechanical Purchase Contracts	350,301	645,101	515,701
Civil / Structural Purchase Contracts	723,714	746,214	2,269,816
Electrical / C&I Purchase Contracts	258,532	260,532	200,232
Subtotal Purchase Contracts	3,990,031	4,309,331	4,680,531
Mechanical / Chemical Construction Contracts	3,940,802	3,961,302	4,900,802
Civil / Structural Construction Contracts	2,655,178	2,706,478	2,719,978
Electrical/C&I Construction Contracts	1,731,287	1,745,587	1,522,287
Construction Service Contracts	1,318,018	1,318,018	1,318,018
Subtotal Construction Contracts	9,645,284	9,731,384	10,461,085
Total Direct Costs (purchase and construction)	13,635,315	14,040,715	15,141,615
Indirect Costs	2,326,516	2,348,916	2,335,616
Contingency	1,715,900	1,732,800	1,800,400
Escalation	Included	Included	Included
Total Capital Requirements	17,677,732,	18,122,432	19,277,632

Direct costs (total of the purchase and construction contracts) consist of purchased equipment and its installation, as well as miscellaneous costs. Purchased equipment costs include the cost for purchasing the FGD technology equipment from an equipment vendor (including taxes and freight). The construction costs also consider retrofit-related issues, based on the existing site configuration. Finally, miscellaneous costs account for the costs for additional items such as site preparation, buildings, and other structures. The direct cost estimates were based on the following assumptions:

- A regular supply of construction craft labour and equipment is available.
- Normal lead times for equipment deliveries.
- Construction utilities (power, water, air) would be readily available.

Indirect costs are those costs that are not related to the equipment purchased, but are associated with any engineering project, such as the retrofit of a new control technology. Indirect costs include the following:

- Engineering.
- Construction Management.
- Project Insurance.
- Performance Bond.

- Contractor Overhead and Profit.

4.1.1 Contingency

Contingency accounts for unpredictable events and costs that could not be anticipated during the normal cost of development for a project. The contingency cost category includes items such as possible redesign and equipment modifications, errors in estimation, unforeseen weather-related delays, strikes and labour shortages, escalation increases in equipment costs, increases in labour costs, delays encountered in start-up/commissioning, etc.

4.1.2 Estimate Exclusions

The capital cost estimates do not include the following:

- Testing for environmental hazards, including remediation, and removal or disposal of (but not limited to) asbestos, lead paint, underground contamination, and polychlorinated biphenyls.
- Labour and material costs resulting from underground interferences.
- Salvaging or storage of equipment or structures.
- Scrap values.
- Upgrade or repairs to off-site roads, bridges, and foundations, if required.
- Owner's costs.
- Operational spares.

4.2 Operations and maintenance cost

Operations and maintenance costs typically consist of the following categories:

- Reagent costs.
- By-product disposal costs, which is a combination of the gypsum, pre-treatment solids, and crystallizer salts disposal costs.
- Auxiliary power costs.
- Steam costs.
- Water costs.
- Wastewater disposal costs.
- Operating labour costs.
- Maintenance materials and labour costs.

The costs for reagent, electric power, by-product disposal, wastewater disposal, and water are variable annual costs that are dependent on the amount of pollutant removed. Operations and maintenance materials and labour are fixed annual costs that do not vary with these factors. Table 6 lists the annual consumption rates, Table 7 the Unit Costs for Input and Outputs for the FGD Process, and Table 8 the estimated operating costs. The Technology Selection Study Design Basis [3] lists this data and the major economic evaluation criteria used to obtain the operations costs.

Table 6: Consumption Rates

Description	**Option 1 Wet FGD**	**Option 2 Wet FGD + Gas Cooler**	**Option 3 Dry FGD**
Reagent	Limestone	Limestone	Lime
Hourly consumption, kg / hr	125,735	125,735	105,300
Consumption per year*, tonnes	991,295	991,295	830,185
By-product for Disposal	Gypsum	Gypsum	By-product+Ash
Hourly generation, kg / hr	233,250,	233,250,	308,000
Total generation per year*, tonnes	1,838,940	1,838,940	2,428,272
Steam			
Hourly consumption, kg / hr	21,000	21,000	0
Total consumption per year*, kg	124,173,000	124,173,000	0
Water			
Hourly consumption, 1,000 L / hr	1,179.5	818.1	748.2
Total consumption per year*, 1,000 L	9,299,178	6,449,900	5,898,809
Wastewater Disposal (ZLD)			
Hourly generation, 1,000 L / hr	75.2	73.8	0
Total generation per year*, 1,000 L	444,658	436,379	0
Auxiliary Power			
Hourly consumption, MWh / hr	54.45	61.20	54.18
Total consumption per year*,MWh	357,406	409,393	388,132
Operating Labour			
Number of operation staff	89	89	64
Total man-hours per year	185,120	185,120	133,120
** Based on a capacity factor of 90 percent or 8,760 hours of equivalent full load operation per year.*			

Table 7: Unit Costs for Inputs and Outputs for FGD

	Limestone	Lime
Reagent/Sorbent (R/tonne)	475	1800
By-product for Disposal (R/tonne)	30	30
Steam (R/1000 kg)	91	
Water (R/m3)	21.16	21.16
Wastewater Disposal (ZLD) (R/m3)	477.32	
ZLD Pretreatment Solids Disposal (R/tonne)	680	
ZLD Crystallizer Salts Disposal (R/tonne)	1000	
Auxiliary Power (R/MWhr)	421	421
Operating Labour (R/hr)	240	240

Table 8: Annual Operating Costs (ZAR)

	Limestone (w/o gas cooler)	Limestone (w/gas cooler)	Lime
Reagent/Sorbent	470,865,125	470,865,125	1,494,333,000
By-product for Disposal	55,168,200	55,168,200	72,848,160
Steam	11,299,743	11,299,743	
Water	196,770,606	136,479,884	124,818,798
Wastewater Disposal (ZLD)	212,244,157	208,292,424	
ZLD Pretreatment Solids Disposal	40,739,480	40,739,480	
ZLD Crystallizer Salts Disposal	31,351,000	31,351,000	
Auxiliary Power	150,467,926	172,354,453	163,403,572
Operating Labour	44,428,800	44,428,800	31,948,800
Total Operating Costs	1,213,335,037	1,170,979,109	1,887,352,330

4.2.1 Reagent Costs

Reagent costs include the cost of the material and delivery of the reagent to the facility. Additional costs associated with reagent preparation processes are included in the energy and water costs. Reagent costs are a function of the quantity of the reagent used and the price of the reagent. The quantity of reagent used will vary with the reagent purity and quantity of pollutant that must be removed, as well as the reagent utilisation. The WFGD technology utilises limestone as a reagent. The CFB technology utilises lime as a reagent, which has a typical cost multiplier of three to four times that of limestone on a per ton basis.

4.2.2 Auxiliary Power Costs

Additional auxiliary power will be required to run the new control technology systems applied to the facility. The power requirements of each system vary, depending on the type of technology and the complexity of the system. The report considers the power costs associated with the process energy requirements which includes the FGD process electrical consumption, FGD common electrical consumption, differential power of the ID fans and ZLD equipment electrical consumption.

The difference in the fan differential pressure requirement was considered for electrical costs to operate the FGD technologies evaluated in this report. The cost for changes in the ID fan power requirements were added for the WFGD. The additional pressure drop for the flue gas water-cooled heat exchanger (WFGD with cooler option) was used to determine additional ID fan power consumption in addition to the WFGD increase. For the CFB option, only the differential pressure of the CFB module was considered as additional system pressure drop, since the FFP currently exists in the system and will be replaced with similar equipment.

Predicted pressure drops for the components are 14.7 mbar for the WFGD, 8 mbar for the flue gas cooler, and 15 mbar for the absorber portion of the CFB.

Auxiliary power costs for the ZLD system were only included for the WFGD systems, since no waste water is produced for the DFGD system.

4.2.3 Water Costs

Water would be required for all of the FGD technologies considered.

4.2.4 Steam Costs

Steam would be required for the zero liquid discharge (ZLD) plant operations for heating the waste water to evaporate the water to be reused and crystallise the brine for disposal as required.

4.2.5 Water Disposal Costs

This estimate assumes that the typical WFGD by-product is dewatered to an average of 10 percent moisture content, which is then landfilled. Although the by-product gypsum could be washed to attain acceptable chloride content and be utilised for the production of wallboard, this estimate assumes all of the by-product will be landfilled. The extracted water from the by-product can then be returned to the process, reducing the overall water requirements. This process requires the control of contaminates, primarily chlorides, in the scrubber slurry. To limit chloride levels, a liquid stream is bled from the process. This liquid stream is distilled in the planned ZLD system, with salts and sludge containing about 15 to 20 percent moisture being landfilled. The remaining high quality water will be returned to the plant for reuse in the FGD system. The costs of ZLD system chemicals and the waste landfill disposal are included.

Note that this study only considers the WFGD wastewater and not any other waste streams as included in the BDR [11]. The DFGD system produces no FGD wastewater stream.

4.2.6 By-product Disposal Costs

The DFGD waste does not produce a currently marketable product and would require that all the ash and scrubber by-product be disposed of by landfilling. For the purposes of this study, only the differential cost of landfilling the additional by-product has been calculated to allow equal comparison of all technologies.

The WFGD waste will consist of the gypsum produced by the FGD process, pre-treatment solids from the ZLD Pre-treatment plant, and then salt produced by the ZLD Crystallizer plant. The gypsum and pre-treatment solids should be able to be landfilled together. The crystallizer salts may require a separate landfill depending on how the South African Department of Environmental Affairs determines to classify this waste.

The ash from the existing FFP plant is currently landfilled on the plant site and is not impacted by the installation of either of the WFGD technologies.

4.2.7 Operating Labour Costs

Operating labour costs are determined by estimating the number of employees required to operate the new equipment. This estimate was based on common industry practice and is only a suggested quantity. After the control technology has been added, a final determination of the staffing levels will be required. The WFGD labour costs were based upon 89 operations, maintenance, and supervisory personnel. Since the CFB absorber has no wastewater to be disposed of as a result of the scrubbing process, the operating labour for this option was reduced by 25 personnel that are not required for the operation of a ZLD system.

4.2.8 Maintenance Material and Labour Costs

The annual maintenance materials and labour costs are typically estimated as a percentage of the total equipment costs of the system. Based on typical electrical utility industry experience, maintenance materials and labour are estimated to be approximately 1.25 percent (approximately 0.75 percent for materials and 0.50 percent for additional contract labour) of the total direct capital costs according to the retrofit technology. Some initial recommended spare parts are included in the capital costs.

4.2.9 Cooler Operation and Maintenance Costs

The operating and maintenance costs for the WFGD Cooler option would be greater than the base WFGD option due to additional activities such as washing, repair of erosion and corrosion within the gas cooler, and maintaining additional rotating equipment. The electricity costs would also increase due to the increased pressure drop from the cooler. The by-product disposal costs would also increase minimally, while the wastewater disposal costs would decrease slightly. The raw water consumption would be reduced by 20-30%.

4.3 Implication to the electricity tariff (Eskom)

The incremental difference in terms of the “tariff increase” between the wet and CFB-FGD technologies is expected to be approximately 0.45%.

Eg. Baseline “Tariff Increase” including WFGD is X% therefore “Tariff Increase” with CFB-FGD would be X% + 0.45 %.

5. RAW RESOURCE AVAILABILITY

5.1 Fundamental raw resource definition

The raw resources required to operate a WFGD system are water and limestone, whereas the resources required to operate a CFB are lime and water. Lower quality limestones can effectively be utilised in the WFGD process however higher quality limestones are required to produce the lime products required for the CFB-FGD technology.

5.1.1 Sorbent Usage

The application of a semi-dry CFB technology to the Medupi Power Station would result in significant changes to the equipment as compared to the BDR WFGD design [11]. The limestone handling would be replaced by lime handling systems for receiving pebble lime deliveries and for processing the pebble lime into the required hydrated lime necessary for use in the DFGD absorbers. The makeup water system supply may be marginally impacted with the requirement for filtration of all the water through a 100 µm filter. In addition, there are some limitations for the hardness and chloride content for the makeup water used to hydrate the pebble lime that may require some softening of this process stream; however, the majority of the water required by the semi-dry absorber process would be directed to a makeup water tank for direct injection into the absorber flue gas stream.

As stated earlier, the reagent demand for lime and limestone are similar; however, the pebble lime delivered to the site cannot be stored outdoors and will need to be unloaded into silos versus open air piles for limestone. Based on the demand, approximately 17,640 tons per week of pebble lime sorbent will be required. The design, as shown in the redundancy sizing criteria, indicates two quicklime silos, which will supply all of the hydrators, and six hydrated lime silos will be required to receive the product from the 18 anticipated quick lime hydrators (two required for each unit with one spare).

An additional ash silo will be required to receive the increased ash from the FFP/FGD system compared with the WFGD. A conveyor will be required to move the ash to the existing ash disposal system. Details of this installation are not included in this study. However, consideration of the new silos and pneumatic conveying system from the FFP product silo to the existing ash silo is included in the estimated costs of the system.

5.1.2 Energy and Water Usage

The pros and cons of wet versus dry flue gas desulphurisation (technologies have been well documented for quite some time and the important points have been highlighted in this report. The complete value chain of each technology is however dependent on the characteristics unique to the region of implementation. The benefit of lower water consumption with semi-dry technologies when compared to wet technologies is widely known however most comparisons are based on the sorbent delivery to the power plant without consideration given for the processing of the sorbent before delivery. The processing of the sorbent before delivery includes both water and energy requirements. It is also important to note that energy requirements include an inferred water requirement inherent to the power generation process. A desktop study was conducted to compare these requirements for the conventional wet and circulated fluidized bed FGD technologies for Medupi Power Station.

Both technologies are considered to be energy and water intensive. The figure below gives an indication of the processing steps that require energy and water in the value chain.

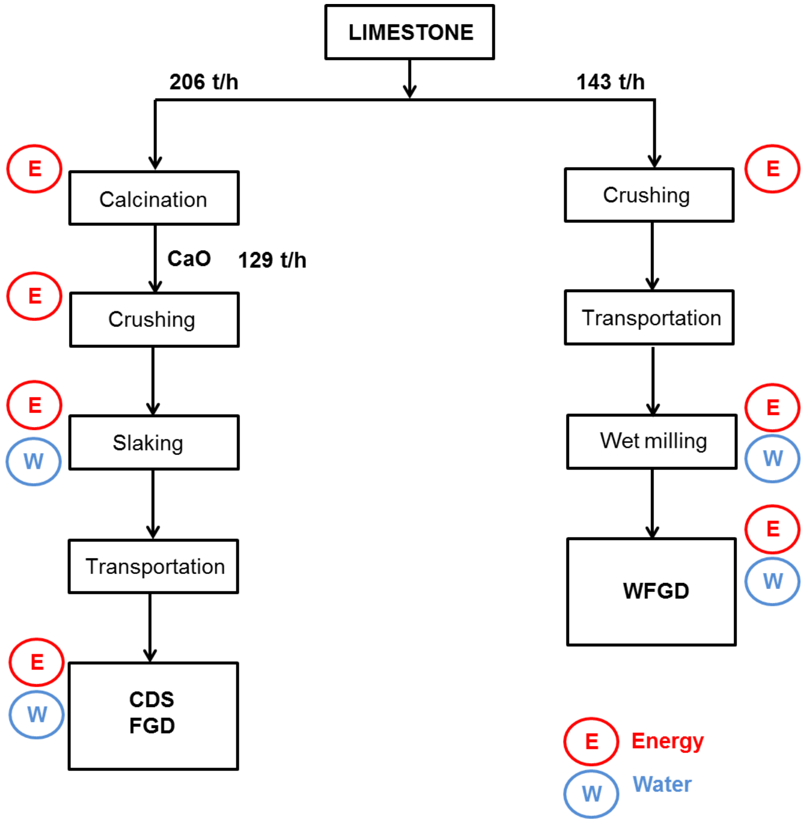

Figure 11: Overview of water and energy requirements for the WFGD and CFB-FGD technologies.

A breakdown of the energy and water requirements associated with both the WFGD and CFB-FGD technologies are indicated below.

Table 9: Breakdown of Water and Energy Requirements for the WFGD and CFB-FGD Technology (per annum).

		Delivery to site	**Reagent Preparation**	**Reactor and other processes**	**Pressure drop**
WFGD		no processing required	Milling + Suspension		
	Water [m³]		3 613 669	2 884 733	
	Power [MW]		24 125	211 080	12 437

		Delivery to site	Reagent Preparation	Reactor and other processes	Pressure drop
WFGD with Cooler (100°C)		no processing required	Milling + Suspension		
	Water [m³]		3 583 940	1 054 160	
	Power [MW]		24 125	211 080	19 328
WFGD with Cooler (90°C)		no processing required	Milling + Suspension		
	Water [m³]		3 583 940	551 943	
	Power [MW]		24 125	211 080	19 328
CFB-FGD		Calcination & Crushing	Slaking		
	Water [m³]		438 869	3 268 677	
	Power [MW]	860 375	19 402	104 497	31 093

As mentioned above the energy requirements include an inferred water requirement inherent to the power generation process. The energy and water requirements associated with each technology are given in Table 10 below.

Table 10: Total Water and Energy Requirements for the WFGD and CFB-FGD Technology (per annum).

	WFGD	WFGD (with Cooler 100°C)	WFGD (with Cooler 90°C)	CFB-FGD
Total Water (m^3/annum)	6 498 402	4 638 100	4 135 883	3 707 546
Total Power (MW/annum)	247 642	254 533	254 533	1 015 367
Power to Water (m^3/annum)	49 450	50 826	50 826	202 752
Total Water (m^3/annum)	**6 547 852**	**4 688 927**	**4 186 709**	**3 910 298**
Percent of Base Case	**100%**	**72%**	**64%**	**60%**

Both the wet and semi-dry technologies require water. The CFB-FGD technology requires about 60% of the WFGD water requirement. The WFGD water requirement could be reduced through the introduction of upstream flue gas cooling. However based on the experiences of international power plants equipped with flue gas coolers accounted in this report suggest that the use of the coolers for the purposes of achieving water savings may result in significant operation and maintenance drawbacks that may ultimately lead to plant downtime.

5.2 Sorbent usage (non-quantitative)

The WFGD process uses finely ground limestone and the CDS technologies use dry hydrated lime. Lime is produced from limestone through a process called calcination and hydrated lime is produced by mixing lime with water under controlled conditions. The use of characteristically different sorbents therefore means different plant designs, plant configurations, and plant operating requirements.

Limestone is an abundant naturally occurring material consisting mainly of calcium carbonate. A brief study of literature on the material reveals that its chemical composition, mineralogical characteristics and chemical reactivity differs considerably from region to region and sometimes from seam to seam in the same mine. It is this variability that renders some limestones more useful than others depending on the application. In South Africa, limestone deposits can be found along the northern – western coastal line with inland deposits in the Northern Cape, North-West and Limpopo. Gauteng has mostly what is classified as dolomite (i.e. less reactive calcites) deposits.

Calcination is a process of converting limestone ($CaCO_3$) into lime (CaO) by thermal decomposition. The temperature required for the reaction to take place is typically between 850 °C and 1 340 °C subject to the dissociation temperature of the carbonates in the limestone. The degree of 'burning' (soft burn, medium burn and hard burn) is often used to characterise the lime produced. 'Soft burn' lime is preferred for CDS since it is more reactive but the production of this requires a more delicate balance of the calcination process parameters and is therefore difficult to produce.

The production of good quality lime is not only product function of the calcination process parameters but also the intrinsic properties of the parent material. The limestone's crystal structure, shape and behaviour during the calcination process in addition to its quality affects the results, meaning that not all limestones are suitable for calcinations or are able to produce a suitable product especially for CDS. Furthermore, the conversion of roughly 1 tonne lime from limestone requires about 2 tons of pure limestone.

During operation, the WFGD is fed with about 1.02 – 1.05 mols of limestones per mol of captured SO_2 depending on process design and limestone quality. The process can operate with $CaCO_3$ content in the limestone of between 85% - 98%. The CDS requires hydrated lime quality of above 90% with stoichiometric ratio (SR) of between 1.4% and 2% for every mol of SO_2 in the raw gas to achieve comparable SO_2 removal efficiency. The higher SR requirement of the CDS means that the process uses relatively larger amounts of sorbent compared to the WFGD for comparable performance. Since burnt lime is produced from limestone, this implies that the CDS process requires more limestone than the WFGD process.

The CDS process also requires higher quality lime. As discussed above, not all limestones are suitable for this purpose. While some regions in South Africa have limestone deposits that can potentially be used for this purpose, other regions notably lack such. This situation is most true in the South African context since the country's power plants are concentrated inland with potential sustainable limestone sources situated over 700 km away. Interactions with lime suppliers in the country indicate that the limestone deposits in the regions surrounding the power stations are not conducive for calcination and the production of a good quality lime product as would be required for the CDS. The cost drivers for desulphurisation technology selection in terms of the sorbent include the quality, and transportation of sorbent which can be significant depending on the distance between the sorbent source and the end-user.

One needs to consider the broader socio-economic environment in context of the technical challenges related to the calcination of limestone to produce high quality hydrated lime. The intention is to utilise limestone sources that are available within the areas closer to the power station in an effort to stimulate mining development and the creation of jobs leading to further economic growth and development in an economically stagnant region (i.e. Lephalale, Marble Hall and Thabazimbi). The lower quality limestones in this region can be utilised in the WFGD process however these available limestones cannot be used to produce hydrated lime in the qualities that are required for the CDS technologies and will therefore have to be sourced in from the Northern Cape. Implementation of any CDS technology therefore eliminates the potential for the socio-economic growth and development envisaged for the region in and surrounding the power station. Sourcing of hydrated lime from the Northern Cape will also have a negative impact on the cost to consumer due to the transportation costs.

5.3 Water usage (non-quantitative)

The Integrated Vaal River System is the most important bulk water supply system in the country, supplying water to 60% of the country's economy and 45% of the population. This covers the whole of Gauteng, but also to important areas in Mpumalanga, North West, Free State, Northern Cape and soon to the all-important developments near Lephalale in Limpopo. The system receives water from KwaZulu-Natal via the Tugela-Vaal water transfer scheme and Orange River via the Lesotho Highlands Water Project and many other catchments.

Rand Water supplies approximately 1600 million m^3/a of potable water to users in the area (see figure 12 below) of which approximately 50% (800 million m^3/a) is supplied to users located in the Crocodile River Catchment. Of this, approximately 60% (480 million m^3/a) of this water is treated by Waste Water Treatment Works in the Crocodile Catchment and released as return flows. These return flows make up an artificial resource which is growing over time due to increasing demand for potable water supplied from the Vaal System. Whilst some of the return flows are being utilised there is currently a surplus which results in high dam levels in the Crocodile Catchment of which Hartbeespoort Dam is a prime example.

Dams were constructed in the Crocodile Catchment to maximise the potential use of the natural water resource. The additional artificial water resource means that the dams are spilling more frequently and the water flowing into the ocean. The Department of Water and Sanitation has identified this surplus resource (return flows) for use for industrial purposes in the Lephalale area in the Waterberg (Mokolo Catchment).

The full yield of Mokolo Dam (43.8 million m^3/a) has been allocated for: provision for the reserve; irrigation; Lephalale Municipality; Eskom and Exxaro. Phase 1 of the Mokolo and Crocodile Water Augmentation Project (MCWAP) supplies water to Eskom, Exxaro and the Lephalale Municipality which has been allocated a maximum of 7.2 million m^3/a for its current needs. The Mokolo Dam via Phase 1 is currently the only source of water to the area. A drought in the Mokolo Catchment would thus result in a water shortage in the Lephalale area affecting irrigators, the Lephalale the community and potentially the supply of electricity to the country at large. The development of Phase 2A will mitigate all these risks and it will present an opportunity for economic development in the area which cannot take place without it. Phase 2A is thus required to supplement existing allocations for both existing and future developments.

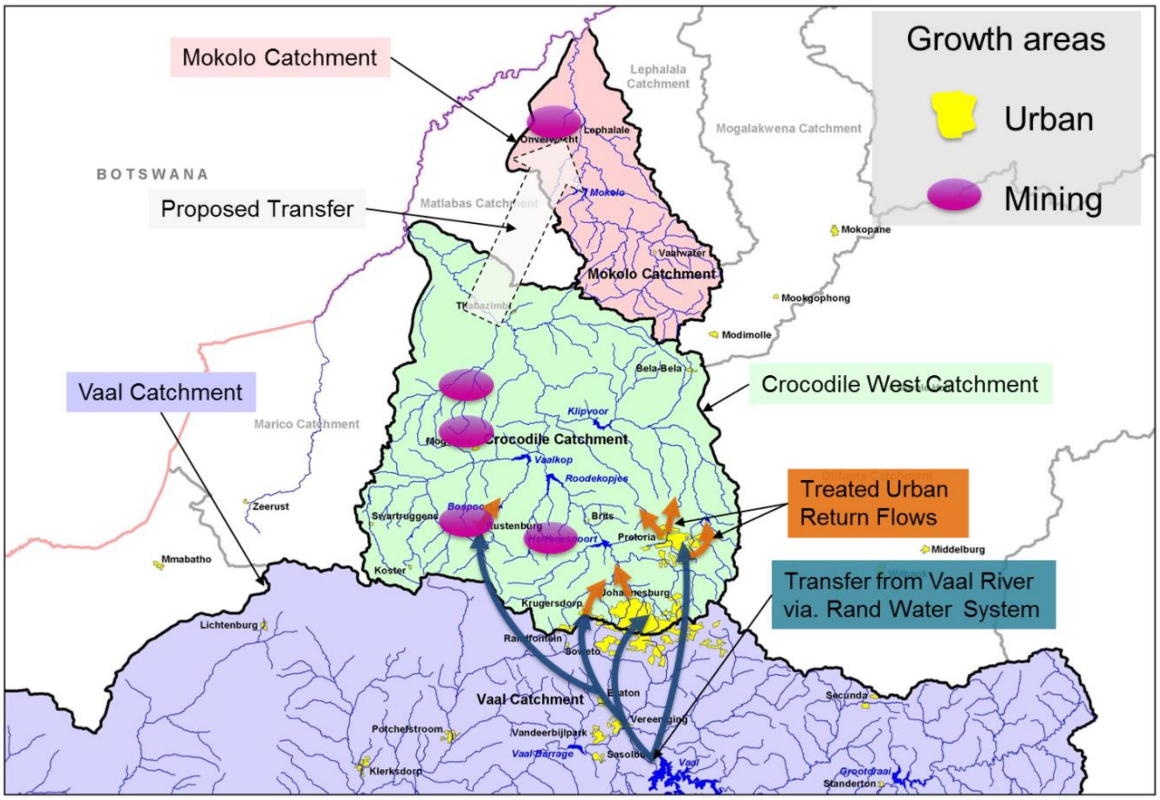

Figure 12: Water Resource Systems

6. CONCLUSION AND RECOMMENDATION

The FGD technology study evaluated available FGD technologies to identify applicable FGD technologies and specific approaches that can be implemented at the Medupi Power Station. The applicable FGD technologies were evaluated and compared on performance, operational requirements, and impacts to the Medupi Power Station when considering a retrofit. The technologies that were evaluated are WFGD, WFGD with cooler, and Dry FGD using CFB.

The impacts to the long term operation of the Medupi Power Station were reviewed in Section 5.0 of this report. The raw resource required for the operation of each type of FGD technology such as sorbent usage, parasitic energy consumption, and water requirements for the operation of the technology was reviewed and compared between technologies. Additionally, considerations from current operation of commercially available flue gas cooling technologies were considered for the alternative of utilising WFGD with flue gas cooler.

While the implementation of WFGD with flue gas cooling has the potential to reduce the WFGD water consumption the practical challenges cannot be ignored as this is expected to have a significant impact on the maintainability and availability of the power plant and the cost of electricity to the consumer. Furthermore all three power stations from Europe visited by Eskom during the benchmarking exercise advised against the installation of the system due to the problematic operation that it provides. WFGD with flue gas cooling is therefore not considered as a feasible option for Medupi.

The implementation of the WFGD technology has the potential to contribute to the broader socio-economic development of Lephalale and its surrounding areas because the WFGD has the flexibility of using lower quality limestones that can be sourced from areas closer to the power station. Furthermore the water supply for the WFGD at Medupi is part of the Phase 2A water augmentation project which is being developed to maximise the potential use of the natural water resource in the Crocodile catchment for industrial use in Lephalale and the surrounding areas. The development of Phase 2A therefore creates an opportunity for economic development in the area which cannot take place without it.

The DFGD technology resulted in a 9% higher capital cost for implementation due to modifications required for existing ductwork design and the addition of a new fabric filter system to the existing FFP in order to retrofit this technology. Although the DFGD processes use slightly less water for the Medupi site, the estimated operating expense for the DFGD is 53% higher than the WFGD system, mostly due to the significantly higher cost of the lime reagent.

It is therefore recommended that Eskom continue with its plan to construct the WFGD technology without the inclusion of a flue gas cooler as this is still the best long term option for SO_2 removal at Medupi Power Station. Based on the information presented in this report it is evident that this is the most efficient, sustainable and broadly (i.e. technical, social, cost) responsible solution for both Eskom and South Africa going forward.

7. AUTHORISATION

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8. REVISIONS

Date	Rev.	Compiler	Remarks
September 2013	0	David Harris Project Manager Black & Veatch	
May 2014	1	David Harris Project Manager Black & Veatch	Final document for Authorisation and Publication
July 2017	1.1	Daniel Chang Project Manager Black & Veatch	
October 2017	1.2	Daniel Chang Project Manager Black & Veatch	
December 2017	1.3	Daniel Chang Project Manager Black & Veatch	Updated final document for authorisation and publication

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10. ACKNOWLEDGEMENTS

- None

List of Attachments

(The following listed set of Documents is available under separate cover)

Process Flow Diagrams

P06259-R-PFD-005 Wet FGD without Cooler – Worst Coal LS; 96% CaCO3
006265-R-PFD-021 Wet FGD with Cooler – Worst Coal 96% CaCO3
006265-R-PFD-010 Dry / CFB Cluster 1 – Worst Coal 93.07% CaO

Process Area Arrangement Drawings

P06259-Z4010-501-09 Wet FGD without Cooler
006265-Z4010-XXX Wet FGD with Cooler
006265-Z4050-001-00 Dry / CFB
006265-Z4050-002-00 Dry / CFB Single Unit Overview

Data Sheets

P06259-S-TAB-0xx-DRAFT Wet FGD / CBF Comparison Overall Data Sheet

Eskom	Report	Group Technology

Title:	**Medupi FGD Retrofit Basic Design Report**	Unique Identifier:	**200-122784**
		Alternative Reference Number:	**178771.40.1000**
		Area of Applicability:	**Engineering**
		Documentation Type:	**Report**
		Revision:	**0**
		Total Pages:	**105**
		Next Review Date:	**Not Applicable**
		Disclosure Classification:	**CONTROLLED DISCLOSURE**

Compiled by	**Functional Responsibility**	**Authorised by**
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Date: .....30 September 2014........	Date:	Date: ....

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Document	SPF File Number	Document / File Number
Single Line Diagram ZLD Treatment MV & LV Board	0.84/28751	178771-CBCG-E1009
Single Line Diagram Essential MV & LV Board	0.84/28751	178771-CBCG-E1010
Single Line Diagram Limestone And Gypsum Handling MV & LV Board	0.84/28751	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up MV Board	0.84/28751	178771-CBCG-E1012
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Distributed Control System System Description	200-123563	178771.43.2401
Local Control Philosophy	200-114237	178771.41.0108
DCS Architecture Diagram	0.84/38951	178771-CHYQ-K8001
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Process Control System Philosophy	200-109912	006265-T-HBU-508
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General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
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General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
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Equipment List	200-57316	006265-S-LIS-002
Piping List	200-112366	006265-S-LIS-020

LIST OF ATTACHMENTS (VOLUME II)

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Medupi FGD ERA Schedule (All Activities)	200-117150	178771.24.2010.26
Estimate Plan	200-93608	178771.25.2001
Medupi FGD Retrofit FGD Technology Selection Study	200-55815	178771.41.0050
Medupi FGD Retrofit FGD Technology Selection Study Design Basis	200-93484	178771.41.0051
Navisworks 3D Model	--	--
Absorber Steel Structure 1/3 & 4/6 Structural Analysis	200-109547	006265-S4010-100
Absorber Steel Structure 2 & 5 Structural Analysis	200-109557	006265-S4010-200
Structural Analysis Raw Gas Duct w/Air Cooler 1/4	200-113436	006265-S4250-110
Structural Analysis Raw Gas Duct w/Air Cooler 1/4	200-113121	006265-S4250-111
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Limestone Steel Structure Ball Mill	0.84/38936	006265-Z4320-100

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

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Limestone Preparation Building Layout 0.00	0.84/38193	006265-Z4320-201
Limestone Preparation Building Layout 20.00	0.84/38194	006265-Z4320-202
Layout; limestone building, control and placement 0.00 m	0.84/38053	006265-Z4320-501
Layout; limestone building, control and placement 20.00 m	0.84/38054	006265-Z4320-502
Piping System Limestone Building 0.00M	0.84/38402	006265-Z4320-701
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Limestone Feed Tank 2 Arrangement	0.84/38229	006265-Z4381-021
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FGD Common Substation, Beams For Slab at +7.530m Level, Reinforcement Details	0.84/36915 sht. 9	
FGD Common Substation, Beams For Slab at +7.530m Level, Reinforcement Details	0.84/36915 sht. 10	
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Limestone and Gypsum Handling Substation, General Arrangement of Steelwork, Roof Plan and Section	0.84/38510 sht. 2	
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Limestone Offloading Building, General Arrangement of Steelwork East Elevation	0.84/38964 sht 5	
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Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 8	
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Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 10	
Limestone Unloading and Receiving Building, Foundations	0.84/38964 sht 11	
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Basic Design Calculation File, Limestone Preparation Building, Ball Mill Hall	200-99433	
Basic Design Calculation File, FGD Common Substation	200-99435	
Medupi FGD Design Calculation File, Stormwater Drainage For Area West of Boiler to Road 09	200-99437	
Basic Design Calculation File, Gypsum Dewatering Building	200-99730	
Basic Design Calculation File, Limestone Preparation Building, Day Silo Bay Support Structure	200-102307	
Basic Design Calculation File, FGD Makeup Water Pre-Treatment Building	200-102512	
Basic Design Calculation File, Absorber Pump House Steel Structure and Foundation Design	200-102526	
Basic Design Calculation File, Raw Water Pump Station, Plinth Design	200-103034	
Basic Design Calculation File, Emergency Generation Building	200-108081	
Basic Design Calculation File, ZLD Building	200-109051	
Basic Design Calculation File, Common Pump Building	200-109052	
Basic Design Calculation File, Limestone and Gypsum Handling Substation	200-109266	
Basic Design Calculation File, Limestone Receiving Building	200-110226	
Basic Design Calculation File, Gypsum Storage Building	200-110444	

OTHER BASIC DESIGN DOCUMENTS (NOT ATTACHED)

Document	SPF File Number	Document / File Number
Basic Design Calculation File, Absorber Pump House Substation Concrete and Foundation Design.........................	200-110445	
Basic Design Calculation File, Essential Service Substation...	200-110446	
Medupi FGD: Geotechnical Investigation Scope of Works	200-115317	

1. INTRODUCTION

The Medupi Power Station Flue Gas Desulfurization (FGD) Retrofit Project consists of the addition of FGD systems to six 800 megawatt (MW) coal fired steam electric generating units being constructed in Limpopo Province, approximately 15 kilometres (km) west of the town of Lephalale, South Africa. The units are planned to enter commercial operation sequentially beginning at the end of 2014. The FGD Project will result in the addition of wet limestone open spray tower FGD systems to each of the operating units and will be operational within six years following commercial operation of the respective generating units.

The Medupi plant is currently under construction. Each of these units has been designed and is being constructed with provisions incorporated into the space and equipment design to accommodate the installation of wet limestone FGD systems. Each of the six FGD absorbers will treat the flue gas from one boiler; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, limestone preparation, FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant.

The basic design presented herein was developed by a collaborative team blend of Eskom, Steinmüller Engineering, and Black & Veatch with an integrated division of responsibility. Basic design for the FGD Process and associated facilities was performed by the team for the complete scope of work necessary to fully integrate the FGD into the operating plant.

The content of this document is based upon a multi-contract engineering, procurement, and construction management (EpCM) approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package engineering, procurement, and construction (EPC) (or hybrid) approach at a later stage. Changes to the contracting approach will affect the results presented herein.

2. SUPPORTING CLAUSES

2.1 SCOPE

This report presents the results of the Basic Design Phase, including project scope definition, execution planning, and estimated capital and operations and maintenance costs.

2.1.1 Purpose

This document summarises the status and outcome of the Medupi FGD Retrofit Basic Design phase results and activities and describes the achievement of the design goals in terms of meeting the stakeholder requirements. This document, together with the design output documentation of the Basic Design Phase, will be submitted to a project design review board for technical assessment.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions with specific reference to Medupi Power Station.

2.2 NORMATIVE / INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] Design Base Standard – Doc no: 474-190

[2] Design Review Procedure – Doc no: 240-5311 3685

[3] Engineering Drawing Office and Engineering Documentation Standard – N.PSZ 45-698

2.2.2 Informative

[4] Medupi User Requirements (URS) Rev. 4 – Doc no: NC/001

[5] Medupi Project Design Manual (PDM) – Doc no: 200-32065

[6] Eskom Air Quality Strategy – Doc no: 32-1143

[7] National Environmental Management Act 2004 (Act 39 2004)

[8] Medupi FGD Retrofit Conceptual Design Report Rev. 2 - Doc no: 200-61771

[9] Modification of Chimney Compensator and Nozzles, and Addition of Coating to the 316L Stainless Flue Liners, Rev. 1 – Doc no. 203-44134

[10] For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum – Doc no: 257-185172

[11] Guideline: Possible alternatives for the disposal of chemical wastes produced by the Flue Gas Desulphurisation process – Doc no: 200-128401

[12] Scope of Works, Concept Design for disposal of waste produced by the Medupi Flue Gas Desulphurisation Retrofit Project – Doc no: 200-137848

2.3 DEFINITIONS

None.

2.3.1 Classifications

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
BOP	Balance of Plant
CaF_2	Calcium Fluoride
$CaCl_2$	Calcium Chloride
$CaCO_3$	Calcium Carbonate
$CaSO_3$	Calcium Sulphite
$CaSO_4$	Calcium Sulphate
$CaSO_4 \cdot 2H_2O$	Calcium Sulphate Dihydrate
CCCW	Closed Cycle Cooling Water
CDR	Concept Design Report (SPF file 200-61771)
CPP	Condensate Polisher Plant

Abbreviation	Description
DC	Direct Current
DCS	Distributed Control System
ECP	Engineering Change Proposal
EDG	Emergency Diesel Generator
EIA	Environmental Impact Assessment
ENS	Effluent Neutralisation Sump
EPC	Engineering, Procurement, and Construction (Contract)
EpCM	Engineering, Procurement, and Construction Management (project approach)
FGD	Flue Gas Desulfurization
FMECA	Failure Modes, Effects, and Criticality Analysis
HAZOP	Hazard and Operability (Analysis)
HCl	Hydrogen Chloride
HF	Hydrogen Fluoride
I/O	Input and Output
ID	Induced Draft
IT	Information Technology
km	Kilometre
kV	Kilovolt
LFCR	Levelized Fixed Charge Rate
LV	Low Voltage
m	Metre
$MgSO_4$	Magnesium Sulphate
MPa	Mega Pascal
MV	Medium Voltage
MW	Megawatt
MWh	Megawatt-hour
O_2	Oxygen
O&M	Operations and Maintenance
ppm	Parts per Million
P&ID	Piping and Instrument Diagram
PDRA	Project Definition Readiness Assessment
PDM	Project Design Manual
PWDR	Present Worth Discount Rate
RAM	Reliability, Availability, and Maintainability (Analysis)
SO_2	Sulphur Dioxide
SO_3	Sulphur Trioxide
TOC	Total Organic Compounds
UPS	Uninterruptible Power Supply
V	Volt

Abbreviation	Description
ZAR	South African Rand
ZLD	Zero Liquid Discharge

3. BASIC DESIGN INFORMATION

3.1 KEY DESIGN ASSUMPTIONS

A project design basis was established at the outset of the project to define the technical and functional requirements to which the Medupi FGD Retrofit Project is to be designed.

The Project Design Manual (PDM) (178771.22.0000, SPF file 200–61989), attached, was prepared specifically for the Medupi FGD Retrofit Project consistent with the Medupi Power Station User Requirements Specification Revision 4 [4]. A Project Design Manual [5] was previously prepared for the Medupi Power Station Project which served as the model for this document.

A conceptual design for the Medupi FGD Retrofit was concluded in May 2012. The Medupi FGD Retrofit Conceptual Design Report [8] documents the results of the Concept Design phase and serves as the baseline from which the Basic Design was performed.

3.2 DESIGN APPROACH

The content of this document is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the results presented herein.

3.2.1 Design Inputs

In support of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) [7], Eskom's Air Quality Strategy [6] established a sulphur dioxide emissions target of less than 400 mg/Nm^3 at 6 percent O_2 for power stations commissioned between 2002 and 2017 and recommended that flue gas desulphurization be retrofit to the Medupi Power Station.

As described further in Section 3.3.1, the Medupi FGD Retrofit is designed to accommodate differentiation in coal quality (design coal and "worst" coal), limestone quality (85 percent purity and 96 percent purity), and operation with and without attemperation air (the attemperation air must be added to the flue gas at the inlet of the fabric filter in order to protect the fabric filter, if the temperature of the flue gas is too high). The "worst" coal has higher sulphur content in comparison to the design coal.

As described further in Section 3.3.2, a significant change in the design basis compared to the Concept Design phase is the limestone qualities. In order to be able to use also limestone with lower quality, two different limestone qualities (one with 96 wt. percent calcium carbonate ($CaCO_3$) and one with 85 wt. percent $CaCO_3$) were chosen for the design of the plant and all subsystems. Assumed limestone analyses were developed and used for the Basic Design; however the actual limestone composition is not yet defined.

3.2.1.1 Open Issues from the Concept Phase

The following issues were identified in the Conceptual Design Report [8] and end-of-phase reviews for resolution or completion during the Basic Design phase of the project.

Table 1: Open Issues from Concept Phase

Item No.	Origin	Action	Comments or Resolution	Closed Date
1		Ensure all interfacing packages are informed accordingly	Eskom comments on the Interface List received 6-Feb-14	6-Feb-14
3		Evaluation of existing Unit/BOP network to accommodate the additional controllers	Duplicate item; refer to item R25	15-Apr-13
4		Evaluation of the HVAC/space/flooring in existing rooms for additional equipment	Duplicate item; refer to item R26	15-Apr-13
5		Advise client and confirm client requirements for a dedicated ZLD control room	Will be dedicated control room. Added to Record of Decision Table item 6 (see Section 3.2.1.2)	03-Jun-13
6		Evaluate the option of issuing a variation to the existing Medupi Alstom C&I contract	Duplicate item; refer to item R35	15-Apr-13
7		Evaluation of existing Unit/BOP electrical system to accommodate the additional Unit/BOP loads	Duplicate item; refer to item R15	15-Apr-13
8		Identification of requirement as well as interface/tie-in points for FGD auxiliary transformers	Refer to Section 3.5.3.15.1 herein. Indicative quotation received from Grid Planning on 25-Mar-14	25-Mar-14
9		Investigate requirement as well as location of FGD diesel generator	Refer to Section 3.5.3.15.4 herein	16-Jan-14
10		Update the PDM to reflect the correct civil codes and standards	Duplicate item; refer to item R37	15-Apr-13
11		Geotechnical Study must be done to determine the soil conditions for areas of FGD and ZLD	Duplicate item; refer to item R38	15-Apr-13
12		Evaluate the need for potable and fire water booster pumps	Duplicate item; refer to items R8 and R9	31-Oct-13
13		Limestone and Gypsum railing, delivery and off take specification/clarification	Refer to Sections 3.5.3.6 and 3.5.3.7 herein	5-Dec-13
14		Integrate the required materials handling facilities for loading and unloading limestone, bulk fuel oil, gypsum and general cargo with the rail yard	Limestone Receiving drawing revised to add grade elevation. This is the starting point for the rail design to be developed	14-Apr-14

Item No.	Origin	Action	Comments or Resolution	Closed Date
R1	CDR page 284/966	Flow Modelling to ensure that duct-stack system is favourable for wet operation	Neither the Steinmüller nor Black & Veatch scope for the Basic Design included condensation and wet flow modelling to identify whether the existing wet stack liquid collection provisions will perform adequately under the updated FGD Design Basis or if they require modifications that should be accounted for in the basic design execution (see Section 3.24.1 item 1)	Open
R2	CDR page 284/966	Third party condensation calculations	Duplicate item; refer to item R1	31-Oct-13
R3	CDR page 284/966	Third party review for the need of additional liquid collection facilities in the breeching and flue	Refer to Section 3.5.3.4 herein	4-Feb-14
R4	CDR page 284/966	Third party review of flue discharge velocities and buoyancy to determine if exit modifications are necessary for adequate dispersion and elimination of possible plume downwash which may be caused by the wake formed on the downwind side of the flue and stack shell (such as a choke; reduction in diameter at flue exit)	Eskom is reviewing dispersion capability at stack exit Updated stack exit conditions were developed during Basic Design execution (see Section 3.24.1 item 2)	Open
R5	CDR page 284/966	Review and validate the “No Reheat Dispersion Modelling Study” document to determine the accuracy of: a) existing criteria, b) meteorological data, c) dispersion type and modelling domain, and the current Steinmüller parameter flow data	Duplicate item; refer to item R4	11-Dec-13
R6	CDR page 284/966	Review adequacy of existing chimney drain piping and chimney drain system termination points for the case of additional liquid collection	Duplicate item; refer to item R3	31-Oct-13
R7	CDR page 284/966	Review continuous emissions monitoring system to determine if any modifications may be required due to the FGD retrofit project	No modifications are required	13-Jun-13
R8	CDR page 296/966	Evaluate the fire protection system to evaluate the need for a booster pump	Fire water booster pump is required	16-Jan-14
R9	CDR page 296/966	Evaluate the potable water system to evaluate the need for a booster pump	Potable water booster pump is required	31-Oct-13

Item No.	Origin	Action	Comments or Resolution	Closed Date
R10	CDR page 296/966	Determine where service connections are required for plant maintenance	Captured on the P&IDs	5-Dec-13
R11	CDR page 296/966	Confirm the design inlet temperature for equipment cooling	Cooling water temperature is 34 °C	16-Jan-14
R12	CDR page 296/966	Evaluate the cooling tower location	Cooling tower location near FGD ZLD Treatment System confirmed during Basic Design	23-Jan-14
R13	CDR page 304/966	Develop the expected system draft losses for the design and expected cases including duct and FGD pressure drop following layout of the FGD inlet and outlet ductwork	Expected system draft losses developed and reviewed by the project team during Basic Design	23-Jan-14
R14	CDR page 304/966	Evaluate the system impacts of the addition of a gas-to-gas heater on ID fan operations	Fan capacity was reviewed during Basic Design and is adequate for anticipated gas cooling heat exchanger pressure loss	31-Oct-13
R15	CDR page 331/966	Evaluate if the existing electrical system will be able to support the addition of FGD unit and BOP loads. The cost for the supply and installation of the station service transformers was not included in the FGD retrofit project cost in the conceptual design report	Refer to Section 3.11 herein	27-Mar-14
R16	CDR page 345/966	Arrangement and configuration of the gypsum material handling facilities	Refer to Section 3.5.3.7 herein and Record of Decision Table items 2, 3, 4, and 5 (see Section 3.2.1.2)	1-Aug-13
R17	CDR page 345/966	Arrangement and configuration of the commercial-grade gypsum temporary storage facilities	Not needed; refer to Record of Decision Table item 3 (see Section 3.2.1.2)	1-Aug-13
R18	CDR page 363/966	Update the Medupi Water Balance with the FGD system design	Water balance was updated following Concept Design on 27-Mar-12. FGD water balance is complete; Medupi overall water balance is under revision	Open
R19	CDR page 363/966	Verify the FGD wastewater chemistry and quantity	Wastewater chemistry can not be definitively established until the final limestone analysis is established at procurement. Assumptions are documented in the wastewater treatment mass balance. Issue identified for resolution during execution (see Section 3.24.1 item 19)	12-Sep-13
R20	CDR page 363/966	Evaluate wastewater treatment systems to determine the best option for treating the FGD wastewater. The evaluation should include other treatment options such as eutectic freeze desalination	Reviewed during Basic Design; basis for the Basic design is brine concentrator/crystallizer technology as described in Section 3.5.3.8 herein	17-Oct-13

Item No.	Origin	Action	Comments or Resolution	Closed Date
R21	CDR page 363/966	Determine the dilution ratio to re-use the effluent from the condensate polisher regeneration	Condensate polisher regeneration effluent will not be used in FGD; refer to Section 3.5.3.5 herein	24-Oct-13
R22	CDR page 363/966	Evaluate whether the backwash flow from the sand filter can be directed to the Reclaim Water Tanks	FGD Makeup Water pretreatment backwash will be directed to the dirty water drains system; refer to Section 3.5.3.5 herein	11-Jul-13
R23	CDR page 363/966	Evaluate whether the ZLD distillate can be directed to the Reclaim Water Tanks	ZLD distillate may be returned to FGD Reclaim Water Tanks; refer to Section 3.5.3.8 herein	18-Feb-14
R24	CDR page 379/966	Addition of a dedicated control room for the ZLD equipment	Will be dedicated control room. Added to Record of Decision Table item 6 (see Section 3.2.1.2)	03-Jun-13
R25	CDR page 379/966	Capability of the existing BOP network to accommodate additional FGD controllers	The FGD DCS system is on its own network and will have a dedicated loop with dedicated controllers and network equipment. Therefore there should be little to no effect to the on the overall plant network traffic. A bi-directional loop is provided for reliability so that a break in the fibre will not affect the network	7-Aug-14
R26	CDR page 379/966	Evaluate HVAC/ space/floor loading capacity in existing rooms for the additional supply	Additional space is not available in the existing unit C&I equipment rooms; refer to Record of Decision Table item 24 (see Section 3.2.1.2)	22-Apr-13
R27	CDR page 33/966	Evaluate the addition of flue gas reheat to reduce the FGD water consumption	Refer to Section 3.5.3.2 herein and Record of Decision Table item 12 (see Section 3.2.1.2)	8-Aug-13
R28	CDR page 33/966	Confirm the commercial operation date for the first Medupi generating unit. Update FGD project schedules accordingly	The basis for the Basic Design is commercial operation of Unit 6 in December 2014	14-Apr-13
R29	CDR page 33/966	Evaluate if the existing tunnels will be able to support the addition of the new power cables. CDR assumed that adequate space was available. No additional tunnels are considered due to congestion in main plant areas	Rack space is existing and is allocated for the FGD cables	24-Jan-14
R30	CDR page 33/966	Confirm quantity of FGD make-up water pre-treatment backwash as there is a limitation on the allowable flow to the dirty water drains system	Backwash quantity is within allocation	12-Sep-13
R31	CDR page 33/966	Confirm the supply, quality and chemical reactivity of limestone	Limestone Quality Range Study was performed during Basic Design; refer to Section 3.3 herein	11-Jul-13

Item No.	Origin	Action	Comments or Resolution	Closed Date
R32	CDR page 33/966	Determine the configuration and means of support for isolation of the bypass duct (the current exhaust duct to the chimney)	Refer to Section 3.5.3.2 herein	20-Aug-14
R33	CDR page 33/966	Interface details need to be developed for all interfacing systems	Eskom comments on the Interface List received 6-Feb-14	6-Feb-14
R34	CDR page 33/966	RAM study	Refer to Section 3.16.3 herein	6-Jun-14
R35	Medupi Design Review Meeting 24/05/2012	Evaluate the option of issuing a variation to the existing Medupi Alstom C&I contract	Cost estimate basis is a stand-alone DCS; refer to Section 3.5.3.16 herein	Open
R37	Medupi Design Review Meeting 24/05/2012	Update the PDM to reflect the correct civil codes and standards	Review and revisions completed during Basic Design	25-Feb-14
R38	Medupi Design Review Meeting 24/05/2012	Conduct a geotechnical study to determine the soil conditions for areas of FGD and ZLD	Eskom to complete prior to start of detailed design. Issue identified for resolution during execution (see Section 3.24.1 item 3)	Open
R39	Email: Additional Action	Limestone and Gypsum railing, delivery and offtake	Duplicate item; refer to 13	14-Apr-13

3.2.1.2 Record of Decision Log

Changes in FGD and balance of plant designs compared to the previous conceptual design were tracked and evaluated by the team for approval. A record of these changes and approvals was maintained in the Record of Decision Log (178771.40.2000, SPF file 200-137693), attached.

3.2.2 Design Process

Black & Veatch was responsible for the overall project execution coordination and technical coordination and among the project parties (Eskom, Steinmüller, and Black & Veatch). This includes documenting the design basis and applying the change management process. Technical coordination was facilitated through the use of the design toolset to avoid physical interferences and coordinate design conditions at terminal and interface points.

3.2.3 Design Verification

Each of the project parties reviewed the work done by others during the execution of the Basic Design. Important aspects of this review include quality, accuracy, completeness, and conformance to project requirements; however this review does not relieve the originator of accountability for that work.

A log of the unverified assumptions made during Basic Design (attached) was developed to track those assumptions which were relied upon to develop the design. These unverified assumptions will need to be reviewed and resolved during the execution phase through the use of vendor submittals, additional studies/investigations, coordination with the existing plant, etc. It is assumed that the flue gas ductwork design will include both the positive and negative pressure design cases (a value of +/-40 mbar, at the design temperature of 200° C.

Eskom will follow the Design Review Procedure [2] to baseline the Basic Design.

3.2.4 Design Criteria

The PDM (178771.22.0000, SPF file 200–61989), attached, was prepared which detailed the plant design and performance criteria.

Refer to the following documents (attached) for additional information on the Design Criteria.

Document	SPF File Number	Document / File Number
FGD Redundancy and Size Evaluation	200-92612	006265-S-TAB-010
Balance of Plant Sizing Criteria	200-55814	178771.41.0103

3.2.5 Codes and Standards

The PDM (178771.22.0000, SPF file 200–61989), attached, was prepared which detailed the plant design and performance criteria. Section 2.0 of the PDM identifies the applicable South African codes, local codes and ordinances, Eskom-specific codes, or international codes, processes, and standards to be used in the design of the plant/facility/system.

3.3 KEY DESIGN DRIVERS

3.3.1 Controlling Design Cases

The Medupi FGD Retrofit will be designed to accommodate variations in coal and limestone quality. The FGD system will also be designed to cater for the operation of the attemperation air system that will be installed as part of the Medupi Power Station as a preventative measure to reduce the flue gas temperature at the inlet of the Fabric Filter Plant. The following design cases were considered in the design of the FGD:

- Design Coal, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Worst Coal, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Worst Coal + attemperating air, 100 percent BMCR, 85 percent $CaCO_3$ in limestone
- Design Coal, 100 percent BMCR, 96 percent $CaCO_3$ in limestone
- Worst Coal, 100 percent BMCR, 96 percent $CaCO_3$ in limestone
- Worst Coal + attemperating air, 100 percent BMCR, 96 percent $CaCO_3$ in limestone

Each of the design cases mentioned above influences FGD plant performance as well as mass and volume flow rates. The controlling design cases are different for each parameter. Respectively the highest value of the parameter was chosen for the design of the plant. An evaluation of the FGD Design Controlling Cases (P06259-S-TAB-015, SPF file 200-925446), attached, identified the design parameters which would establish the design basis for FGD and auxiliary systems design.

Table 2: Design Load Cases

Load case	Design Coal pH 5.1	Design Coal pH 5.4	Worst Coal pH 5.1	Worst Coal pH 5.4	Worst Coal + Attemp Air pH 5.1	Worst Coal + Attemp Air pH 5.4
Volume Flow [Nm³/h, dry @ 6% O_2]	2,427,381	2,427,381	2,495,388	2,495,388	2,716,068	2,716,068
Act. O_2 [%]	4.64	4.64	4.55	4.55	6.65	6.65
Inlet Temperature [°C]	137.0	137.0	137.0	137.0	137.0	137.0
Inlet Pressure [mbar]	928.7	928.7	931.2	931.2	934.3	934.3
H_2O [Vol-%]	8.33	8.33	8.84	8.84	8.02	8.02
SO_2 conc. Inlet [mg/Nm³,dry @ 6% O_2]	3.405	3.405	5.338	5.338	5.378	5.378
SO_3 Inlet conc. [mg/Nm³,dry @ 6% O_2]	34	34	53	53	53	53
HCl conc. Inlet [mg/Nm³,dry @ 6% O_2]	160	160	160	160	160	160
Limestone quality [% $CaCO_3$]	85	96	85	96	85	96

3.3.2 Limestone Quality

A decision was made to revise the design basis limestone quality so that the FGD system design could accommodate a lower quality limestone, which might be more readily available. The change in limestone quality impacted nearly all aspects of the new facilities, including sizing and layout for the limestone handling and preparation systems, the absorbers, gypsum processing and handling systems, and water treatment system.

A Limestone Quality Range Study (006265-T-STD-110, SPF file 200-113244), attached, was performed to to qualitatively evaluate the suitability and impact of different limestone qualities on sizing, process performance, operations and maintenance of FGD equipment.

3.3.3 Water Quality

The initial water supply for the project will be sourced from the Mokolo Dam. The Mokolo water supply will eventually be replaced by water from the Crocodile-West water system. The water quality and constituents for these two sources of water were included in Article 1.4.4 “Water” of the PDM (178771.22.0000, SPF file 200–61989), attached. The water quality and constituents influenced the design of the FGD Makeup Water Pretreatment and Waste Water/Zero Liquid Discharge Treatment systems.

3.3.4 Geology and Seismology

The geology and seismology information associated with the station site was included in Article 1.6.3 "Geology and Seismology" of the PDM (178771.22.0000, SPF file 200–61989), attached. The site is underlain by sedimentary rocks of the Waterberg Group and there are several faults located in the area. This information influenced the design outcome of the civil, structural, chemical, and low pressures services sections.

3.4 PROCUREMENT STRATEGY

A Project Procurement Plan (178771.23.1110, SPF file 200-92430), attached, was developed to provide Engineering input to the Procurement Strategy to be developed by Eskom Commercial. A Project Procurement Matrix is included to define the plan for executing the purchasing, contracting, technical and procurement specifications, expediting, inspection and testing, remittance, logistics and material control for the equipment, material and services; and for each procurement package.

The Project Procurement Matrix defines the contract breakdown structure for the project execution schedule described in Section 3.20 and the project cost estimate described in Section 3.21.1.

The contents of the Project Procurement Plan are based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the cost and schedule for the project. It is recommended that a packaging workshop be held to vet the schedule and interface coordination issues prior to finalization of the contracting and packaging strategies.

3.5 PROJECT DESCRIPTION

3.5.1 Project Breakdown Structure

The Kraftwerk Kennzeichen System (KKS) system was used as the basis for classifying and designating both plant equipment and their associated documents, including the project execution schedule described in Section 3.20 and the project cost estimate described in Section 3.21.1. The following Table contains a list of the Codes and Descriptions used to breakdown the areas, systems, sub-systems, specifications, and major components.

The project breakdown structure used herein is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the coding applied in the cost estimate and the schedule for the project.

Table 3: Work Breakdown Structure

Medupi ERA Area		Medupi ERA Systems / Specification	
Code Value	**Description**	**Code Value**	**Description**
ABS	3-2-1 Absorber Area	AAA	Administration & Milestones
ABA	6-5-4 Absorber Area	GRP	Grouping Plan
BMH	Bulk Material Handling Area	FWL	Firewall
CSA	FGD Common Substation Area	ANK	DC Switchgear (110 / 220V)
MWA	FGD Makeup Water Area	BCT	AC Power Supply (6600V)

GDA	Gypsum Dewatering Area	BCG	FGD Auxiliary Transformer
LPA	Limestone Preparation Area	BFG	AC Power Supply (400V)
RAY	Rail Yard Area	BN_	Essential Service AC
STC	Startup & Commissioning	BRV	Emergency Generation
SUB	Substation Area	BSB1	Utility Rack -EC
ZLD	ZLD Area	BSB2	Utility Rack -PDC
ALL	All Areas	BTW	24V DC Power Supply
		CFU	Construction Facilities Area
		CMA	Communications
Medupi ERA Company		CPU	Lightning Protection
Code Value	**Description**	EEB	Earthing
EC	Engineering Consultant	EEC	Raceway / Cable Tray
A	All	GAU1	Site Arrangement
V	Vendor	GAU2	Demolition Drawing
PDC	Process Design Consultant	GAU3	Plot Plan
E	Eskom	GNG	Zero Discharge Treatment
		GNG2	TOC Scavenger
		GNR	Zero Liquid Discharge (ZLD) Building
Medupi ERA Discipline		GNR1	Zero Liquid Discharge (ZLD) Area
Code Value	**Description**	GKC	FGD Potable Water
C	Civil	GKC2	FGD Sanitary
M	Mechanical	HTD1	Flue Gas Desulfurization
E	Electrical	HTD2	Absorber Pump House
A	All	HNA	Flue Gas Duct
P	Procurement	HNC	Induced Draft Fan
CN	Construction	HTG	Oxidation Air
PM	Project Management	UBD1	Limestone Off-Loading and Storage Area
CH	Chemical	HTJ	Limestone Receiving Store Reclaim Area Conveyor
L	LPS	HTJ1	Limestone Prep Area Conveyor
V	Vendor	UBD	Limestone Unloading and Receiving Building
		HTK	FGD Additive Preparation and Supply
		HTK2	FGD Additive Preparation and Supply - Silos and Slide gate
Medupi ERA Deliverable		HTL	Gypsum Bleed Tank / Absorber Drain Tank Area 4-6
Code Value	**Description**	HTL5	Gypsum Bleed Tank / Absorber Drain Tank Area 1-3
ADMIN	Administration & Milestones	HTL1	Gypsum Hydrocyclone and Belt Filter + Filtrate
AR	Architectural	HTL2	Gypsum Bleed Drain System
CA	Conveyor Arrangement	HTL3	Waste Water HC Feed Tanks
GEO	Geotechnical Design	HTL4	Waste Water Hydrocyclone 1-3

SPEC	Specification	HTN	FGD Solids Dewatering
D	Ductwork	HTP	FGD Solids Conveying and Storage
CNST	Construction	HTQ1	FGD Process Water Supply
F	Foundation	HTQ3	Process Water Tank 1-3
OL	PDC Rack General Arrangement	HTQ4	Waste Water Reclaim
RD	Roads & Grading Plan	HTT1	FGD Blowdown Limestone Slurry Preparation Building Sumps
SD	Site Drainage Plan	HTT2	FGD Blowdown Recycle Pump Building Sumps Units 1-3
ST	Steel/Concrete Structures	HTT3	FGD Blowdown Recycle Pump Building Sumps Units 4-6
U	Undergrounds	HTT4	FGD Blowdown ZLD Sumps
CALC	Calculations	HTT5	FGD Blowdown Gypsum Dewatering Building Sumps
FD	Functional Descriptions	HTT6	FGD Blowdown FGD Makeup Water Pretreatment Sump
GA	General Arrangements	HTT7	FGD Blowdown Process Water Tanks Sump
HVAC	HVAC	HTT8	FGD Blowdown Reclaim Water Tanks Sump
INS	Insulation	HTT9	FGD Blowdown ZLD Holding Tank Sump
ISO	Isometrics & Hangers	HTT10	FGD Blowdown Gypsum Bleed/Absorber Drain Tank Sumps
MAD	Maintenance & Access Drawings	HY_	Distributed Control System
MB	Mass Balances	LBG	FGD Auxiliary Steam
MFD	Material Handling Flow Diagrams	PGB	FGD and Wastewater Treatment Closed Cycle Cooling Water
PFD	PFD's	QFB	FGD Compressed Air
PID	Piping & Instrument Diagrams	SGA	FGD Fire Protection
SYSD	System Descriptions	STU	Electrical Tunnels / Underground Utilities
COMM	Communications	UAD	Switchyard Area
CP	Construction Power	UBE	FGD Common Substation
ERTH	Earthing	UBD4	Limestone Unloading and Gypsum Storage Area Substation
LP	Lightning Protection	UBD5	FGD Essential Services Substation
TRAY	Tray	UBD6	Absorber Pump House Substation
SCHEM	Schematic Diagrams	UBN	Emergency Generation Building
SL	Single Line Drawings	UGA1	FGD Makeup Water Pretreatment Area
CSP	Control System Philosophy	UGA	FGD Makeup Water Pretreatment Building
LIST	Lists	UGA2	Raw Water Pump Building
LOG	Logics	UGE	Gypsum Storage Building
HU	Hook-Ups	UGQ	Gypsum Dewatering Building
SA	Site Arrangement	UGQ1	Gypsum Dewatering Area
DD	Demolition Drawing	UGQ2	Gypsum Storage Area
PP	Plot Plan	UHE	Chimney Flow Model

CIR	Circuits	UHT1	FGD Area GA for 6, 5, 4
HAZ	HAZID	UHT2	FGD Area GA for 3, 2, 1
RAM	RAM Study	UUU	FGD Common Pump Building (Potable, CCCW, Air Compressor, Fire)
FEM	FMECA	UVE1	Limestone Preparation Area
		UVE	Limestone Preparation Building
		UZA	Roads and Grading
		UGM	Site Drainage
		GEO	Geotechnical Design
		HAZ	HAZID
		FEM	FMECA
		RAM	RAM Study
		61.3901	FRP Ductwork
		61.4000	Structural Steel and Carbon Steel Ductwork
		63.2800	DC System and UPS
		63.3601	Medium Voltage Switchgear and Bus
		63.3603	Low Voltage Switchgear and Motor Control Centres
		63.3800	FGD Station Service Transformers
		65.2300	FGD Wastewater Treatment (ZLD)
		65.3240	Gypsum Dewatering System
		67.0400	Material Handling System (Furnish & Install)
		67.9200	Pumps and Agitators
		67.9277	Absorber Spray (Recycle) Pumps
		67.9300	Compressed Air Equipment
		67.9441	Oxidation Air Blowers
		67.9732	Limestone Slurry Preparation System
		71.0204	Railroad Construction
		71.0402	Substructures Construction
		71.0403	Superstructures Construction
		73.0000	Electrical Construction
		73.0600	Substation Construction
		73.0604	Construction IT and Communication (Furnish and Install (Construction)
		73.5001	Permanent Plant IT
		74.0000	Control & Instrumentation
		65.3211	FGD Absorber (Furnish Only)
		77.0453	Material Handling System
		77.1000	Mechanical Construction
		77.5450	Field Erected Tanks
		78.0102	Geotechnical Investigation
		78.0106	Surveying

	78.0600	Site Services (Furnish & Install)
	78.0601	Medical Services
	78.0602	Security Services
	78.1300	Construction Canteen Operation
	STC	Startup & Commissioning

3.5.2 Existing Facilities

The Medupi plant is currently under construction. Each of these units has been designed and is being constructed with provisions incorporated into the space and equipment design to accommodate the installation of wet limestone FGD systems. Each of the FGD systems is designed to provide desulfurization for a single generating unit at the site. The Site Arrangement (178771-CGAU-G1001, SPF file 0.84/28836) and Plot Plan (178771–CGAU–G1000 SPF file 0.84/36776), attached, show the existing construction plan and the new FGD equipment. Each of the six generating units is independently operated; common facilities are provided for electrical power, water, coal supply, and coal combustion waste disposal.

Each of the units is currently equipped with fabric filters and induced draft (ID) fans. The fabric filters remove the majority of the fly ash from the coal combustion process, and the ID fans provide the necessary draft to overcome the system resistance. The ID fans were designed with additional margin to overcome the additional system resistance due to the future installation of the FGD equipment.

The ID fans currently discharge directly to the chimney flue associated with each unit. The FGD system will include additional dampers and ductwork to divert flue gas to the FGD absorbers and return it to the chimney and to provide a bypass of the FGD systems as may be required by system operation. The chimney flues are lined with corrosion-resistant liners to handle saturated flue gas resulting from future operation of an FGD plant.

Modifications required for the existing facilities are described in Section 3.5.4.

3.5.3 FGD Retrofit Project Facilities

Each FGD absorber will treat the flue gas from one of the six boilers; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, reagent preparation, FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant.

The project scope includes the following:

- FGD system, including pumps, agitators, oxidation air blowers
- Flue gas ductwork and draft system modifications
- Makeup water supply and pretreatment
- Chimney modifications
- Limestone receiving, storage, and handling system
- Limestone preparation system
- Gypsum refinement and dewatering system
- Gypsum handling and storage systems and waste gypsum disposal

- FGD zero liquid discharge (ZLD) treatment system and waste disposal
- Auxiliary steam system
- Closed cycle cooling water system inlcuding wet cooling tower and heat exchanger
- Fire protection systems and facilities
- Compressed air supply
- Potable water supply
- Blowdown sumps
- High voltage power supply
- Medium voltage power supply
- Low voltage power supply
- Emergency electrical supply and emergency diesel generator
- Essential electrical supply
- Control equipment for equipment protection, operation, and monitoring
- Interconnecting piping systems
- Onsite fencing, roads, and railroad interfaces
- Drainage systems, including storm water, sanitary, chemical, and wastewater
- Construction facilities (associated with this project)

3.5.3.1 FGD System

The sulphur contained in the coal will form sulphur dioxide (SO_2) when combusted. Uncontrolled SO_2 emissions for the design (1.2 percent sulphur, air dried basis) coal will be approximately 3,714 mg/Nm^3 (milligram per normal cubic metre), dry, actual oxygen (O_2)[1] and approximately 5,855 $mg/Nm^3$for the worst-case (1.8 percent sulphur, air dried basis) coal, dry, actual O_2. In order to comply with the environmental protection limit of 400 mg/Nm^3 (dry) at 6 percent O_2[2], it is necessary that the Medupi plants be capable of reducing the SO_2 by 94 percent from the worst-case coal.

In the wet limestone FGD process, limestone (consisting primarily of $CaCO_3$) reacts with the gaseous SO_2 and forms nontoxic gypsum crystals ($CaSO_4 \cdot 2\ H_2O$). To achieve this reaction, the limestone must be ground into fine particles to provide maximum surface area for the reaction. A mixture of limestone, reaction byproducts, and water will be recirculated from the absorber reaction tank to spray headers in the upper part of the absorber. The slurry will be atomized into fine droplets by spray nozzles and distributed throughout the flue gas entering the absorber.

The absorber will be a large cylindrical tower with several limestone slurry spraying levels, where the acidic flue gas comes into contact with the limestone slurry. A study to evaluate the whether the absorber should be insulated was performed (refer to the Rubber Lining vs Rubber Lining with Insulation Study Cost Estimation, 006265-T-STD-001, SPF file 200-92792), with a recommendation to insulate the absorber. A decision on this is pending, and will need to be resolved during the execution phase of the project, however the cost estimate presented herein includes the cost to insulate the absorbers.

[1] 3,405 mg/Nm^3, dry at 6 percent O_2

[2] 5,338 mg/Nm^3, dry at 6 percent O_2

During their return to the absorber reaction tank, the slurry droplets will absorb the acid components SO_2, SO_3 (sulphur trioxide), HF (hydrogen fluoride), and HCl (hydrogen chloride) from the flue gas. The water from the slurry will evaporate and saturate the flue gas, cooling it to the adiabatic saturation temperature. The water loss will be compensated for by the addition of process water.

Solids retention time in the absorber reaction tank and the addition of the oxidation air will allow the formation and growth of gypsum crystals. The oxidation air will be supplied by air compressors located near the absorbers and will be fed into the absorber sump through lances that will distribute the air in the absorber sump. The air that is blown into the reaction tank is needed to oxidize the calcium sulphite ($CaSO_3$) to calcium sulphate ($CaSO_4$). To minimize the potential for scaling at the wet/dry interface, the oxidation air will be quenched with water (refer to the Wet Oxidation Cooling Study, 006265-T-STD-004, SPF file 200-100123), although the design for this was not completed during the Basic Design, the required equipment and materials have been included in the project cost estimate.

Above the spray banks, a coarse separator (mist eliminator) will be installed for initial droplet separation from the flue gas. Downstream of this, a second mist eliminator stage will remove the majority of any liquid droplets still remaining. The runoff from the droplet separators will be returned to the absorber. The flue gas, relieved of the majority of the SO_2 and saturated with water, will leave the absorber and flow to the chimney.

A summary of the major absorber design parameters is provided in Table 4.

Table 4: Absorber Design Parameters

Parameter	Value
Flue Gas Volume	2,590,000,Nm³/hr, dry, 6% O_2
SO_2 Removal Efficiency (%)	up to 95
Absorber Height (m)	35.5
Absorber Diameter (m)	17.5
Reaction Tank Diameter (m)	21.5
No. of Spray Banks	4 and 1 spare
Recirculation Pumps (m³/hr)	9,600 (4 and 1 spare)
Mist Eliminator	2 Stage with Flushing System
No. of Reaction Tank Agitators	4 with Oxidation Air Lances
Absorber Gas Velocity (m/s)	4
Materials of Construction	Carbon Steel with Rubber Lining

The absorber slurry will be limited to a concentration of 30,000 parts per million (ppm) of chlorides for material considerations, and a bleed stream of liquid from the absorber reaction tank will be required to maintain the concentration below this level. This bleed stream will be treated in the FGD ZLD Treatment System so that the usable liquid can be returned for reuse by the FGD plant or existing water treatment plant, and a waste stream of salts and sludge will be produced for disposal in landfill facilities. Details regarding these landfill disposal facilities are being developed separately from this report.

A bleed stream of the absorber slurry will be pumped from the absorber reaction tank to the gypsum bleed tank for storage until it is processed in the gypsum dewatering system described below.

Refer to the following documents (attached) for additional information on the FGD System.

Document	SPF File Number	Document / File Number
PFD Design Coal, 85% $CaCO_3$	0.84/30068	006265-R-PFD-001
PFD Worst Coal, 85% $CaCO_3$	0.84/30067	006265-R-PFD-002
PFD Worst Coal, Attemperating Air, 85% $CaCO_3$	0.84/30066	006265-R-PFD-003
PFD Design Coal, 96% $CaCO_3$	0.84/30065	006265-R-PFD-004
PFD Worst Coal, 96% $CaCO_3$	0.84/30064	006265-R-PFD-005
PFD Worst Coal, Attemperating Air, 96% $CaCO_3$	0.84/30063	006265-R-PFD-006
FGD Design Controlling Cases	200-92546	P06259-S-TAB-015
Absorber Sizing Design Report	200-93401	006265-A-SKI-001
Rubber Lining vs Rubber Lining with Insulation Study Cost Estimation	200-92792	006265-T-STD-001
FGD Oxidation Air Blower Optimize Energy Consumption Study	200-99553	006265-T-STD-201
Wet Oxidation Cooling Study	200-100123	006265-T-STD-004
Operability Study	200-92095	006265-T-STD-100
FGD Startup and Shutdown Concept	200-99436	006265-T-STD-200
System Description Absorber and Oxidation Air	200-57986	006265-T-HBU-505
P&ID Absorber 1	0.84/29755	006265-R-PID-001
P&ID Absorber 2	0.84/38961	006265-R-PID-002
P&ID Absorber 3	0.84/38962	006265-R-PID-003
P&ID Absorber 4	0.84/38963	006265-R-PID-004
P&ID Absorber 5	0.84/38946	006265-R-PID-005
P&ID Absorber 6	0.84/38965	006265-R-PID-006
P&ID Oxidation Air Absorber 1	0.84/36058	006265-R-PID-091
P&ID Oxidation Air Absorber 2	0.84/38982	006265-R-PID-092
P&ID Oxidation Air Absorber 3	0.84/38983	006265-R-PID-093
P&ID Oxidation Air Absorber 4	0.84/38984	006265-R-PID-094
P&ID Oxidation Air Absorber 5	0.84/38985	006265-R-PID-095
P&ID Oxidation Air Absorber 6	0.84/38986	006265-R-PID-096
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
Absorber 1+4 Overview	0.84/38429	006265-Z4010-100
Absorber 1+4 Sections	0.84/38430	006265-Z4010-101
Absorber 2+5 Overview	0.84/38431	006265-Z4010-200
Absorber 2+5 Sections	0.84/38432	006265-Z4010-201
Absorber 3+6 Overview	0.84/38325	006265-Z4010-300
Absorber 3+6 Sections	0.84/38326	006265-Z4010-301
Spraybanks Overview	0.84/37879	006265-Z4145-001
Mist Eliminator	0.84/37878	006265-Z4146-001
FGD Absorber Erection Manual	200-108895	006265-T-STD-250

3.5.3.2 Flue Gas Duct System

The flue gas coming from the boiler will pass through the fabric filter and the ID fan upstream of the FGD plant.

It is planned that the existing ductwork from the ID fans to the chimney will be retained as bypass ductwork around the new FGD plant. The bypass will protect the absorbers in case of malfunction/emergency conditions (for example, no cooling water is available and high temperature flue gas is incoming) or curtailment of the raw water supply to the Medupi Power Station. To avoid a complete plant shutdown in case of a short-term absorber malfunction, the flue gas can be routed through the bypass ductwork system until the absorber can be restarted. The bypass will also provide startup flexibility, so that the boiler and FGD can be started up independent of each other.

The path of the flue gas leaving the existing plant ID fans for the chimney will be modified to allow the addition of an absorber inlet and outlet duct and with the addition of dampers, the existing ductwork will serve as a bypass of the FGD system. The inlet, outlet, and bypass dampers will be double louver dampers. Seal air blowers will supply sealing air between the dampers to minimize any leakage of flue gas through a closed damper. A recommendation for the location and tie-in and a support concept was presented for the additional loads for the bypass damper located within the existing ductwork is presentedin the document, “Support of Bypass Tie-In with Hitachi Duct Design Study” (006265-T-STD-210, SPF file 200-108729), attached. The support of the dampers at the inlet to the bypass ducts at absorbers 1, 3, 4 and 6 is more difficult because of the load imposed upon the Hitachi duct beneath the dampers. It is believed that this part can support the additional load, but as an alternative, a solution with additional support for the damper was also presented. Eskom is investigating the support and connection provisions with Hitachi, for further resolution during the execution phase.

Flue gas will enter the absorber and flow from bottom to top.

An analysis was performed to determine the feasibility and operating characteristics of flue gas cooling options upstream of the FGD absorbers. The addition of flue gas cooling has the potential to reduce the amount of water evaporated and discharged with the clean flue gas. This would reduce the overall process water requirements for the FGD system. The layout of the ductwork and equipment supports the future addition of flue gas cooling heat exchangers, however this equipment is not included in the Basic Design or the cost estimate presented herein, however it is planned to be added to the scope in the execution phase.

Refer to the following documents (attached) for additional information on the Flue Gas Duct System.

Document	SPF File Number	Document / File Number
System Description Flue Gas Path and Bypass	200-58510	006265-T-HBU-504
P&ID Flue Gas Path Absorber 1	0.84/37976	006265-R-PID-151
P&ID Flue Gas Path Absorber 2	0.84/38973	006265-R-PID-152
P&ID Flue Gas Path Absorber 3	0.84/38976	006265-R-PID-153
P&ID Flue Gas Path Absorber 4	0.84/38987	006265-R-PID-154
P&ID Flue Gas Path Absorber 5	0.84/38993	006265-R-PID-155
P&ID Flue Gas Path Absorber 6	0.84/38994	006265-R-PID-156
Material Concept for the Inlet Duct	200-107275	006265-T-STD-240
Technical Evaluation of Flue Gas Cooling Options	200-110410	006265-T-STD-260
Support of Bypass Tie-In with Hitachi Duct Design Study	200-108729	006265-T-STD-210
General Arrangement, FGD Area Units 1-3	0.84/37963	178771-CUHT-G2015
General Arrangement, FGD Area Units 4-6	0.84/37964	178771-CUHT-G2016
Raw Gas Duct with Aircooler 1/4 Duct Overview	0.84/38345	006265-Z4250-110
Raw Gas Duct with Aircooler 2/5 Duct Overview	0.84/38346	006265-Z4250-120
Raw Gas Duct with Aircooler 3/6 Duct Overview	0.84/38347	006265-Z4250-130
Clean Gas Duct Absorber 1/4 Duct Overview	0.84/38348	006265-Z4250-210
Clean Gas Duct Absorber 2/5 Duct Overview	0.84/38349	006265-Z4250-220
Clean Gas Duct Absorber 3/6 Duct Overview	0.84/38350	006265-Z4250-230

3.5.3.3 Draft System

The existing ID fans have been provided with sufficient additional pressure capacity to provide the additional pressure increase necessary to overcome the system resistance of the FGD retrofit. As a part of the final design, the following items are recommended for further evaluation to optimize the design of the ductwork and minimize the pressure losses through the existing ductwork.

- Install turning vanes in the ID fan discharge elbow (if not already installed)

- Install a splitter plate and turning vanes in the "T" box that is located immediately downstream of the ID fans
- Consideration should be given to replacing the "T" box that is located downstream of the absorber to reduce pressure loss

Refer to the following documents (attached) for additional information on the Draft System.

Document	SPF File Number	Document / File Number
Induced Draft Fan Analysis Study	200-55815	178771.41.0104

3.5.3.4 Chimney

The existing chimneys will be reused with minor modifications needed. Each chimney contains the flues from three boilers. The inside diameter of the existing flues is adequate for the flue gas flow volumes, and the borosilicate block liner's transitional velocity for condensation re-entrainment is sufficiently above the calculated worst-case design so that re-entrainment of moisture droplets will not occur.

The steel flue liner material for Medupi is identical to the Kusile Power Station project, which uses 316 L stainless steel. As explained in an Engineering Change Report (ECR), "Modification of Chimney Compensator and Nozzles, and Addition of Coating to the 316L Stainless Flue Liners" [9]; corrective action has been recommended for the Kusile Power Station site, consisting of replacement of nozzles and components of the compensator made from 316 L material; and the coating of all exposed 316 L flue liner plate and hatches. The original chimney design did not fully account for the low pH levels and high chloride design conditions downstream of the wet FGD, considering the design life of the plant. This ECR concluded that C276 material should have been used for the exposed steel components rather than 316 L stainless steel. A study should be carried out to determine the schedule impacts and cost impacts for the coating, lining, and/or replacement with C276 material of the items currently made of 316L material, and to recommend whether the modifications should be made while the Medupi Power Station is under construction, after power station startup but prior to the FGD Retrofit Project work, or as part of the FGD Retrofit Project scope.

Condensation calculations and flow modelling will need to be performed during detailed design to assure duct-stack system is favourable for wet operation and to review the need for additional liquid collection facilities in the breeching and flue.

Modifications to the chimney drain piping and the chimney drain system are necessary to return collected condensation to the Gypsum Bleed Tanks is described in the Stack Water Collection Study, attached.

Refer to the following documents (attached) for additional information on the Chimney.

Document	SPF File Number	Document / File Number
Chimney Analysis	200-55812	178771.41.0101
Stack Water Collection Study	200-106540	006265-T-STD-230

3.5.3.5 FGD Makeup Water and Process Water Supply

Makeup water for the FGD system will be supplied from the existing raw water reservoir. The reservoir has two compartments to supply water from either the Crocodile West or the Mokolo water supplies. A backwashable strainer pretreatment system will provide treatment of the makeup water for the FGD equipment.

FGD makeup water will be supplied by two of the low-pressure raw water pumps drawing water from either of the two basins at the water reservoir. Three 50 percent capacity low-pressure raw water pumps will be provided to secure the necessary backup in water supply. After pretreatment, the majority of water is sent to the Process Water Tanks for utilization in the FGD process. The makeup water is also used for the FGD Closed Cycle Cooling Water System cooling tower makeup and the FGD ZLD Treatment System uses. The backwash water from the backwashable strainers will be discharged into the existing dirty water drains system.

Condensate polisher plant (CPP) waste stream from the existing water treatment plant (WTP) was evaluated for use as makeup water to the FGD system as described in the FGD System Water Supply/Wastewater Disposal Study (178771.41.0107, SPF file 200-55817). The average flow is 4.57 cubic metres per hour with an instantaneous flow of 100 cubic metres per hour. The routing of the CPP waste stream from the WTP to the FGD would require extensive work (due to this plant area being constructed with most pipelines below ground). Prediction of the waste stream quality would also be difficult due to unknowns regarding the chemicals required for the cleaning process around the membrane systems at the WTP. Therefore the CPP waste stream will follow its current process, i.e., flowing into the effluent neutralisation sump (ENS) and being pumped by the concentrate pumps at the ENS to Dirty Water Tank 1.

The three Process Water Tanks (two in operation and one spare) have a storage capacity of 8 hours of full load operation, supplying all FGD plant water demands. Six process water pumps each will provide 100 percent redundancy, with one spare pump for each tank, to secure the necessary backup in water supply. Water will be delivered from these pumps to all systems needing clean process water.

The makeup water will be used to replace evaporation losses in the absorbers. This will be done primarily via mist eliminator washing. Other uses for this water will be washing the gypsum and preparing fresh limestone suspension.

Makeup water will be consumed completely in the FGD process plant; no water will be returned to the existing plant, with the exception that the water effluent from the FGD makeup water pretreatment plant will be returned to the dirty water drains system.

Refer to the following documents (attached) for additional information on the Makeup Water and Wash Water Supply.

Document	SPF File Number	Document / File Number
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
FGD Makeup Water Supply System Description	200-58478	178771.43.6607
FGD Makeup Water Supply P&ID	0.84/30078	178771-CHTQ-M2667A
System Description Process Water Supply, Filtrate and Reclaim Water	200-58506	006265-T-HBU-503
P&ID Process Water Tanks	0.84/29764	006265-R-PID-070
P&ID Process Water Distribution	0.84/36057	006265-R-PID-075
General Arrangement, FGD Makeup Water Pretreatment Area	0.84/36244	178771-CUGA-G2003
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004

3.5.3.6 Limestone Handling and Limestone Preparation Systems

New limestone material handling systems will receive limestone arriving via rail cars and trucks, sampled automatically with one online elemental analyser[3], stock out the material, and reclaim and convey it to

[3] If technically feasible at the time the project is implemented. Note that as of today, online elemental analyser is not an established, widely-used application for power plants.

the limestone silos located in the Limestone Preparation Area. The limestone stockpile will provide 30 days' worth of limestone storage for use in the FGD system and is equipped with dust suppression sprays.

Depending on the outcome of negotiations with Transnet Freight Rail (TFR), three alternative limestone transportation scenarios are possible. Under scenario 1, limestone will be transported to the station on flatbed rail wagons in bottom discharge containers. The containers will be offloaded from the trains via a gantry crane which will move the container above the underground hopper (HPR-2), where the limestone will be discharged directly into the hopper (HPR -2). Under scenario 2, limestone will be transported to the station via bottom discharge wagons. These rail wagons will run on rail tracks above the underground hopper (HPR-1), where the wagons will discharge limestone directly into the hopper (HPR-1). Under scenario 3, limestone will be delivered to the station by means of side tipper trucks, which will tip limestone directly into the underground hopper (HPR-2).

Limestone in the hopper will be extracted with a belt feeder and fed onto the underground link conveyor. The underground link conveyor will feed the limestone stockout conveyor with a traveling tripper that will feed the limestone stacker.

The limestone pile will be reclaimed using a portal scraper reclaimer to feed the limestone reclaim conveyor, which will transfer limestone to three limestone storage silos (day bins) located in the Limestone Preparation Area. From the reclaim conveyor, material will be transferred to a reversible shuttle conveyor. The centre bin will be fed directly from the reclaim conveyor. The outer bins will be fed by the reversible shuttle conveyor.

The system will include an emergency offloading facility for limestone delivered via side tripper truck at both the limestone receiving underground hopper and at the limestone stockpile. Emergency reclaim from the stockpile will be possible using a scraper chain feeder that will directly feed the limestone reclaim conveyor.

Each of the three limestone silos will have a storage capacity which will serve half the station requirements for 24 hours, according to the design consumption indicated in the PDM (178771.22.0000, SPF file 200–61989), attached.

From the three limestone silos, the limestone will be fed into the wet ball mills by weigh belt feeders. These ball mills will be constructed as overflow ball mills. The mill itself will primarily consist of a rotating drum containing steel balls. The total mill feed flow will be composed of water and new limestone feed, which will pass through the grinding chamber and be reduced in size. The ground slurry will be collected in the ball mill circulation tank and classified by means of pumps and a hydrocyclone station. The final product will flow from the hydrocyclone overflow by gravity to the limestone slurry feed tanks, with oversize particles being recycled to the mill inlet for additional grinding.

Refer to the following documents (attached) for additional information on the Limestone Handling and Limestone Preparation Systems.

Document	SPF File Number	Document / File Number
System Description Limestone	200-58340	178771.43.1004
Limestone Handling Plant Process Flow Diagram	0.84/37821	
System Description Limestone Mill and Slurry Preparation	200-57985	006265-T-HBU-502
P&ID Limestone Slurry Preparation Line 1	0.84/36056	006265-R-PID-061
P&ID Limestone Slurry Preparation Line 2	0.84/38971	006265-R-PID-062
P&ID Limestone Slurry Preparation Line 3	0.84/38972	006265-R-PID-063
P&ID Limestone Slurry Feed	0.84/29758	006265-R-PID-020
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37789	
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37790	
FGD Limestone Rec Str Reclaim Conveyor Arrangement	0.84/37791	

Document	SPF File Number	Document / File Number
General Arrangement, Limestone Unloading and Receiving Area	0.84/37961	178771-CUVD-G2025
General Arrangement, Limestone Unloading and Receiving Building	0.84/37962	178771-CUVD-G2026
Limestone Prep Bldg Conveyor Arrangement LCVY-3	0.84/37756	
Limestone Prep Bldg Conveyor Arrangement LCVY-4	0.84/37757	
General Arrangement, Limestone Preparation Area	0.84/36532	178771-CHTJ-G2005
General Arrangement, Limestone Preparation Building	0.84/36531	178771-CHTJ-G2006A

3.5.3.7 Gypsum Refinement and Dewatering System

Gypsum will be produced as a byproduct of the wet scrubbing process. The gypsum crystals will be contained in a slurry consisting primarily of gypsum, a mixture of salts (magnesium sulphate [$MgSO_4$], calcium chloride [$CaCl_2$]), limestone, calcium fluoride (CaF_2), and dust particles. Refinement is necessary to separate the gypsum from the unwanted material and produce a material that is suitable for commercial re-use (i.e., cement, wallboard, etc.).

Refinement of gypsum will proceed in two steps: separation and dewatering. Separation will be done by means of gypsum hydrocyclones, followed by a second dewatering stage using horizontal vacuum belt filters.

Slurry from the absorber will be fed via the absorber bleed pumps to gypsum bleed tanks. From the gypsum bleed tanks, the slurry will be fed into the gypsum hydrocyclone station. The overflow from the hydrocyclone station, primarily containing the finer portion of solid particles (fine gypsum particles, fresh limestone, insoluble impurities of limestone and fly ash), will be fed into the reclaim water tanks. A small amount of the gypsum hydrocyclone overflow must be bled off from the system into the wastewater treatment plant to avoid concentration of fine particulate and dissolved chlorides. This portion of the overflow will be sent to the wastewater hydrocyclones feed tank. From there, the wastewater (now containing only a small amount of very fine particles) will be pumped into another hydrocyclone battery, which will separate even finer particles from the wastewater. The overflow from these wastewater hydrocyclones will be sent to the wastewater treatment system, while the underflow (containing most of the remaining particles) will be directed to the reclaim tanks.

The underflow from the gypsum hydrocyclones, containing primarily coarse gypsum particles, will enter directly onto the horizontal vacuum belt filters. The gypsum slurry will be deposited onto the belt filter cloth in a layer of definite thickness to ensure constant parameters and dewatering performance. This gypsum solids layer will be dewatered by applying vacuum to the back side of the belt filter cloth. The extracted liquid will be recycled to the FGD reclaim water system.

To produce commercial-grade gypsum, it is necessary to keep the chloride content of the gypsum under a certain limit. Therefore, during the dewatering process the filter cake will be washed with FGD makeup water to decrease the chloride content to the level acceptable for the commercial-grade gypsum product.

The gypsum being discharged from the horizontal vacuum belt filter will be dropped onto one of two collecting conveyors by means of bifurcated chutes. An online monitoring system installed within the gypsum production process will be used to indicate the gypsum quality. The collecting conveyor will take the gypsum to a transfer house where the gypsum will be transferred to one of two gypsum link conveyors which feed a series of gypsum conveyors. The gypsum conveyors will either feed material to the overland ash conveyors for co-disposal of the gypsum with the ash, or alternatively will feed material to an elevated mobile tripper car at the gypsum storage facility[4]. The elevated tripper car will be able to

[4] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

stack gypsum in three different piles or into one continuous pile. The elongated pile will allow sampling while a portion is being reclaimed. The gypsum storage facility will be required to accommodate 100 percent of the total gypsum production for three days; however it is anticipated that only 20 percent of gypsum will be required for commercial sale purposes.

Acceptable commercial grade gypsum will be reclaimed from the storage pile using mobile equipment and mobile belt (apron) feeders, and conveyed to a load out system. Acceptable material can also be loaded via mobile equipment into trucks.

The remaining gypsum will be reclaimed using mobile equipment and a mobile belt (apron) feeder and conveyed to either of the two overland ash conveyors, and combined with the ash for disposal in the on-site ash landfill.

Refer to the following documents (attached) for additional information on the Gypsum Refinement and Dewatering System.

Document	SPF File Number	Document / File Number
Byproduct Disposal Study	200-55816	178771.41.0106
System Description Gypsum Dewatering System	200-59838	006265-T-HBU-507
P&ID Gypsum Bleed/Emergency Drain Tank 1	0.84/29757	006265-R-PID-010
P&ID Gypsum Bleed/Emergency Drain Tank 2	0.84/38966	006265-R-PID-015
P&ID Gypsum Dewatering Line 1	0.84/36054	006265-R-PID-031
P&ID Gypsum Dewatering Line 2	0.84/38967	006265-R-PID-032
P&ID Gypsum Dewatering Line 3	0.84/38968	006265-R-PID-033
P&ID Gypsum Dewatering Line 4	0.84/38969	006265-R-PID-034
P&ID Gypsum Dewatering Line 5	0.84/38970	006265-R-PID-035
P&ID Filtrate Tanks	0.84/36055	006265-R-PID-037
P&ID Waste Water HC Feed Tanks	0.84/29760	006265-R-PID-040
P&ID Waste Water HC Stations	0.84/29761	006265-R-PID-050
P&ID Reclaim Tanks	0.84/29762	006265-R-PID-055
General Arrangement, Gypsum Dewatering Area	0.84/36527	178771-CHTL-G2007
General Arrangement, Gypsum Dewatering Building Ground Floor EL 902.4	0.84/36520	178771-CUGQ-G2008A
General Arrangement, Gypsum Dewatering Building EL 911.4	0.84/36521	178771-CUGQ-G2008B
General Arrangement, Gypsum Dewatering Building EL 918.4	0.84/36522	178771-CUGQ-G2008C
General Arrangement, Gypsum Dewatering Building EL 924.4	0.84/36523	178771-CUGQ-G2008D
General Arrangement, Gypsum Storage Area	0.84/37881	178771-CUGE-G2023
General Arrangement, Gypsum Storage Building	0.84/37993	178771-CUGE-G2024
System Description Gypsum	200-58339	
Gypsum Handling Plant Process Flow Diagram	0.84/37820	
FGD Solids Conveying and Storage Arrangement GCVY-1&2	0.84/37780	
FGD Solids Conveying and Storage Arrangement GCVY-3&4	0.84/37781	
FGD Solids Conveying and Storage Arrangement GCVY-5&6	0.84/37782	
FGD Solids Conveying and Storage Arrangement GCVY-7&8	0.84/37783	
FGD Solids Conveying and Storage Arrangement GCVY-9	0.84/37784	
FGD Solids Conveying and Storage Arrangement GCVY-10	0.84/37785	
FGD Solids Conveying and Storage Arrangement GCVY-11	0.84/37786	

Document	SPF File Number	Document / File Number
FGD Solids Conveying and Storage Arrangement GCVY-12	0.84/37787	
FGD Solids Conveying and Storage Arrangement GCVY-13	0.84/37788	

3.5.3.8 FGD ZLD Treatment System

A new FGD ZLD Treatment System will treat the FGD system chloride bleed stream, the total organic carbon (TOC) scavenger regeneration wastewater from the existing plant, and FGD cooling tower blowdown streams. The FGD ZLD pretreatment equipment will consist of two 100 percent trains. Each 100 percent train will be capable of treating 103 cubic metres per hour (m^3/h). The brine concentrator/crystallizer equipment will receive the treated effluent from the FGD ZLD pretreatment equipment and will consist of four 50 percent trains. Each 50 percent train will be capable of treating 52 m^3/h.

The FGD chloride bleed and FGD cooling tower blowdown streams will first be directed to one FGD ZLD Pretreatment Holding Tank and two 100 percent capacity FGD ZLD Pretreatment Holding Tank Forwarding Pumps. In addition to the FGD chloride bleed stream and FGD cooling tower blowdown, the tank will receive filter press filtrate and off-spec recirculation from the FGD ZLD pretreatment process. Due to the high pH of the TOC scavenger wastewater which could cause precipitation of solids in the ZLD Pretreatment Holding Tank, it will be transferred directly to the FGD ZLD pretreatment process. The TOC scavenger regeneration wastewater quality will not be fully known until the system is operating within the existing plant, however a preliminary estimate of the quality indicates that additional treatment is not expected. Once the existing water treatment plant system is operational, the TOC scavenger wastewater stream will need to be monitored to establish the typical concentrations, types of organics, and variability. The eventual FGD ZLD pretreatment and brine concentrator/crystallizer equipment supplier will need to determine if the established concentrations and types of organics are acceptable. If not, it may be necessary to treat the stream for organics before it is sent to the FGD ZLD pretreatment process or provide a slip stream off of the brine concentrator to dispose of the organics separately. Depending on the type and concentration of organics, problems with foaming and solids dewatering could result in the FGD ZLD Treatment System. If the FGD ZLD Treatment System distillate is sent to the FGD system as makeup, then similar issues could occur in the FGD system.

The cooling tower blowdown from the FGD closed cycle cooling water system is currently planned to be sent to the FGD ZLD Treatment System; however, based on the expected quality of the blowdown, it could be recycled as makeup to the FGD.

The wastewater streams will be pretreated to convert hardness to sodium and remove the suspended solids and heavy metals prior to the brine concentrator/crystallizer process. The FGD ZLD pretreatment process will include physical/chemical treatment of the water to precipitate solids and heavy metals from the water. Lime and soda ash are used to convert the dissolved calcium and magnesium to sodium so that the water can be effectively treated in the downstream brine concentrators and crystallizers. The FGD ZLD pretreatment equipment will use large amounts of lime and soda ash; therefore, it is important to confirm the necessary quantity and quality of lime and soda ash that can be obtained. Using trucks with an 18,000 kg capacity and plant operation with 85 percent limestone purity, approximately one truck of lime is required every 8 hours and one truck of soda ash every 5 hours. After chemical treatment, the precipitates are settled out in clarifiers as solids slurry, which is sent to a filter press dewatering system. The water is recovered from the solids slurry and returned back to the clarifier. Slurry from the clarifier will be sent to filter presses. The filter press filtrate will be returned back to the FGD ZLD Pretreatment Holding Tank. The physical/chemical treatment system will be sized to handle the incoming flows plus the filtrate from the filter presses and any other process recycle streams. The solids will be collected in a concrete bunker or dumpsters placed underneath the presses.

Flow from the FGD ZLD pretreatment process will be directed to a brine concentrator feed tank. Chemicals will be fed to this tank as required for feed to the brine concentrator. The water from this tank will then be pumped through the brine concentrator influent heat exchangers and into the deaerator. The brine concentrators will utilize a seeded slurry process.

The brine concentrator portion of the system operates by using mechanical vapour compression. The brine concentrators will be designed to produce a distillate product stream and a concentrated brine waste stream from the treated wastewater. The distillate product will be combined with distillate from the crystallizer portion of the system and directed to the plant for reuse. Two independent waste blowdown streams will be utilized to maintain close control of the recirculating brine chemistry. A seed recycle system recovers and recycles seed from the waste brine stream back to the recirculating brine. The concentrated brine waste stream will be fed to the crystallizer feed tanks for intermediate storage. Steam will be sparged into the tank to maintain the tank contents at a predetermined temperature, to prevent corrosion to downstream equipment and quenching of the crystallizer recirculating brine (which may lead to foaming). The steam driven crystallizers will then remove the balance of the recoverable water, and a stream of wet solids will be discharged from each centrifuge. Within the crystallizer, water will be continuously evaporated while a small purge stream is circulated through the centrifuge to remove the waste for disposal. Excess liquid from the centrifuge will be returned for further concentration. The brine concentrator will have a foam detection system to detect any excess amount of foaming in the brine concentrator. Steam may be used for brine concentrator startup steam and deaerator steam.

If the TOC content in the effluent from the FGD Zero Liquid Discharge Treatment System (the “ZLD distillate”) is low (≤29 ppm), it would be suitable for use as makeup water to the FGD plant, which would offset some of the fresh water demand of the FGD. It is anticipated that ZLD distillate may also be suitable for other uses within the Medupi Power Station. To provide operational flexibility, the Basic Design includes provisions for the ZLD distillate to be directed to either the Reclaim Tanks or existing Medupi Water Treatment Plant RO Feed Tank. Dewatered sludge will be disposed of using trucks to transport to onsite or offsite dumps, and dewatered brine will also be disposed of using trucks to transport to onsite or offsite dumps[5].

Refer to the following documents (attached) for additional information on the FGD ZLD Treatment System.

Document	SPF File Number	Document / File Number
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
FGD Zero Liquid Discharge (ZLD) Treatment System Description	200-58476	178771.43.6405
P&ID FGD ZLD Treatment	0.84/30077	178771-CGNG-M2645
Byproduct Disposal Study	200-55816	178771.41.0106
General Arrangement, FGD ZLD Treatment Area	0.84/37792	178771-CGNR-G2009
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010

3.5.3.9 Auxiliary Steam System

The FGD Auxiliary Steam System will be designed to distribute auxiliary steam to the wastewater treatment area to be used for the FGD zero liquid discharge treatment system. The FGD Auxiliary Steam System connects the plant Units 1-3 and Units 4-6 auxiliary steam header to the FGD ZLD treatment system area auxiliary steam header. The FGD Auxiliary Steam System will continuously supply the auxiliary steam requirements for the FGD ZLD Treatment System during normal operation, startup, and shutdown.

[5] Note that disposal of the ZLD and pretreatment waste disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

Auxiliary steam is provided to the brine concentrator deaerator equipment within the FGD ZLD Treatment System, where it is used to heat the brine (wastewater) solution. The steam is mixed within the treatment process and recovered with the ZLD distillate, and therefore there is not a return stream for steam or steam distillate. Auxiliary steam flow requirements herein are estimated and will require confirmation by the FGD ZLD Treatment System supplier.

Refer to the following documents (attached) for additional information on the Auxiliary Steam System.

Document	SPF File Number	Document / File Number
FGD Auxiliary Steam System Description	200-58353	178771. 43.0601
P&ID Auxiliary Steam System	0.84/30083	178771-CLBG-M2061

3.5.3.10 FGD Closed Cycle Cooling Water

A new, stand-alone closed cycle cooling water (CCCW) system will provide heat rejection for the heat exchangers associated with FGD equipment that requires water cooling. The heat rejection requirement for this equipment is generally larger than for other equipment that is air cooled.

The CCCW system will provide cooling water to the following equipment.

- Limestone ball mill lubrication system
- FGD system air compressors
- Brine concentrator/crystallizer equipment in the FGD ZLD Treatment area

Cooling water for the CCCW system will be of condensate quality and supplied by the existing plant through a 50 mm pipeline to the CCCW Expansion Tank. The tank is elevated to provide sufficient suction head for the closed cycle cooling water pumps and to fill the system by gravity. Once filled, the expansion tank will only require small amounts of water to maintain level in the tank and keep the system filled. A minimum tie-in pressure of 496 kPa is sufficient to fill the system during commissioning at a rate of 189 lpm. Two 100 percent closed cycle cooling water pumps will be designed to supply cooling water to the FGD equipment heat exchangers. The CCCW heat exchangers will transfer heat from the circulating cooling water to the auxiliary cooling water. The open cycle cooling water pumps will take suction from a multi-cell wet cooling tower and pump the auxiliary cooling water through the CCCW heat exchangers and to the wet cooling tower. The wet cooling tower will reject heat from the auxiliary cooling water to atmosphere and return it to the system at a specified design temperature. Makeup water due to evaporation and blowdown will be provided from the FGD Makeup Water Supply System Blowdown from the cooling tower will be directed to the FGD ZLD Pretreatment Holding tank. An acid feed system including a storage tote and feed skid will feed acid to condition the open cycle circulating water.

Refer to the following documents (attached) for additional information on the FGD Closed Cycle Cooling Water System.

Document	SPF File Number	Document / File Number
FGD and Wastewater Treatment Closed Cycle Cooling Water System Description	200-58471	178771. 43.3202
P&ID FGD and Wastewater Treatment Closed Cycle Cooling Water System	0.84/30084	178771-CPGB-M2322
General Arrangement, FGD ZLD Treatment Area	0.84/37792	178771-CGNR-G2009

3.5.3.11 Fire Protection

The existing fire protection system will be extended to supply fire water for both automatic and manual firefighting at locations in the FGD area. Existing fire water pumps will provide pressure for FGD fire protection. New fire water booster pumps will be used to maintain fire water pressure at elevated points within the system.

Refer to the following documents (attached) for additional information on the FGD fire protection.

Document	SPF File Number	Document / File Number
Fire Protection/Detection Assessment Report	474-9699	
FGD Fire Protection System Description	200-58473	178771.43.3621
P&ID FGD Fire Protection	0.84/30086	178771-CSGA-M2361
Conceptual Fire Hydrant Locations	0.84/37851	178771-SK-M0003
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027

3.5.3.12 Compressed Air

The compressed air system will supply dry air for all the service and instrument air users in the FGD area. Two 100 percent FGD air compressors and two 100 percent filter / air dryers will be designed to provide compressed, oil-free air at the required capacity and pressure to meet the compressed air requirements. Air receivers located in the FGD Common Pump Building, Absorber Pump Buildings, FGD ZLD Treatment Building, Limestone Preparation Building, Gypsum Dewatering Building, and FGD Makeup Water Pretreatment Building will provide surge capacity and maintain a relatively constant air supply flow and pressure to the FGD area users.

Refer to the following documents (attached) for additional information on the Compressed Air System.

Document	SPF File Number	Document / File Number
FGD Compressed Air System Description	200-58467	178771.43.1802
P&ID FGD Compressed Air	0.84/30085	178771-CQFB-M2182

3.5.3.13 Potable Water

The existing plant potable water system will be extended to supply potable water to the safety shower/eyewash stations, washdown hose connections, ablution facilities, HVAC equipment, lab faucets, and other potable water users in the FGD area. Two 100 percent potable water booster pumps will ensure adequate flow and pressure to meet system demands. The pumps will be tied into the Essential Services Substation and the Emergency Diesel Generator so that potable water is available when the plant is without power. Backflow preventers will be provided as required to prevent contamination into the potable water system and backpressure regulators will be used to isolate the nonessential water users in the event of low system pressure.

Refer to the following documents (attached) for additional information on the Potable Water System.

Document	SPF File Number	Document / File Number
FGD Potable Water System Description	200-58477	178771.43.6604
P&ID FGD Potable Water	0.84/30075	178771-CGKC-M2664

3.5.3.14 FGD Blowdown System

The FGD blowdown system collects and conveys process waste fluids by means of drain trenches, sumps and sump pumps. The sumps and trenches will be below grade, reinforced concrete structures located in the Absorber Pump Buildings, FGD Common Pump Building, FGD makeup water pretreatment area, absorber drain and gypsum bleed tank area, FGD ZLD Treatment Building and area, Limestone Preparation Building and area, and Gypsum Dewatering Building and area. Process wastewaters and slurries in these buildings/areas will discharge into the trenches, which are sloped to drain by gravity into the associated sumps. Sumps which receive slurry will have agitators to maintain solids suspension. Each sump will contain two 100 percent sump pumps to transfer the sump contents to the appropriate discharge location. Sump level measurement will start and stop the sump pumps in an alternating mode that automatically cycles between pumps to ensure even run time. Sump pumps and pipelines that transfer slurry include flushing with process water upon pump shutdown.

Refer to the following documents (attached) for additional information on the FGD Blowdown System.

Document	SPF File Number	Document / File Number
FGD Blowdown System Description......................................	200-58469	178771.43.2819
P&ID FGD Limestone Preparation Building Sumps	0.84/30079......................	178771-CHTT-M2281A
P&ID FGD Gypsum Dewatering Building Sumps...................	0.84/30080......................	178771-CHTT-M2281B
P&ID FGD Limestone Preparation Area Sumps	0.84/30081......................	178771-CHTT-M2281C
P&ID FGD Makeup Water Pretreatment Sump.......................	0.84/30082......................	178771-CHTT-M2281D
P&ID FGD ZLD Treatment Area Sumps..................................	0.84/38020......................	178771-CHTT-M2281E
P&ID Absorber Drain and Gypsum Bleed Tank Area Sumps..	0.84/38021......................	178771-CHTT-M2281F
P&ID FGD ZLD Treatment Building Sumps	0.84/38022......................	178771-CHTT-M2281G
P&ID FGD Gypsum Dewatering Area Sumps	0.84/38023......................	178771-CHTT-M2281H
P&ID FGD Common Pump Building Sump	0.84/38024......................	178771-CHTT-M2281J
P&ID Unit 1 Absorber Pump Building Sumps.........................	0.84/38025......................	178771-1HTT-M2281
P&ID Unit 2 Absorber Pump Building Sumps.........................	0.84/38026......................	178771-2HTT-M2281
P&ID Unit 3 Absorber Pump Building Sumps.........................	0.84/38027......................	178771-3HTT-M2281
P&ID Unit 4 Absorber Pump Building Sumps.........................	0.84/38028......................	178771-4HTT-M2281
P&ID Unit 5 Absorber Pump Building Sumps.........................	0.84/38029......................	178771-5HTT-M2281
P&ID Unit 6 Absorber Pump Building Sumps.........................	0.84/38030......................	178771-6HTT-M2281

3.5.3.15 FGD Auxiliary Electric Power System

3.5.3.15.1 High Voltage Power Supply

A new 132 kilovolt (kV) power supply will be installed at the 132 kV switchyard to provide back-up power to the FGD Common system. A new 132/12 kV transformer will step-down voltage for a new 11 kV FGD Common board switchgear which will supply the FGD Fire Water Electric Pump and an 11/6.9 kV FGD Back-up transformer. The 11/6.9 kV FGD Back-Up Transformer supplies a new 6.6 kV FGD Common Plant Back-Up Supply Board.

This back-up power supply is required to maintain 100 percent redundancy in the FGD Common power system as required by the User Requirements Specification [4] due to capacity limitations on Medupi Station Transformer 1 and 2. Extension of the 132 kV busbar and installation of the 132/12kV transformer will be the responsibility of Eskom transmission.

Refer to the following documents (attached) for additional information on the High Voltage Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)..	200-62087	
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12 ...	178771-CBCG-E1012

Document	SPF File Number	Document / File Number
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001

3.5.3.15.2 Medium Voltage Power Supply

New FGD auxiliary transformers will transform 11 kV three-phase power supplied from the existing 11 kV system to 6900 volt (V) three-phase power. The FGD auxiliary transformers will supply 6900 V, three-phase power to the FGD plant and absorber board switchgear buses through main breakers. The switchgear buses for similar service will be connected through a tiebreaker. For instance, the 6.6 kV Unit 1 FGD Plant Board 1 and the 6.6 kV Unit 1 FGD Plant Board 2 will be connected through a tiebreaker. The main breakers and the tiebreaker make it possible for a switchgear bus to be fed from two separate sources. This configuration will be used for all 6.6 kV switchgear with the exception of the 6.6kV FGD Common Plant BRD 1 and 6.6kV FGD Common Plant BRD 2 which will be connected to the 6.6kV FGD Common Plant Back-Up Supply BRD.

The switchgear buses will distribute power through feeder breakers to 6.6 kV FGD loads. These 6.6 kV loads will consist of large 6600 V motors, variable speed drives associated with 6.6 kV loads (such as for the limestone conveyors), 6.6 kV switchboards, and FGD load centre transformers.

Refer to the following documents (attached) for additional information on the Medium Voltage Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (6600V) System Description	200-58166	178771.43.0404
Single Line Diagram Unit 6 Absorber MV & LV BRD	0.84/28751 – Sheet 2	178771-6BCG-E1002
Single Line Diagram Unit 5 Absorber MV & LV BRD	0.84/28751 – Sheet 3	178771-5BCG-E1003
Single Line Diagram Unit 4 Absorber MV & LV BRD	0.84/28751 – Sheet 4	178771-4BCG-E1004
Single Line Diagram Unit 3 Absorber MV & LV BRD	0.84/28751 – Sheet 5	178771-3BCG-E1005
Single Line Diagram Unit 2 Absorber MV & LV BRD	0.84/28751 – Sheet 6	178771-2BCG-E1006
Single Line Diagram Unit 1 Absorber MV & LV BRD	0.84/28751 – Sheet 7	178771-1BCG-E1007
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD ZLD Treatment MV & LV BRD	0.84/28751 – Sheet 9	178771-CBCG-E1009
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Single Line Diagram FGD Limestone and Gypsum Handling MV & LV BRD	0.84/28751 – Sheet 11	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12	178771-CBCG-E1012
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014

3.5.3.15.3 Low Voltage Power Supply

The 400 V FGD auxiliary power system will consist of low-voltage (LV) switchgear, power cables, and low voltage loads. The main supply to the LV switchgear will be from the 6.6 kV switchgear through the 6.6 kV/0.42 kV dry-type transformers. The 6.6/0.42 kV dry-type transformer will be an integral part of the LV switchgear. Switchgear busbar voltage will be 400 V AC, three-phase, 50 Hz, 4-wire, and 230 V AC 2-wire is utilized for control and protection of the switchgear. The distributed control system (DCS) and the Emergency Trip Relays utilize 24V DC.

Main power supply to a board (or switchgear) is through a 6.6/0.42 kV dry-type, delta-wye transformer (except 400 V limestone unloading boards 1 and 2 which are supplied from the 400 V Limestone Handling boards). Tie-breakers connect boards of similar service. The tie-breaker and incomer breaker are equally sized. The main breakers and the tie-breaker make it possible for a switchgear bus to be fed from two separate sources.

The switchgear buses will distribute power through feeder breakers to 400 V FGD loads. These 400 V loads are 400 V motors, variable speed drives, motor operated valves, distribution panels, DC panels, motor starters, etc.

Refer to the following documents (attached) for additional information on the 400 Volt Auxiliary Electric System.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (400V) System Description	200-58141	178771.43.0403
Single Line Diagram Unit 6 Absorber MV & LV BRD	0.84/28751 – Sheet 2	178771-6BCG-E1002
Single Line Diagram Unit 5 Absorber MV & LV BRD	0.84/28751 – Sheet 3	178771-5BCG-E1003
Single Line Diagram Unit 4 Absorber MV & LV BRD	0.84/28751 – Sheet 4	178771-4BCG-E1004
Single Line Diagram Unit 3 Absorber MV & LV BRD	0.84/28751 – Sheet 5	178771-3BCG-E1005
Single Line Diagram Unit 2 Absorber MV & LV BRD	0.84/28751 – Sheet 6	178771-2BCG-E1006
Single Line Diagram Unit 1 Absorber MV & LV BRD	0.84/28751 – Sheet 7	178771-1BCG-E1007
Single Line Diagram FGD Common MV & LV BRD	0.84/28751 – Sheet 8	178771-CBCG-E1008
Single Line Diagram FGD ZLD Treatment MV & LV BRD	0.84/28751 – Sheet 9	178771-CBCG-E1009
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Single Line Diagram FGD Limestone and Gypsum Handling MV & LV BRD	0.84/28751 – Sheet 11	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up Supply MV & LV BRD	0.84/28751 – Sheet 12	178771-CBCG-E1012
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001

3.5.3.15.4 Emergency Electrical Supply

A new 2000 kVA emergency diesel generator (EDG) will provide emergency shutdown power at 6.6 kV AC upon the loss of normal 6.6 kV AC power. Sizing for the EDG to support FGD loads requires a unit rated 2000kVA. The existing 2500kVA Medupi EDG's do not have this additional capacity to support these loads.

The EDG will be connected to a 6.6 kV essential switchgear and provide a backup power feed to the essential 6.6 kV pumps. The essential power will then be distributed to step-down transformers which will supply 400 V AC essential boards in each of the FGD clusters, from which it will distribute power to loads such as the valves that must operate on the loss of power to the FGD system, agitators that must be started or operated during the time when power is lost to prevent limestone slurry from solidifying, emergency lighting, and any other loads that require power on the loss of the normal 400 V AC power.

The existing EDG building is sized to accommodate only the three existing units. In addition, the existing essential reticulation system has not been configured to allow the addition of the FGD essential loads. There is not sufficient space for the new FGD EDG building and Essential Services Substation near the Medupi EDG Building due to the existing, electrical trenches, compressor house substation, and inclined coal conveyor drive house. The proposed location for the FGD EDG building is more centrally located to service the FGD loads.

Refer to the following documents (attached) for additional information on the Emergency Electrical Supply.

Document	SPF File Number	Document / File Number
Emergency Generation System Description	200-58170	178771.43.0411
Single Line Diagram FGD Essential MV & LV BRD	0.84/28751 – Sheet 10	178771-CBCG-E1010
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.5.3.15.5 Essential Electrical Supply

New 230 V AC uninterruptible power supply (UPS) systems with dedicated 220 V DC batteries and chargers will be provided for each Unit Absorber Pump Building Substation, FGD Common Substation, Limestone and Gypsum Handling Substation, FGD ZLD Treatment Building, FGD Emergency Generation Building and all other FGD building containing low voltage (400V) boards. These UPS systems will provide essential power for board control as well as functioning as “dip-proof” power supplies to maintain contactor position.

New 220 V DC nickel-cadmium batteries with dedicated chargers will be provided to supply essential power for control of medium voltage (11 & 6.6 kV) boards.

Refer to the following documents (attached) for additional information on the Emergency Electrical Supply.

Document	SPF File Number	Document / File Number
FGD Essential Service AC System (UPS) Description	200-58167	178771.43.0409
Medupi Project FGD Electrical Load List	0.84/39020	178771-DE-1001
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.5.3.16 Control System

The existing Medupi control and instrumentation system will be extended to include all equipment required to allow the operator to operate and monitor the FGD, limestone handling, gypsum de-watering and handling, FGD ZLD, and power plant processes and be fully informed of their status.

The existing DCS for the Medupi Power Station is an Alstom ALSPA and is configured for seven distinct networks, one network for each of the six generating units (the power islands) and one for the common plant, referred to as the balance-of-plant (BOP).

A stand-alone DCS will be added for the FGD systems and subsystems. The DCS will provide control, display, alarming, reporting, and archive capabilities for the retrofit of new FGD systems for Units 1 through 6 and their associated subsystems. These subsystems include limestone handling and byproduct disposal. The FGD system DCS network will be independent of the plant DCS networks. However, the signal interface between the FGD DCSs and plant DCS will be hardwired. Local work stations will be provided for these DCS systems and all other FGD system subsystems with the exception of the FGD ZLD Treatment System.

The FGD DCS system will be on its own network and will have a dedicated loop with dedicated controllers and network equipment. Therefore there should be little to no effect to the on the overall plant network traffic. A bi-directional loop is provided for reliability so that a break in the fibre will not affect the network.

The FGD ZLD Treatment System will be provided with a dedicated control room in the FGD ZLD Treatment Building. Monitoring of the FGD ZLD Treatment System will be available in the BOP Control Room but control will be performed in the FGD ZLD Control Room on a permanent basis.

Refer to the following documents (attached) for additional information on the Control System.

Document	SPF File Number	Document / File Number
Distributed Control System System Description....................	200-123563	178771.43.2401
I/O Study		
Local Control Philosophy...	200-114237	178771.41.0108
FGD Network Architecture Diagram.....................................	0.84/38951.....................	178771-CHYQ-K8001
FGD Instrument List..	200-58413	178771-DK-1001

3.5.4 Modifications to Existing Facilities

Several modifications to the existing facilities have been identified.

1. An Interface List (178771-DM-1006, SPF file 200-60397), attached, was developed to identify the location and design requirements for interface points with the existing plant.
2. Chimney modifications will be required as described in Section 3.5.3.4.
3. A new 132 kV power supply will be installed at the 132 kV switchyard to provide back-up power to the FGD Common system as described in Section 3.5.3.15.1.
4. Interface and isolation of the FGD and bypass ductwork is described in Section 3.5.3.2.
5. Supply of the FGD Auxiliary Steam System from the existing plant auxiliary steam supply is described in Section 3.5.3.9.
6. The new gypsum conveyor system will connect with the overland ash conveyor as described in Section 3.5.3.7.
7. Waste gypsum and water treatment solid waste will be disposed in the existing onsite ash dump, as described in Section 3.14.2.

3.6 SITING

The project scope will be located within the existing boundaries of the Medupi Power Station, with one exception (refer to the Site Arrangement, 178771-CGAU-G1001, SPF file 0.84/28836, and the Plot Plan, 178771-CGAU-G1000, SPF file 0.84/36776, attached). A new raw water pipeline will be installed from the existing Raw Water Pump Building to the new Raw Water Pretreatment Building as shown on the Conceptual Raw Water Makeup Route with Road and Rail Crossings (drawing 178771-SK-M0001, SPF file 0.84/36053), attached.

3.7 BUILDING FACILITY LAYOUT DESIGN

Each FGD absorber will treat the flue gas from one of the six boilers; commercial-grade saleable gypsum will be produced as a byproduct. A cluster of three absorbers will be located near each of the plant's two chimneys. Systems for makeup water, reagent preparation (limestone), FGD byproduct (gypsum) dewatering and storage/disposal, and treatment of the wastewater stream will be common to all FGD absorbers in the plant. The 3D model was used to ensure that the access requirements associated with operations, maintenance, and construction activities were maintained. The 3D model was also used to coordinate the interfaces between the FGD process and Balance of Plant equipment.

The project scope includes the addition of several new buildings. Refer to the following documents (attached) and Section 3.8.2 for additional information on the buildings and facilities.

Document	SPF File Number	Document / File Number
FGD Buildings and Structures System Description	200-101738	178771.43.0801
General Arrangement, Unit 1 Absorber Pump Building	(not yet assigned)	178771-1UHT-G2017
General Arrangement, Unit 2 Absorber Pump Building	(not yet assigned)	178771-2UHT-G2018
General Arrangement, Unit 3 Absorber Pump Building	(not yet assigned)	178771-3UHT-G2019
General Arrangement, Unit 4 Absorber Pump Building	(not yet assigned)	178771-4UHT-G2020
General Arrangement, Unit 5 Absorber Pump Building	(not yet assigned)	178771-5UHT-G2021
General Arrangement, Unit 6 Absorber Pump Building	0.84/36796	178771-6UHT-G2022
General Arrangement, Raw Water Pump Building	0.84/36385	178771-CUGA-G2011
General Arrangement, FGD Common Substation	0.84-36243	178771-CUBE-G2013
General Arrangement, FGD Makeup Water Pretreatment Building	0.84/36795	178771-CUGA-G2004
General Arrangement, Common Pump Building	0.84/38747	178771-CGKC-G2027
General Arrangement, Limestone Unloading and Receiving Building	0.84/37962	178771-CUVD-G2026
General Arrangement, Limestone and Gypsum Handling Substation	0.84/37960	178771-CUBV-G2014
General Arrangement, Limestone Preparation Building	0.84/36531	178771-CHTJ-G2006A
General Arrangement, Gypsum Dewatering Building Ground Floor EL 902.4	0.84/36520	178771-CUGQ-G2008A
General Arrangement, Gypsum Dewatering Building EL 911.4	0.84/36521	178771-CUGQ-G2008B
General Arrangement, Gypsum Dewatering Building EL 918.4	0.84/36522	178771-CUGQ-G2008C
General Arrangement, Gypsum Dewatering Building EL 924.4	0.84/36523	178771-CUGQ-G2008D
General Arrangement, Gypsum Storage Building	0.84/37993	178771-CUGE-G2024
General Arrangement, FGD ZLD Treatment Building	0.84/37689	178771-CGNR-G2010
General Arrangement, FGD Essential Service Substation and Emergency Generation Building	0.84/37880	178771-CUBN-G2012

3.8 CIVIL INFRASTRUCTURE AND BUILDING DESIGN

3.8.1 Civil Infrastructure

The following assumptions were made for the basic design phase; minimal terrace cut-and-fill would be necessary in the main FGD process area, and all ground floor building slabs and equipment and vessel foundations will be at the same top-of-concrete elevation.

Basic design and or layout of the site work including roads, storm water drainage, limited area terrace cut and fill at the limestone unloading area, and new dirty water dam was completed to provide the cost for the necessary facilities for the FGD Retrofit Project. Access roads to buildings and areas and tie-in roads to existing plant roads were developed to provide the necessary access to buildings, equipment, and areas as developed in this phase. The road construction basic design criteria including widths, radii of turns; and materials of construction were based on the Medupi Power Station roads.

Storm water drainage facilities were designed following the design example of existing work for the Medupi Power Station (refer to the FGD Stormwater Drainage Layout for Area West of Boiler to Road 09 drawing, SPF file 0.84/35608, attached), and assumes the existing system is capable of accepting the dirty storm water run-off from the main FGD process area. For estimating the costs, a new Storm Water Dirty Dam was designed and shown on the Plot Plan (178771-CGAU-G1000, SPF file 0.84/36776), attached, near the Gypsum Storage Building.

During the Basic Design phase, it was determined that additional drainage design was required for the Medupi Power Station; requiring terrace drawing 0.84/193 to be updated. Drainage in this area is being coordinated with the Medupi FGD Retrofit Project's drainage needs between Road 10 and the existing boiler area; refer to ECP 200-107457.

The assumption was made that a rail-spur connecting the Plant rail yard (by others) and the Limestone Unloading Facility would have an interface point adjacent to and 25 metres from the Limestone Unloading Facility. Beyond this interface the rail yard additions are outside the scope of the Medupi FGD Retrofit Project.

Further, it was assumed that all material handling equipment; conveyors; and transfer buildings will be furnished and erected by the material handling contractor.

3.8.2 Buildings, Structures, and Foundations

Buildings consist of foundations, superstructures, building architectural enclosures, building lighting, floor sump pits and trenches where applicable, fire protection, including the Isolation Control Valve (ICV) chamber area and the Consolidated Building Management System (CBMS) and HVAC equipment, as well as architectural commodities and finishes.

The building superstructures mainly consist of two types; cast-in-place reinforced concrete portal frames, or laterally-braced steel framing. Some elevated platforms will be concrete on metal deck, and in other locations galvanized steel grating on steel framing.

The building designs relied on the building arrangement (refer to Section 3.7) for size, height, number of floors, arrangement of platforms and stairways, maintenance and egress requirements, and location of fire-rated walls for area separation where applicable, as well as cut-outs in floors and walls for equipment access.

The mechanical loads for the process equipment were developed by the project team. The load criteria developed was based upon the PDM (178771.22.0000, SPF file 200–61989) attached, S.A.N.S. codes, and investigations of site-specific environmental conditions, with the assumption made for the Basic Design phase that wind load governed the lateral load case over the seismic lateral load case for all buildings. Geological data for the main FGD process area was not available during the Basic Design. Soil bearing capacities and modulus values were assumed after reviewing Medupi Power Station data representing a strong in-situ rock formation with moderate fracturing for foundation design. Localized subgrade variability and site-specific data may require several design cases during the detailed design phase.

Building foundations are assumed to be founded upon the in-situ rock or compacted structural backfill over in-situ rock, with shallow spread footings, pad footings, or shallow mat foundations rather than deep piling-type foundations. Due to in-situ rock being close to the surface, it was assumed that deep piling-type foundations would not be applicable. The foundations will be reinforced 35 MPa cast-in-place concrete.

Process tank foundations were designed assuming ring-beam foundations bearing on in-situ rock.

The structural calculations for buildings and equipment foundations were based upon unverified assumptions, and as such, are only for cost estimating purposes. None of the basic design phase calculations are applicable to actual construction – new calculations during the detailed design phase will be required.

For the Basic Design phase, assumptions were made for unknown data or loads, and are identified in an unverified assumptions log (refer to Section 3.2.3). In support of the definitive cost estimate, simplifications were also used such as not designing structural connections for structural steel structures; using a density factor for the amount of reinforcing steel estimated per cubic metre of cast-in-place concrete structures and foundations; assumption that wind loading case governed over seismic; and setting assumed values for geotechnical variables such as soil bearing capacity; modulus of subgrade reaction; and California bearing ratio.

The physical criteria for buildings such as building footprint size and number of levels; the type of building construction such as a concrete of a steel superstructure and masonry or metal wall panelling walls; and operating and maintenance access requirements were covered in detail in the FGD Buildings and Structures System Description (178771.43.0801, SPF file 200-101738). A high level overview is given in the subsections below.

3.8.2.1 Limestone Preparation Building

The ball mill bay within the Limestone Preparation Building is a lateral portal frame/longitudinally-braced steel superstructure with an overhead bridge crane for maintenance. Access platforms are furnished with the equipment. The limestone day bin bay supports the three limestone day bins and the limestone conveyors above the day bins. Also within this bay are the bin outlets, weigh belt feeders, and the limestone classifiers (hydro-cyclones).

The Limestone Preparation Building day bin bay structure foundation was designed as a matt foundation bearing on in-situ rock and assuming the need for epoxy-grouted tension tendons (rock anchors) to carry uplift forces caused by large over-turning forces due to the high centre-of-gravity of the three day bins.

The ball mill foundations were assumed to consist of a matt foundation, isolated from the building foundation, and a pedestal for each ball mill as required by the arrangement and design of the ball mill equipment.

3.8.2.2 Gypsum Dewatering Building

The Gypsum Dewatering Building is a laterally-braced steel superstructure with multiple floors and maintenance monorails and hoists over each vacuum filter.

3.8.2.3 Substations

All substations are cast-in-place concrete portal-frame superstructures.

3.8.2.4 Absorber Pump House Buildings

The Absorber Pump House buildings are laterally-braced steel superstructures. The Pump Houses are adjacent to but independent of the cast-in-place superstructure substation buildings in all six locations.

For cost estimating purposes, the Absorber Vessel foundations were assumed to be round, reinforced concrete matt foundations; two metres thick, bearing on in-situ rock. Absorber Pump House Building columns adjacent to the vessel would also be supported on this foundation.

3.8.2.5 Gypsum Storage Building

The Gypsum Storage Building is a large lateral portal-frame/longitudinally braced steel superstructure. The building requires roof trusses 5 metres or more in depth due to the large span distance between the side walls. A gypsum conveyor gallery runs the length of the building, and is above the building's roof.

3.8.2.6 FGD Zero Liquid Discharge Treatment Building

The FGD Zero Liquid Discharge Treatment Building is a very large building with a conventional laterally-braced steel superstructure.

3.8.2.7 Raw Water Pretreatment Building

The Raw Water Pretreatment Building houses strainers; chemical feed equipment; and the electrical/control equipment. Access platforms and stairways are provided to the elevated electrical room above the cable spreading room. The building is a single story concrete superstructure with concrete block walls, and insulated metal roof panelling. The building is supported by a concrete matt foundation. The ground floor contains trenches which drain to an outside sump pit. A sodium hypochlorite storage tank is adjacent to the building, on a separate foundation.

3.8.2.8 Utility Rack

The Utility Rack superstructures are steel frames with lateral and longitudinal bracing systems. The rack's typical ground clearance is 6.5 metres, and the typical overall height is 12.5 metres. The typical width of racks is 3 metres. The racks have three to four levels for process piping with all electrical tray on the top level. Racks with limited maintenance access from the ground have galvanized steel grating catwalk platforms.

The Utility Rack foundations were assumed to be matt foundations (in some locations for multiple frames), bearing on in-situ rock, and incorporating rock anchors for uplift forces.

3.9 MECHANICAL DESIGN

This section provides a summary of the general mechanical design for the FGD Retrofit Project. Descriptive information regarding the mechanical design for the FGD and supporting systems is provided in Section 3.5.3.

For estimating the project costs during the Basic Design, equipment sizing calculations were performed to determine approximate equipment duty sizes. Sizing calculations for pumps, compressors, heat exchangers, tanks, cooling tower, sumps, strainers and HVAC equipment were performed. A 3D model was used to plan/design the equipment arrangements for space control and to determine approximate building size requirements. This allowed maintenance and access space allocation and planning. general arrangement drawings for buildings and areas were produced as an export from the 3D model.

It was assumed that all FGD ZLD pretreatment and brine concentrator/crystallizer equipment will be furnished by the ZLD supplier. This includes piping, valves, clarifiers, pumps, tanks, filter presses, silos, brine concentrators, crystallizers and all other associated equipment. Conceptual design for this equipment was performed only to the extent to estimate flows required for the water mass balance calculations and to determine approximate sizes of equipment for space allocation and general arrangement design. Detailed design of this equipment is very supplier-specific and is performed by the suppliers.

Refer to the following documents (attached) for additional information on the mechanical design.

Document	SPF File Number	Document / File Number
FGD Buildings and Structures System Description	200-101738	178771.43.0801
FGD Zero Liquid Discharge System Description	200-58476	178771.43.6405
FGD Potable Water System Description	200-58477	178771.43.6604
Sumps System Description	200-58469	178771.43.2819
Interface List	200-60397	178771-DM-1006
FGD BOP Equipment List	200-58423	178771-DM-1005
Equipment List	200-57316	006265-S-LIS-002
Equipment Load List Absorber	200-108957	P06265-S-LIS-010
Equipment Load List Dewatering	200-108992	P06265-S-LIS-011
Equipment Load List Limestone Preparation	200-108993	P06265-S-LIS-012

3.10 PIPING DESIGN

This section provides a summary of the general piping design for the FGD Retrofit Project. Descriptive information regarding the design for the FGD and supporting systems is provided in Section 3.5.3.

For estimating the project costs during the Basic Design, pipe sizing calculations and Piping and Instrument Diagrams (P&IDs) were produced. The piping was modelled in the 3D model based on the P&ID's and general arrangements using the calculated sizes. Modelling the piping assisted in the planning/designing of pipe routing around equipment to ensure space control. Modelling the piping also allowed the extraction of piping lengths from the 3D model to be used for cost estimating purposes. All BOP large bore piping (65 mm and larger) was sized and modelled with the exception of ZLD supplier piping. BOP small bore piping (50 mm and smaller) was only modelled if necessary to support space control purposes.

With the exception of the Auxiliary Steam System, the majority of piping is considered to be "cold supported" piping and does not require pipe stress analysis. A preliminary pipe stress analysis was performed on the Eskom-provided existing plant pipe routing and the additional auxiliary steam pipe associated with the FGD Retrofit Project. The preliminary analysis indicates that the pipe routing is generally acceptable but that further refinements and analysis will be needed during detailed design.

Refer to the following documents (attached) for additional information on the piping design.

Document	SPF File Number	Document / File Number
FGD Auxiliary Steam System Description	200-58353	178771.43.0601
Pipeline List	200-58414	178771-DM-1001
FGD In-Line Components List	200-58419	178771-DM-1003
FGD Valve List	200-58416	178771-DM-1002A
FGD Relief Valve List	200-58417	178771-DM-1002B
Piping List	200-112366	006265-S-LIS-020
Valve List	200-62262	006265-S-LIS-030
Interface List	200-60397	178771-DM-1006

3.11 ELECTRICAL DESIGN

The electrical system design was performed based on information developed by the project team. Single line diagrams were developed for each unit's absorber and the FGD common system. A detailed load list was maintained, which includes cable sizing calculations. Calculations for battery and UPS systems and the emergency diesel generator were performed. Load flow, motor starting, and short circuit studies were performed by Eskom with input and review from Black & Veatch.

The electrical design allows for 100 percent redundancy in the power supply system for the FGD which allows for reliable operation and safe shut down of the system in case of loss of power. Transformers, medium voltage boards, low voltage boards and all other electrical devices have been calculated and sized to carry the estimated electrical load as defined in the electrical load list. Cable sizing and routing was performed using the load list formulas, the Medupi site arrangement drawings, and model.

For detailed descriptions of the electrical design, see Subsections 3.5.3.15.1 through 3.5.3.15.4.

Refer to the following documents (attached) for additional information on the electrical design.

Document	SPF File Number	Document / File Number
Medupi FGD Retrofit Evaluation (load flow, fault and motor start-up studies)	200-62087	
AC Power Supply (400V) System Description	200-58141	174330.43.0403
AC Power Supply (660V) System Description	200-58166	174330.43.0404
24V DC Power Supply System Description	200-58165	174330.43.0407
DC Switchgear (110/220 V) System Description	200-58133	174330.43.0408
Essential Service AC System Description	200-58167	178771.43.0409
Emergency Generation System Description	200-58170	174330.43.0411
Index FGD MV & LV Single Line Diagrams	0.84/28751	178771-CBCG-E1000
Single Line Diagram Unit 1 Absorber MV & LV Board	0.84/28751	178771-1BCG-E1007
Single Line Diagram Unit 2 Absorber MV & LV Board	0.84/28751	178771-2BCG-E1006
Single Line Diagram Unit 3 Absorber MV & LV Board	0.84/28751	178771-3BCG-E1005
Single Line Diagram Unit 4 Absorber MV & LV Board	0.84/28751	178771-4BCG-E1004
Single Line Diagram Unit 5 Absorber MV & LV Board	0.84/28751	178771-5BCG-E1003
Single Line Diagram Unit 6 Absorber MV & LV Board	0.84/28751	178771-6BCG-E1002
Single Line Diagram FGD Common MV & LV Board	0.84/28751	178771-CBCG-E1008
Single Line Diagram ZLD Treatment MV & LV Board	0.84/28751	178771-CBCG-E1009
Single Line Diagram Essential MV & LV Board	0.84/28751	178771-CBCG-E1010
Single Line Diagram Limestone And Gypsum Handling MV & LV Board	0.84/28751	178771-CBCG-E1011
Single Line Diagram FGD Common Back-Up MV Board	0.84/28751	178771-CBCG-E1012
FGD Electrical Load List	0.84/39020	178771-DE-1001
Interface List	200-60397	178771-DM-1006

3.12 CONTROL AND INSTRUMENTATION DESIGN

The control and instrumentation system design was performed based on information developed by the project team. Input/output (I/O) and instrument lists were maintained based on this information. The stand-alone DCS was designed for FGD system operation based on the requirements of the instrument and I/O lists.

The FGD system DCS network will be independent of the plant DCS networks. However, the signal interface between the FGD DCSs and plant DCS will be hardwired.

For detailed descriptions of the control and instrumentation design, see Subsection 3.5.3.16.

Refer to the following documents (attached) for additional information on the Control and Instrumentation Design.

Document	SPF File Number	Document / File Number
Distributed Control System System Description	200-123563	178771.43.2401
Local Control Philosophy	200-114237	178771.41.0108
DCS Architecture Diagram	0.84/38951	178771-CHYQ-K8001
Process Control System Philosophy	200-109912	006265-T-HBU-508
System Description, FGD Process Control Concept	200-58278	006265-T-HBU-509
Functional Description Absorber	200-111269	006265-T-HBU-540
Functional Description Absorber Bleed System	200-112494	006265-T-HBU-541

Document	SPF File Number	Document / File Number
Functional Description Mist Eliminator Flushing	200-112499	006265-T-HBU-542
Functional Description Flue Gas Path	200-110087	006265-T-HBU-510
Functional Description Wet Ball Mill	200-112362	006265-T-HBU-630
Functional Description Limestone Slurry Feed	200-110747	006265-T-HBU-640
Functional Description Bleed/Emergency Drain System	200-112486	006265-T-HBU-660
Functional Description Dewatering System	200-113405	006265-T-HBU-670
Functional Description Gypsum Dewatering Line	200-112364	006265-T-HBU-671
Functional Description Waste Water System	200-113408	006265-T-HBU-672
Functional Description Reclaim Water System	200-111980	006265-T-HBU-673
Functional Description Process Water	200-110227	006265-T-HBU-610
Logic Diagram Absorber	200-111720	006265-D-DIA-540
Logic Diagram Absorber Bleed	200-112374	006265-D-DIA-541
Logic Diagram Mist Eliminator	200-112704	006265-D-DIA-542
Logic Diagram Flue Gas Path	200-110758	006265-D-DIA-510
Logic Diagram Limestone Slurry Feed	200-112092	006265-D-DIA-640
Logic Diagram Gypsum Bleed/Drain System	200-113119	006265-D-DIA-660
Logic Diagram Dewatering System	200-113481	006265-D-DIA-670
Logic Diagram Waste Water System	200-113682	006265-D-DIA-672
Logic Diagram Reclaim System	200-112385	006265-D-DIA-673
Logic Diagram Process Water	0.84/38056	006265-D-DIA-010
Signal and Alarm List Absorber Mist Eliminator Flushing and Oxidation	200-114401	006265-S-LIS-263
Signal and Alarm List Flue Gas Path	200-112711	006265-S-LIS-261
Signal and Alarm List Limestone Preparation	200-115861	006265-S-LIS-265
Signal and Alarm List Limestone Slurry Feed	200-113439	006265-S-LIS-262
Signal and Alarm List Gypsum Bleed and Drain	200-110785	006265-S-LIS-267
Signal and Alarm List Dewatering System	200-117087	006265-S-LIS-268
Signal and Alarm List Waste Water System	200-117080	006265-S-LIS-266
Signal and Alarm List Reclaim System	200-114673	006265-S-LIS-264
Signal and Alarm List Process Water	200-109384	006265-S-LIS-260
Hook Ups	200-112554	006265-A-SKI-010
FGD Instrument List	200-58413	178771-DK-1001
Measuring Point List	200-102532	006265-S-LIS-250
Interface List	200-60397	178771-DM-1006

3.13 UTILITIES REQUIRED

Table 5 lists the annual consumption rates for the utilities and consumables for the FGD Retrofit project.

Table 5: Consumption and Production Rates

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
Reagent (Limestone)		
Hourly consumption, kg / hr	143,236	125,735
Consumption per year[1], tonnes	1,129,272	991,295
Byproduct for Disposal (Gypsum)		
Hourly generation, kg / hr	247,537	233,250
Total generation per year1, tonnes	1,951,581	1,838,940

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
Steam		
Hourly consumption, kg / hr	21,000	21,000
Total consumption per year[2], kg	124,173,000	124,173,000
Water		
Hourly generation, 1,000 L / hr	1157.5	1179.5
Total generation per year[1], 1,000 L	9,125,730	9,299,178
Auxiliary Power		
Hourly consumption, MWh / hr	40.87	40.87
Total consumption per year[3], MWh	322,186	322,186
Hydrated Lime (Ca Hydroxide)		
Hourly consumption, kg / hr	2,297	3
Total consumption per year[2], kg	13,582,161	17,739
Soda Ash (Sodium Carbonate)		
Hourly consumption, kg / hr	3,331	3,035
Total consumption per year[2], kg	19,696,203	17,945,955
Sodium Sulphate, 50% solution		
Hourly consumption, kg / hr	546	602
Total consumption per year[2], kg	3,228,498	3,559,626
Caustic, 50% solution		
Hourly consumption, kg / hr	202	212
Total consumption per year[2], kg	1,194,426	1,253,556
Sulphuric Acid, 66 Baume		
Hourly consumption, kg / hr	75	81
Total consumption per year[2], kg	443,475	478,953
Ferric Chloride, 50% solution		
Hourly consumption, kg / hr	11	10
Total consumption per year[2], kg	65,043	59,130
Antiscalant, 100% solution		
Hourly consumption, kg / hr	4.6	4.6
Total consumption per year[2], kg	27,200	27,200
Antifoam, 100% solution		
Hourly consumption, kg / hr	5.4	5.4
Total consumption per year[2], kg	31,930	31,930
Polymer, 100% solution		
Hourly consumption, kg / hr	3	2
Total consumption per year[2], kg	17,739	11,826
FGD ZLD Pretreatment Solids Waste (Clarifier Solids for Disposal)		
Hourly discharge, kg / hr	20,330	10,132
Total discharge per year[2], tonnes	120,211	59,911

Description	For 85 Percent $CaCO_3$ Limestone	For 96 Percent $CaCO_3$ Limestone
FGD ZLD Treatment Solids Waste (Brine Concentrator/Crystallizer Solidsfor Disposal)		
Hourly discharge, kg / hr	5,288	5,302
Total discharge per year[2], tonnes	31,268	31,351

[1]*Based on a capacity factor of 90% of 8760 hours of equivalent full load operation per year.*

[2]*Based on a capacity factor of 90%, a utilization factor of 75%, and 8760 hours of equivalent full load operation per year.*

[3]*Based on a combination of a capacity factor of 90%, a ZLD utilization factor of 75%, a common utilization factor of 60%, a process utilization factor of 90%, and 8760 hours of equivalent full load operation per year.*

[4]*All cases based on Worst Coal, except Water is based on Worst Coal + Attemperating Air.*

3.14 WASTE MANAGEMENT

3.14.1 Water Purification

As identified in Section 3.5.3.8, a new FGD ZLD Treatment System will treat the FGD system chloride bleed stream, the TOC scavenger rejects from the existing plant, and FGD cooling tower blowdown streams.

The FGD chloride bleed stream is pre-treated as described in Section 3.5.3.8 to remove the suspended solids and heavy metals prior to the brine concentrator/crystallizer equipment. The FGD ZLD pretreatment process will include chemical treatment of the water to precipitate solids and heavy metals from the water. The precipitates are settled out in a clarifier as sludge, which is sent to a filter press or similar dewatering system. The water is recovered from the sludge and returned back to the clarifier. The de-watered solids will be directed to a storage bin for disposal.

As described in Section 3.5.3.8, the FGD ZLD Treatment System distillate will be directed to either the Reclaim Tanks or existing Medupi Water Treatment Plant. The dewatered solids and dewatered brine will be disposed of either on or off-site in an area designed for the FGD ZLD pretreatment and brine concentrator/crystallizer wastes.

Document	SPF File Number	Document / File Number
Water Supply / Wastewater Disposal Study	200-55817	178771.41.0107
FGD Makeup Water Supply System Description	200-58478	178771-43-6607
FGD Zero Liquid Discharge System Description	200-58476	178771.43.6405

3.14.2 Waste Storage and Transportation

Solid waste streams from the Medupi FGD Retrofit Project consist of gypsum from the Gypsum Refinement and Dewatering System described in Section 3.5.3.7, and sludge from the FGD ZLD Treatment System described in Section 3.5.3.8.

As the basis for the Basic Design it was assumed that under normal operating circumstances, up to 20 percent of the gypsum would be sent to market. Gypsum that is not able to meet commercial-grade specifications or is chosen not to be sold would be treated as a waste stream and combined with the ash for disposal in the onsite ash dump[6]. Eskom requested the existing ash dump designers (Jones and Wagener, Engineering and Environmental Consultants) to evaluate the existing ash dump for co-disposal of ash and gypsum in terms of capacities (both with and without the excess coal stockyard currently designed to be located on the west end of the northern ash dump), liner applicability, and slope stability. The gypsum characteristics and details provided to the designers were based on data from the Basic Design and it was requested that the assessment be performed for the 100 percent and 80 percent (20 percent saleable) disposal of gypsum. Jones and Wagener advised that there is sufficient space in the existing ash dump for the co-disposal of ash and gypsum (under the worst case, i.e., 100 percent gypsum disposal) provided that the excess coal stockyard is removed. This result together with the rest of the response from the designers can be found under SPF document no. 257-185172, "For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum" [10]. Eskom Engineering has developed a Scope of Works [12] document to be issued to the already appointed Environmental Impact Assessment (EIA) consultant to execute development and assessment of alternatives for the disposal of gypsum produced, together with conceptual design of the preferred and back up alternatives for presentation to the competent authority. The waste classification study to be executed by the EIA consultant will inform the preferred and back up alternatives.

From the dewatering process, gypsum will drop from vacuum filters onto one of two side-by-side collecting conveyors by means of bifurcated chutes. Gypsum will be transported via a series of gypsum conveyors. The gypsum conveyors will either feed non-saleable gypsum to the overland ash conveyors for co-disposal with the ash[7], or alternatively will feed saleable gypsum to the gypsum storage facility. At the gypsum storage facility, gypsum will be stacked out in three different piles or into one continuous pile. Gypsum which does not meet commercial-grade specifications will be reclaimed via mobile equipment and a mobile belt (apron) feeder and conveyed to the overland ash conveyors for co-disposal with the ash.

The chloride bleed stream and cooling tower blowdown stream from the Medupi FGD Retrofit Project and the TOC scavenger rejects from the existing plant will be pre-treated in a clarifier to remove suspended solids and heavy-metals. The solids and heavy-metals that precipitate out of the chloride bleed stream in the clarifier will be collected as sludge. The sludge (solids) will be collected in a concrete bunker or dumpsters placed underneath filter presses. In the FGD ZLD Treatment System, a brine concentrator/crystallizer will be utilized to concentrate solids of the wastewater. A guideline report was undertaken by Eskom for the Medupi Power Station, presenting various possible options of disposing the FGD chemical wastes. The guideline report together with all supporting documentation, recorded meeting minutes and e-mail communications can be found under SPF document no, 200-128401, “Guideline: Possible alternatives for the disposal of chemical wastes produced by the FGD process” [11]. For the Basic Design, it was assumed that the collected sludge from the FGD ZLD pretreatment and the concentrated and dewatered brine solids from the FGD ZLD Treatment System will be disposed of using trucks to transport to onsite or offsite dumps. It should be noted that the guideline report has now been converted into a Scope of Works [12] document to be issued to the already appointed EIA consultant to execute development and assessment of alternatives for the disposal of chemical sludge and chemical solids (salts) produced, together with conceptual design of the preferred and back up alternatives for presentation to the competent authority. The waste classification study to be executed by the EIA consultant will inform the preferred and back up alternatives.

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[6] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

[7] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

Document	SPF File Number	Document / File Number
Byproduct Disposal Study	200-55816	178771.41.0106
Water Supply / Waste Water Disposal Study	200-55817	178771.41.0107
Gypsum Handling Plant Process Flow Diagram	0.84/37820	
FGD Solids Conveying and Storage Arrangement GCVY-1&2	0.84/37780	
FGD Solids Conveying and Storage Arrangement GCVY-3&4	0.84/37781	
FGD Solids Conveying and Storage Arrangement GCVY-5&6	0.84/37782	
FGD Solids Conveying and Storage Arrangement GCVY-7&8	0.84/37783	
FGD Solids Conveying and Storage Arrangement GCVY-9	0.84/37784	
FGD Solids Conveying and Storage Arrangement GCVY-10	0.84/37785	
FGD Solids Conveying and Storage Arrangement GCVY-11	0.84/37786	
FGD Solids Conveying and Storage Arrangement GCVY-12	0.84/37787	
FGD Solids Conveying and Storage Arrangement GCVY-13	0.84/37788	
FGD Zero Liquid Discharge (ZLD) Treatment System Description	200-58476	178771.43.6405

3.15 MAINTENANCE REQUIREMENTS

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to ensure that the plant included sufficient features to ensure safe and efficient maintenance can be carried out. The following aspects were reviewed for all plant areas:

- Access to plant item from normally provided floors and platforms or special access provisions, such as permanently installed ladders and local platforms.
- Adequacy of lifting and handling devices.
- Area available for in-situ work.
- Adequacy of lighting to allow inspections and maintenance to be performed.
- Interference with the operation and maintenance of other structures and systems.
- Adequacy of the maintenance and storage facilities.
- Electrical and mechanical isolation devices, including devices which are lockable to enable the application of Permits to Work as per ESKOM standards.
- Draining and venting facilities on active systems.
- Adequacy of spare parts.
- Suitable electrical and compressed air supply points are included to ensure that portable tools can be used to perform maintenance activities.

Refer to the following documents (attached) for additional information on the maintenance requirements.

Document	SPF File Number	Document / File Number
Maintenance and Access Diagram FGD Medupi	200-110120	006265-T-STD-400
Maintenance and Access Drawing Pumphouse	0.84/38274	006265-Z4010-611
Maintenance Staffing Plan	200-103917	006265-S-TAB-020
Maintenance and Access Drawing Gypsum Dewatering Building +0.000M	0.84/38263	006265-Z4020-601
Maintenance and Access Drawing Gypsum Dewatering Building +9.000M	0.84/38264	006265-Z4020-602
Maintenance and Access Drawing Gypsum Dewatering Building +16.000M	0.84/38265	006265-Z4020-603
Maintenance and Access Drawing Limestone Building 0.00M	0.84/38260	006265-Z4320-601
Maintenance and Access Drawing Limestone Building +20.0M	0.84/38261	006265-Z4320-602
Maintenance and Access Drawing Gypsum Bleed Tank Area	0.84/38262	006265-Z4330-601
Evaluation of Access Equipment for Maintenance of Top Entry Agitators	200-114243	006265-T-STD-410
Mobile Equipment Plan	200-120679	178771.43.1007

3.16 DESIGN ASSESSMENT

3.16.1 Compliance with Stakeholder Requirements

The URS compliance evaluation shown in Table 6 is based on adherence to Medupi Power Station User Requirements Specification Revision 4 [4], Section 8.1.34.

Table 6: URS Compliance Evaluation

URS Section	Specification	Adhered to Yes/No	Comments
8.1.34.1	SO_2 Removal Efficiency	Yes	Complies to the SA Government Minimum Emission standards effective April 2010 and Eskom's Air Quality Strategy Doc no. 31-1143
8.1.34.2	Water Consumption	Yes	The FGD water Consumption is within the projected allocation
8.1.34.3	Sorbent	Yes	Compliant
8.1.34.4	Computational Fluid Dynamic (CFD) Modeling	Yes	CFD modelling was performed
8.1.34.5	Control and Instrumentation Interface	Yes	Compliant
8.1.34.6	Power Consumption	Yes	Based on Basic Design Estimate
8.1.34.7	Pressure Drop	Yes	Within the ID fan limits
8.1.34.8	Stack and Exit Temperature	No	This requirement is no longer applicable based on the dispersion model results performed by Eskom Environmental. Formal Engineering change to be lodged with ECP committee

URS Section	Specification	Adhered to Yes/No	Comments
8.1.34.9	Corrosion and Erosion Protection	Yes	Compliant
8.1.34.10	Waste Product	Yes	Provision made to dispose or store Gypsum for salability[8].
8.1.34.11	Stacks	Yes	Chimney modifications are required, refer to Section 3.5.3.4.

Please note that adherence to the URS is based on information available at the completion of the Basic Design Phase.

3.16.2 Operability Assessment

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to ensure that the plant included sufficient features to ensure safe and efficient operation can be carried out. A description of the operational process was developed to ensure that the plant functions according to the design requirements under normal and abnormal conditions, and how the human interface would be achieved.

Refer to the following documents (attached) for additional information on operability.

Document	SPF File Number	Document / File Number
Operability Study	200-92095	006265-T-STD-100
FGD Startup and Shutdown Concept	200-99436	006265-T-STD-200
Local Control Philosophy	200-114237	178771.41.0108
Process Control System Philosophy	200-109912	006265-T-HBU-508
System Description, FGD Process Control Concept	200-58278	006265-T-HBU-509

3.16.3 Reliability, Maintainability, Availability Assessment

A Reliability, Availability, and Maintainability (RAM) Assessment (SPF Doc No 474-9289) was performed at the conclusion of the Concept phase for the Medupi FGD Retrofit Project. This evaluation was considered as input to the Basic Design.

RAM analysis was also performed during the Basic Design in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to evaluate decisions made during design, such as levels of redundancy, general equipment types, and general equipment configurations. The team review issue of the report identified two main component types which affect the unavailability and recommended improvements in the oxidation air absorber motor and its agitator. Team review comments have not been incorporated at this time.

A Failure Modes, Effects, and Criticality Analysis (FMECA) was performed during the Basic Design to identify potential failure modes, failure causes and subsequent failure effects on system performance.

Refer to the following documents (attached) for additional information on these analyses.

Document	SPF File Number	Document / File Number
RAM Analysis	200-127168	
FMECA Analysis	200-122279	178771.41.0201

[8] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

3.16.4 Procurability Assessment

All equipment and materials required for the Medupi FGD Retrofit Project are available in the international market. To assist in the identification of equipment and materials available within South Africa, it was intended to issue a contractor questionnaire, however this could not be accomplished during Basic Design. Information from the Kusile FGD installation was reviewed to identify potential local suppliers for equipment and materials (Table 7) and fabrication and construction contractors (Table 8).

Table 7: Local Supply Capability for Equipment and Materials

Commodity/Scope	On Shore	Off Shore	Country	Comments
MV Motors	X		South Africa	Full local capability - design, supply and install
Grounding & Lightning System, Lighting & Small Power, I&C Installation	X		South Africa	Full local capability - design, supply and install
Variable Speed Drive	X	X	Partial	Local suppliers available, critical components are imported
On-Off Recycle Valves	X		South Africa	Full local capability - design, supply and install
On-Off Actuated Motorized & Pneumatic Valves	X		South Africa	Full local capability - design, supply and install
Control Valves	X		South Africa	Full local capability - design, supply and install
Instrumentations		X		
Flue Gas Analysers		X		
Oxidation Air Blowers		X		
Sump Pumps		X		
Mist Eliminator		X		
Agitators		X		Local agents, equipment is imported
Absorber Spray Nozzles		X		
Flake Lining	X			
Suction Strainer		X		
Ball Mills	X	X	Partial	Shared scope and capability, main contractor offshore
Dewatering System	X	X	Partial	Shared scope and capability, main contractor offshore
Recirculation Pumps	X	X	Partial	Shared scope and capability, main contractor offshore
Water Pumps	X		South Africa	Full local capability - design, supply and install
Horizontal Slurry Pumps	X		South Africa	Full local capability - design, supply and install
Bridge Cranes	X		South Africa	Full local capability - design, supply and install

Commodity/Scope	On Shore	Off Shore	Country	Comments
Elevators	X		South Africa	Full local capability - design, supply and install
Hoist	X		South Africa	Full local capability - design, supply and install
Dedusting System	X		South Africa	Full local capability - design, supply and install
Heating & Ventilation (HVAC) - Package	X		South Africa	Full local capability - design, supply and install
BoP FRP Piping	X		South Africa	Full local capability - design, supply and install
Recycle Pipes (FRP)	X	X	Partial	Shared scope and capability, main contractor offshore
GRP Spray headers	X	X	Partial	Shared scope and capability, main contractor offshore
Piping Insulation	X			Full local capability - design, supply and install
Expansion Joint - Piping	X			Full local capability - design, supply and install
Absorber Modules Alloy Material		X		High alloy material not readily available locally
Lances Material (SMO254)		X		Lances material (SMO254) not readily available
Duct Works (FRP)	X	X		Shared scope and capability, main contractor offshore
Expansion Joint - Ducts	X		South Africa	Full local capability - design, supply and install
Buildings - Architectural Enclosures and Finishes	X		South Africa	Full local capability - design, supply and install
Cable - Control & Instrumentation (All Sizes)	X		South Africa	Full local capability - design, supply and install
Cable - Low & Medium Voltage	X		South Africa	Full local capability - design, supply and install
Cooling Tower	X		South Africa	Full local capability - design, supply and install
Fire Protection Equipment	X		South Africa	Full local capability - design, supply and install
Materials Handling Equipment	X		South Africa	Full local capability - design, supply and install
Metal Wiring Channels	X		South Africa	Full local capability - design, supply and install
Panel Boards	X		South Africa	Full local capability - design, supply and install
Pipe Supports	X		South Africa	Full local capability - design, supply and install
Piping (CS, SS)	X		South Africa	Full local capability - design, supply and install

Commodity/Scope	On Shore	Off Shore	Country	Comments
Raceway (Cable Tray)	X		South Africa	Full local capability - design, supply and install
Transformers Various Sizes	X		South Africa	Full local capability - design, supply and install
Structural Steel (Steel, Grating, Handrails, Access Platforms, Utility Rack)	X		South Africa	Full local capability - design, supply and install
Water Treatment System	X		South Africa	Full local capability - design, supply and install
Waste Water Treatment System (ZLD)	X		South Africa	Full local capability - design, supply and install
Surveying and Geotech	X		South Africa	Full planning capabilities and execution
Spray Nozzles		X		Potential to develop local capability specific for FGD application
Switchgear	X	X		Shared scope and capability - breakers imported
Compressed Air Equipment	X		South Africa	Full local capability - design, supply and install

Table 8: Local Supply Capability for Fabrication and Construction Contractors

Scope	On Shore	Off Shore	Country	Comments
Absorber- Grinding and C276 Welding -Erection	X		South Africa	Full local capability
Absorber Tower Preassembly and Assembly	X		South Africa	Full local capability
All Tanks/Silos Erection	X		South Africa	Full local capability
Structural Steel- Erection	X		South Africa	Full local capability
Absorber Pre-Assembling	X		South Africa	Full local capability
Ducting Installation and Installation	X		South Africa	Full local capability
Steel and Profile Fabrication	X		South Africa	Full local capability
Absorber/Tanks/Silos - Field Erected Tanks	X		South Africa	Full local capability
Grouting	X		South Africa	Full local capability
Metal Decking	X		South Africa	Full local capability
Concrete Slab	X		South Africa	Full local capability
Scaffolding	X		South Africa	Full local capability
C276 Inlet Duct Alloy Fabrication	X		South Africa	Full local capability
Tanks Secondary Structure-Fabrication	X		South Africa	Full local capability

Scope	On Shore	Off Shore	Country	Comments
Absorber Blasting and Rubber Lining	X	X	South Africa	Shared scope and Capability, Main Contractor offshore
Mechanical Package	X		South Africa	Full local capability
Lighting	X		South Africa	Full local capability
Insulation and Lagging	X		South Africa	Full local capability
Foundation (Excavation, Backfill, Reinforcing, etc.)	X		South Africa	Full local capability
Piping	X		South Africa	Full local capability
Tanks Secondary Structure-Fabrication	X		South Africa	Full local capability
Terrance Construction(Site Earthworks, Grading, Drainage, Roads and Surfacing, Erosion Control, Landfill)	X		South Africa	Full local capability
Abs Module-Loading - Transport-Lifting Package	X		South Africa	Full local capability

3.16.5 Constructability Assessment

As a retrofit project, constructability of the design was evaluated during the review of each project deliverable.

The Construction Execution Plan (178771.41.0111, SPF file 200-60812), attached, evaluated the conceptual design for constructability and access and made recommendations to be considered during detailed design and construction. Demolition and relocation requirements are shown on FGD Area Demolition and Relocation Plan (178771-CGAU-S3002, SPF file 0.84/36017), attached. The conceptual construction area and lay down site arrangement are shown on the Construction Facilities Drawing (178771-DS-1003, SPF file 0.84/36018), attached.

The content of the Construction Execution Plan is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the construction management approach presented therein.

3.16.6 Inspectability and Testability Assessment

The plant design and layout was reviewed in accordance with the Medupi Power Station User Requirements Specification Revision 4 [4] to confirm that sufficient features, such as test ports, sample connections, access platforms, instrumentation, redundant equipment, etc. were included to enable in-service inspections and/or tests to be performed to the respective system to verify that the system meets the design requirements/specifications (i.e., a field performance test or inspection of a pump).

3.16.7 Sustainability Assessment

Per the User Requirements Specification [4], the design life of the FGD plant supports the overall plant life requirement of 200,000 hours over 50 years. The Basic Design of the Medupi FGD Retrofit includes standby spare equipment to support the ongoing maintenance of the plant to support continued operations throughout the plant life. Refer to the RAM Analysis in Section 3.16.3 for additional details regarding the suitability of the plant standby equipment.

Limestone sourcing will not be completed during the Basic Design phase; however it is recommended that a minimum of two sources be developed so that plant operation is not subject to interruption based on disruption of a single limestone supply.

3.16.8 Expandability Assessment

The FGD retrofit will consume considerable land area to the west of the main power block and would limit the physical space available for plant expansion. The FGD plant and associated auxiliaries have been designed to meet the required performance on a variety of fuel and operating scenarios (refer to the FGD Design Controlling Cases, P06259-S-TAB-015, SPF file 200-92546, attached).

Provisions have been included in the Basic Design to allow the future installation of gas cooling heat exchangers upstream of the FGD absorber modules, to reduce the water consumption of the FGD system. Refer to the Technical Evaluation of flue Gas Cooling options (006265-T-STD-260, SPF file 200-110410), attached, for additional information on this process.

As described in Section 3.5.3.7, the FGD system is designed to produce a saleable byproduct, however as described in Section 3.14.2, it is anticipated that only 20 percent of the gypsum would be sent to market. If market demand for the gypsum byproduct develops to a level where sale of greater than 20 percent of the gypsum production capacity of the FGD plant is economically viable, modification of the material handling systems would be required to increase the loadout capacity of the system.

The capability for future expansion of the FGD plant to achieve greater removal efficiency or to treat higher sulphur fuels was not a design objective; however the FGD is designed to achieve SO_2 emissions according to the Eskom Air Quality Strategy [6], i.e. 400 mg/Nm³ at 6 percent O_2. The emissions standard of South Africa only requires a SO_2 reduction below 500 mg/Nm³ referred to an O_2 content of 10 percent. Therefore, the necessity of a future expansion of the FGD plant to achieve greater removal efficiency is not expected. If required to further increase the removal efficiency, each absorber possesses a redundant spray bank which can also be operated in parallel with the other spray banks, or adipic acid can be added to the absorber.

3.16.9 Project Development Readiness Assessment Review

An end-of-phase Project Development Readiness Assessment (PDRA) will be conducted for the project after the conclusion of the Basic Design. The following Table 9 provides the locations within this report for supporting information related to PDRA assessment elements. For those items where Table 9 indicates "None," the information related to those elements is outside the scope of this report.

Table 9: PDRA Element References

PDRA Element		Basic Design Document Reference(s)
I. Basis of Project Decision		
	Manufacturing Objectives/Criteria	
A1	Reliability Philosophy	• User Requirements Specification [4], Section 1.5 • Basic Design Report, Section 3.16.3 Reliability, Maintainability, Availability Assessment
A2	Maintenance Philosophy	• User Requirements Specification [4], Section 4.5 • Basic Design Report, Section 3.15 Maintenance Requirements

PDRA Element		Basic Design Document Reference(s)
A3	Operating Philosophy	• User Requirements Specification [4], Section 4.4 • Basic Design Report, Section 3.16.2 Operability Assessment
	Business Objectives	
B1	Products	• Basic Design Report, Section 3.5.3.7 Gypsum Refinement and Dewatering System
B2	Business Need and Purpose	• Basic Design Report, Section 2.2.2 Informative
B3	Project Strategy	• Basic Design Report, Section 0 • Introduction (project charter)
B4	Affordability and Life-Cycle-Cost Drivers	• None
B5	Capacities	• Basic Design Report, Section 3.2.4 Design Criteria
B6	Future Expansion	• Basic Design Report, Section 3.16.8 Expandability Assessment
B7	Expected Project Life Cycle	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.14 Waste Management
B8	Social and Economic Development Planning	• Eskom procurement and contracting strategy
	Basic Data R & D	
C1	Technology Selection	• Medupi FGD Retrofit Technology Selection Study (200-55815)
C2	Processes	• Basic Design Report, Section 3.5.3.1 FGD System
	Project Scope	
D1	Project Objective Statement	• Basic Design Report, Section 1 • Introduction (project charter)
D2	Design Philosophy	• Basic Design Report, Section 3.2.4 Design Criteria
D3	Site Characteristics Available vs. Required	• System Descriptions • Basic Design Report, Section 3.9 Mechanical Design (interface table) • Basic Design Report, Section 3.2.4 Design Criteria
D4	Dismantling/Demolition Requirements	• Basic Design Report, Section 3.16.5 Constructability Assessment
D5	Lead/Discipline Scope of Work	• Basic Design Report, Section 3.5.1 Project Breakdown Structure • Basic Design Report, Section 3.20 Scheduling
D6	Project Schedule	• Basic Design Report, Section 3.20 Scheduling
	Value Engineering	
E1	Process Simplifications	• FGD Redundancy & Size Evaluation (006265-S-TAB-010, SPF file 200-92612) • Balance of Plant System Sizing Criteria Study (178771.41.0103, SPF file 200-55814)

PDRA Element		Basic Design Document Reference(s)
E2	Value Engineering Process	• List of Attachments (Volume II) (Duct material, absorber insulation, and piping materials etc. studies)
E3	Design for Constructability	• Basic Design Report, Section 3.16.5 Constructability Assessment
II. FRONT END DEFINITION		
	Site Information	
F1	Site Location	• Basic Design Report, Section 3.6 Siting
F2	Surveys and Soil Tests	• Basic Design Report, Section 3.2.4 Design Criteria
F3	Environmental Assessment	• None
F4	Permit Requirements	• None
F5	Utility Sources/Supply Conditions	• Basic Design Report, Section 3.9 Mechanical Design (interface table)
F6	Fire Protection/Safety Considerations	• Basic Design Report, Section 3.17.2 Fire Safety Assessment • Basic Design Report, Section 3.9 Mechanical Design
	Process/Mechanical	
G1	Process Flow Sheets	• List of Attachments (Volume II) (P&IDs, Flow Sheets etc.)
G2	Heat and Material Balances	• Basic Design Report, Section 3.5.3.1 FGD System • Basic Design Report, Section 3.14.1 Water Purification (Water balance in attached study)
G3	Piping and Instrument Diagrams	• List of Attachments (Volume II) (P&IDs, Flow Sheets etc.)
G4	Process Safety Management	• Basic Design Report, Section 3.16 Design Assessment • Basic Design Report, Section 3.17 Safety Assessment • Basic Design Report, Section 3.23 Risk Register
G5	Utility Flow Diagrams	
G6	Project Specifications	• Basic Design Report, Section 3.2.4 Design Criteria (WIPs under development)
G7	Piping/Cabling/Conveying System Requirements	• Basic Design Report, Section 3.2.4 Design Criteria (WIPs under development)
G8	Plot Plan	• Basic Design Report, Section 3.6 Siting
G9	Equipment Lists	• Basic Design Report, Section 3.9 Mechanical Design • Basic Design Report, Section 3.11 Electrical Design
G10	Line List	• Basic Design Report, Section 3.10 Piping Design
G11	Tie-In List	• Basic Design Report, Section 3.9 Mechanical Design (interface table)
G12	Specialty Items Lists	• Basic Design Report, Section 3.10 Piping Design

PDRA Element		Basic Design Document Reference(s)
G13	Instrument Index	• Basic Design Report, Section 3.12 Control and Instrumentation Design (Instrument list)
	Equipment Scope	
H1	Equipment Status	• Basic Design Report, Section 3.4 Procurement Strategy
H2	Equipment Location	• List of Attachments (Volume II) (Plot Plan, Site Arrangement, General Arrangements)
H3	Equipment Utility	• Basic Design Report, Section 3.13 Utilities Required
	Civil/Structural/Architectural	
I1	Civil/Structural Requirements	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.8 Civil Infrastructure and Building Design • List of Referenced Documents (calcs, steel drawings, etc.)
I2	Architectural Requirements	• Basic Design Report, Section 3.2.4 Design Criteria • Basic Design Report, Section 3.8 Civil Infrastructure and Building Design • List of Referenced Documents (architectural drawings, etc.)
	Infrastructure	
J1	Water Treatment	• Basic Design Report, Section 3.5.3.5 FGD Makeup Water and Process Water Supply • Basic Design Report, Section 3.5.3.8 FGD ZLD Treatment System • Basic Design Report, Section 3.14.1 Water Purification • List of Attachments (Volume II) (site drainage, system descriptions)
J2	Loading/Unloading/Storage Facilities Requirements	• Basic Design Report, Section 3.5.3.6 Limestone Handling and Limestone Preparation Systems • Basic Design Report, Section 3.5.3.7 Gypsum Refinement and Dewatering System
J3	Transportation Requirements	• Basic Design Report, Section 3.6 Siting (Plot plan - roads) • Basic Design Report, Section 3.16.5 Constructability Assessment • Logistics study is part of Rail Yard Project
	Instrument & Electrical	
K1	Control Philosophy	• Basic Design Report, Section 3.12 Control and Instrumentation Design
K2	Logic Diagrams	• Basic Design Report, Section 3.12 Control and Instrumentation Design
K3	Electrical Area Class	• None
K4	Substation Requirements	• Basic Design Report, Section 3.11 Electrical Design

PDRA Element		Basic Design Document Reference(s)
K5	Elect One Line Diagrams	• Basic Design Report, Section 3.11 Electrical Design
K6	Instrumentation and Electrical Specifications	• Basic Design Report, Section 3.11 Electrical Design • Basic Design Report, Section 3.12 Control and Instrumentation Design
III. EXECUTION APPROACH		
	Procurement Strategy	
L1	Identify Long Lead/Critical Items	• Basic Design Report, Section 3.4 Procurement Strategy • Basic Design Report, Section 3.20 Scheduling
L2	Procurement Procedures/Plans	• Eskom procurement and contracting strategy
L3	Procurement Responsibilities	• Eskom procurement and contracting strategy
	Deliverables	
M1	CADD/Model Requirements	• List of Attachments (Volume II) (in Project Execution Plan; IT tools plan)
M2	Deliverables Defined	• (Project Deliverables Register)
M3	Distribution Matrix	• None
	Project Control	
N1	Project Control Requirements	• None
N2	Project Accounting Requirements	• None
N3	Risk Analysis	• None
	Execution Plan	
P1	Owner Approval Requirements	• None
P2	Engineering/Construction Plan/Approach	• None
P3	Shut/Turnaround Requirements	• None
P4	Pre-Commissioning/Turnover Sequence	• None
P5	Startup Requirements	• None
P6	Training Requirements	• None

3.17 SAFETY ASSESSMENT

Each building and area layout associated with the Basic Design of the Medupi FGD Retrofit was reviewed using the 3D Model and 2D drawings to ensure that the plant design and layout included life-safety considerations in accordance with the Fire Protection and Life Safety Design Standards (240-56737448 and 240-54937450) per subsection 1.11 “Fire Protection” of the PDM (178771.22.0000, SPF file 200–61989), attached.

3.17.1 Industrial Safety Assessment

A Hazard and Operability analysis (also known as HAZOP study or HAZOP) was performed during the Basic Design (SPF file 200-135697) to identify potential hazards in the system and to identify potential operability problems with the system. The preliminary (team review) version of the report is included with the final Basic Design Report.

3.17.2 Fire Safety Assessment

A Plant Fire Protection/Detection Assessment (SPF file 474-9699), attached, for the new FGD plant was performed by Eskom. The assessment was carried out to define and analyse all fire risks associated with the plant in view of the plant-specific considerations regarding design, layout and anticipated operating requirements.

3.18 INVESTMENT PROTECTION

The primary FGD subsystem which requires special protective measures is the absorber internals. In the event of a unit trip with loss of electrical power, hot gas would pass through the ductwork and absorber as the boiler is ventilated and cools down. It is possible for this hot gas to damage the rubber lining and mist eliminator within the absorber, and may cause a fire. To protect the absorber internals, a flue gas bypass is included as described in Section 3.5.3.2. The bypass isolation dampers are powered from the Emergency Electrical Supply as described in Section 3.5.3.15.4.

3.19 SECURITY

The FGD retrofit will not adversely affect the plant's security requirements.

3.20 SCHEDULING

Three documents were created and reviewed by the team to develop the Level 3 ERA schedule. The first document was the system matrix (178771.24.2010.20, SPF file 200-106694). The system matrix identifies the systems and associated engineering deliverable that will be utilized during the execution phase. The second document was the procurement matrix (refer to Section 3.4). The procurement matrix was used to establish how the equipment would be packaged to be purchased and the construction contracting strategy. The third document is the schedule fragnets. The fragnet shows the sequence of activities from start of a work process to the completion of a work process. Once the system and procurement matrix's were reviewed, typical fragnets (fragments of a network) (refer to the list of referenced Basic Design documents) were developed for each system and deliverable.

A Work Break Down Structure (WBS) was created in the schedule using the KKS systems that will be used for this project (refer to Section 3.5.1 herein). The WBS was used to develop the planning document known as the system matrix.

Long lead equipment and critical items were taken into consideration when developing the detailed level 3 schedule. It is important to get the long lead equipment awarded early in order to receive vendor information to support engineering deliverables, construction installation and commissioning. The long lead equipment for this project are considered to be the FGD absorbers, oxidation air blowers, absorber spray (recycle) pumps, material handling system, gypsum dewatering system, Limestone Preparation System, FGD station service transformer and FGD wastewater treatment (ZLD).

A level 3 ERA schedule (178771.24.2010.26, SPF file 200-117150) was developed using the fragnets to show detailed logic relationship between engineering, procurement, construction and commissioning.

A level 2 ERA Schedule (178771.24.2010.21, SPF file 200-117133), attached, was developed to show summary bars for engineering by system and deliverable, procurement and construction. The level 2 schedule was derived from the construction planning areas and packaging plan. The level 2 schedule was a roll up of activities produced directly from the Primavera level 3 schedule

The level 1 ERA schedule (178771.24.2010.20, SPF file 200-117132), attached, that was developed during the Concept Phase was updated to reflect changes from the level 3 logic driven schedule. The level 1 Microsoft Visio indicates the timelines for bid and award, vendor engineering, fabrication and delivery, construction, and pre commissioning for the first unit's FGD and the common equipment. It is planned that subsequent units are to be completed at six month intervals.

The start of the ERA phase was based on a start date of October 2016 due to funding constraints. The commercial operation of the first FGD system is planned to be complete by January 2022. The remaining units are planned to be completed at six month intervals. It was assumed that 60-day outage dates will be selected based on the ideal construction sequence, rather than as dictated by the dates for the first Mini General Overhaul (MGO). Therefore at this time the tie-in outages may not align with other work at the Power Station. Actual outage dates will be coordinated with Eskom Generation during execution of the project.

These schedules are based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the project design basis, project scope, execution plan, or contracting approach will impact the time for completion and activity relationships and durations.

The critical path begins with the bid and award of major long lead equipment. The critical path continues through construction of the foundations, followed by building erection so the equipment, piping, electrical and controls can be installed prior to commissioning of the FGD system and balance of plant equipment. It is anticipated that an outage will occur to tie in the new FGD ductwork to the existing operating ductwork.

3.21 LIFE CYCLE COST ANALYSIS

The life cycle cost analysis presented in this section includes the levelized annual fixed charges on capital and levelized annual operating costs (consumables, labour, and maintenance) associated with the FGD retrofit to the Medupi Power Station.

The capital cost estimates include the cost for FGD and ancillary systems, auxiliary electric, structural, mechanical and other required balance-of-plant system upgrades. The operating cost estimates were based on operation at full-load conditions.

3.21.1 Capital Cost Estimate

A preliminary Capital Cost Estimate (178771.25.2000, SPF file 200-128137), attached, was developed for the equipment and materials, construction, and engineering costs to implement the Medupi FGD Retrofit Project. This estimate was developed from historical pricing and quantities and includes escalation and contingency, but excludes Owner's costs (such as project development, Owner personnel for engineering, startup, and construction management, taxes, financing, or Owner contingency for these items). A summary of the capital costs are provided in Table 10.

The Capital Cost Estimate is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC (or hybrid) approach at a later stage. Changes to the contracting approach will affect the cost and schedule for the project.

Table 10: Capital Cost Estimate Summary

Description	Cost, ZAR
Civil / Structural Purchase Contracts	723,714,300
Mechanical Purchase Contracts	350,301,400
Electrical Purchase Contracts	258,531,500
Environmental Purchase Contracts	2,657,483,600
Subtotal Purchase Contracts	**3,990,030,800**
Civil / Structural Construction Contracts	2,655,178,000
Mechanical Construction Contracts	3,940,802,000
Electrical Construction Contracts	1,320,101,500
Control and Instrumentation Construction Contracts	411,185,900
Construction Service Contracts	1,318,016,900
Subtotal Construction Contracts	**9,645,284,300**
Indirect Costs	2,326,516,300
Contingency	1,715,900,400
Escalation	Included
Total Capital Requirements	**17,677,731,800**

3.21.1.1 Estimate Basis

The capital cost estimate is a definitive-level (±10 to 15 percent accuracy) estimate presented in 2014 South African Rand (ZAR) based on information obtained from the following sources:

- Steinmüller in-house database.
- Black & Veatch in-house database.
- Publicly available cost data.

Direct costs consist of purchased equipment and its installation, as well as miscellaneous costs. Purchased equipment and material costs include the cost for purchasing equipment and construction materials from multiple subcontractors in accordance with the Project Procurement Plan (178771.23.1110, SPF file 200-92430), attached. The installation costs also consider retrofit-related issues, based on the existing site configuration. Finally, miscellaneous costs account for the costs for additional items such as site preparation, buildings, and other structures. The direct costs estimates were based on the following assumptions:

- A regular supply of construction craft labor and equipment is available.
- Normal lead-times for equipment deliveries.
- Construction utilities (power, water, air) would be readily available.

3.21.1.2 Estimate Exclusions

The capital cost estimate does not include the following:

- Testing for environmental hazards, including remediation, removal or disposal of, but not limited to: asbestos, lead paint, underground contamination, and PCBs.
- Labor and material costs resulting from underground interferences.
- Salvaging or storage of equipment or structures.
- Scrap values.
- Upgrade or repairs to off-site roads, bridges and foundations, if required.
- Owner's costs such as project development, Owner personnel for engineering, startup, and construction management, taxes, financing, or Owner contingency for these items.
- Operational spares.
- Local taxes.

3.21.1.3 Indirect Costs

Indirect costs are those costs that are not related to the equipment purchased, but are associated with any engineering project such as the retrofit of a new control technology. Indirect costs include the following:

- Contingency.
- Engineering (contractor engineering and Owner's Engineer).
- Construction management.
- Contractor indirect costs.
- Project insurance.
- Performance bond.
- Contractor overhead and profit.

3.21.1.4 Contingency

Contingency accounts for unpredictable events and costs that could not be anticipated during the normal cost development of a project. The contingency cost category includes items such as possible redesign and equipment modifications, errors in estimation, unforeseen weather-related delays, strikes and labour shortages, escalation increases in equipment costs, increases in labour costs, delays encountered in start-up, etc.

3.21.1.5 Escalation

Escalation costs account for changes in cost from the date of estimate (today) until the date of actual expenditure. Escalation was based on 3 percent average escalation from April 2014 to the midpoint of construction, which yielded an overall escalation rate 12.6 percent. This escalation rate was applied to all labour and material costs included in the estimate and is included in the estimate line items.

3.21.2 Operations and Maintenance Cost Estimate

An preliminary Operations and Maintenance (O&M) Cost Estimate (178771.25.2000, SPF file 200-128137), attached, was developed to show incremental O&M costs associated with the addition of FGD to the Medupi Power Station.

A summary of the O&M costs are provided in Table 11.

Table 11: Operations and Maintenance Cost Estimate Summary

Description	Annual Station Cost For 85 Percent $CaCO_3$ Limestone (2014 ZAR)	Annual Station Cost For 96 Percent $CaCO_3$ Limestone (2014 ZAR)
Scrubber Reagent	429,123,000	470,865,000
Auxiliary Power	135,640,000	135,640,000
Water	143,265,000	145,988,000
Steam	11,300,000	11,300,000
FGD ZLD Pretreatment and Treatment System Chemicals		
Hydrated Lime (Ca Hydroxide)	37,549,000	49,000
Soda Ash (Sodium Carbonate)	86,214,000	78,553,000
Sodium Sulphate, 50% solution	4,463,000	4,920,000
Caustic, 50% solution	9,631,000	10,108,000
Sulfuric Acid, 66 Baume	2,452,000	2,648,000
Ferric Chloride, 50% solution	275,000	250,000
Antiscalant, 100% solution	1,880,000	1,880,000
Antifoam, 100% solution	124,000	124,000
Polymer, 100% solution	548,000	365,000
FGD ZLD Pretreatment Solids Waste (Clarifier Solids for Disposal)	3,606,000	1,797,000
FGD ZLD Treatment Solids Waste (Brine Concentrator/Crystallizer Solids for Disposal)	938,000	941,000
Byproduct Disposal (Gypsum)	58,547,000	55,168,000
Maintenance	220,972,000	220,972,000
Permanent Plant Personnel	44,429,000	44,429,000
Total Annual Operations and Maintenance Cost (2014 ZAR)	**1,190,956,000**	**1,185,997,000**

3.21.3 Total Levelized Annual Cost Analysis

This section provides a lifecycle costs analysis consisting of a total levelized annual cost and a cumulative present worth analysis for retrofitting an FGD system at the Medupi Station. Economic criteria used in the lifecycle cost analysis were developed collaboratively between Eskom and Black & Veatch. Economic inputs to the lifecycle cost analysis are described below and summarized in Table 12.

- Evaluation period -- The economic life of the project was assumed to be 40 years.
- General escalation rate -- The general escalation rate was used to escalate the costs capital to the date of commercial operation and escalate O&M cost for future years.
- Present Worth Discount Rate (PWDR) -- The PWDR is used to discount future cash flow values to a present values.
- Levelized Fixed Charge Rate (LFCR) -- The LFCR is the single rate which, when applied to the total capital cost of a project, determines the levelized annual revenue requirements needed to recover all fixed costs associated with the capital of the project and provide the necessary return to meet an originations weighted average cost of capital.
- The lifecycle cost analysis includes the cost of capital and the cost of annual O&M expenses.
- The lifecycle cost analysis does not include any debt issuance fees, debt reserve fund costs, payment in lieu of taxes, annual insurance premiums, profit, etc.
- All analyses are pre-tax.

Table 12: Lifecycle Cost Analysis Economic Criteria

Description	Value
First Year of Operation, year	2022
Evaluation Period, years	40
Present Worth Discount Rate, percent	8.9
Levelized Fixed Charge Rate, percent	10
General Escalation Rate, percent	6

A levelized annual cost consisting of annual levelized fixed charges on capital and annual levelized O&M costs is summarized in Table 13. The annual levelized fixed charges on capital are the product of total capital cost, as reported in Table 10, and the LFCR. Annual levelized O&M costs consist of levelized annual costs for consumables, maintenance, and plant personnel.

Table 13: Total Levelized Annual Costs

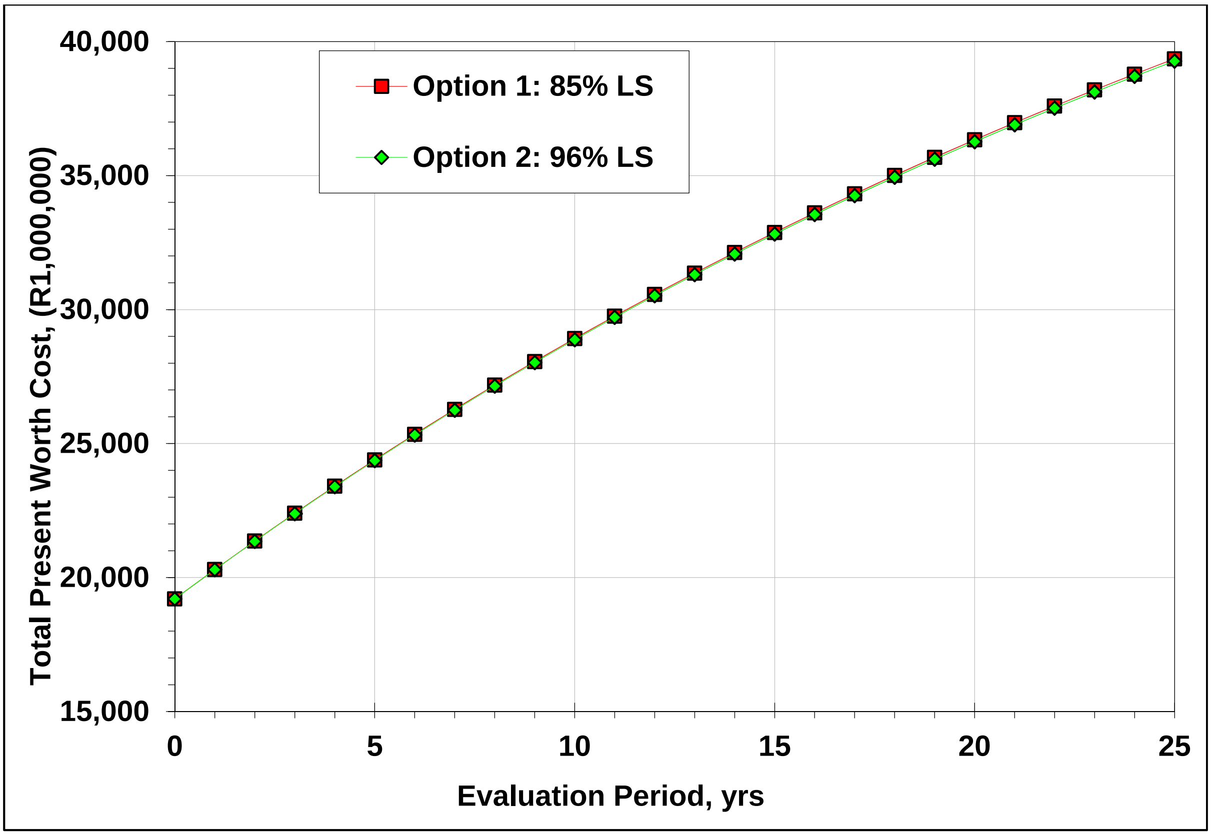
Description	Annual Cost, For 85 Percent $CaCO_3$ Limestone ZAR	Annual Cost, For 96 Percent $CaCO_3$ Limestone ZAR
Levelized Fixed Charges on Capital	1,767,773,000	1,767,773,000
Levelized Annual O&M Costs		
Scrubber Reagent	899,268,000	986,742,000
Auxiliary Power	284,247,000	284,247,000
Water	300,225,000	305,931,000
Steam	23,680,000	23,680,000
ZLD Pretreatment Solids Disposal Cost	7,557,000	3,766,000
ZLD Treatment Solids Disposal Cost	1,966,000	1,971,000

Description	Annual Cost, For 85 Percent $CaCO_3$ Limestone ZAR	Annual Cost, For 96 Percent $CaCO_3$ Limestone ZAR
ZLD Pretreatment/Treatment Chemicals Cost	299,955,000	207,251,000
Byproduct Disposal	122,692,000	115,610,000
Maintenance	463,067,000	463,067,000
Permanent Plant Personnel	93,105,000	93,105,000
Total Levelized Annual O&M Costs	2,495,761,000	2,485,370,000
Total Levelized Annual Costs	**4,263,534,000**	**4,253,143,000**

3.21.3.1 Cumulative Present Worth

The cumulative present worth consist of a cumulative summation of present worth total annual costs comprised of the annual fixed charges on capital and present worth operating costs. Figure 1 presents the cumulative present worth costs for the FGD retrofit at the Medupi Power Station over a 25 year period.

Figure 1: Cumulative Present Worth Analysis



3.22 TESTING AND COMMISSIONING

The sequence for turnover of the project for pre-commissioning and start-up were included in the Construction Execution Plan (178771.41.0111, SPF file 200-60812). The Construction Execution Plan also outlined the methodology to test the systems/plant design to prove that all requirements are met; validate the integrity of the installation; and ensure the system operates as intended, such that it may be put in service.

3.23 RISK REGISTER

A Risk Analysis was performed to identify major risks associated with executing the Medupi FGD retrofit project, and document the plans and strategies to manage and mitigate those risks. At this stage of project development, identifiable risks are generally those that arise based upon the planned project execution strategy or are typical for large projects of this nature. As project development continues, it is anticipated that the risk mitigation plans identified herein will be refined, and additional risks will be identified and appropriate mitigation strategies developed.

The content of this analysis is based upon a multi-contract EpCM approach in line with the Project Definition planning. This approach is under review and may be revised to a multi-package EPC or hybrid EPC approach at a later stage. Changes to the contracting approach may affect the risks, costs, and schedule addressed herein.

3.23.1 Risk Analysis

This document addresses risks for the Medupi FGD Retrofit Project in the following areas.

- Cost
- Schedule
- Change
- Quality
- Commercial
- Technical/Performance
- Labour Resources
- Procurement
- Information Technology (IT) Tools
- Safety
- Construction Execution

Each area is considered individually, and the key risk mitigation activities are summarized in Section 3.23.2.

3.23.1.1 Cost Risk

Cost risks are those items which have the potential to increase the project costs beyond the budgeted or projected costs for the project.

Table 14: Project Cost Risk Analysis

Potential Cost Risk	Analysis	Mitigation
Accuracy of project cost estimate	The project cost estimate may be subject to inaccuracies in equipment and material prices, labor costs, and labor productivity. Vendor quotations for major equipment used to support the project estimated developed during the Basic Design were limited to approximately 10 percent of the equipment and material costs.	Use historical prices, costs, and productivities, and include appropriate levels of escalation and contingency.
Incomplete scope of cost estimate	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. Incomplete information development at the time of procurement may be addressed through conservative assumptions in material quantity.	Include allowances for conservative design in the project budget.
Changes in design	The input of new information or new requirements to the project during execution can result in design changes and possible rework.	See change risk analysis below.
Cost escalation, pricing volatility	The long duration of the project exposes the project to increases in the cost of equipment, materials, and labor due to inflation, worldwide demand, and other world events.	Escalation and contingency estimates in the project budget address escalation uncertainty. Transfer escalation risk to the contractors through firm pricing covering delivery and services for the duration of the project.
Scope growth	During project execution, identification of additional scope which was inadvertently omitted during conceptual design but required for the project can result in increased project costs.	1. Identification and resolution of project scope issues during basic design. 2. Include contingency for design evolution. 3. Limit project scope exclusively as needed to implement the FGD retrofit.
Construction productivity	Experience at the Medupi and Kusile construction sites has shown that contractor performance can delay the project schedule which increases project costs.	See labor resource risk below.
Availability of skilled labour resources	Experience at the Medupi and Kusile construction sites has shown that the availability of skilled laborers can increase project costs.	See labor resource risk below
Craft labour strikes	Experience at the Medupi and Kusile construction sites have proven that a strike can delay the project which leads to increased costs to the project.	Execute the project as planned. Work additional hours to recover lost time to the schedule.

3.23.1.2 Schedule Risk

Schedule risks are those items which could cause project delays which would impact the commercial operation of the FGD systems.

Table 15: Project Schedule Risk Analysis

Potential Schedule Risk	Analysis	Mitigation
Project initiation	The schedule from the start of engineering and procurement activities until operation of the first FGD system is 68 months. This time is necessary to support procurement, engineering, fabrication, delivery, and construction of the Unit 6 FGD and common systems.	ERA approval by the end of second quarter 2015 and full project release by the third quarter 2016 is needed to achieve operation of the first FGD unit by January 2022.
Overall schedule duration	Sufficient time is needed to develop the design prior to releasing procurement packages, to establish firm quantities and to coordinate design inputs from other packages. The current project schedule supports limited design input from early packages.	1. Execute the project as planned to support timely information exchange. 2. Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
Open design issues	A list of open design issues at the conclusion of the Basic Design has been maintained and is included in the Basic Design Report. Timely resolution of these issues will be necessary to maintain the overall project schedule.	1. Pursue resolution of design input issues (e.g., geotechnical investigation) prior to release for execution phase engineering. 2. Review open issues list at the outset of execution phase, establish milestones for resolution, and monitor progress toward resolution.
Schedule coordination	The project schedule spans 10 years and affects multiple generating units. There is a high potential for external events to arise which would impact the schedule.	Conduct regular planning and coordination meetings with the various project stakeholders, including plant management to discuss overall schedule and upcoming events.
Procurement bid/award cycle duration	The long period of time necessary to bid, evaluate, and award procurement packages prevents the timely receipt of design information from earlier packages as input in developing subsequent procurement packages.	1. Establish high quality estimates where possible, using material takeoffs developed during Basic Design. 2. Execute the project as planned to support timely information exchange. 3. Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
Changes in design	The input of new information or new requirements to the project during execution can result in design changes and possible rework. Design changes can also result in the delay of accurate information from earlier awarded packages.	See change risk analysis below
Changes in procurement packaging	The project schedule presumes that engineering information will be provided from certain packages as design input for other packages. Changes to the packaging plan could affect the project schedule if information is not available in a timely manner.	Include schedule impacts as an evaluation criterion when considering potential changes to the packaging plan.

Potential Schedule Risk	Analysis	Mitigation
Construction productivity	Experience at the Medupi and Kusile construction sites has shown that contractor performance can delay the project schedule which increases project costs.	See labor resource risk below
Craft labour strikes	Experience at the Medupi and Kusile construction sites have proven that a strike can delay the project which leads to increased costs to the project.	Execute the project as planned. Work additional hours to recover lost time to the schedule.
Overwhelming the capacity of equipment suppliers	The FGD wastewater treatment system is relatively large and potentially may be problematic for equipment suppliers to meet a typical schedule. The risk is even higher for the brine concentrator and crystallizer equipment which uses more exotic metallurgy.	Assess vendor capabilities during the supplier prequalification process.

3.23.1.3 Change Risk

Change risks are those items arising from the input of new information or new requirements to the project during execution. Most often, change risks ultimately impact the project cost, schedule, or both.

Table 16: Project Change Risk Analysis

Potential Change Risk	Analysis	Mitigation
Change management	A defined change identification and approval process is needed to ensure that potential changes are screened for approval and information is provided to the affected parties.	1. Document the change management process as part of project execution plan early in the project. 2. Communicate the plan to the project participants.
Design interface	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. Incomplete information development at the time of procurement creates the risk for design changes and contractor change orders. Design changes can also affect the flow of information from the earlier procurement packages.	1. To the extent possible, schedule procurement package development following the scheduled receipt of vendor engineering information from prior packages. 2. Make conservative design assumptions to develop preliminary information that is needed prior to confirmation by receipt of vendor information.

3.23.1.4 Quality Risk

Quality risks are those items which can negatively influence the quality of the installation, with associated impacts on the safety, operability, maintainability, or life of the operating facility.

Table 17: Project Quality Risk Analysis

Potential Quality Risk	Analysis	Mitigation
Quality assurance reviews	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have a demonstrated quality track record.	1. Establish a Quality Assurance Plan as part of the project execution plan. 2. Assess and screen vendor capabilities during prequalification.
Field quality management	While responsibility for quality belongs to the individual contractor, centralized quality management is necessary to provide accountability.	1. Implement a project-specific Field Quality Management program to verify quality. 2. Provide quality training to project field staff.
Design interface	Incomplete or inaccurate engineering interface among procurement packages could result in design coordination errors.	See Change Risk analysis above.
Poor familiarity with Eskom requirements	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have prior experience with Eskom, and are not familiar with Eskom processes, procedures, and unique requirements.	1. Identify potential issues early through specification review. 2. Provide early notice during supplier prequalification. 3. Allow sufficient time in the procurement and contract performance periods for corrective action by contractors.

3.23.1.5 Commercial Risk

Commercial risks are those items related to supplier and contractor terms and conditions which can influence project risks described in this report.

Table 18: Project Commercial Risk Analysis

Potential Commercial Risk	Analysis	Mitigation
Schedule coordination	Timely, accurate, and compatible schedule information is needed from the contractors to facilitate overall project coordination.	Include provisions to require regular updates to contractor schedules to be provided in Primavera format.
Warranty	The typical "OEM" scope for the FGD system is planned to be broken into multiple packages. Overall performance risk arising from the coordination of the design and performance requirements is transferred to Eskom in this execution model.	Utilize Process Design and Engineering Management Partners who have experience with the design and performance coordination associated with the supply of FGD equipment.

3.23.1.6 Technical / Performance Risk

Technical and performance risks are design-related items which can impact the utility of the facility for the end user.

Table 19: Project Technical / Performance Risk Analysis

Potential Technical / Performance Risk	Analysis	Mitigation
FGD process design	FGD process design is new to Eskom. The absence of design experience could result in design errors.	Utilize experienced Process Design Partner to develop the Medupi FGD process design and mentor Eskom engineers during the design process. Utilize experienced Engineering Management Partner to review the design based on prior experience.
Operational training	Eskom has limited experience with wet FGD system operation. Proper operation will require skilled operators.	1. Plan for thorough vendor training as well as process training by Process Design Partner. 2. Begin training process early, so that a number of trained operators are available during startup for “on-the-job” training in FGD system operation. 3. Ensure that adequate technical support field services are included in the FGD-related packages.
Limestone availability and suitability	The quality, chemical reactivity, and availability to the Medupi site of limestone in sufficient quantities will not be known until the limestone procurement contract is established.	1. Limestone Sourcing Study was performed as input to the Basic Design to establish the likely values and variation for important limestone characteristics. 2. Develop a procedure for limestone specification development, testing, and evaluation as a basis for establishing a contract. 3. Solicit limestone supplier qualifications as to the availability, cost, and quality of limestone. 4. Verify that mass and water balances are within ranges once final limestone qualities have been established.
Waste gypsum disposal	It is assumed that up to 20 percent of the gypsum produced by the FGD system will be sold. The remaining quantity of gypsum is assumed to be disposed in the existing ash dump. The physical and regulatory capability to accept the gypsum produced during the life of the plant should be verified.	1. The physical capability has been assessed by Jones & Wagener (refer to For Information Only: Medupi Power Station, FGD, Jones and Wagener Letters for Co-Disposal of Ash and Gypsum [10]) which concluded that there is sufficient space provided that the excess coal stockyard is removed. 2. Complete regulatory review [12].
Water quality	The design basis water quality for the Mokolo and Crocodile West water supplies is based on prior sampling and may not be representative of the water quality available to the plant in 2020.	1. Raw water pretreatment and wastewater treatment design provides operating flexibility to address some variation in the inlet composition. 2. Routinely monitor the as-delivered water quality to establish typical values and variability for the key constituents.

Potential Technical / Performance Risk	Analysis	Mitigation
Organics in the TOC scavenger wastewater	The TOC scavenger wastewater is sent to the FGD wastewater treatment system. A high level of organics could result in foaming, solids dewatering issues, and high levels of organics in the distillate recovered from the treatment system. High levels of organics in the distillate could cause similar problems in the FGD if it is recycled back to the FGD. The TOC scavenger wastewater quality will not be fully known until the system is operating within the existing plant.	1. Routinely monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability. 2. A specific operating plan to handle the organics in the stream needs to be created. It may be necessary to treat the stream for organics prior to sending it to the FGD wastewater treatment system. It may also be necessary to take a slip stream off of the brine concentrator and dispose of it separately.
FGD wastewater treatment plant turndown	During early operations there will only be one out of six FGDs in operation and the potential exists that the FGD could operate at a high turndown in terms of flue gas flow and chlorine in the coal. This would result in a very high turndown with respect to the FGD wastewater that must be treated. The brine concentrator and crystallizer portions of the FGD wastewater treatment system have limited turndown capability.	1. The train configuration for the FGD wastewater treatment system was established to mitigate this issue. 2. Assess vendor capabilities during the supplier prequalification process and contract negotiations.
Chemical availability	The FGD wastewater treatment system will use a large amount of lime and soda ash. The availability to the Medupi site in sufficient quantities should be verified.	Confirm that current contracts in place are sufficient to meet the quality and large quantities of lime and soda ash that will be required.
FGD wastewater treatment solids disposal	The FGD wastewater treatment will generate a large amount of solids. Two different types of solids will be generated with one being fairly insoluble while the other being fairly soluble. The disposal method for these solids has not been identified.	A disposal plan should be identified to determine if there are any modifications that need to be made to the Basic Design to accommodate the disposal method. Refer to Guideline: Possible alternatives for the disposal of chemical wastes produced by the Flue Gas Desulphurisation process [11]. Complete regulatory review of disposal alternatives [12].
Chlorine demand of raw water supply	The chlorine demand of the Mokolo and Crocodile West raw water supplies has not been identified. The chlorine demand directly affects the amount of sodium hypochlorite that must be fed to the raw water supply to mitigate biological growth issues in the downstream equipment. The sodium hypochlorite feed system has the potential of being undersized depending on the chlorine demand of the raw waters.	The as-delivered water quality of the Mokolo and Crocodile West raw water supply should be monitored so that the chlorine demand can be verified.

3.23.1.7 Labour Resources Risk

Labour resources risks are related to the availability of the engineering, manufacturing, and construction labour needed to implement the project.

Table 20: Project Labour Resources Risk Analysis

Potential Labour Resources Risk	Analysis	Mitigation
Engineering staff availability	Project implementation will require significant engineering staff levels.	1. Early identification of the required staffing levels during the Basic Design. 2. Staff levels supplemented by Process Design and Engineering Management Partners.
Engineering staff experience	Eskom has limited experience with wet FGD system engineering and design.	1. Early identification of the required staffing levels during the Basic Design. 2. Key staff positions filled with experienced engineers from Process Design and Engineering Management Partners. 3. Ensure that Eskom staff with otherwise high experience levels participate to guide and mentor third party engineering staff regarding Eskom standards and practices.
Specialized artisan labour	The Medupi FGD Retrofit Project work scope includes a significant amount of welding/joining, in particular for the Field Erected Tank package and fiberglass reinforced plastic (FRP) piping. Adequate numbers of skilled artisan welders will be needed to execute the work in a timely manner.	1. Assess vendor capabilities during the supplier prequalification process. 2. Establish a training program (if needed) in advance of the need for artisan labor onsite.
General construction labour availability	Project implementation will require significant construction staff levels over an extended period of time. It is assumed that union and expat labor will be utilized during construction, with an average manpower of approximately 1,250 workers.	Develop a craft recruiting and retention program to be implemented onsite which addresses long term craft retention strategies such as longevity bonuses, advanced training courses and certifications resulting in promotion or pay increases, etc.
Construction labour productivity	Construction labor productivity will vary based upon the overall demand for construction labor in the region. Greater demands for skilled labor may result in lower productivity from the available work force.	1. Estimate development incorporates productivity experience for the Kusile and Medupi Power Station construction projects. 2. Estimate includes contingency for labor productivity uncertainty.

3.23.1.8 Procurement Risk

Procurement risks are those items related to obtaining and delivering the needed equipment and materials for the project.

Table 21: Project Procurement Risk Analysis

Potential Procurement Risk	Analysis	Mitigation
Contract bid / award duration	Design information for many procurement packages depends on receipt of design information from earlier packages and subsequent engineering design. The long contract award cycle inhibits information availability development at the time of procurement, increasing the risk for design changes and contractor change orders. Late award of the early packages would prevent the inclusion of accurate information in later packages.	Schedule allows 12 months for bid, evaluation, and award of all packages. Contract award should be made as early as possible to improve the availability of engineering information for subsequent packages.
Long lead times for certain items	Recently, the lead times for some common commodity items and engineered equipment have increased over historical values, primarily due to global demand.	Appropriate lead times based on recent experience have been factored into the Project Execution Schedule.
Local purchase objectives	The scope of work for the Medupi FGD Retrofit Project may require items that are not currently readily available in South Africa.	1. Assess vendor capabilities utilizing Eskom's established qualification process during the supplier prequalification process engaging all pertinent Medupi FGD Retrofit Project cross team members. 2. Organize procurement packages to allow local suppliers to aggregate materials or equipment which are sourced from outside South Africa with other, locally available items.
Experience with suppliers	The scope of work for the Medupi FGD Retrofit Project may require engaging new suppliers who do not have prior experience with Eskom, and are not familiar with Eskom processes, procedures, and unique requirements.	See quality risk analysis above
Project procurement team turnover	Continuity of procurement team and contract administration support personnel is necessary for the accurate and timely administration of the process.	Assign dedicated staff from start to finish (Works Information development through Contract Closeout) with detailed knowledge of the awarded contract.
Procurement document control	Concurrent access by the project team to the current revisions of all contract documents is necessary for accurate and consistent contract management.	Establish a central filing system that retains all documents throughout the project. Documents may only be stored on personal computers for individual reference and use.

Potential Procurement Risk	Analysis	Mitigation
Consistent and complete contract structure	Consistency of document content and structure minimizes the potential for scope gaps and supports fair and consistent contract management.	Establish a set of uniform procurement document guides with documented format that defines (but not limited to): 1. Full complete drawings. 2. Agreed-upon schedule based upon early completion with multiple milestones that show / ensure confirmation of progress. 3. Engineering information complete. Reference contract bid/award duration mitigation above – engineering information for subsequent packages. Include not-to-exceed quantities to compensate information to come from later packages.

3.23.1.9 IT and Tools Risk

IT and tools risks are risks related to the technology used for engineering and information management during project engineering and construction.

Table 22: Project IT and Tools Risk Analysis

Potential IT and Tools Risk	Analysis	Mitigation
3D model	The 3D model developed during the basic design must be converted for use in SmartPlant during project execution.	Conversion and testing of the 3D model should be performed in advance of execution release.
Document review	Timely availability of and access to review comments to project documents is needed to support smooth progress of the design work.	1. Eskom to provide user access and training for Process Design and Engineering Management Partners to access documents via SPF platform. 2. Project management to ensure that deadlines for document review are reasonable and are understood by the team and enforced.
SmartPlant design suite availability and functionality	Eskom, Process Design and Engineering Management Partners may utilize different engineering platforms. During design execution the full team must operate within a single, unified design environment. The Eskom platform does not currently support real time, remote, third party collaboration.	1. Develop a detailed IT and tools plan, indicating the tools, functionality, and processes to be implemented during design. 2. Conduct configuration validation testing with third-party engineering partners before commencing design engineering.

3.23.1.10 Safety Risk

Safety risks are related to the prevention of physical harm or injury from the activities associated with the design, construction, or operation and maintenance of the project.

Table 23: Project Safety Risk Analysis

Potential Safety Risk	Analysis	Mitigation
Overall site safety	It is anticipated that the normal risks associated with construction activities will be present for the Medupi FGD Retrofit Project.	Develop and implement a site safety program addressing safety-related training and orientation, injury management, general safety procedures, reporting requirements, and environmental protection issues needed to provide a safe working environment.
Workforce coordination	The Medupi FGD Retrofit Project will be executed within the confines of an operating power generation facility. Safe execution of the project will require close coordination with plant operations and any ongoing construction activities at the site.	Conduct regular planning and coordination meetings with the operations and construction management at the plant site to discuss upcoming construction activities.
Congested areas	Much of the workforce will be working in close proximity to one another. Many overhead crane lifts will be occur with workers in and around the cranes.	Conduct regular coordination meetings to discuss the dangers of the close working conditions and overhead work.

3.23.1.11 Construction Execution Risk

Construction execution risks are related to activities which could cause project delays which would impact the commercial operation of the FGD systems.

Table 24: Construction Execution Risk Analysis

Potential Construction Execution Risk	Analysis	Mitigation
Improper erection sequence	Some of the Medupi FGD Retrofit Project structures are located in congested areas. FGD erection sequence must be defined in detail and closely followed to provide cost effective installation.	1. Develop and implement a detailed Construction Execution Plan for the work. 2. Generate work packages for critical work activities such as major component lifts that require heavy haul and major rigging, outage tasks that require close coordination with adjacent activities and are time restrained, or work scope that requires a very specific erection sequence, to establish detailed lift plans, level III break out schedules, step-by-step execution sequences, detailed inspection and acceptance criteria, etc..

Potential Construction Execution Risk	Analysis	Mitigation
Lack of coordination between contractors	FGD Project work scope will be divided between multiple contractors. Individual contractor work scope execution must be coordinated into a seamless project execution plan to provide cost effective installation.	1. Develop scope in sufficient detail to identify and assign interface responsibility before contract award. 2. Ensure adequate construction management staff is provided to oversee the work. 3. Generate a detailed division of work (DOW) for each contractor to minimize scope gap. 4. Conduct frequent project coordination meetings with the contractors. 5. Share resources between contractors whenever possible. 6. Project contract managers must be pro-active, oversee field work continually, and address issues impacting work immediately.
Temporary construction facilities not available when needed	The FGD project will be executed over an extended period of time in an operating generation facility. Areas reserved for temporary construction facilities will be constantly re-assigned as needed to support various plant projects during this time. Adequate facilities must be properly allocated for FGD project use throughout project execution.	1. Develop a detailed construction facility, utility, and services plan for the life of the FGD project. 2. Develop contingency plans which provide alternate construction facilities in case emergency plant operations seize reserved facility areas.

3.23.2 Key Risk Management Activities Summary

The key risk management activities identified above are summarized below by area of primary responsibility.

3.23.2.1 Project Development

- ERA approval by the end of second quarter 2015 and full project release by the third quarter 2016 is needed to achieve operation of the first FGD unit by January 2022.
- A disposal plan for the waste gypsum and the wastewater treatment system byproduct should be identified to determine if there are any modifications that need to be made to the Basic Design to accommodate the disposal method.

3.23.2.2 Project Management

- Conduct regular planning and coordination meetings with the various project stakeholders, including plant management to discuss overall schedule and upcoming events.
- Ensure that Eskom staff with otherwise high experience levels participate to guide and mentor third party engineering staff regarding Eskom standards and practices.

- Develop a detailed IT and tools plan, indicating the tools, functionality, and processes to be utilized during design and project execution.
- Begin operational training program early, so that a number of trained operators are available during startup for "on-the-job" training in FGD system operation.

3.23.2.3 Engineering

- Conversion to SmartPlant and testing of the 3D model developed during the Basic Design should be performed in advance of execution release.
- Initiate geotechnical and as-built site surveys following project funding approval, in advance of detailed design.
- Document the change management process as part of project execution plan.
- Establish a Quality Assurance Plan as part of the project execution plan.
- Ensure that adequate technical support field services are included in the FGD-related packages.
- Verify that mass and water balances are within ranges once limestone qualities have been verified.
- A specific operating plan to handle the organics in the stream needs to be created. It may be necessary to treat the stream for organics prior to sending it to the FGD wastewater treatment system. It may also be necessary to take a slip stream off of the brine concentrator and dispose of it separately.
- Conduct SmartPlant configuration validation testing with third-party engineering partners before commencing design engineering.

3.23.2.4 Procurement

- Utilize any change in project schedule duration to delay later packages and maximize information availability from earlier packages.
- Supplier prequalification should include assessments of the following.
  - Supplier demonstrated quality track record.
  - Supplier capability to supply the required work volume.
  - Specialty system design capability and experience (e.g., wastewater treatment).
  - Availability of specialized artisan labor.
  - Capability to supply local content.
- Address Eskom processes and procedures and quality requirements during the supplier prequalification process.
- Solicit limestone supplier qualifications as to the availability, cost, and quality of limestone.
- Transfer escalation risk to the contractors through firm pricing covering delivery and services for the duration of the project.
- Include provisions to require regular updates to contractor schedules to be provided in Primavera format.

- Include requirements for adequate field technical support and thorough training of Eskom personnel.
- Schedule allows 12 months for bid, evaluation, and award of all packages. Contract award should be made as early as possible to improve the availability of engineering information for subsequent packages.
- Perform a lime and soda ash sourcing study during detailed design. Solicit supplier qualifications as to the availability, cost, and quality of lime and soda ash
- Assign dedicated staff from start to finish (Works Information development through Contract Closeout) with detailed knowledge of the awarded contract.
- Establish a central filing system that retains all documents throughout the project. Documents may only be stored on personal computers for individual reference and use.
- Establish a set of uniform procurement document guides with documented format.

3.23.2.5 Construction

- Develop and implement a detailed Construction Execution Plan for the work.
- Implement a project-specific Field Quality Management program to verify quality.
- Provide quality training to project field staff.
- Establish a training program (if needed) in advance of the need for artisan labor onsite.
- Develop a craft recruiting and retention program to be implemented onsite.
- Develop and implement a site safety program addressing safety-related training and orientation, injury management, general safety procedures, reporting requirements, and environmental protection issues needed to provide a safe working environment.
- Conduct regular coordination meetings to discuss the dangers of the close working conditions and overhead work.
- Conduct regular planning and coordination meetings with the operations and construction management at the plant site to discuss upcoming construction activities.
- Conduct frequent project coordination meetings with the contractors.
- Generate work packages for critical work activities such as major component lifts that require heavy haul and major rigging, outage tasks that require close coordination with adjacent activities and are time restrained, or work scope that requires a very specific erection sequence, to establish detailed lift plans, level III break out schedules, step-by-step execution sequences, detailed inspection and acceptance criteria, etc..
- Develop a detailed construction facility, utility, and services plan for the life of the FGD project. Develop contingency plans which provide alternate construction facilities in case emergency plant operations seize reserved facility areas.
- Integrate operator trainees into the startup and commissioning phases of construction to enhance seamless turnover of FGD systems to plant operations.
- Assign discipline Field Engineers to coordinate OEM FGD technical advisor schedules to ensure their field hours are efficiently utilized to resolve FGD installation issues and educate construction personnel.

3.23.2.6 Operations

- Plan for thorough vendor training as well as process training by Process Design Partner.
- Begin training process early, so that a number of trained operators are available during startup for “on-the-job” training in FGD system operation.
- Integrate operator trainees into the startup and commissioning phases of construction to enhance seamless turnover of FGD systems to plant operations.
- Routinely monitor the as-delivered water quality for the Mokolo and Crocodile West water supplies to establish typical values and variability for the key constituents.
- Routinely monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability.

3.24 OTHER DESIGN ISSUES

3.24.1 Unresolved Issues from Basic Design

The following issues were identified during the development of the basic design which will require resolution or completion during or in some cases, prior to the execution phase of the project.

1. Perform condensation calculations and flow modeling to assure duct-stack system is favorable for wet operation and to review the need for additional liquid collection facilities in the breeching and flue.
2. Third party review of flue discharge velocities and buoyancy to determine if exit modifications are necessary for adequate dispersion and elimination of possible plume downwash which may be caused by the wake formed on the downwind side of the flue and stack shell (such as a choke; reduction in diameter at flue exit). Updated stack exit conditions were developed during Basic Design.
3. Execute a geotechnical investigation; including soil borings, test pit samples, and laboratory testing with report of results, to furnish applicable criteria to be used to define foundation design parameters during the detailed design phase, and to determine site-specific seismic design criteria for all structures.
4. Execute an as-built survey of the foundations and structures in the areas affected by the FGD Retrofit Project in advance of detailed design.
5. Resolve clash between absorber piping and the roof, and its support structure, for all six absorber pump houses.
6. Perform design for the oxidation air quench system (refer to Section 3.5.3.1).
7. Decide whether the absorber should be insulated (refer to Section 3.5.3.1).
8. Evaluate eliminating the bypass ductwork and dampers and demolition of the existing ductwork to avoid maintenance of these components for the duration of the plant life. Would require revisiting the issues raised in Section 3.5.3.2.
9. Resolve clash between existing Hitachi ductwork support foundations and new FGD process tank foundations. The proposed solution will be to reduce the diameter of the emergency Drain Tanks and raise the side wall height to maintain tank capacity.
10. Decide whether to include the gas cooling heat exchanger (refer to Section 3.5.3.2) to reduce water consumption.

11. Determine the schedule impacts and cost impacts for the coating, lining, and/or replacement with C276 material of the items currently made of 316L material, and recommend whether the modifications should be made while the Medupi Power Station is under construction, after power station startup but prior to the FGD Retrofit Project work, or as part of the FGD Retrofit Project scope (refer to Section 3.5.3.4).
12. Determine environmental criteria which may impact storm water runoff and retention design, new dirty water dam, and FGD blowdown system discharges to the existing storm water drainage system and existing dams. The determination of whether a new dirty water dam is needed will not be determined until the detailed design phase of the project. The need for a new dirty water dam was assumed during the Basic Design phase to capture the cost.
13. Coordinate the grade elevations and location and number of catch basins shown on the FGD Stormwater Drainage Layout for Area West of Boiler to Road 09 (SPF file 0.84/35608), attached, with the as-built Medupi Power Station grading and drainage (SPF file 0.84/193). The Medupi Power Station Project (Gibb Consulting) is updating the Power Station plan based on the attached input from the Medupi FGD Retrofit Project team.
14. Further investigate the existing ash dump for the additional tonnage of gypsum to be deposited there and complete regulatory review [12]. Must verify against existing design for size and stability.
15. Develop an implementation plan for the necessary modifications to the overland ash conveyor to facilitate co-disposal of ash and gypsum[9]. Coordinate with Medupi Power Station Operations staff regarding outage requirements for tie-in.
16. Confirm or correct the unverified assumptions described in Section 3.2.3.
17. Confirm the water qualities for the Mokolo and Crocodile West waters by routinely monitoring the water sources to establish typical values and variability.
18. Determine the chlorine demand for the Mokolo and Crocodile West waters so the hypochlorite feed to the FGD Makeup Water System can be accurately estimated.
19. Verify the FGD wastewater expected chemistry and quantity once the quality, chemical reactivity, and availability of limestone to the Medupi site is finalized.
20. Once the Medupi Power Station water treatment plant system is operational, monitor the concentrations and types of organics in the TOC scavenger wastewater stream to establish typical levels and variability.
21. Consult FGD ZLD treatment equipment suppliers to determine if the established concentrations and types of organics are acceptable and determine if additional treatment of the TOC scavenger wastewater stream will be necessary based on established operating data. It may be necessary to treat the stream for organics prior to sending it to the FGD ZLD Treatment System or provide a slip stream off of the brine concentrator to dispose of the organics separately.
22. Consult FGD ZLD treatment equipment suppliers to determine the type and quantity of organics that will pass into the distillate stream.
23. Revise the CCCW and FGD ZLD Treatment Systems design to implement sending the open cycle cooling water blowdown to the Reclaim Water Tanks in lieu of the FGD ZLD Treatment System.
24. Confirm that current contracts in place are sufficient to meet the quality and large quantities of lime and soda ash that will be required for the FGD ZLD Treatment System.

[9] Note that the possibility of co-disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

25. The FGD ZLD Treatment System will generate a large amount of solids. Develop a disposal plan to determine the detailed solids disposal method[10].
26. Review redundancy requirements of FGD ZLD Pretreatment Holding Tank.
27. The Basic Design assumes that a stand-alone DCS will be added for control of the additional FGD-related scope. A decision whether to extend the existing DCS or design, procure, and install a stand-alone system has not been made at this time.
28. Evaluate the recommendations arising from the FMECA Study Report (178771.41.0201, SPF file 200-122279) for possible implementation in the design.
    a. Implement oxidation air cooling (refer to item 6 above and Section 3.5.3.1).
    b. Implement spray bank drain nozzle.
    c. Consider compressed air backup to dampers.
    d. Consider modular diesel generators.
    e. Consider revising CCCW strainers from Y-type to duplex basket type if there is chance of high airborne debris.
    f. Provide possibility for visual inspection of hydrocyclone underflow for the wastewater hydrocyclone and gypsum hydrocyclone stations.
29. Resolve Team Review comments on deliverables which could not be resolved during the Design Basic phase.
30. Eskom requested to change the format of KKS codes as follows (for example): 1 0HTD20 AM001, meaning to incorporate a blank (space) between the particular groups. Steinmüller indicated that is a lot of additional work and hard to update all drawings and studies within the remaining short period. Steinmüller proposed to change the format of KKS code prior to start and during the detail design phase. Eskom agreed. In the AGENDA (usually created by Carel) of the Eskom – Steinmüller internal process meeting 02nd April, item 16. Indicates: “KKS formatting hard to implement – implement in Detail design – find space in Basic Design Report”.
31. Resolve the means for support of the dampers at the Hitachi interface points as described in Section 3.5.3.2.
32. The following interferences discovered during 3D Model reviews will be resolved during detailed design. Interferences between piping will need to be resolved during detailed design during which time all of the design partners will be using the same 3D model. The 3D model will also be updated during detailed design to incorporate vendor specific information.
    a. Absorber Pump Houses: Absorber recycle pump discharge pipe clashes with roof structure.
    b. Absorber Pump Houses 1-5: Duct clashes with building.
    c. Absorber 5 Pump House: Pipe out of position, pipes terminate in fresh air, pipes interfere with pull space and walkway.
    d. Absorber 4 Pump House: Pipe runs into concrete base and clashes with absorber. Pipes clash with rack. Nozzle in incorrect position.
    e. Utility Rack Intersection at Absorber 6 Drain Tank: Pipes clash with cable trays, Pipes clash.
    f. Utility Rack Intersection at Absorber 4: Pipes clash with each other and with cable trays.

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[10] Note that disposal of the ZLD and pretreatment waste disposal will be confirmed with the current waste classification study [12], and thereafter the competent authority.

g. Limestone Slurry Feed Tanks: Pipes run through one another.

h. Utility Rack Intersection at Limestone Slurry Feed Tank West: Pipes clash.

i. Process Water Tank: Misalignment of pipe and nozzle. Reclaim Tanks: Pipes terminate in fresh air.

j. Utility Racks at Reclaim Tanks: Pipes clash with Utility Rack and other pipes, pipework incomplete, clashes with Utility Rack.

k. ZLD Holding Tanks: Pipes terminate in fresh air.

l. Utility Racks between Reclaim Tanks and Limestone Slurry Feed Tanks: Firewater pipe clashes with other pipes.

m. Emergency Drain Tank: Foundation for Units 4-6 and 1-3 clashes with existing ductwork foundation. A possible resolution would be to reduce the diameter/increase the height of the tank to reduce the size of the foundation.

n. Absorbers: Vertical steelwork clash with Absorber.

o. Ductwork Access Doors: Ductwork access doors to be added to the 3D Model

p. Utility Rack: Investigate the possibility of adding a small utility rack between the two clusters for cable tray, air, water, and auxiliary steam piping to reduce the cost associated with routing these utilities through the Unit 6, 5, 4 cluster.

q. Gypsum Dewatering: Two of the hydrocyclones were relocated to avoid a clash between the hydrocyclone and the support steel below the hydrocyclone. The steel will be modified to allow a straight run of pipe.

r. Gypsum Dewatering Building: Roof is lower. Clashes with walkways.

s. Access to valves: Access to all valves to be provided for operation and maintenance purposes in accordance with URS requirements. Platforms to be added as needed.

3.25 LESSONS LEARNED

1. Equipment and building layouts developed during Conceptual Design should be conservatively sized so that access for operations and maintenance can be maintained as the scope is more fully developed during Basic Design and project execution and equipment support subsystems (such as ball mill lubrication skids) are identified and included in the design.
2. Test data which are required as inputs to the Conceptual and Basic Design phases must be identified early so that budget and schedule can be allocated to conducting the tests in advance of commencing the design, so that design progress is not affected by the time required to execute and deliver these design inputs.
3. The detailed (Level 3) schedule for each phase of the project should be developed, reviewed by the relevant stakeholders (including discipline resource managers), and finalized prior to the start of engineering for that phase. Prerequisites for schedule finalization include scope of work, deliverables, and division of work.
4. Resource planning (i.e., manpower requirements by discipline) is required to ensure that deliverables are completed according to the engineering schedule.
5. Consumables quality (e.g., limestone) which have a significant influence on system and/or process design should be identified and defined prior to the start of engineering for a particular phase of project development.

6. The schedule for the completion of the relevant RAM, HAZOP, and FMECA analyses should take cognizance of the time it takes to complete these complex analyses for any future projects.
7. End-of-phase review and baselining process should identify specific documents and/or aspects of the design for design freeze, which are then subject to the change management process. It was not clear to the project team which aspects of the Concept Phase design are subject to change management, as compared to documents which are expected to evolve during the Basic Design. Since the design is expected to mature during Basic Design, it would be cumbersome for every document produced during Basic Design to be subject to change management. For example, it would be expected that the FGD Mass Balances/Process Flow Diagrams from the Concept Phase would be frozen (aside from changes to the design basis, such as the limestone quality) but the P&IDs would continue to be refined during Basic Design. Likewise at the conclusion of the Basic Design it is anticipated that the number and general location of the buildings would be fixed, but the exact dimensions will be established when dimensions are established using contractor data. However, efficient execution of the Basic Design (and later, Detail Design) requires that the design proceed from a fixed baseline, with significant changes documented and reviewed for any cost or schedule impacts to the project prior to approval.

4. AUTHORISATION

This document has been seen and accepted by:

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5. REVISIONS

Date	Rev.	Compiler	Remarks
March 2014	DRAFT 0.0	David Harris Black & Veatch	Initial Draft Report.
March 2014	DRAFT 0.1	David Harris Black & Veatch	Revised based on team comments.
August 2014	DRAFT 0.2	David Harris Black & Veatch	Revised based on team comments. Confirmatory review issue.
September 2014	0	David Harris Black & Veatch	Team Review comments incorporated.

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The following people were involved in the development of this document:

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7. ACKNOWLEDGEMENTS

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TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MEDUPI RAIL YARD AND OFFLOADING FACILITY
CONCEPT REPORT – EXECUTIVE SUMMARY

Report reference number: 1184-099-4-100-R-0001-Rev03

Concept Executive Summary

Revision: 04

Total pages: 24

Report submitted by:

Bosch Holdings Consortium

13 March 2015

CONTROLLED DISCLOSURE

EXECUTIVE SUMMARY

Eskom is currently constructing the Medupi Power Station near Lephalale in the Limpopo Province. A flue gas desulphurisation plant (FGD), which reduces sulphur dioxide emissions by at least 90% by reacting it with a limestone sorbent, will be retrofitted at the Medupi Power Station. It will therefore be required to deliver limestone to the Power station via the existing rail network. A new Rail yard and associated materials handling system will therefore be required. The potential also exists for the FGD gypsum by-product from the Power station operations to be sold into the market, however the volumes and target clients to date have not yet been identified nor determined.

Bosch Holdings Consortium, hereafter referred to as the Consultant, received a task order from Eskom to carry out an Options study, Concept design as well as a basic design of the Materials handling system and a detailed design of the Rail Yard. The scope of the rail yard design therefore includes all the project stages from the pre-feasibility to the detail design phase, whilst the material handling is limited to basic design only.

The scope of work related to the Concept design as per the Task order is the following:-

- Electrical requirements
- C& I requirements
- Civil requirements
- Road and Rail requirements
- Walkway requirements
- Geotechnical and Hydrological studies
- Fire protection requirements
- Buildings and Services requirements
- Water Management requirements
- Fencing (Security fencing) requirements
- More comprehensive costing for different options (Capex and Life cycle costing)
- Environmental requirements
- Storm water protection requirements

The stakeholder's requirements for the project were captured in the Stakeholders Requirements Definitions (SRD) report (200-130118) that was approved by Eskom on 17 June 2014. The Design Criteria Report (200-130171) for the project was compiled by the Consultant and approved by Eskom on 17 June 2014.

The Concept Study carries forward the results of the Options Report (1184-099-4-100-R-0001-Rev02 Options study report) that was approved by Eskom on 29 October 2014. A comprehensive Train operations simulation report (1184-099-4-100-Rev02 Simulation report) was also compiled and approved by Eskom on 29 October 2014.

This Concept report, structured in three parts (Volumes 1 to 3), develops the preferred option identified in the Options report for the Medupi rail siding. A linear type yard layout was identified as the most suited option to take forward into the next phase of the project. The Concept report provides an overview of the engineering processes followed and the system design status at the end of the concept phase. The three volumes must be read together. The acceptance of the report will allow the Consultant to proceed to the basic design phase for the Materials handling and to the detailed design phase for the Rail Yard.

Volume 1 Rail Yard and Services

The rail yard will handle bulk limestone, to be used as a sorbent, for use in the retrofitted FGD plant. Depending on market demand, bulk gypsum will also be despatched via the rail yard.

The scope of the new rail yard is to provide the Medupi Power Station with a rail yard solution and rail operations that will ensure that the yard is capable to receive and off-load 1,200,000 t/a of Limestone and to load and despatch 400,000 t/a of FGD Gypsum.

This Volume covers the Concept Design of the proposed rail yard and all other services required to operate the yard. The next phase of the Rail Yard and Services part of the project will be the detailed design phase which will complete the project.

The following battery limits define the scope of the rail yard and services study:

- The rail layout within the Medupi yard itself
- Current Transnet Freight Rail train operating methodology
- Allowance for future signalling systems from the TFR mainline into and out of the yard
- Allowance for the associated future electrification of the yard
- Allowance for Rail Area Lighting
- All the associated facilities required for the maintenance and operation of the yard

Volume 2 Materials Handling

This Volume covers the Concept Design of the proposed Materials Handling system that will be required to off-load the Limestone and load the Gypsum. The next phase of the Materials Handling part of the project will be the basic design phase which will complete the project.

The Options study identified a tippler as the most appropriate technology choice for handling of the limestone. During the Concept phase, a further assessment was conducted to determine the most optimum choice of tippler i.e. a single wagon rotary tippler versus a single wagon side tippler. A detailed life cycle cost assessment was conducted and forms part of Volume 2.

For the limestone materials handling, the scope of work is from the tippler to discharge onto the stacking conveyor; the battery limit at the stockyard is the underside of the transfer chute to the stacking conveyor. For gypsum materials handling, the scope of this project covers from the stockyard to the rail wagon loading facility; the battery limit at the stockyard is the top of the reclaim hoppers.

Volume 3 Appendices

This Volume presents 20 appendices containing details such as drawings, diagrams, information, assessment reports and costing relevant to both Volumes 1 and 2.

MDR MINUTES OF MEETING AND ACTION LIST

The MDR meeting was held on 22 January 2015. The minutes of this meeting and the MDR action list is attached (see Appendix A). A separate meeting was held on 29 January to discuss the LPS (Fire protection and detection) issues. The minutes of that meeting is attached as Appendix B.

The C&I department provided final feedback on Rev2 on 19 February 2015. An action list was compiled (see Appendix C) and Rev3 was issued for approval. The C&I department approved Rev3 with comments on 27 February 2015. The action list was updated with these comments and incorporated into Rev4.

REVISIONS

Rev.	Status	Issued by	Date
01	Issued for review	Francois Retief	4/12/2014
02	Updated with Electrical and C&I changes	Francois Retief	29/1/2015
03	Updated with all MDR changes including C&I issues from 19 February 2015	Francois Retief	20/2/2015
04	Updated with final C&I issues after meeting held on 27 February 2015	Francois Retief	13/3/2015

APPENDIX A - MINUTES OF MDR MEETING HELD ON 22 JANUARY 2015

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MDR FOR THE APPROVAL OF THE CONCEPT DESIGN REPORT

DOCUMENT NUMBER: 1184-099-1-100-M-0019-1

Meeting held at Eskom Enterprise Park on the 22nd of January 2015 at 10:00am

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Attendees: F. Retief, M. Mzebetshana, R. Venter, D. van der Schyff, P. Basson, D. Smart, S. Manngo, D. Fransman, B. Van Wyk, T. Blom, R. Thijs, D. Bredenkamp, D. Bezuidenhoudt, W. Kusel, S. Inderlall, R. Ranaka, A. Wiid, K. Shebe (by phone)

Apologies: B. Tyson

Distribution: Eskom project team, Bosch Consortium project team

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		Action	***Date***
1	**Approval of Previous Minutes**	There were no previous minutes to approve. The objective of the MDR meeting is to approve the Concept design report. The Concept design report was handed to Eskom on 4 December 2014.	
2	**Matters Arising**	1. All the feedback received from Eskom up to the MDR meeting was compiled in a list and distributed at the meeting. A number of issues raised at the meeting were added to the list. Each item on the list was discussed and the resolution and actions were noted in the “Resolution” column. The MDR action list is attached to	

these minutes. Action: All

2. The information that needs to be sent from the Weighbridge to the Medupi central control room needs to be clarified. This is required for the next phase of the project i.e. basic and detailed design. Action. S. Manngo

3. An operational manual will be required for the train operations i.e. as part of the detailed design. This must clearly describe and outline the train operations in the yard. Action: D. vd Schyff

4. It was decided that a Side tippler is the preferred solution to be taken to basic design. The main reasons for this decision are the following:-

* The Side Tippler is the most cost-effective option if the full lifecycle cost is taken into account.

* The cycle time of the Side Tippler is adequate for the offloading of limestone.

* CAR wagon types are used in the design. Should TFR at a later stage demand (i.e. as part of the Service design) that another type of wagon is used, then it will impact the design of the Rotary tippler but there will be no impact if a Side tippler is used.

The impact (if any) of the difference in the power consumption between the Side tippler and Rotary tipplers needs to be investigated before the above decision is finalized. Action: F. Retief

5. B. Van Wyk (GTE – Electrical) stated that he is satisfied with the design philosophy and approve the Concept design subject to the Electrical items in the MDR action list being resolved.

6. Civil Engineering approved the Concept design subject to the Civil items in the MDR action list being resolved.

7. Materials handling (D. Smart and A. Wiid) approved

the Concept design subject to the BMH items in the MDR action list being resolved.

8. R. Renaka (Chemical COE) approved the Concept design.

9. S. Manngo (PED) approved the Concept design.

10. Approval by the Power station to be handled by Eskom. Action: M. Mzebetshana

11. K. Shebe (GTE – C&I) stated that feedback will be provided after the completion of an internal process to finalize all comments. Some issues mentioned are (1) All interfaces to be clearly defined, (2) make sure the availability is adequate, (3) align maintenance and spares with the Medupi power station systems. Action: K. Shebe

12. No feedback was received from LPS (Fire Engineering). It was decided that a meeting between Bruce Tyson and Roger Bosch will be facilitated in order to obtain approval of the Fire detection and protection services in the Concept design report. Action: F. Retief/ M. Mzebetshana

13. It was mentioned by Eskom that a HAZOP study needs to be done before the basic and detailed design is started. Eskom to provide the requirements of such a study to the Consultant. Action: M. Mzebetshana

14. Conclusion: The Concept design is approved subject to the following:-

* The issues as per the attached MDR action list is resolved

* Feedback and approval by the Power Station (see point 10 above)

* Feedback is received on the C&I issues (see point 11 above)

* Feedback is received on the Fire detection and protection issues (see point 12 above)

3 Next Meeting Not required

Prepared by: Francois Retief – 23/1/2015

MDR ACTION LIST

1	Vol1 Section 8.1 & Vol 2 – Section 9.1	How will DC be generated. UPS or chargers with battery bank ?	Electrical	UPS with battery back up. Concept report to be updated. Action: S. Inderlall
2	Vol1 Section 8.7.2 & Vol 2 – Section 9.6.2	Where will 110V DC come from ?	Electrical	From the UPS Concept report to be updated. Action: S. Inderlall
3	Vol1 – Table 6 on page 37 & Vol2 – Section 9.7 Electrical equipment list	A description of the concepts that will be use during the design phase to be added to give assurance that the design will be in accordance with Eskom's specifications, redundancy principles etc. Maybe backed-up by a concept single line diagram.	Electrical	A description of the concepts will be inserted before the electrical equipment list where reference will be made to Eskom's specifications. A single line diagram will be generated. Concept report to be updated. Action: S. Inderlall
4	Vol1 – Table 6 on page 37 & Vol2 – Section 9.7 Electrical equipment list	Section on Earthing and lightning protection to be added Section on power conditioning to be added Section on motors Section on VSD's Section on cables Type and sizing criteria Section on substations	Electrical	Sections on Earthing and lightning protection, power conditioning, motors, VSD's and cable type and sizing criteria will be included. W.r.t substations, a description of a typical Eskom substation will be included. Concept report to be updated. Action: S. Inderlall
5	Executive summary – Volume 2 Materials	…the battery limit at the stockyard is the top of the reclaim feeders. Feeders or hoppers ?	BMH	Noted, this will be corrected in the document – the term hoppers will be used. Executive summary to be

	Handling			updated. Action: F. Retief
6	Vol2 – Section 2	Later in the document and on the drawings you refer to hoppers, not feeders?	BMH	Noted, this will be corrected in the document as per the above item. Concept report to be updated. Action: D. Bezuidenhoudt
7	Vol 1 – Section 3.3 & Vol2 – Section 3.3	Add COLTO to abbreviations table	Civils	Will be added in abbreviations table in Vol 1 & Vol 2 Concept report to be updated. Action: W. Kusel
8	Vol 1 – Section 3.7 & Vol2 – Section 3.7	Obtain input from LPS CoE LDE – the fire protection for the BMH systems should be aligned with the rest of the Medupi FGD material handling systems.	BMH (LPS)	Information regarding the rest of Medupi FGD fire systems is required to ensure such. This relates to fire protection and fire detection. (related to email to B Tyson 24 November 2014) Roger Bosch to contact Bruce Tyson to resolve issue: Action: R. Bosch
9	Vol2 – Section 5.1.2	What is the reason for an intermediate horizontal conveyor? Doesn't the feeder belt discharge via a chute onto the inclined belt? The drawing does not show this clearly. Also note: the location of the belt feeder and incline belts on the Rotary Tippler arrangement drawing are out of position – they are conventionally located centrally under the hopper, not to the side.	BMH	There will multiple hoppers beneath the tipped rail wagon to receive the limestone, this is due to the length of the rail wagon, (and hence feeders). These will in turn discharge onto this horizontal conveyor which is required to discharge limestone to the inclined belt conveyor. This layout is based on a typical rotary tippler layout; the centreline of the hopper discharge and hence the belt conveyor is not necessarily central to the tippler, but we agree that they are also not necessarily off-centre. These details will be further developed during the basic design phase. Integrated split hopper with singel feeder as proposed at Kusile to be investigated for

				Basic design. Action: D. Bezuidenhoudt
10	Vol2 – Section 5.2.1	The function of the horizontal limestone belt conveyor needs to be clarified further.	BMH	Please see resolution for point 9 above.
11	Vol2 – Section 5.2.2	Controlled discharge of Gypsum. What is the proposed bin storage/discharge operating philosophy? i.e. do you propose having some buffer storage – which may require active mechanised discharge (screw conveyor type silo)? Or rather a chute-type bin, effectively containing minor material surge between wagon filling?	BMH	We propose some buffer storage which would provide for the changeover period between the two separate train sections. Further discussed in item 18.
12	Vol2 – Section 5.4	E, C&I is not a conventional term within Eskom. Rather say: Electrical, and C&I…	BMH	Will change all E, C&I to Electrical, and C&I Concept report to be updated. Action: S. Inderlall
13	Vol2 – Section 5.5.1	Second belt conveyor. Can't thus be eliminated ?	BMH	Please see comments as per point 9 above.
14	Vol2 – Section 5.5.1	The tippler will be controlled and monitored directly from the administration building and will be equipped with CCTV cameras in order to provide visual feedback to the control room operators. Is this type of operation an accepted & safe convention? No natural line of sight to the tippler for the Operator?	BMH	A separate control room with an operator at the tippler station will be provided; CCTV will be included for monitoring from the administration building. A separate control room at the tippler to be included in the basic design for the materials handling. Action: D. Bezuidenhoudt/ S. Inderlall The repositioning of the main admin building and control room to the tippler needs to be investigated in the next phase. Action: F. Retief
15	Vol2 – Section 5.5.2	Mobile earthmoving equipment will reclaim from the gypsum stockpile and discharge to belt feeders which discharge to the	BMH	Yes, this will be altered in the Concept Design Report. Concept report to be updated. Action: D.

		reclaim belt conveyor. Hoppers ?		Bezuidenhoudt
16	Vol2 – Section 5.5.2	The rail wagons will be manipulated and positioned by means of a rail wagon positioner arrangement and the feed to them will be controlled by a gate at the underside of the feed bin. This discharge control gate & hopper design will need careful consideration during basic design – gypsum flow-ability issues.	BMH	Noted, a number of options to ensure the gypsum flow are available.
17	Vol2 – Section 5.6 Safety Concept	Emergency exit routes from underground tunnel/pit areas considered?	BMH	Yes, two exit routes will be required at the tippler station/"pit". A minimum of one additional exit route (apart from at the end of the tunnel) will be required at the tunnel due to the length of the tunnel.
18	Vol2 – Section 8.3 Gypsum loading	An overhead surge bin, which will straddle the rail at the gypsum loading point, is required to provide control and surge capacity before loading into the rail wagons. Capacity of surge bin ? How will discharge be controlled? This needs to be carefully considered for this gypsum material which presents poor flow-ability.	BMH	The surge bin capacity proposed would be 250 tons. This would allow for the change over time between train sections. Due to the poor flow characteristic of gypsum the bin also has a minimum practical size (it could have been slightly smaller otherwise). We have discussed this with potential suppliers and they have used gypsum bins before without the need for screws or ploughs but these options are available – these details will be further developed during the basic design phase. The above will be investigated and implemented with the basic deisgn. Action: D. Bezuidenhoudt
19	Vol2 – Section 10.2	Temperature control on motor. Maybe state 'thermal overload' or	BMH	Will change temperature control to thermal motor

		'motor protections' C&I LDE to confirm.		protection. Concept report to be updated. Action: S. Inderlall
20	Vol2 – Section 10.2	Belt misalignment switches. Use belt drift switches.	BMH	"Belt misalignment switch" is acceptable and will leave as is. C&I LDE has confirmed this. Concept report to be updated. Action: S. Inderlall
21	Vol 1 & Vol2 – Section 3 Key design assumptions	Include items for walkways alongside tracks for train inspectors, and buildings to accommodate yard staff.	Rail Yard – Philip Van Heerden	Vol 1 Section 2.1.2 makes reference to the design specifications pertaining to walkways. A separate paragraph can be included in Section 3 with a more descriptive summary of the walkways and building requirements for yard staff Concept report to be updated. Action: D. vd Schyff
22	Vol 1 & Vol2 – Section 3.1	Ensure that TFR will be prepared to fit the number of CAR wagons required for the Medupi service with rotary couplers. (TFR may insist on fitting its entire CAR fleet to maintain flexibility of operation in serving other users, and charge Eskom for the refit).	Rail Yard – Philip Van Heerden	The TFR service design will address this issue. This item has been discussed in length with TFR and they confirmed that CAR wagons will not be fitted with rotary couplers. If a Side tippler is going to be used then rotary fitted wagons are not required any more.
23	Vol 1 – Sections 3.3, 4.5.2 and 14.1 & Vol2 – Sections 3.3, 4.5.2 and 13.1	Various earthworks specifications are proposed that include COLTO, TRH4 and Transnet's S410. In my view we should use only the S410 because: a. The yard space is relatively confined and difficult for a contractor to work on different specifications. b. TFR will be required to operate the yard and might be more agreeable in the knowledge that its specification was used.	Civils – Philip Van Heerden	The S410 does not make provision for geometric design of roads. Used the TRH4 for the geometric design of the service road. All layer works will be done to the S410 specifications. The report refers to the COLTO specification when referring to the Geotechnical Investigations report. The COLTO specification will be removed from section Normative Standards in both Vol 1 and Vol 2 of the reports Reference is made in 2.1.2 Perway Design to Transnet

24				S410 for substructure. According to R&H Civil design reference should only be made to S410 and SANS1200DN. Concept report to be updated. Action: W. Kusel
24	Vol2 – Section 8.3	My information is that gypsum coagulates and would require agitation in the surge bin to convert it into powder form so that it could flow freely for loading into a railway wagon. A more practical solution might be to discharge the gypsum directly from an overhead conveyor into the wagons.	BMH – Philip Van Heerden	Feeding directly from the belt conveyor would present numerous problems in terms of feed regulation and uneven load distribution. See item 18 for further discussion on gypsum load out proposal.
25	Vol 1 – Section 13 & Vol2 – Section 12	A proposal should be included to drain the yard. This should include manholes with grids suitably protected from the ingress of ballast. The manholes should be connected to an underground pipe network leading storm water to discharge.	Civils – Philip Van Heerden	This is the proposed method to drain the yard. Indicated on cross section on drawing 0.84/40141. Will include a more detailed and clear section in Vol 1 and Vol 2 of the report. Concept report to be updated. Action: W. Kusel
26	Concept layout drawing 0.84/40134	Fence clashing with the stormwater trench. There is no space for an access road next to the fence. The fence will need to be rerouted or perhaps a retaining wall will be required ?	Civils – Tony Haupt	The fence position is dependent on the railway line position. Space should be provided for the service road of the fence. The retaining wall option will be investigated during the detail design stage. This will be dealt with in the next phase of the project. Action: W. Kusel
27	Concept layout drawing 0.84/40134	The terrace is over the stormwater trench. A large culvert an perhaps a redesign of the drainage system will be required.	Civils – Tony Haupt	The existing stormwater trench will be replaced by culverts to join the existing culverts. The existing stormwater culvert sizes will be reviewed in conjunction with the new proposed culverts. This will be dealt with in the next phase of the project. Action: W. Kusel

28	Concept layout drawing 0.84/40134	The fire water valve pit is under the embankment. It will be necessary to relocate it to the South.	Civils – Tony Haupt	Will relocated the valve pit to an appropriate position. This will be dealt with in the next phase of the project. Action: W. Kusel
29	Concept layout drawing 0.84/40134	The Limestone and Gypsum Substation is not indicated and there is a clash with the fence.	Electrical, Civils – Tony Haupt	Will include Eskom's planned Limestone substation in concept layout drawing. Will move the fence to a suitable position after final placement of Limestone and Gypsum Substation on the approved layout plan. This will be dealt with in the next phase of the project. Action: W. Kusel/ S. Inderlall
30	Concept layout drawing 0.84/40134	The fence is clashing with the access road for Gypsum Stockpile.	Civils – Tony Haupt	Will move fence to suit Gypsum stockpile access road This will be dealt with in the next phase of the project. Action: W. Kusel
31	Concept layout drawing 0.84/40134	This manhole is covered by the terrace.	Civils – Tony Haupt	The manhole should be relocated to the south of the terrace footprint. This will be dealt with in the next phase of the project. Action: W. Kusel
32	Substation and cable route 0.84/40138	This substation is shown in the incorrect position see drawing 0.84/3 Station Layout and 0.84/40134 Main Concept Layout.	Electrical – Tony Haupt	From drawing 0.84-567-01-08 (received from Mr Van Wyk) the planned limestone storage sub is indicated correctly on drawing 0.84/40134-Substation and cable route. This will be dealt with in the next phase of the project. Action: S. Inderlall
33	Substation and cable route 0.84/40138	This lighting mini sub is directly next to the Gypsum and Limestone Substation see drawing 0.84/3 Station Layout and 0.84/40134 Main Concept Layout.	Electrical – Tony Haupt	The lighting mini sub is a proposed mini sub where the position can be changed, there is a possibility of using existing ring feed mini subs at Medupi for lighting as discussed with Mr Van Wyk and there might not be a need for this mini sub.

				Position will be changed accordingly. Concept report to be updated. Action: S. Inderlall
34	Civils layout drawing 0.84/40141	The statement in the Civils layout drawing 0.84/40141 “Divert stormwater to new storm water culvert to be installed by others” needs to be looked at. All stormwater issues to be incorporated in the design of the Rail yard.	Civils – Tony Haupt	The overall stormwater operation and design will be reviewed during detail design stage. A new culvert was newly installed on site. Can this be confirmed by Eskom? This culvert size will be reviewed and incorporated into the overall stormwater design of the rail yard. The impact of all stormwater issues resulting from the rail yard area will be considered. It is not in the scope to look at stormwater issues outside the rail yard area. This will be dealt with in the next phase of the project. Action: W. Kusel
35	BMH layout for Side Tippler 0.84/40137	Walkway on inclined Gypsum belt to be included.	BMH	Concept report to be updated. Action: D. Bezuidenhoudt
36	Vol2 Materials handling	Process flow diagram required	BMH	Concept report to be updated. Action: D. Bezuidenhoudt

APPENDIX B - MINUTES OF MDR LPS MEETING HELD ON 29 JANUARY 2015

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

CONCEPTUAL DESIGN - MDR FOR THE LPS (FIRE PROTECTION AND DETECTION)

DOCUMENT NUMBER: 1184-099-1-100-M-0021-1

Meeting held at Eskom Enterprise Park on the 29th of January 2015 at 14h00

Attendees: F. Retief, R. Thijs, B. Tyson, R. Bosch, T. Haupt

Apologies: None

Distribution: Eskom project team, Bosch Consortium project team

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		Action	*Date*
1	**Approval of Previous Minutes**	There were no previous minutes to approve. The objective of the meeting is to approve the LPS (Fire protection and detection) section of the Concept design report. This meeting is in addition to MDR held on 22 January 2015.	
2	**Matters Arising**	1. The connection point of the potable water shown on drawing 0.84/4014 (see Volume 3, Appendix 8 of the Concept design report) was provided by Graham James. This point needs to be verified and confirmed. Action: T. Haupt	

2. The potable water pressure is 1 bar. This needs to be taken into account in the basic and detailed design. Action: W. Kusel

3. The fire water valve pit that is under the embankment was discussed. This is item 28 of the MDR list. A solution to this must be included in the detailed design. Action: W. Kusel

4. It was suggested that a list of terminal points be set up and maintained. This includes the potable and fire water connections. Action: R. Thijs

5. The fire monitoring system must interface to the CBMS (Central Building Management System) at the Medupi power station. The CBMS is in package 18 and the contact person is Abrie Nieuwoudt. The type of interface, protocol and the signals to be transferred must be defined in the next phase of the project. Action: S. Inderlall/R. Bosch

6. Municipal submission and local authority approval is not included in the scope of the task order and will be the responsibility of the contractor.

7. Bruce Tyson approved the Concept design with respect to the LPS services and fire protection and detection.

3	**Next Meeting**	Not required

Prepared by: Francois Retief – 30/1/2015

APPENDIX C – C&I ACTION LIST PREPARED ON 20 FEBRUARY 2015 AND UPDATED ON 12 MARCH 2015

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONCEPT REPORT – C&I ACTION LIST

Report reference number: 1184-099-4-100-R-0001-Rev01
Concept Design C&I action list
Revision: 01
Total pages: 7

Item	Reference	Comment	Section	Resolution
1	General	There are two volumes of the concept design report which look similar. There are no sections explaining how the two volumes relate. There should be a preamble that describes all the volumes and all the supporting documentation of the concept design.	C&I	The Concept design report that was handed over to Eskom on 4 December 2014 is structured as follows: 1. Executive summary 2. Volume 1 – Rail Yard and services 3. Volume 2 – Materials handling 4. Volume 3 – Appendices The Executive summary descibes all the volumes and how they relate to each other. Volume 3 describes and lists all the supporting documentation.
2	General	The Concept design states that the rail yard will handle limestone. It doesn't mention the Bulk fuel oil and general cargo mentioned in the SRD and the Design Criteria report. The scope of the project should be clarified. If a change is scope is required then a Design Change to the SRD should be initiated.	C&I	The Bulk fuel oil and general cargo was removed from the Medupi Rail siding by Eskom. The ROD 200-70810 refers. This is also referred to in the Concept report – refer to Volume 1 - Section 4.2.3
3	Vol 1 – Section 9.2	The design states that train movement in the yard will be authorized by radio train orders and no signaling will be provided. The basis for this design decision is not clear. The lack of signaling equipment increases the chances of train accidents and also does not provide the CTC with oversight of the yard. The basis of excluding signalling from the scope should be clarified. It is expected that the design can still be done within the ambit of this project even though the implementation could be at a later stage.	C&I	This is not part of the scope of the task order and had been discussed extensively. The only requirement was to make provision in the rail design to accommodate the signalling and OHTE in the future. Please also refer to Volume 1 – Section 5.5.3.1 and Volume 1 – Section 9.3.
4	Vol 1 – Section 2.1.4	Why are some of the points being designed to be mechanical? The decision to make some points mechanical and others electrical	C&I	One could have automated the yard but it was viewed as part of the future signalling. The email from Danie van der Schyff dated 13

		should be clearly justified.		February provides an overview of the various options that were considered. This was incorporated in Rev3 of the Concept design report – refer to Volume 1 - Section 9.3. For a yard of this size with low traffic volumes the manual operated system is recommended.
5	Volume 3 – Appendix 22	The Network architecture drawing does not have a drawing number. The drawing number must be in the Eskom template.	C&I	The drawing has been updated with the number 0.84/43218 and is in the Eskom template – refer Volume 3 – Appendix 22
6	General	There's a control system layout drawing provided as part of the package. There are elements of the control systems that are not discussed as part of the design. BMS, Access Control etc. Description for design concepts and decision of the concepts should be provided and justified.	C&I	The Concept report was updated. Please refer to Volume 1 – Section 9.1 and Volume 2 – Section 10.1.
7	General	There are no Condition Assessment Systems provided as part of the scope. Why were they not provided. The responsibility for maintenance is not clear. Where are the Condition Assessment Systems?	C&I	We propose that Condition Assessment is considered in the next phase of the project.
8	General	How has the design considered future signalling design in their rail design? Has the type of track circuit been considered? Will it be a jointless or jointed track circuit? Is there any interlocking done on the tracks? How will train presence be managed on the tracks without a signalling system?	C&I	Train operation procedures and the operating concept for the materials handling are described in the Concept report. Refer to Volume 1 - Section 5.5.3 for a description of the shunt operations and Volume 2 - Section 5.5 for the Materials handling operating concept and Volume 2 - Section 8 for a description of the materials handling operations. We have also added the an additonal section on the general operating procideure – refer to Volume 1 Section

				5.5.3. More detailed operation procedures and control philosophy is not seen as part of the Concept design and will be part of the next phase of the project (i.e. basic design) and will be addressed accordingly. TFR (Rail Directives) will also formalise the final operating procedure based on our submission of siding operating procedure to them.
9	General	The Concept does not speak on dust suppression – this has to do with operator wellness and environmental considerations.	C&I	This has been discussed and agreed that it is not required due to nature of product. There will be dust extraction in the Tippler vault. Eskom BMH has advised and confirmed this is the case. This was again confirmed in the HAZOP workshop held on 12 February.
10	Volume 3 – Appendix 22	Network Architecture drawing shows redundant network how was this design decision arrived at? Are there redundant routes (physical and logical)?	C&I	The redundancy of the system is dependent on the reliability and availability required for the plant. The final availability and reliability requirements are not finalized at the stage of Concept Design and we should therefore be looking at the best case option based on the information know at the time. In terms of process followed, it is based on the experience we have had on similar installations where automation and operator busses/ networks tend to be redundant as this is also a single point of failure. For a concept design, the option of having two routes seemed justified with the view of finalising that in the basic design. The Concept report was updated. Please refer to Volume 1 – Section 9.1 and

				Volume 2 – Section 10.1.
11	Volume 1 – Section 5.1.1	The decision has been taken to use the Massive T4 in motion weigh bridge for standardisation purposes. MR indicated that the basis decision to standardise was not discussed in the Concept Design report. This will be an issue as the engineering and business justification is not mentioned.	C&I	Eskom indicated that they already identified the most appropriate technology during the Majuba project i.e. the Massive T4 in motion weighbridge. As such they indicated that they want to standardize technology at sites. The Concept design report has been modified and references to the T4 weighbridge has been removed. Refer to Volume 1 – Section 5.1.1. The choice of the appropiate make and model weigh bridge will be part of the next phase of the project.
12	General	There is no documented operating and control philosophy for the system in the concept report. This should also include the interlocks or interfaces between Eskom operations and Transnet operations.	C&I	Train operation procedures and the operating concept for the materials handling are described in the Concept report. Refer to Volume 1 - Section 5.5.3 for a description of the shunt operations and Volume 2 - Section 5.5 for the Materials handling operating concept and Volume 2 - Section 8 for a description of the materials handling operations. We have also added the an additonal section on the general operating procideure – refer Volume 1 Section 5.5.3. More detailed operation procedures and control philosophy is not seen as part of the Concept design and will be part of the next phase of the project (i.e. basic design) and will be addressed accordingly. TFR (Rail Directives) will also formalise the final operating procedure based on our submission of siding

				operating procedure to them.
13	General	The Concept Design mentions a Control Room but does not indicate if this a new control room, it's location and its operation. The team unanimously indicated that the concept of this room is not clear. The Medupi URS was specific in only allowing for 2 control rooms in Medupi, namely the Outside Plant Control Room and the Units Control Room – Why did the designers not consider just a control panel? How was the decision to add another control room at the yard arrived at which contravenes Medupi URS & were other options considered – where is this documented in the concept design?	C&I	The Rail Yard is separate from the main plant and therefore requires its own operations or control room that is local to the operations. This is common practice and is also a TFR requirement for this type of operations. Tutuka and Majuba are both done this way. It was discussed and minuted in the project progress meeting held on 17 October that the Majuba building requirements is to be used as a basis for the Medupi design. It was also minuted at the progress meeting on 17 October that a control room is required. At the progress meeting held on 6 November this was again discussed and confirmed and it was noted in the minutes that an elevated control room is required. The operatons or control room is an integrated part of the administration building and is required to house the Operator stations for the control of the materials handling and the weigh bridges plus give an overall visual of the rail yard. The operations of the yard are seen to be independent of the main Medupi control room. The requirement for a operations or control room is covered in the following sections of the Volume 1 of the report i.e. 2.1.3, 5.5.1, 7.2.4, 8.3, 9.1 and 9.5. The Concept report (both Volume 1 and 2) has been updated so that it is called a Rail yard operations room instead of a Rail yard control

				room.
14	General	The network architecture drawing shows dynamic IP addressing – why is this so – Eskom uses static addressing – where is the design process and decision on this documented.	C&I	The drawing 0.84/43218 has been updated to indicate static addressing – refer to Volume 3 Appendix 22
15	General	Maintenance responsibilities need to be clarified.	C&I	In In Volume 1 (Section 5.4.1) it is stated that "The maintenance of the rail yard will be undertaken by a contractor (Transnet) to the same standards as clearly covered in the Transnet maintenance manuals". In Section 5.4.3 is states that "The maintenance of the shunt locomotive will be undertaken by an approved contractor (Transnet) to the same standards as clearly covered in the OEM maintenance manuals. All other maintenance will be the responsibility of Eskom or a suitable subcontactor appointed by Eskom. The Concept report has been updated to reflect this – refer to Volume 1 – Section 2.1.1 and Volume 2 – Section 5.4.

Bosch Holdings Consortium

BOSCH HOLDINGS	TE Thabile Engineering	Thabo Consulting	NEMAI CONSULTING

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONCEPT DESIGN REPORT VOLUME 1

RAIL YARD AND SERVICES

Report reference number: 1184-099-4-100-R-0001-Rev04 Concept Vol1 Rail Yard and Services

Revision: 04

Total pages: 63

Report submitted by:

Bosch Holdings Consortium

13 March 2015

Bosch Holdings Consortium

BOSCH HOLDINGS	Thabile Engineering	Thabo Consulting	NEMAI CONSULTING

CONCEPT DESIGN REPORT FOR THE MEDUPI RAIL SIDING DOCUMENT APPROVAL		
CONSULTANT -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM CIVIL ENGINEERING -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM BMH DEPARTMENT -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM ELECTRICAL ENGINEERING -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM C&I DEPARTMENT -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM LPS (FIRE ENGINEERING) DEPARTMENT -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM CHEMICAL DEPARTMENT -- NAME	-- SIGNATURE	------------------------------ DATE
MEDUPI ARRANGMENT DESIGN -- NAME	-- SIGNATURE	------------------------------ DATE
MEDUPI POWER STATION -- NAME	-- SIGNATURE	------------------------------ DATE
ESKOM PED DEPARTMENT -- NAME	-- SIGNATURE	------------------------------ DATE

	COMMENTS	ORIGINATOR
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ABBREVIATIONS

Abbreviation	Description
A	amps
AC / ac	Alternating Current
AVI	Automatic Vehicle Identification
C&I	Control & Instrumentation
CMS	Control and Monitoring System
COLTO	Committee of Land Transport Officials
CSW	Continuous Surface Wave
CTC	Centralised Traffic Control
DC / dc	Direct Current
DCP	Dynamic Cone Penetrometer
FGD	Flue Gas Desulphurisation
HMI	Human Machine Interface
HVAC	Heating Ventilation and Air Conditioning
km/h	kilometres per hour
kV	Kilo Volts
kVA	Kilo Volt Amperes
kW	KiloWatts
l/s	litres per second
LAN	Local Area Network
m/20m/20m	Metre per 20metre per 20metre
m/s	metres per second
m^3	cubic metres
MAP	Mean annual precipitation
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
mm	millimetres
Mtpa	Million tons per annum
OHTE	Overhead Traction Equipment
OPC	Open Platform Communications
ORS	Owner's Requirement Specification
OTT	ON-TRACK Technology
Perway	Permanent way (meaning the railway line)
PIS	Plant Information System

Abbreviation	Description
PLC	Programmable logic controller
SCADA	Supervisory control and data acquisition
SQL	Structured Query Language
t	Ton
t/a or tpa	Tons per annum
t/h or tph	Tons per hour
TFR	Transnet Freight Rail
UPS	Uninterrupted Power Supply
uPVC	Unplasticized Poly Vinyl Chloride
V	volts
VLR	Vertical Load Receptor

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LIST OF FIGURES

1. INTRODUCTION

This concept study develops the preferred options identified in the Options report for the Medupi rail siding. This document provides an overview of the engineering processes followed and the system design status at the end of the concept phase. The document describes the results of technical assessments and compliance with stakeholder requirements, technical risks identified, lessons learned during the design process and outstanding issues for this design phase. This document further provides references to approve the design output documentation.

The rail yard will handle bulk limestone, used as a sorbent, for use in the retrofitted FGD plant. Depending on market demand, bulk gypsum will also be despatched via the rail yard.

The scope of the new rail yard is to provide the Medupi Power Station with a rail yard solution and rail operations that will ensure that the yard is capable to receive and off-load 1,200,000 t/a of Limestone and to load and despatch 400,000 t/a of FGD Gypsum.

This report covers the Concept Design of the proposed rail yard and all other services required to operate the yard. The next phase of the Rail Yard and Services part of the project will be the detailed design phase which will complete the project.

The following battery limits define the scope of the rail yard and services study:

- The rail layout within the Medupi yard itself;
- Current Transnet Freight Rail train operating methodology;
- Allowance for future signalling systems from the TFR mainline into and out of the yard.
- Allowance for the associated future electrification of the yard
- Allowance for Rail Area Lighting;
- All the associated facilities required for the maintenance and operation of the yard

2. SCOPE OF CONCEPT DESIGN

The Concept Study carries forward the results of the Options Report (1184-099-4-100-R-0001 REV02) which has been approved by Eskom. It will provide the engineering solutions for the optimisation of the materials handling, rail yard and all other associated rail systems and sub-systems. The scope of the Rail yard and services section focuses on the following end-state per discipline:

2.1 Disciplines

2.1.1 Train Operations

Based on the layout that was proposed during the Options Study, a final concept design of the train operations in the Medupi Yard is undertaken. The design takes into consideration all safety issues as will be considered by the Rail Safety Regulator.

Rail operations include the movement of the shunt locomotive in the yard as well as maintenance and fuelling facilities that may be required. The maintenance of the rail yard and shunt locomotive will be undertaken by a contractor (Transnet) to the same standards as clearly covered in the Transnet and OEM maintenance manuals. All other maintenance will be the responsibility of Eskom or a suitable subcontactor appointed by Eskom.

The rail process fits in with TFR's Operating Philosophy with regards to mainline locomotives, crews and turnaround time of 12hrs.

2.1.2 Permanent Way (Perway)

Transnet perway design guidelines are used as basis for the Concept design

- Manual E.10 – 1996 Railway Track Work
- Specification S116 – Rails
- Specification PWM 2/5 dated 1996 - Sleepers
- Specification S406 – Ballast
- Specification S410 – Substructure
- Specification for walkways - Drawing KY100 C301 dated 2009/05
- Manual for Track Maintenance 2012

2.1.3 Rail Systems (In-Motion Weighbridge)

Provision is made for the installation of two Trade and Metrology approved assized in-motion weighbridges.

One in-motion weighbridge will be positioned at the "Stop Board" on line 1 (run-off line from TFR mainline) leading towards the yard, to weigh all incoming and outgoing wagons. The other in-motion weighbridge will be positioned just after the load-out station to weigh and assess the loading profile of the FGD Gypsum loaded in the rail wagons.

Both in-motion weighbridges will be fitted with automatic vehicle identification (AVI) readers to identify the respective rail wagons. The in-motion weighbridges will be linked to send the required data to the Rail Yard operations room.

2.1.4 Rail Systems (Signalling and yard control)

Provision is made for the installation of the following mechanical turnouts:

- 60kg/m 1:12 Tangential turnout with Rail-bound crossing on concrete bearers with rodding to suite electric operated switch box according to VAE drawing No. 10008-000-00 in accordance with the current Transnet Freight Rail specifications applicable on the Thabazimbi to Lephalale rail infrastructure
- 48kg/m 1:12 Secant turnout with rail-bound crossing on concrete bearers complete with mechanical point sets (hand-tumblers) according to VAE drawing No. E7129 in accordance with the current Transnet Freight Rail specifications
- 48kg/m 1:9 Secant turnout with rail-bound crossing on universal concrete bearers complete with mechanical point sets (hand-tumblers) according to VAE drawing No. 4303-000-00 in accordance with the current Transnet Freight Rail specifications

Provision is made for a Rail yard operations room to monitor and control locomotive movements from a central point in the yard. The yard control will be achieved by implementing an open channel radio communication system whereby all train movements are verbally communicated. Each train driver will be aware of the authorised movements and can immediately report conflicting train movements to the Rail yard operations room.

Allowance (excluding design and costing) will be made for future signalling of the yard in accordance with Transnet Freight Rail specifications set out for the Waterberg post 2020 development.

2.1.5 OHTE

Allowance will be made for future installation of OHTE in the yard in accordance with Transnet Freight Rail specifications set out for the Waterberg post 2020 development.

2.1.6 Electrical Control and Instrumentation

The required electrical control and instrumentation scope of work for the Medupi rail yard project relate to the electrical power supply for the bulk material handling equipment, lighting for the rail yard, electrical feed for signalling and all other equipment that requires a power source.

The electrical system is expected to provide all equipment within the rail yard boundaries with electrical power. Three-phase power will be required since different equipment operate at different voltages. Consideration to existing equipment and systems being implemented at Medupi power station will be considered where the rail yard can integrate with the larger system installed.

2.1.7 Civil Services

The civil services layout was determined by the final perway alignment position. The bulk earthworks were designed and placed relative to the existing fence boundary. An access road will be provided to serve as a ring road to all facilities on the rail yard. The facilities will be serviced with potable water, fire water and septic tanks for the ablution facilities.

Stormwater channels and structures were designed to provide a division between storm water and the dirty water from the gypsum loading facility.

3. KEY DESIGN ASSUMPTIONS

3.1 TFR specifications for rail facilities in the Waterberg

TFR has been engaging with various companies individually on the future plans for the Waterberg and confirmed the required rail loading specifications and operational parameters for the design of future rail sidings, yards and loading facilities. The current Medupi yard design incorporated the required specifications as stipulated by Transnet and include the following:-

- The earthwork layers of the yard designed to 26 ton axle load bearings
- Provision for future OHTE installation in the yard
- Provision for in-motion weighbridges and automatic vehicle identification systems
- Gradients to required specification in yards

3.2 Train Operations

The proposed train operations was based on the following assumptions:-

- Annual tonnages to be transported by rail for each commodity (1,200,00 t/a of Limestone and 400,000 t/a of FGD Gypsum)
- Transnet Freight Rail operating a drop-off pick-up type of mainline service
- Transnet Freight Rail mainline locomotives will split the limestone train and position wagons at tippler
- CAR-type wagons used for the transport of Limestone (Type of coupler system still to be determined)
- CAR-type wagons used for the transport of the FGD Gypsum

- 12hrs train handling time applicable within the yard
- Private shunt locomotive required to perform the shunting in the yard (Outsourced to Transnet)
- Limestone offloaded by either a single wagon rotary tippler or a single wagon side tippler
- FGD Gypsum loaded by means of a rapid load-out station
- 342 operational days (365 days less 5 days holiday, 2 days single line operations and 16 days shutdown of corridor for maintenance)

3.3 Yard Layout

The design of the yard layout was based on the following assumptions:

- Transnet Freight Rail train operating procedures
- Track layout based on maximum train consists for each commodity;
- Line classification N2 and alternatively N1 line if 60kg/m rails could be procured from TFR;
- Maximum gradient to be 1:150 towards Thabazimbi with departure grade of 1:200,1:100 towards Lephalale and 1:800 on staging lines;
- The sub-structure is based on 26ton axle load;
- Vertical curves with permissible rate of change of 0.150m/20m/20m for yard and 0.040m/20m/20m on run-off line;
- Yard curvature 275m radii except at gathering roads which can be reduced to 200m;

The superstructure is based on 20 ton axle load and the perway material will consist of the following:

- Class 900A 48kg/m rail in 18m nominal lengths or 60kg/m rails if Eskom succeed in procuring second hand rails from Transnet;
- P2 reinforced concrete sleepers complete with new HDPE pads and Pandrol fastenings at 700mm spacing;
- Top of rail to formation level at 600mm;
- Ballast profile of 1200m³/km as per Transnet Freight Rail Maintenance Manual – 2002 Annexure 4 sh. 1 of 1;
- 200mm ballast under sleepers as per Transnet Freight Rail Maintenance Manual – 2002 Annexure 4 sh. 1 of 1
- 1 x 60kg/m 1:12 Tangential turnout with Rail-bound crossing on concrete bearers with rodding to suite electric operated switch box according to VAE drawing No. 10008-000-00 in accordance with the current Transnet Freight Rail specifications applicable on the Thabazimbi to Lephalale rail infrastructure
- 1 x 48kg/m 1:12 Secant turnout with rail-bound crossing on concrete bearers complete with mechanical point sets (hand-tumblers) according to VAE drawing No. E7129 in accordance with the current Transnet Freight Rail specifications
- 15 x 48kg/m 1:9 Secant turnout with rail-bound crossing on universal concrete bearers complete with mechanical point sets (hand-tumblers) according to VAE drawing No. 4303-000-00 in accordance with the current Transnet Freight Rail specifications
- 2 x Hays derailers to fit 48kg/m rails complete with timber bearers and fittings
- 1 x 40 or 48kg/m stop block complete with timber bearers and fittings.

3.4 Walkways

The following assumptions have been made regarding the walkways next to the rail tracks

- Walkways design shall be carried out in accordance with the TFR Specification for walkways as reflected on drawing no KY100 C301 dated 2009/05
- Walkways shall be provided along both sides of each track across structures where train crews regularly work on the ground for shunting, train inspections, etc.
- The walkway will be filled up to the level of the top of the ballast with material giving good drainage and a sound walking surface.
- The width of the standard walkway horizontal surface is based on the required clearance from the track and the minimum width required for safe passage next to the train. The minimum width of the walkway and ballast profile as measured from the outer rail, to the shoulder of the walkway will be 2000mm. The minimum standard walkway detail is therefore 700mm wide.
- The walkways will stretch along the full length of the tracks.

3.5 Bulk Earthworks

The following assumptions have been made regarding bulk earthworks:

The bulk earthworks layer works is designed to accommodate a 26t axle load. It is assumed that the existing stock piles will be cleared before the commencement of construction. A letter dated 6 August 2014 from Eskom requested the design team to review all earthwork designs due to the quality of material available from stockpiles, deteriorating from G5 to G6 and G7 (COLTO classification). For the concept design stage it is assumed that all materials G7 and higher will be imported from commercial sources.

See TRH4 Table 13 for material grading specifications.

3.6 Service Road

It is assumed for costing purposes that the service road will be constructed with imported material from commercial sources due to the shortage of suitable material on site.

3.7 Stormwater

The following assumptions have been made regarding stormwater:

The Stormwater will be modelled with a MAP 437mm as discussed with Eskom. It is assumed that the Medupi stormwater master plan including structure sizes will be available for the detail design stage. The dirty storm water from the Gypsum loading facility will be drained into a new pollution control dam that will be designed by the FGD project team.

3.8 Potable Water

The following assumptions have been made regarding potable water:

The Medupi plant operates with two separate water networks for fire and potable water. A connection point was provided by the client to connect to the existing potable water network. It is assumed that the existing water network will have sufficient pressure and capacity.

3.9 Fire Water

The following assumptions have been made regarding fire water:

The Medupi plant operates with two separate water networks for fire and potable water. A connection point was provided by the client to connect the existing fire water network. It is assumed that the existing fire water network will have sufficient pressure and capacity required. No provision will be made for fire water storage.

3.10 Sewerage

It was confirmed in a client agreement that the security post, locomotive workshop and administration building will be served with three container tank systems.

3.11 Fencing

The following assumptions have been made regarding fencing:

The existing three tier national key-point fence will be moved by Eskom to the north of the rail way site prior to construction. The existing service road fence will be used as the rail yard boundary fence.

3.12 Electrical

The following assumptions have been made regarding the electrical system:

- Electrical power will be distributed into the rail yard utilizing the proposed 6.6kV lime stone handling substation.
- Maximum of 5MVA will be required to run the rail yard.
- Cabling will be selected to have a volt drop better than 5%
- Existing mini-subs will be used for high mast lighting.
- Yard Lighting required will be at a 20 Lux minimum average.
- Future signalling will be required post 2020
- Future Electrification of Transnet freight rail lines will be required

4. DESIGN APPROACH

4.1 Design Inputs

4.1.1 Stakeholder Requirements

The stakeholder's requirements for the project was captured in the Stakeholders Requirements Definitions (SRD) report (200-130118) that was supplied to the client and signed off on 17 June 2014.

During the options phase the client required that the layout options be compared by means of project life cycle costing. First the unit cost to source the limestone from Lime Acres, Pienaarsrivier and Marble Hall was compared. Thereafter the unit cost for using wagons fitted with rotary couplers versus bottom discharge was also compared. Refer to the Options Study Report (1184-099-4-100-R-0001 REV02) in Volume 3 – Appendix 15.

4.1.2 Design Criteria Report

This document (200-130171) was compiled by the Consultant and signed off by the client of 17 June 2014.

4.2 Design process

4.2.1 Planning

A linear type yard layout was identified as the most suited option to take forward into the next phase of the project. The planning of this phase started with the approval process of the layout options phase and involved getting consensus on issues that were raised. These issues included balloon versus linear type layouts. Refer to the Options Study Report (1184-099-4-100-R-0001 REV02) in Volume 3 – Appendix 15.

Similarly a tippler was identified as the most appropriate technology choice for handling the limestone. A further assessment was conducted by the Consultants to determine the most optimum choice of tippler i.e. single wagon rotary tippler versus single wagon side tippler and this is discussed in more detail in the Concept design report Volume 2 (Materials handling).

4.2.2 Rail Yard Design Criteria

The design criteria that were agreed at the beginning of the project have been maintained and are listed in section 4.4 below.

The only change to the original design criteria relates to the number of wagons required for the transport of limestone which changed from 50 to 60 wagons. This is as a result of using the most suited rail wagon based on volumetric capacity to transport the limestone.

4.2.3 Options Development

The options were developed during the options phase of the project and are fully discussed in the Options study report (1184-099-4-100-R-0001-Rev02). Refer to Volume 3 Appendix 15 for a copy of this report.

Nine yard layout options were developed. These options have different rolling stock flows and material handling procedures in practice.

The most preferred layout option taken forward into the concept design phase was a more simplistic layout of layout option 1.

This was as a direct result of Eskom excluding the need to make provision for the handling of general cargo and bulk fuel oil. Refer to the Eskom Record of Decision (200-70810) approved on 13 October 2014.

4.2.4 Design Reviews

The design reviews are part of the regular meetings held between the Consultant's design team and the Eskom technical review teams. The reviews will culminate in the multidisciplinary design review (MDR) meeting which will be held after the completion of the draft concept report. A Hazop workshop will also be conducted as part of the detailed design review process.

4.2.5 Design Optimisation

The yard layout design that has been developed in this concept phase has undergone many reviews and has been optimised to meet the requirements of the stakeholders. A meeting with Transnet Freight Rail took place on 14 October 2014 and the results of the meeting led to further optimisation of the design.

The outcomes of the MDR and the Hazop will be used to incorporate final improvements in the detailed design.

4.2.6 Design finalisation

Before the start of the next phase which is the Detailed Design Phase, there is a need for design finalisation and a design freeze. Any issues that have not been finalised at this stage of the process will have to be excluded from the final design.

4.2.7 Specification

Specifications will be produced in the Detailed Design Phase

4.2.8 Quantities

A Bill of Quantities will be produced in the Detailed Design Phase although provision has been made for a high level Capex cost estimate as part of the concept study.

4.3 Design Verification

A site visit was conducted with the project design team and Eskom Technical Staff on 15 October 2014. Existing services and Eskom design requirements were verified on site. The site visit was concluded with a technical meeting addressing any outstanding information required. The design verifications were reviewed on an ongoing basis as part of the regular meetings held between the design team and the Eskom Technical review team.

4.4 Design Criteria

4.4.1 Train Operations

The rail operational process is based on the following criteria:

- All train will arrive at the Medupi Yard from the Thabazimbi direction.
- Limestone trains will arrive full and depart empty in 60 CAR-type wagon consist hauled by 4 Class 39 Diesel-Electric locomotives in a head-end traction configuration.
- FGD Gypsum trains will arrive empty and depart full in 50 CAR-type wagon consist hauled by 3 Class 39 Diesel-Electric locomotives in a head-end traction configuration.
- Train arrival and departure intervals will be dictated by the Transnet Freight Rail service design applicable to the Medupi Yard.
- The minimum design train length applicable to the yard clearance allowing for coupler play, draw-gear stretch and train handling is 969 m for a 60 CAR-type wagon train, including locomotives
- The maximum number of train-consists to be accommodated within the Medupi Rail Yard at any time is four.
- The ideal shunting locomotive configuration is one Class 36 Diesel-Electric locomotive.

4.4.2 Alignment Design

- Minimum Curve Radius - 200m at gathering roads
- Minimum staging gradient - 1:800
- Mainline turnout - 60 kg/m 1:12 tangential

- Yard turnouts - 48 kg/m 1:9
- Track Centres - 5.5 to 12m

4.4.3 Permanent Way Criteria (Loaded)

- Track structure - 20 ton Axle Load (Class N2)
- Gauge - 1065mm
- Rails - 48 kg/m
- Sleepers - P2 @ 700mm spacing
- Ballast - 1200m³/km

4.5 Codes and Standards

Various codes and standards including International standards, South African standards (Transnet and Eskom) will be applied in the design of the railway yard and associated infrastructure; these will be specified in the relevant technical specifications for each type of equipment. The following codes and standards have been used and considered in the development of this concept design:

4.5.1 Informative Standards

- TRH17: Geometric design of rural roads (Geometric Design)
- TRH14: Guidelines for road construction materials
- TRH4: Structural design of flexible pavements for interurban and rural roads

4.5.2 Normative Standards

- SANS 1200 (Bill of Quantities and cost estimates)
- SANS 10142-1 The wiring of premises SANS 10142- Wiring code
- SANS-10198 Selection, handling and installation of electric power cables not exceeding 33kV
- SANS-60439 Low-voltage switchgear and control gear assemblies
- SANS-10114 Artificial lighting of interiors
- SANS- 62305 Protection against lightning

4.5.3 Client Standards

- Eskom's station cabling and racking standard 200-11768
- Cabling will be selected to have a volt drop better than 5%
- Lighting will have a minimum average illumination level of 20 lux for outdoor as per SANS 10389-1 : 2003 Exterior lighting
- Eskom's Distribution Specification – Part 22: Medium-Voltage miniature substations for systems with nominal voltages of 11kV and 22KV- Document reference DSP 34-1621
- Earthing and lightning protection standard 200-11757
- Specification for switchgear and associated equipment for voltages up to and including AC 1090 V and DC 1200 V 240-56227516

4.5.4 Other Stakeholders Standards

- TFR - Manual E.10 – 1996 Railway Track Work
- TFR - Specification S116 – Rails
- TFR - Specification PWM 2/5 dated 1996 - Sleepers
- TFR - Specification S406 – Ballast
- TFR - Specification S410 – Substructure
- TFR - Specification for walkways - Drawing KY100 C301 dated 2009/05
- TFR - Manual for Track Maintenance 2012
- TFR S410 Specifications (Services roads and rail way layer works)
- TFR - Specification CEE-0018_ISS_90 for high mast lighting of outdoor areas
- TFR - Specification CEE-0003_ISS_90 for street lighting and yard lighting
- The Guidelines for Human Settlement Planning and Design (Roads, Water and Sanitation)

5. SYSTEM DESCRIPTION

5.1 Process Description

5.1.1 Rail Systems (In-Motion Weighbridges)

There are various Trade and Metrology approved in-motion weighbridge systems available. Provision is made for the installation of two in-motion weighbridges and automatic vehicle identification readers. One in-motion weighbridge will be installed at the entrance to the tippler to weigh incoming and outgoing wagons to determine the mass of the either the full or empty wagon. One in-motion weighbridge will be installed on the outgoing side of the FGD Gypsum load-out station to detect overloads and skew loading. A desktop computer and printer will be installed in the Rail yard operations room. Each of the in-motion weighbridge installations will be connected to the desktop computer in the Rail yard operations room. Triggering of the systems are done via through-beam presence detectors.

An example of a typical in motion weight bridge installation is shown below

Figure 1 – Typical in-motion weighbridge installation

5.1.2 Rail Systems (Shunt Locomotive)

The Class 36-000 model type GE SG108 and Class 36-200 model type GM-EMD SW1002 diesel-electric locomotives are the preferred locomotives used by Transnet for shunting operations in yards and sidings. The Class 36 is a general purpose locomotive that is equipped with two station controls for bi-directional operations.

Figure 2 – Class 36-000 locomotive

The specifications of the Class 36-000 locomotive is reflected in the table below:-

Table 1 - Class 36-000 Locomotive Specifications

Power Type	Diesel-electric
Designer	General Electric
Model	GE SG10B
AAR Wheel arrangement	Bo-Bo
Gauge	1,067 mm
Bogies	2.082 m wheelbase
Wheelbase	10.782 m
Width	2.727 m
Height	3.924 m
Axle Load	18,250 kg
Locomotive weight	72,000 kg average 73,000 kg maximum
Fuel Type	Fuel oil
Fuel Capacity	2 200 to 2 250 liters
Prime mover	GE 7FDL-8 4 stroke V8
Engine ROM range	385 rpm low idle 450 rpm idle 1,050 rpm maximum
Engine Type	Diesel
Aspiration	GE 1408 turbocharger
Generator	DC 10 pole GE 5GT-581C15
Traction motors	Four GE 5GE-761-A13 DC 4 pole * 665A 1 hour * 665A continuous at 15 km/h (9.3 mph)

Transmission	92/19 gear ratio
Multiple working	4 maximum

The performance figures of the Class 36-000 locomotive is reflected in the table below

Table 2 – Class 36-000 Locomotive Performance figures

Maximum speed	100 km/h
Power Output	875 kW starting 800 kW continuous
Tractive effort	176 kN starting 141 kN continuous at 14 km/h
Factor of adhesion	25% starting 20% continuous
Locomotive brake	28-LAV-1
Locomotive brake force	70% ratio at 345 kpa brake cylinder pressure
Train brakes	800 liters main reservoir. Compressor capacity at idle - 0.033m³/s Exhauster capacity at idle – 0.130m³/s
Safety systems	Vigilance control, two station controls

5.1.3 Rail Systems (In-Motion Weighbridges)

5.2 External Interfaces

5.2.1 Rail Systems (In-Motion Weighbridges)

An evaluation of the various in-motion weighbridge systems will have to be made to determine the external interfaces required with the local Medupi systems.

5.3 Control and Instrumentation System

Refer to drawing 0.84/43218 (Volume 3 Appendix 22) for the conceptual control system network architecture.

The Control system for the Medupi rail yard will be a standalone system where maintenance, spare keeping and monitoring will be handled from the main plant local to the rail yard.

Allowance will be made for the Control systems of the Medupi rail yard, to integrate to the other systems in the Medupi power station plant's system. The standards and specifications will be in line with the current requirements for Control and Instruments systems installed at Medupi power station.

The Automation technology to be considered will be Programmable Logic Controllers and by implementing similar Architectures the required standardisation will be achieved across Medupi Power Station.

There will be a requirement for a Plant Information System (PIS) that will make near real time and historical plant information available to third party applications. All PIS databases will be accessible by third party software applications on the Clients by means of SQL series. These third party applications will only be able to read data from the PIS databases

Control and instrumentation cables will be armoured for outdoor applications. All cables will be shielded, with a minimum conductor section of 0.5 mm2. Cables above ground is to be laid in trays or on ladder racks and will be segregated from power cables in accordance with International standards. Cables will be labelled and conductors will be identified at terminations by ferrule number or suitable proprietary method.

Instrumentation will be provided from reputable vendors. Where possible instrumentation will be similar to current specifications installed at the main power plant

Instrumentation will be provided with the necessary ingress protection for the location. Instrumentation located outdoors will be protected with sunshades.

Instruments measurement principles will be properly chosen to meet the following requirements:

- Medium
- Servicing without interrupting process
- Installation possibilities and accessibility
- Ambient and process conditions
- Operational ranges and accuracy

An option would be to use the Siemens PLC. This technology is currently being used at Medupi power station's main plant. Using SIMATIC WinCC which is a SCADA and HMI system from Siemens, monitoring and controlling physical processes in Medupi Rail yard can be done successfully.

5.4 Maintenance Concept

5.4.1 Rail Systems (Rail infrastructure)

The reliability of the infrastructure is inbuilt in the components that are used in the construction. The design criteria that have been used are the standards set by Transnet for sidings and yards. The maintenance of the rail yard will be undertaken by a contractor (Transnet) to the same standards as clearly covered in the Transnet maintenance manuals. This should ensure a high reliability during operation of the Medupi yard.

5.4.2 Rail Systems (In-Motion Weighbridges)

Due to the remoteness of the site, it will be necessary to train in-house personnel as to the first-line repair procedure. It is recommended that contingency spares be supplied by the preferred supplier. With most of the local in-motion weighbridge systems the suppliers can access the data on the centralisation desktop computer by means of a VPN access that allows them to provide a far more rapid response to support queries since faults can be remotely diagnosed and solved. Should a fault be such that it cannot be rectified remotely, a technician will be dispatched within a predetermined reaction time as agreed between Eskom and the supplier.

5.4.3 Rail Systems (Shunt Locomotive)

The maintenance of the shunt locomotive will be undertaken by an approved contractor (Transnet) to the same standards as clearly covered in the OEM maintenance manuals.

The following inspections and maintenance schedules will be conducted at the locomotive shed at Medupi:

Table 3 – Local locomotive inspections and maintenance

Inspection Type	Interval	Duration
Fueling examination	Daily	1 hour
2 Weekly Inspection	14 days	1 to 2 hours
Type A Examination	30 days	8 hours
Type B Examination	91 days	2 days

The following maintenance schedules will be conducted at an approved locomotive maintenance facility located off-site from Medupi

Table 4 – Remote locomotive inspection and maintenance

Inspection Type	Occurrence	Duration
Type C Examination	182 days	2 – 3 days
Type D Examination	365 days	5 days

5.4.4 Electrical Control and Instrumentation

The electrical, control & instrumentation systems for the Medupi rail yard will be a standalone where maintenance, spares holding and monitoring should be individual procedures separate from the main plant.

When designing the electrical, control & instrumentation for Medupi rail yard, integration to the main Medupi power station plant's system will be considered, where equipment used and specifications to be installed will be in line with systems already installed at Medupi power station. Making provision for integration will assist with less down time at the rail yard if faults arise.

Physical buttons on control panels and operating desk are known as hardwired I/O's, they can easily be traced by wirings done on their terminals. Buttons implemented on SCADA/HMI screens to operate logic are considered as soft I/O's. They can be traced by checking in the logic.

Current control equipment installed in Medupi power station are Siemens PLC, this technology will be considered when specifying equipment for Medupi rail yard. By implementing this philosophy, a maintained standard will be achieved across the Medupi Power station.

5.5 Operating Concept

5.5.1 Rail yard operations room requirements

When considering the Rail yard operation room, there are a number of factors and equipment that need to be taken into account. This must all be under a common roof to create a Rail yard operations room which aims to achieve the following:

- Improved communications between operational staff
- Reduced manpower costs in terms of supervision requirements
- Reduced construction costs

There are two critical factors that must be considered when a Rail yard operations room is designed:

- Equipment and tools to perform the task
- The human factor

The human factor is to ensure that operators manning the system must be in an environment conducive for the task at hand e.g. lighting design, air-conditioning design must be considered.

The main areas of focus for the operator evaluation are as follows:

- Controls
- Visual Displays
- Work Space
- Seating
- Communications

- Movement around the control console
- Documentation requirements
- Emergency Requirements
- Personal belongings
- Bathrooms
- Kitchen area
- Relaxation area
- Thermal comfort
- Lighting
- Auditory Environment

The control of Gypsum loading will also be done from this room where two control desks must be available.

5.5.2 Rail Systems (In-Motion Weighbridges)

The in-motion weighbridge system detect and weigh each wagon to provide an accurate measurement of the mass and the load distribution within the wagon. The AVI Readers identifies the wagon number as read from the RFID tags on the Transnet wagons.

The information of the in-motion weighbridge and the AVI readers are automatically merged and reflected on a desktop computer in the Rail yard operations room. In-motion weighbridges are trigger-based and is self-arming. A trigger occurs when the train presence is detected at which point data acquisition begins. Real-time data is acquired from the in-motion weighbridge and AVI reader, followed by analysis and data extraction. The information is time and dated stamped to reflect the actual transaction time.

Typical data that can be extracted from in-motion weighbridges are:

- Current Status – This will include the condition of the equipment at each installation. The current status will also be visible, i.e. idle or acquisition mode.
- Current alerts – A list of alerts for the current rain will be displayed, in descending order of severity
- Traffic History – A scrollable list of historic transactions will be permanently visible. A simple select and click will permit the operator to view and print train consist detail.
- Alert history – A scrollable list of history alerts will be permanently visible. A simple select and click will permit the operator to view and print alert history.
- The following data is produced and available on the desktop computer:-
- Individual Wagon Mass
- Train Mass
- Left to Right Balance (mass distribution)
- Front to Back Balance (mass distribution)
- Wagon Speed
- Wagon Time / Date of weighing
- Unique Wagon Number (AVI output)

Refer to Volume 3 Appendix 17 for ON-TRACK Technology Massize-T4 Track-side Installation detail.

5.5.3 Rail System (Shunt Operations)

The rail process in the yard is described below. Unless otherwise stated all train movements and indexing of wagons in the yard are duly authorised by means of open radio communication before being executed..

5.5.3.1 General Operating Procedure

All train movement on the Thabazimbi to Lephalale mainline is controlled from Pyramid South. A train-control officer in the Track Warrant office at Pyramid South controls the movement of trains over the main line in the track warrant section between Rustenburg and Ellisras.

The Track Warrant train-control officer, in collaboration with the Medupi Yard Master, controls the movement of trains to and from the Medupi yard.

The Medupi Yard Master is responsible for the admittance and despatching of trains, and controls all movements in the Medupi yard. Whilst in the Medupi yard, Transnet Freight Rail personnel must strictly comply with the instructions of the Medupi Yard Master.

The Track Warrant train-control officer and drivers of trains communicate by means of train radios on the track warrant open channel. The Track Warrant train-control officer, area planner/yard master/control shunter at Thabazimbi, and the Medupi Yard Master communicate with one another by means of telephones.

The area planner at Thabazimbi must, before the despatch of a train to the Medupi yard, contact the Medupi Yard Master and confirm that the train can be accommodated for unloading limestone or loading gypsum in the Medupi yard. The Track Warrant train-control officer will in good time inform the Medupi Yard Master of a train en route to Medupi and furnish the expected time of arrival.

On arrival of the train at Medupi, the driver must bring the train to a standstill on the run-off line short of the stop board leading into the Medupi yard and not proceed further unless, or until, he/she has received from the Yard Master a private siding walkie-talkie and verbal authority at the board, to pass the board.

The Medupi Yard Master must, before authorising the driver to enter the Medupi yard, ensure that:

- The runaway points and all other hand-operated points are correctly set for the admittance of the train to the Medupi yard
- The line on which the train is to be admitted is clear and no conflicting movement will take place
- After being authorised to pass the stop board, the driver must proceed onto the designated line and bring the movement to a standstill short of the clearance mark at the forward end
- After the last wagons has arrived within the clearance marks of the yard, the driver must inform the Track Warrant train-control officer accordingly and the Medupi Yard Master must restore the runaway points to the normal position.
- In the case of an ordinary airbrake train, the load must thereafter be secured in accordance with the train operating instructions of Transnet.
- See detailed train operating procedures in the sections below for the respective limestone and gypsum train operations.

Upon departure, either the empty limestone or full gypsum train, will undergo a technical examination and the prescribed train despatching duties will be carried out. Before departing from the Medupi yard, the driver must return the private siding walkie-talkie to the Medupi Yard Master.

When all is in order for the train to depart, the driver must contact the Track Warrant train-control officer and obtain a track warrant token to enter the main line track warrant section and return to Thabazimbi. After the Track Warrant train-control officer has issued the track warrant token he/she must inform the Medupi Yard Master accordingly.

After having received the assurance from the Track Warrant train-control officer that a track warrant token has been issued to the Transnet driver, the Medupi Yard Master must correctly set the points in the exchange yard and the runaway points for the departure of the train and authorise the driver to depart.

After the train has entered the main line and is clear of the runaway points the Medupi Yard Master must restore the runaway points to the normal position.

5.5.3.2 Limestone (Rotary tippler & wagons fitted with rotary couplers)

A train consisting of 60 loaded CAR-wagons arrives from Thabazimbi, and proceeds via the runoff line and stops at the Stop Board leading into the Medupi Rail Yard.

The train is handed over from the TFR mainline control to the local yard control. All train movements in the Medupi yard are controlled by means of verbal communication on open channel radios.

Once authorised the mainline train with the limestone wagons proceeds via line 2 onto line 8. The TFR mainline locomotives proceed and cross over onto line 11 and stop once the 31st wagon is positioned at the clearance markers on line 8. A minimum brake application is made on the train and the brake pipe is closed between wagon 30 and 31. The back consist of 30 wagons are uncoupled at the clearance marker on line 8 and secured, whilst the front consist of 30 wagons are hauled onto line 11 by the TFR mainline locomotives. Once the points are set, the 30 wagons on the line 11 are pushed back until the first wagon is positioned within reach of the wagon indexer and secured on line 10. The brake pipe is closed off on the wagon in front of the TFR mainline locomotives. The TFR mainline locomotives un-couple from the wagon consist and proceed forward onto line 12, where the points are set towards line 13. Once the points are set the TFR mainline locomotives proceed via line 13 and line 6 onto line 2. Once clear past the point set, the points are set to allow the TFR mainline locomotives to move back and couple to the 60 empty CAR-wagons positioned on line 7.

During this time the end-off train device is removed from the last full wagon positioned on line 8 and placed on the last empty wagon positioned on line 7. The train is ready to depart the yard once the technical inspection of the wagons and applicable brake test has been completed. The local yard control hands the train control back over to the TFR mainline control and once authorised, the empty train departs for Thabazimbi on the next available train slot. The shunt locomotive moves into position on line 8 and couples onto the front of the loaded wagon consist.

Un-loading of the full wagons commence once authorisation is received that it is safe to do so. Once authorised the shunting locomotive move into position and couples onto the front of the 30 loaded wagons staged on line 8. The shunt locomotives hauls the full wagons onto line 11 via the cross over between line 8 and line 11. The train stops once the rear is clear of the point set leading onto line 10. The points are set and the shunt locomotives push the full wagons back onto line 10 until the first wagon is positioned within reach of the wagon indexer at the tippler and secured. The brake pipe is closed off on the wagon in front of the shunt locomotive, and the shunt locomotive un-coupled. In all cases, the prescribed safety and hand-shaking procedures have to be carried out prior to the commencement of the actual indexing and un-loading process.

The shunt locomotive proceeds via the necessary lines and moves into position on line 10 to remove the empty wagons from line 10. The un-loading process stops once the shunt locomotive has to clear wagons from line 10. Once authorised the shunt locomotive move and couples onto the front of the first empty wagon consist on the western side of the tippler on line 10. The brake pipe is connected through and the brake system fully charged by means of the compressor equipment of the shunting locomotive. The shunt locomotive hauls the empty 30 wagons onto line 2 and the train is stopped once clear of the points leading back onto line 7. The points are set whereupon the shunt locomotive proceed to propel the 30 empty wagon consist back onto line 7. The shunt locomotive stop the train once the first wagon is positioned at the furthermost clearance marker on line 7. The shunt locomotive can remain attached to the wagons or un-couple, stand clear and wait until the second consist of 30 wagons are unloaded before moving back onto line 10. The same process is repeated to remove the second consist of 30 wagons from the tippler and placing it on line 7.

Once the empty wagon consist is combined into a train, the prescribed technical inspection and A-brake test is performed. Thereafter an emergency brake application is made prior to the shunt locomotive being un-coupled from the train. The shunt locomotive obtain authorisation and proceed to the next location as required.

5.5.3.3 Limestone (Single wagon side tippler)

Same procedure as discussed above but with the following difference. Each full wagon is uncoupled from the wagon consist before it is placed at the tippler. Thereafter the empty wagons are coupled together and the brake pipes between the wagons coupled. Two additional shunters are required during the offloading of the wagons using the single wagon side tippler.

One shunter to assist with the uncouple of the wagons from each other prior to placement at the tippler and one shunter to assist with the movement control of the empty wagons once discharged from the tippler. When required the empty wagons can be placed on line 4 and loaded with gypsum instead of departing the yard as empty wagons.

5.5.3.4 FGD Gypsum

A train consisting of 50 empty CAR-wagons arrives from Thabazimbi, and proceeds via the runoff line and stops at the Stop Board leading into the Medupi Rail Yard. The train is handed over from the TFR mainline control to the local yard control. All train movements in the Medupi yard are controlled by means of verbal communication on open channel radios. Once authorised the full train proceeds via line 2 onto line 4 and the train stops once the first empty wagon is positioned under the load-out station and the 1st wagon within reach of the wagon indexer. A minimum brake application is made on the train and the brake pipe closed off on the first wagon in the train consist.

The TFR mainline locomotives un-couple from the empty wagon consist on line 4. Thereafter the mainline locomotive proceed via line 13 and line 6 onto line 3 where it couples to the 50 full CAR-wagons. During the mainline locomotive run-around activity, the end-off train device is removed from the last empty wagon positioned on line 4 and placed on the last full wagon at the rear of the train positioned on line 3. The full train is ready to depart the yard once the technical inspection of the wagons and applicable brake test has been completed. The local yard control hands the train control back over to the TFR mainline control. Once authorised, the full train departs for Thabazimbi on the next available train slot.

The wagon indexer engages onto the couplers between wagon 1 and 2. The loading of the wagons commence once authorisation is received that it is safe to do so. The wagon indexer sequentially move the train consist at slow speed through the load-out station whilst the wagons are loaded in-motion. Once a maximum of 10 wagons are loaded the operation stops, the wagon indexer disengaged, and move back and position between wagons 11 and 12. The shunt locomotives moves into position on line 13 and couple onto the rear of the loaded wagon rake. The brake pipe is connected through and the brake system fully charged by means of the compressor equipment of the shunting locomotive.

The brake pipe between wagons 10 and 11 are closed off and the full wagons un-coupled from the rest of the train. The wagon consist is hauled forward till the last wagon is clear of the point-set between line 5 and line 13. The points are set towards line 3 and the full wagons propelled forward towards the further most clearance marker on line 3. The train is stopped once the first wagon in the wagon consist is positioned at the clearance marker on line 3. A full brake application is made, the brake pipe closed off in front of the shunt locomotive and the shunt locomotive un-couple from the wagon consist. The shunt locomotive move back onto line 13 and stop once positioned clear on line 12.The loading process commence once the shunt locomotive clears line 13 and authorisation is received that it is safe to do so. In all cases, the prescribed safety and hand-shaking procedures have to be carried out prior to the commencement of the actual indexing and loading process.

The process is repeated to load and place the full wagons on line 3. Once the full consist of 50 wagons is combined into a train, the prescribed technical inspection and A-brake test is performed and an emergency brake application made prior to the shunt locomotive being un-coupled from the train. The shunt locomotive obtain authorisation and proceed to the next location as required.

5.5.4 Rail System (Shunt Locomotive)

There are various permutations available for the utilization of the shunt locomotive depending on prevailing conditions and traction requirements.

Section 5.5.3 describes the movement of the shunt locomotive during the offloading of the full limestone wagons and loading of the gypsum wagons.

5.6 Safety Concept

5.6.1 Electrical Control and Instrumentation

General safety design and installation requirements for the electrical system will be as follows:

- No electrical equipment should be mounted on removable walkways or structures.
- Live parts of electrical equipment mounted in enclosures should be shrouded or shielded to prevent unintentional contact (IP2X) by personnel.
- All enclosures and devices with switch disconnecting properties (MCB's, MCCB, switch-disconnectors) must, where applicable have provision for securing by means of padlocks.
- All electrical installations should be such that they are "fail safe", i.e. the failure of the Plant or any circuit, stops the associated drive in a safe state.

General safety design and installation requirements for the lighting system will be as follows:

- All areas where lighting is required should be designed with personnel safety as the first criteria.
- Lighting design and installations should be completed in such a manner as to ensure that lighting provided does not have an adverse effect on any employee's performance while performing their duties. These criteria must comply with the OHS Act.
- Unwanted lighting and glare should be considered to ensure that all employee's safety whilst walking or performing specific tasks is not compromised.

6. SITING

6.1 Site Selection

The rail yard site selection was governed by the following:

- The decision to use the existing rail way network to deliver limestone to the power station.
- The position and layout of the FGD plant.
- Available space within the existing Medupi Power Station fence boundaries.
- The availability of existing services such as potable water, fire water and stormwater drainage structures.

The location of the proposed private siding take-off point is situated at kilometre point 107+128m on the Thabazimbi – Lephalale railway line which is not electrified. TFR is in the process of electrifying the section of track from Thabazimbi. The Consultant and Eskom liaised with TFR in order to incorporate their requirements in the design process.

6.2 SITE CHARACTERISTICS

The general topography of the site can be classified as flat terrain that slopes from the south west to the north east with a slope between 0.5% and 1%. For the construction of the rail yard a large amount of bush clearing will be required as approved by the Environmental Impact Assessment.

Stockpiles on the northern side of the proposed rail yard area are currently in use for other construction projects in Medupi. These stockpiles are to be removed before the commencement of the rail yard construction.

The bulk earthworks for the proposed rail way embankment will require large quantities of fill material. Due to the shortage of material on site all fill material G7 and higher will be imported from commercial sources.

6.3 SITE LAYOUT

Refer to the Main Concept layout drawing no. 0.84/4041 in Volume 3 Appendix 1.

7. BUILDINGS AND SERVICES

7.1 INTRODUCTION

It is required that the rail yard be provided with the following serviced buildings:

- Administration and operations tower building for Eskom and Transnet Freight Rail employees
- Diesel locomotive workshop, utilities rooms and ablutions
- Security office
- Fuel Storage and Dispensing Facility
- Tippler building, including subsurface structure
- Conveyor transfer towers

The administration and operations tower building are proposed to be located in one structure. The diesel locomotive workshop, security office, tippler building and conveyor transfer towers are separate structures.

7.2 ADMINISTRATION AND OPERATIONS TOWER BUILDING

Refer to drawings 0.84/40142 and 0.84/40143 in Volume 3 Appendices 9 and 10.

7.2.1 Design Parameters

The following parameters were applied in sizing the administration building:

- Allow for a staff contingent of 18 (10 TFR & 8 Eskom - split into 3 shifts)
- Separate ablution and change room facilities for both males and females
- Disabled toilet
- Kitchen
- Entrance foyer
- Offices
- No sick or first aid room

- No dining or restroom required
- Onsite parking for 5 vehicles

The following parameters were applied in sizing the operations tower:

- Rail yard operations room to be elevated to provide a view of the tippler. Future gypsum offloading will be monitored by means of CCTV.
- To accommodate 2 control desks
- Server room
- Power room
- No toilet – shared with administration building

It was considered beneficial to make the Rail yard operations room part of the administration building, so as to share in the services.

7.2.2 Siting

The proposed facility is situated to the north east of the proposed tippler building on relatively flat terrain. It will be connected to the infrastructure new roads, and has a view of the tippler facility and the rail yard.

7.2.3 Design

Taking into account the generally harsh environment and the remote location, the approach has been on designing a sustainable and low maintenance building structure. The emphasis is on providing natural light and ventilation, and selected finishes that will stand up to the environment and essentially industrial use, and require minimal maintenance. The structure consists of steel columns and portal frames (for ease and speed of erection) and facebrick brick infill panels. No allowance has been made for green building technology, such as rain water harvesting or solar geysers in the budget estimate.

7.2.4 Administration Building Layout

The building is rectangular on plan, with a central entrance section comprising a foyer and male and female ablutions. The northern wing houses male and female lockers or change rooms, and shower rooms.

The southern wing contains open plan Shunter's room, a storage room, a small kitchen and associated store room. The manager's office is located on the south eastern side of the building. A central concrete stair provides access to the elevated Rail yard operations room. The operations room is raised to 4m above ground floor level. It accommodates two control desks. The server room and power room are located in the stair tower, in close proximity to the operations room.

The roof sheeting overhang provides shade to the operators in the Rail yard operations room, and offices at ground floor level.

7.2.5 Finishes

Floor finishes generally ceramic tiles, except for carpets in offices and epoxy screed to store rooms.

- Wall finishes – washable paint
- Ceilings – vinyl clad gypsum tiles 600 x 1200 externally face brick to match other buildings on site
- Doors veneered, natural timber finish
- Sanitary fittings all white
- Ironmongery stainless steel

- Windows and shop fronts aluminium powder coated with safety glazing

7.3 Diesel Locomotive Workshop, Utilities Rooms and Ablutions

Refer to drawing 0.84/40145 in Volume 3 Appendix 12.

7.3.1 Design Parameters

The following design parameters were applied in sizing the diesel locomotive workshop

- Electrical and communications room
- Wagon repair store / telemetry and train equipment store
- Valuables storage
- Components and equipment
- Wash bay
- Lubricants and consumables
- Compressor room
- Battery store
- Rest room area
- Kitchen
- Ablution and change room facilities for both males and females
- Office

The structure consists of a rectangular clad structure 30m long x 16m wide, which accommodates the locomotives under repair. This raised section of the structure will be clad in mild steel sheeting, on structural steel portal columns.

The utilities rooms and ablutions described above form part of a double storey lean to, located on one side of the locomotive workshop.

7.3.2 Siting

The proposed facility is situated adjacent the (preliminary) pollution control dam, elevated on relatively flat terrain.

7.3.3 Design

Taking into account the generally harsh environment and the remote location, the approach has been on designing a sustainable and low maintenance building structure. The emphasis is on providing natural ventilation, and selected finishes that will stand up to the environment and essentially industrial use, and require minimal maintenance. The structure consists of steel columns and portal frames (for ease and speed of erection) and face brick infill panels. No allowance has been made for green building technology, such as rain water harvesting or solar geysers in the budget estimate.

7.3.4 Finishes

Floor finishes generally ceramic tiles, except for carpets in offices and epoxy screed to store rooms.

- Wall finishes – washable paint
- Ceilings – vinyl clad gypsum tiles 600 x 1200 externally face brick to match other buildings on site

- Doors veneered, natural timber finish
- Sanitary fittings all white
- Ironmongery s/s
- Windows and shop fronts aluminium powder coated with safety glazing

7.4 Security Office

Refer to drawing 0.84/40144 in Volume 3 Appendix 11.

The building consists of an industrial facebrick building, constructed on a raft foundation.

The security office is located adjacent the fenceline. The structure accommodates one counter and one desk, a single toilet and a fridge.

The roof sheeting overhang provides shade protection to the guard.

7.4.1 Finishes

Floor finishes are generally ceramic tiles

- Wall finishes – washable paint
- Ceilings – rhino board
- Externally face brick to match other buildings on site
- External hardwood,
- Ironmongery stainless steel
- Windows aluminium powder coated with safety glazing

7.5 Fuel Storage and Dispensing Facility

The structure consists of an open bunded area for location of the diesel storage tank. This area will be constructed on imported layerworks. A sump will be used to capture and dispose of stormwater entering the bunded area. The open bunded area will be approximately 6m wide x 10,5m long, with the diesel tank located in the centre of the bund.

The dispensing structure will be located immediately adjacent the fuel storage facility, and will consist of a concrete slab 4m wide x 10,5m long. The area will be covered by a monopitch clad structural steel roof, supported on steel columns. Foundations for the columns will be located below the floor slab level.

7.6 Tippler Building, Including Subsurface Structure

This structure is described in more detail, under the mechanical scope of work. Refer to Concept report Volume 2 (Materials handling).

7.7 Conveyor Transfer Towers

These structures are described in more detail, under the mechanical scope of work. Refer to Concept report Volume 2 (Materials handling).

7.8 Mini Sub Requirements

A mini substation may be required where electrical power will be delivered from the main substation in the rail yard namely:

- Mini Substation for lighting

Alternatively existing mini sub "J " may be used to supply the rail yard with lighting depending on available capacity. Refer to the drawing Substations & Cable Routes 0.84/40138 in Volume 3 Appendix 5.

The rail yard mini substations will be in accordance with Eskom's specification.

7.9 Substation requirements

In the event that there is not enough capacity at the Eskom's planned Limestone handling substation a new substation local to the rail yard will be required to supply both the bulk material handling and rail yard and services area.

A typical substation would include the following:

- 2 Step doors for access on either side of the substation
- Fire detection in the substation
- Fire protection in the basement
- 1 single door and 1 double on either side for access and entry of equipment
- Emergency doors with quick release facilities to exit the substation upon and emergency
- Emergency lighting
- HVAC considerations

7.10 Heating Ventilation and Air Conditioning (Hvac)

Non-effective air conditioning systems are often found to be the biggest singular source of discomfort to buildings. Although individual parameters of thermal comfort will vary from person to person the air conditioning system must be designed such that it provides the following parameters:

- Reliability
- Cooling and heating
- Humidity control
- Adequate air circulation
- Air filtration and pressurisation
- Sufficient fresh air
- Adjustability

Combined with the above, it is critically important that the system complies with the following:

- Air diffusion will not cause excessive drafts
- The HVAC system will not create disturbing noise.

Air conditioning systems will be designed such that varying ambient temperatures between day /night and summer / winter will not adversely affect the performance of the system.

8. ELECTRICAL DESIGN

8.1 Power Supply into the Rail Yard

Currently there is a planned 6.6kV limestone handling plant substation as part of the FGD plant where the supply for the rail yard will be delivered. An option would be to utilize either the 6.6kV or 11kV for electrical feed into the yard.

Relay rooms are required to feed local control points and yard equipment. In the yards substation there will be a transformer which steps down the incoming voltage from 6.6kV to 400V for LV equipment and 220 volts ac or 110 volts dc for control and instrumentation. DC will be generated by means of a UPS with a battery backup, the required DC voltage will be tapped off from the UPS.

8.2 Power for the Yard Lighting and Facilities

Currently the existing rail yard operations will be in accordance with Transnet Freight Rail. Therefore lighting in the rail yard will be as per TFR's standards.

Power will be distributed from the main substation in the rail yard into a yard lighting mini substation/kiosk, or an existing mini-sub.

8.3 Power for Rail System (Signalling and Yard Automation)

Currently there will be no signalling required for rail operation and is not applicable for the current design, since train movements on the current network are authorised by means of radio train orders.

Provision will be made for a Rail yard operations room to monitor and control yard movements from a central point in the yard.

8.4 Cable Route, Type and sizing criteria

Refer to the drawing Substations & Cable Routes 0.84/40138 in Volume 3 Appendix 5.

The risk to plant and personnel due to the failure of cable and connection failures is an important consideration. The most important items that are considered during the design phase are the size (length and effective area) of the cables, the type of cable used for the application, cable route, cable supporting and the fire risk of the cables. The cable route will be the most practical and economical route available and where possible cables will be installed on the northern and western sides of the street.

Electrical services will be kept on the opposite side of the road to telecommunication and water services where practically possible.

The types of cable mainly used for new installations are the flame retardant PVC cables and the halogen free (HF) cables. The most important difference in the properties of these two cable types is the high emission of acid gas (hydrogen chloride) from PVC cables in the case of fire whereas no hydrogen chloride gas is released from the halogen free cables. The hydrogen chloride (HCL) gas in combination with other toxic gases that are produced from the burning of PVC. This acid gas is also responsible for the corrosion to steel reinforcement of concrete, steel structures and electronic equipment printed circuit boards. The cables shall be XLPE insulated with flame-retardant reduced halogen emission PVC outer sheath (emit a mass of not more than 15% halogen). Acceptance criteria for insulation shall be in accordance with SANS 1411-2.

Cables shall be manufactured in accordance with SANS 1339 and SANS 1411 Parts 1, 2, 4 and 7.

In the cable size range of 35 mm^2 to 185 mm^2 3½ core cables with a neutral core approximately ½ of the cross sectional area of the phase conductors shall be used. Cabling will be selected to have a volt drop better than 5%.

8.5 Electrical Power Requirements

As mentioned previously there is an already planned 6.6kV/400V substation that has been considered where electrical power will be distributed into the rail yard. All electrical, control and instrumentation equipment are rated at different voltage levels therefore Three-phase electrical power must be supplied into the rail yard.

Electrical power will be distributed from either 6.6kV, 11kV existing substation or the planned 6.6kV limestone handling substation into the main substation locally to the rail yard .Thereafter the voltage will be stepped down and distributed to various equipment on the rail and bulk material handling side.

8.6 Future Electrification Requirements

Transnet freight rail have a future plan of electrifying their existing network which will be used by Medupi for the bulk material handling of limestone and gypsum post 2020.

Electrical considerations must be taking into account when considering cable routes for lighting of the siding under train tracks, as well as positioning of masts will be critical to ensure that when maintenance for these medium and high masts arise, all clearances are maintained.

8.7 Switchgear General Specifications

8.7.1 General

- Switchgear should be supplied in accordance with specification 240-56227516
- Provisions will be made for UPS's in the substation for the switchgear control voltage

8.7.2 Circuit breakers

Circuit Breakers should be of the three pole, single mechanism type, with spring operating mechanism. Spring charging will be done by means of an 110V DC electric motor.

The circuit breakers should be in accordance with the requirements of IEC 62271.Testing of the breakers will be done in accordance with IEC 60060.

8.7.3 Isolating switches

The isolating switches should be of the centre rotating, side break type with manual operating mechanisms. All shaft movements will be facilitated by means of roller or ball bearings.

The centre insulator should rotate with the contact arm. Contacts will be silver plated and spring loaded.

The isolating switches should be in accordance with the requirements of IEC 62271.

Testing of the isolating switches will be done in accordance with IEC 62271.

Insulators used for isolators, should be tested in accordance with IEC 60168 and IEC 62217.

8.7.4 Current Transformers

Current transformers should comply with the requirements as stipulated in IEC 60044.

Insulated bushing material should be of porcelain or silicon rubber or composites and will be tested in accordance with IEC 60168 and IEC 62217.

Testing should be done in accordance with IEC 60060.

Multiple cores should be provided for the different protection requirements as well as for metering.

8.7.5 Voltage Transformers

Voltage transformers should comply with the requirements as laid down in IEC 60044.

Insulating bushings should be porcelain or composite rubber or composites and will be tested in accordance with IEC 60168 and IEC 62217.

Voltage transformers should be of the inductive type.

Testing will be done in accordance with IEC 60060

8.7.6 Surge Arrestors

The arrester should be capable of absorbing lightning and switching surges without damage to the equipment.

Testing will be done in accordance with IEC 60060.

8.8 Concept design description and equipment

Electrical power provided, shall be bulk, dual, AC supplies to low and medium voltage switchboards situated in electrical substations.

Circuits on these boards will be provided for the power supplies to the Plant i.e. motors, cubicles, power distribution boxes, variable speed drives etc. as per the power supplies required.

A dual supply auxiliary power system switchgear philosophy will be adhered to for ancillary plant i.e. when one board is isolated for maintenance purposes; only the electrical equipment supplied from that switchboard are out of operation, the Plant being fed from the other supplies shall remain in operation.

All concepts shall be in accordance with Eskoms standards and similar to the Medupi main plant, if not the same, philosophies shall be adhered to at all times when considering electrical infrastructure at the Medupi rail yard.

8.8.1 Power Conditioning

8.8.1.1 AC Power supply conditions

8.8.1.1.1 Normal AC supply conditions

Extremes of these parameters can occur simultaneously:

- Voltage: ± 5 percent
- Frequency: ± 2.5 percent
- Voltage unbalance: Negative Phase Sequence (NPS) voltage up to 0.02 of nominal Positive Phase Sequence (PPS) voltage
- The Zero Phase Sequence Voltage component can be up to 1% of the PPS component.
- The harmonic distortion of the supply voltage under normal operation will be as follows:
- The Total Harmonic Distortion (THD) of the voltage can be up to 5% of the fundamental component.
- The voltage waveform can contain harmonic components up to the 100th harmonic.
- The amplitude of any individual component can be up to 1% of the fundamental component.

Where variable speed drives are provided the harmonic current values as prescribed in this paragraph shall be adhered to. For all operating conditions, individual harmonic currents shall not exceed (these are measured at the electrical supply boards):

- rms amplitude of 100/n percent, where n is the harmonic number.
- sub-harmonic currents shall not exceed the RMS amplitude of 100n percent, where n is the fraction given by the sub-harmonic frequency divided by the fundamental frequency.

8.8.1.1.2 Abnormal AC power conditions

The supply voltage frequency can reach limits of up to 52.5 Hz and fall as low as 47.5 Hz. This condition can last for up to 1 minute.The amplitude and duration of temporary abnormal voltage conditions which can occur on the power supply are as follows:

- Short duration abnormal conditions: Short duration undervoltage conditions arise either due to a loss of supply or the supply voltage being depressed due to a short circuit on the network.
- Loss of power supply: When the supply is disconnected, the supply voltage either drops rapidly to 0% of nominal value or is sustained at low amplitude at a reduced frequency because of back generation of electrical drives. The initial voltage amplitude during these conditions is less than 80% of nominal value and decays with a time constant of up to 1.5 seconds. The time duration from loss of supply until supply restoration is between 1 second and 2.5 seconds.
- Short circuits: Depression of supply voltage due to short circuits can result in voltages as low as 0% of nominal value. The duration of the drop can be up to 1 second.
- Overvoltages: Overvoltages with amplitudes of 110% of nominal value can occur for up to 10 seconds.
- Medium duration power supply deviations: Voltage depressions of medium duration can be caused by the switching of load, such as starting induction motors. The supply voltage can fall as low as 75% of nominal value and the duration of this depression can be up to 15 seconds.
- **Power swings:** An alternative source of this abnormal condition is when power swings occur after a severe disturbance on the network. The supply voltage amplitude will oscillate at a frequency between 0.2 and 2 Hz. In this case, the voltage can fall as low as 65% of nominal and can rise up to 110% of nominal during a swing. The voltage will not fall below 70% for longer than 0.5 seconds. However, these oscillations, or repeated abnormal voltage conditions, can continue for up to 60 seconds.
- Long duration power supply deviations: Long duration abnormal supply voltage conditions usually originate from operating the plant at its limits. The supply voltage can be up to 110% of nominal value and can drop as low as 90% of nominal value. The duration of such abnormal conditions is up to 6 hours.

The following lightning and switching surge conditions can occur on the power supply system:

- Lightning impulse: Phase-to-earth and/or phase-to-phase lightning impulses with a front time of 1.2 μs, a time-to-half-value of 50 μs, a peak value up to that indicated in the Switchgear Parameter Table and with both positive and negative polarities, as described in IEC 60060-1.
- Switching impulse: Phase-to-earth and/or phase-to-phase switching impulses with a front time of 250 μs, a time-to-half-value of 2500 μs, a peak value up to that indicated in the table in paragraph 5.1 and with both positive and negative polarities, as described in IEC 60060-1.

8.9 SINGLE LINE DIAGRAM

The single line diagram (refer to drawing 0.84-40147 in Volume 3 Appendix 21) shows a high level concept layout of the rail yard area where the main supply will be from the Eskom planned limestone handling plant which feeds the rail yard and services as well as the bulk material handling area. A redundancy principal of 100% will be used which means at any giving point the rail yard will have a spare supply which will be able to carry the entire load of the rail yard. Two 6.6kV boards will further step down to 400V where the low voltage will be distributed from to various equipment ie. FGD plant, Limestone handling, Rail yard operations room, admin building and possible the rail area lighting.

Table 5 – Electrical Equipment List

Electrical Equipment List-Medupi Rail Yard				
Rail yard Substation	**Rail yard & Services**	**Bulk Material Handling**	**Admin Building**	**Operations Building**
Distribution board	**Weighbridge-Building**	**Limestone BMH**	Distribution board	Distribution board
Plug Points	Distribution board	Power supply for IP cameras	Plug Points	Plug Points
Power supply for IP cameras	Plug Points	Power supply for motors & VSD		Monitors
Sensors(fire)	Power supply for IP cameras	Power supply for auxiliaries	Mini substation	
	Mini-substation	Power supply for all C&I	***Lighting inside & outside***	***Lighting inside & outside***
Lighting inside & outside	***C&I***	Mini-substation	Cabling	Cabling
Cabling	Cabling	***C&I***	Lamps /florescent	Lamps /florescent
Lamps /florescent	Trenching	C&I equipment (load cells, sensors, etc.)	Power supply	Power supply
Power supply	Instruments (load cells, sensors, etc.)	Cabling		
	Power supplies	Trenching	***Air-conditioning***	***Air-conditioning***
Air-conditioning			Cabling	Cabling
Cabling	***Lighting inside & outside***	**FGD Gypsum BMH**	Air conditioning Unit	Air conditioning Unit
Air conditioning Unit	Cabling	Power supply for IP cameras	Power supply	Power supply
Power supply	Lamps /florescent	Power supply for motors & VSD		
	Power supply	Power supply for auxiliaries	***Electrical Rooms***	
Transformer(11kV/415v or 6.6kV/415v)		Power supply for all C&I	Power Room	
Cables to Transformer	***Air-conditioning***	mini-substation	Server Room	
Trenching	Cabling	***C&I***		
Bund wall	Air conditioning Unit	C&I equipment (load cells, sensors, etc.)		
Earthing	Power supply	Cabling		
Auxiliaries		Trenching		
Switchgear	***Yard Lighting***			
Circuit breaker	Distribution board			
Isolator	Cabling			
Current transformers	Luminaires + auxiliaries			
Voltage transformers	Masts			
metering units CT+VT	Trenching			
	Day/night sensors			
Panels				
Transformer protection panels				
Metering panels				
Equipment panels				

9. CONTROL AND INSTRUMENTATION DESIGN

9.1 Introduction

Control and instrumentation will be required for both the bulk material handling as well the rail yard and services.

The scope of the C&I project includes the following:

- SCADA and Control System
- Monitoring and Control for Bulk Materials Handling, Rail-yard Equipment
- Interface to Weighbridge standalone systems
- Plant Information system
- Building Management system including lighting management, CCTV, Access control, Intercom/ PA and Fire Detection systems
- Interface to Medupi Power plant
- Field Equipment

The C&I Architecture drawing 0.84/43218 (Refer to Volume 3 Appendix 22) will include a standalone PLC & SCADA system to the Medupi Power plant Control System with an interface to the Medupi Power plant Control system.

The facility control and instrumentation will provide services for the integrated monitoring and control of the Medupi Rail Yard to achieve a Facility-wide integrated system. There will be a local Plant Information System (PIS) which provide facilities for storing and transfer of information to the main power plant concerning the performance of the system, production, facility conditions and performance and provide data in order to obtain the required parameters.

The PIS information as well as information from the BMS can be accessed by the Medupi Power plant control room through the PIS interface and CBMS respectively.

Centralised operation will be deemed to include all actions that will normally be undertaken to accomplish normal and emergency start-up, routine loaded operations, and normal and emergency facility shutdown.

All local controls, control panels and other Human Machine Interfaces (HMI) located inside and outside the CCR, namely in equipment rooms, switchgear rooms or local to the Facility, will in general be regarded as operational facilities and the SCADA and/ or Control and Monitoring System will interface to these facilities and monitor all such operations.

A high-level computer system (HMI) will be provided with multiple operating stations and integrated with the control system to perform local control and monitoring, and for automatic comprehensive data logging and archiving with detailed analysis and reporting for maintenance management. On-line condition monitoring will be provided for equipment.

The communications between SCADA and the PLC as well as the Interfaces to the main power plant are considered to be redundant. This would achieve the best availability at this level however once the plants total availability requirements are confirmed the level of redundancy in all systems including PLC will be addressed. Due to the nature of operations its currently not foreseen to have redundancy at the Field level that requires control by the PLC’s therefore no redundancy in the PLC’s was allowed for.

9.2 Rail Yard and Services

Looking at the rail yard and services, currently no signalling will be required as all train movements on the current network are authorised by means of radio train orders.

I/O systems required may include the following:

- C&I will be required at the weighbridge
- Surveillance of the weigh bridge may be considered.
- Yard control system: Control system will consist of the basic hand operated point sets that will allow for safe and efficient shunting within the yard

9.3 Yard Control System

Given the fact that it is not a prerequisite that yards or sidings be signalled and taking into account the low number of trains that will be handled in the yard, it was identified that the most viable and safe train operating method will be by means of hand operated point sets. All shunt movements will be communicated between the train driver and shunters being by means of open channel handheld radios.

Three approved and well documented control systems were compared:-

- Manual Hand Tumblers
- Automated Yard Control
- Signalled with Central Traffic Control

9.3.1 Manual Hand Tumblers

- Manual hand tumblers in yard
- Points are set manually by shunt personnel
- Point set position indicated by the colour of the head of the tumbler, or
- By the arrow on the new VAE sets
- Shunting movements are communicated by means of hand held radios
- Recommended for small yards with low traffic flows such as the Medupi yard
- Low cost compared to other systems

Figure 3 - Manual hand tumbler

Figure 4 - New VAE sets with arrow

9.3.2 Automated Yard Control

- All the point-sets are automated
- System requires that track vacancy detection equipment on each track
- Position of point-set is indicated by a colour light (Not to be confused with a signal)
- System can either have a local points control or remote points control
- Local points control requires manual activation at each point-set by means of push buttons on the side of the indicator
- Alternatively it can be controlled remote from a control cabin

Figure 5 – Remote control point

- The remote control point will have a computer with a Visual Display Unit to indicate the specific position of each point-set within the yard
- Shunting movements are communicated by means of hand held radios

Figure 6- Points Indicators

- The system is recommended for medium size yards with medium traffic flows
- Opeation is less laborious than the hand operated tumblers due to power operated point-sets
- More expensive than manual hand tumblers

9.3.3 Signalled with Central Traffic Control

- Signalling system using multi-aspect colour light signals
- Electrically controlled point machines

Figure 7 – Example of a typical multi-aspect colour light signal

- Interlocking and power equipment that requires a relay or equipment room

Figure 8 – Example of relay or equipment room

- Requires track vacancy detection such as an electrical track circuit or axle counters

Figure 9 – Example of track vacancy detection equipment

- Points together with the signal and track vacancy is interlocked and no conflicting routes can be set up
- System requires a Centralised Traffic Control office
- Control of points and setting up of routes are done via input from the computer keyboard
- Movement of trains are graphically displayed on a Visual Display Unit

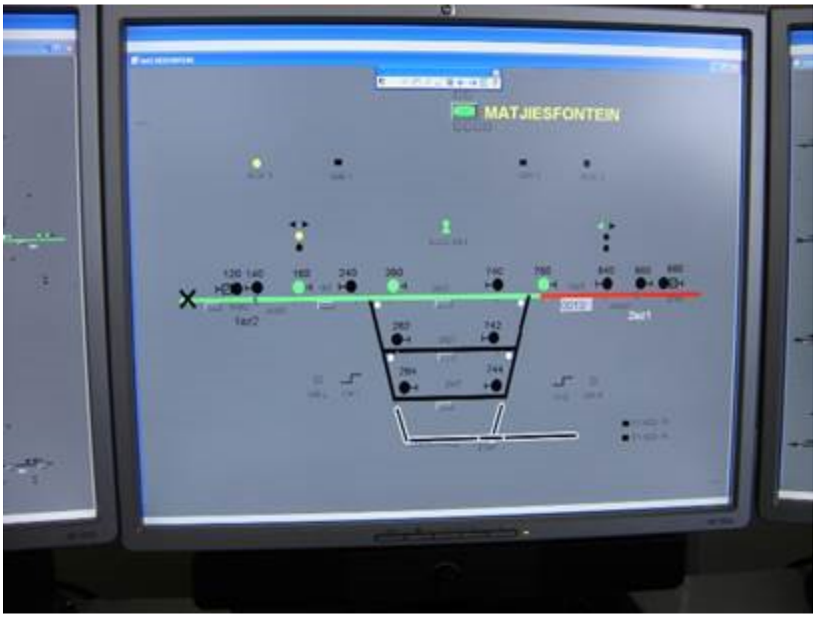

Figure 10 – Graphic display of route

- Should a fault condition occur the point set can be operated by means of a manual crank
- Shunting movements are communicated by means of hand held radios
- Recommended for large yards with high traffic flows
- System is very costly

9.4 Signals and Telecommunication

As mentioned in the previous section there will be no signals in the yard. All train movements on the current network are authorised by means of radio train orders. We do have information that signalling will be required in 2020 and provision is made in the design to accommodate the future signalling A dedicated electrical supply must be available for signalling together with backup power for safety and operational reasons.

9.5 Surveillance

Surveillance will be required for both security measures and monitoring of the rail yard & bulk material handling area. These cameras may monitor the rail yard, railway line, weighbridge as well as the specific areas of the BMH area.

IP cameras will be considered as opposed to analogue cameras due to the resolution and picture quality as well as the type of footage that is required. For example yard monitoring for security may require cameras that can be control by moving 360 degrees as well as zooming capability, whereas monitoring of the rail way line or conveyors maybe require cameras with fixed lenses that have no zooming capabilities.

All footage will be displayed in the Rail yard operations room where dedicated screens will be provided for viewing.

Long term Storage of footage will be provided and easily retrievable via a high resolution DVR.

10. RAIL REQUIREMENTS

Provision is made for a runoff line from the Transnet Freight Rail mainline into the Medupi Rail Yard, to allow the mainline train to rapidly exit the mainline and thus not to cause delays to train operation on the mainline.

Provision is also made for sufficient length of track on the western side of the yard, providing sufficient track to shunt 30 x CAR wagons from the tippler and place them onto the departure line within the yard.

The yard is designed to accommodate the simultaneous staging of two trains consisting of 60 type CAR-wagons within the limestone yard and two trains consisting of 50 type CAR-wagons within the gypsum yard.

Refer to the Concept layout drawing 0.84/40134 in Volume 3 Appendix 1 for more details.

11. YARD LAYOUTS

The proposed yard layout is situated on the western side of the Medupi Power Station. The yard is situated just north of Transnet Freight Rail mainline which runs between Thabazimbi and Lephalale.

The entrance into the yard is from the Thabazimbi side of the Transnet Freight Rail mainline and consist of a runoff section that can accommodate the longest train configuration envisaged to be handled within the siding.

The yard layout is in linear type configuration with six lines parallel to each other, and split into two separate yards and sections linked by means of a locomotive run-around line.

11.1 GYPSUM YARD

- Consist of the following lines/sections:
  - Line 3 – Gypsum departure line
  - Line 4/5 – Gypsum arrivals line with loading facility
  - Line 6 – Locomotive run-around line

11.2 LIMESTONE YARD

- Consist of the following lines/sections:
  - Line 6 – Locomotive run-around line
  - Line 7 - Limestone departure line
  - Line 8/9 - Limestone arrivals line and Not to go line
  - Line 10/11/12 - Limestone unloading line, shunt locomotive shed, shunting neck

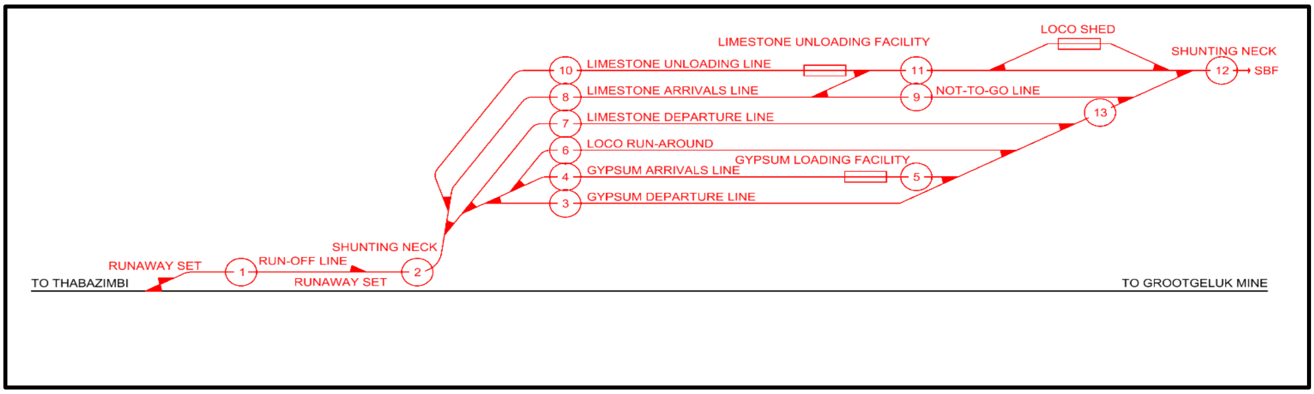

Figure 11 – Layout of Rail Yard

Refer to the Concept layout drawing 0.84/40134 in Volume 3 Appendix 1 and to the Rail plan and profile drawing 0.84/40135 in Volume 3 Appendix 2.

12. SERVICE ROAD REQUIREMENTS

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

The existing rail way is serviced by a 6m gravel road. It is proposed that the new service road connect to this gravel road at the existing rail way crossing. It is proposed that the service road will be designed on the same platform as the rail way to provide level access to all facilities.

The road alignment is be determined by the rail way layout. The road centreline is placed 6m from the rail centreline. The road will be designed and modelled using AutoCAD Civil3D.

Road cross and longitudinal sections will be generated for the service road. This will be accompanied by a detailed layout drawing with setting out data. The SANS 1200 will be used to compile a complete bill of quantities for the service road.

The service road will be designed to the following specifications:

- 6m wide gravel road
- Cross fall between 1:15 and 1:40
- Layer works as specified in the Transnet S410 specifications
- Geometric design to travel with reasonable ease with a 7t truck
- Maximum local depressions and bump of 50mm
- The road centreline will be placed 6m from the outside rail centreline
- Cut and fill slopes at 1:2

The service road will be designed as a 6m wide gravel ring road to service all facilities in the rail yard. The start position will be at the existing service road rail way crossing. The road layer works will be designed to the same standard as the rail way layer works. The road will have a cross fall between 1:15

and 1:40 for storm water drainage. No formal storm water drainage will be installed for the proposed gravel road. Guard rails will be installed on areas of fill more than 0.5m high.

13. STORMWATER AND DIRTY WATER REQUIREMENTS

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

The portion north of the rail way line drains to an earth lined channel at the north side of the rail yard. This channel drains from west to east and exits at a newly upgraded stormwater culvert. The size and capacity of the new culvert should be verified during detail design.

The clean rail way stormwater will be collected using concrete channels and underground pipes to drain into a new proposed earth lined channel that will drain to the newly upgraded culvert. This culvert size will be evaluated using the 1:20 year peak flow to determine the required culvert size due to the increased run off from the rail way yard.

The dirty stormwater from the gypsum loading facility will be collected into an independent concrete channel and underground pipe network that will drain to the proposed pollution control dam that will be designed by the FGD project team. The estimated run off contribution to the pollution control dam will be $0.05m^3/s$ for a 1:20 year return period.

The topographical survey will be used to determine catchment areas and flow paths with the assumed 437mm MAP. The rail way drainage and earth lined channels will be modelled in a Hydro cube model using the rational method for different return periods. The rational method will be used for all the 1:2 and 1:20 year return periods. All required structure sizes will be evaluated and sized accordingly

The Hydro cube analysis will provide peak flow values for the chosen return periods. Pipe, channel and culvert sizes will be determined from this analysis. The SANS 1200 will be used to compile a bill of quantities for stormwater structures.

14. CIVIL SERVICES AND REQUIREMENTS

14.1 Bulk Earthworks

The topographical survey and a site visit clarified numerous stockpiles on the proposed rail way site. It is assumed that all the stockpiles will be removed prior to construction. The bulk earthworks below the rail way main layer works will be constructed using G9 material.

From the topographical survey and final approved rail way layout an AutoCAD Civil3D model will be used to generate setting out data and measurement of quantities.

A detailed bulk earthworks layout drawing with setting out data and cross sections will be issued during detail design stage. Bulk earthworks quantities will be used to compile a SANS 1200 bill of quantities. The layer works will be constructed as per typical section on drawing 0.84/40141 in Volume 3 Appendix 8.

The positions and placement of the platform for the rail way layer works and bulk earthworks was determined by the final approved rail way layout. The platform was designed to ensure that the new toe line will not overlap the existing service road fence.

A letter dated 6 August 2014 from Eskom requested the design team to review all earthwork designs due to the quality of stockpiles deteriorating from G5 to G6 and G7 to COLTO classifications.

For the concept design stage it is assumed that all materials G7 and higher will be imported from commercial sources. With the final geotechnical report outstanding it was assumed (on advice from the Geotechnical Engineer) that the insitu material could be collapsible and would have to be compacted by an impact roller to ensure proper support.

The platform will be designed to accommodate the limestone unloading facility, locomotive shed, diesel storage and the gypsum loading facility on the same level as the rail way lines. The security office and accommodation building will be provided with separate platforms.

The bulk earthworks and rail way layer works will be designed according to the Transnet S410 specifications. All cut and fill slopes for the earthworks will be designed to 1:2. The bulk earthworks will consist of G9 material compacted to 93% MOD AASHTO in layers of 150mm. The rail way layer works will be designed for a 26t axle load to specifications.

14.2 Potable Water

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

Medupi is served by an existing independent potable water network. The connection chamber and position was provided by the client. It was assumed that the connection to the existing network will provide sufficient pressure and flow required for serving the buildings. The pressure and flows at the connection points will be confirmed prior to detail design.

The potable water network serving the facilities will be modelled during the detail design using the Water Mate package.

A detailed calculation report sheet will be generated during detail design illustrating the required pipe sizes and pressures at specific nodes. The SANS 1200 will be used to compile a bill of quantities for all the water pipes.

The potable water network will serve the security office, locomotive workshop and administration building with a stand tap and ablution facilities. Provision will also be made to serve the materials offloading facility and the gypsum loading facility with stand taps.

The following design parameters, which resulted in an estimated peak flow of 0.5l/s, were used as base for the potable water design:

- Population – 18 people
- Unit demand – 80 litres/person/day
- Peak Factor – 4
- Pipe material – 50mm uPVC Class12

It is proposed to install 50mm uPVC class 12 pipes to all buildings in the rail yard. All pipe sizes will be re-evaluated when pressures and flows are known at the connection point. The final pipeline positions and valve placement will be conducted after the approval of the layout plan.

14.3 Sewerage

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

The security office, locomotive workshop and the administration building will be serviced with an ablution facility with three independent container tank systems. The container tank option is proposed due to the general site topography, distance from the network and limited information regarding the existing sewers.

The sewer flows and required pipe sizes will be designed using Pipe Mate. SANS 1200 will be used to compile a bill of quantities for the sewers.

The following design parameters were used as base:

- Population – 18 people
- Unit demand – 80% of potable water consumption, thus 64litres/person/day
- Draining with a tank truck (Honey Sucker) every two weeks

14.4 Civil Works Relating To Electrical

Electrical civil work will be required for the following:

- Lighting Foundations
- Lighting Cable trenching
- Control cable trenching

All excavation, trenching and concrete work will be done to SANS 1200 specifications.

15. GEOTECHNICAL AND HYDROLOGICAL STUDIES

The following scope of work is proposed:

15.1 Desk Study Review

- A desk study review will be undertaken of all the available geotechnical and geological information pertaining to the site including published geological maps and geological and geotechnical reports.

15.2 Fieldwork Will Include The Following

- Test Pits
- Dynamic Core Penetrometer (DCP) Tests
- Continuous Surface Wave (CSW) Tests
- Construction Material Sampling
- Laboratory Testing

15.3 Geotechnical Report

A geotechnical report will be compiled presenting the information obtained during the site investigation including the prevailing site conditions, stratigraphy, material classification and characterisation, geotechnical parameters, preliminary foundation recommendations and recommendations for infill investigations if required. A factual interim report will be issued about one week after the completion of all fieldwork presenting the recorded soil profiles, DCP results and CSW logs but a final interpretive report will only be issued a week after receiving all laboratory results. Rockland will however endeavour to supply the design team with information as it becomes available to allow the design process to proceed with least interruption.

16. WALKWAY REQUIREMENTS

The walkways will be designed in accordance with the Transnet specifications for walkways as reflected in Transnet drawing KY.100.C.301 dated 2009/05. The walkways will be filled up to the level of the top of the ballast with material giving good drainage and a sound walking surface. The minimum distance from the rail to the edge of the walkway will be 2 metres to allow for a safe walking environment next to the track.

17. RAIL AREA LIGHTING REQUIREMENTS

17.1 Background

This section will take into consideration all railway yard lighting required to ensure the correct lux levels will be reached.

The aim is to always provide high quality lighting at minimum cost. This will be achieved by adhering to Transnet's Freight Rail specifications which will combine both medium (15m high) and high (25m high) masts to provide the correct lux level.

Transnet Freight Rail uses two specifications, namely CEE.0018 for High Mast Lighting and CEE.0019 for Medium mast lighting.

Transnet Freight Rail previously required an average illumination level of 3 lux at ground level in its marshalling yards. This has now been increased to a minimum level of 20 lux, depending on the task to be carried out.

Transnet Freight rail's rule of thumb is high masts will be used in larger areas and medium masts in smaller areas or where you have a long, but relatively narrow area.

Lamps utilized to obtain the correct lux level are 400 Watt High Pressure Sodium Discharge Lamps with associated control gear. Different Lamps are being looked at currently by TFR but the total installed cost as well as energy consumption is still higher than for High Pressure Sodium discharge lamps for the same amount of illumination on the ground.

17.2 Automatic Control of Lighting

Day/night sensor will be used for the automatic control of lighting to maintain the required 20 lux minimum average level of illuminance.

17.3 Emergency lighting

Where emergency lighting is required, it will switch on automatically or there will be adequate signage for quick and easy switching manually. The level of illuminance that the emergency lighting provides will at least be the design minimum for the anticipated emergency.

17.4 Lighting in signal boxes and control centres

The Lighting within any signal box, be it directly viewing rail traffic operations or any other circumstance, will have minimised glare and adjustable lighting levels incident upon the operators eyes e.g. dimmable lighting, down lights and desk lamps, as deemed most appropriate for each circumstance.

The Lighting in control centres will be designed in a way that ensures all operates to be able to see any indictors associated with railway operation.

17.5 Authorised walking routes

Authorised walking routes will be illuminated at levels appropriate to the hazards that may be encountered along their route.

As a minimum the maintained illuminance of walking routes will be 20 lux horizontal, measured at the walking surface.

The uniformity, in the horizontal axis, will be equal to or greater than 0.5.

17.6 Railway siding areas

Where sidings and staging areas form part of Rail track controlled infrastructure and are deemed to require illumination as a result of risk assessment, the maintained illuminance will be a minimum of 2 lux vertical, measured at a height of 1.0 m above rail level, and 10 lux horizontal, measured at rail level and may go up to a maximum of 20 lux depending on the task to be carried out.

The uniformity, in the vertical and the horizontal planes, will be equal to or greater than 0.5.

17.7 Emergency escape routes and exits

Where areas outside a station form part of an emergency escape route from Rail track controlled infrastructure, they will be signed and illuminated in such a way as to aid egress in the case of an emergency.

The route will be clearly defined and its associated signs will clearly indicate the direction to be taken for safety. As a minimum the route's maintained illuminance will be 2 lux vertically measured at a height of 1.0 m above the walking surface, and 10 lux horizontally measured at the walking surface.

The route's uniformity, in the vertical and the horizontal planes, will be equal to or greater than 0.5.

17.8 Location of luminaires and masts

All clearances when raising or lowering masts, as well as in AC & DC electrified line areas, the design w.r.t positioning of masts will be such that when staff are maintaining these in the proximity to live equipment, all clearances in all positions of raising and lowering will be maintained in according to the TFR specification.

17.9 Temporary Lighting

In the case where temporary lighting, including engineering worksites are required on rail track infrastructure and/or in close proximity to its boundaries continue to operate, that lighting required will also conform to TFR specifications.
In the cases where it is not possible to achieve these requirements, the specific safety hazards of the temporary lighting must be defined and enforced.
These may include for example; instructions for drivers, clear boundary's descriptions, the provision for specific instructions and notices for distribution and display to all persons affected by the temporary scheme.

17.10 Maintenance

Maintenance of built infrastructure must be carried out as per TFR procedures to ensure that the required illuminance is achieved at all times.

17.11 Lighting Equipment

Rail yard lighting equipment has various options available depending on the task to be performed. Medium and High masts are sometimes designed specifically for certain rail yards where considerations such as height, width, operation, maintenance, cost, luminaires and lux levels must be given some taught.

With regard to medium and high masts the following options are available:

- Highlight mast
- Floodlight mast

- Mid-hinged poles
- Scissor masts

17.12 Highlight Mast

Figure 12: Highlight Mast

Highlight masts are of tubular cones design with a constant rate of taper throughout their entire length and are built up from sections of no more than 3m in length and joined by friction fit only.

Access to the raising and lowering gear is provided through a vandal proof door in the base of the mast. Height vary from 20m to 40m.These masts can be used 360 area lighting and 180 floodlighting.

With regard to TFR rail yard use of masts, there is not flexibility of medium (12m & 15m) heights when it comes to the highlight mast.

17.13 Floodlight Mast

Figure 13: Floodlight Mast

Floodlight masts are of tubular cone design with a constant rate of taper throughout their entire length. Platforms both rectangular and circular consist of a framework with an expanded metal floor and access trapdoor. Access to the lights can be external or internal caged ladders, or the lights can be lowered for maintenance using the 'Raise-lite' mechanism. Height manufactured as required. The masts can be used for 360 area lighting and 180 floodlighting.

With regard to TFR rail yard use of masts, there is flexibility of medium & high mast but flood lighting in a rail environment is not ideal as this may be regarded as a hazard.

17.14 Mid-Hinged Masts

Figure 14: Highlight Mast

Mid-hinge poles are manufactured from square tubing at the bottom and round pipe at the top. Heights from 6m to 12m can be manufactured. The masts can be used for 360 area lighting and 180 floodlighting.

With regard to TFR rail yard use of masts, there is no flexibility of high mast (25m) but hinged masts are a concept that TFR approve off.

17.15 Scissor Masts

Figure 15: Scissor Mast

Scissor Masts have a constant rate of taper throughout their entire length and are of octagonal cross-section, consisting of three major sections. The lower half of the mast is divided into two fully enclosed half sections, which form an octagonal section in the operating position with no unsightly steps or protrusions.

A full octagonal section is joined to the top of the pivoting section by means of a site slip joint. The pivot is located approximately at the mid-point of the mast and consists of two full length stainless steel sleeves.

Height vary between 10m and 25m. These masts can be used 360 area lighting and 180 floodlighting.

Transnet Freight Rail have recommended scissor type mast's where the design can combine both medium and high masts to achieve the correct lux level. For purposed of the concept design this option will be explored with more detail.

For a permanent installation, Transnet Freight Rail has adopted the use of hinged type structures as in preference to the elevating high and medium mast light-cluster type for ease of maintenance.

The Mast's will be designed to carry out the specific quantities of luminaries on top in strict accordance with SABS 0225 code of practice for the design and construction of lighting masts.

Table 6 – Costing

25m mast	R 85 000.00
15m mast	R 75 000.00
12m mast	R 30 000.00
Foundation	R 20 000.00
DB and cabling	R10 000/pole
Lights: 4-lights x R6 000 @	R24 000 per pole
DB cabling and trenching	R50 000
Ps and Gs	R5 000 per pole
Sundries (nuts and bolts and earthing)	R5 000- per pole

Table 7 – Mast Costing

Cost per 25m mast	R 199 000.00
Cost per 15m mast	R 189 000.00
Cost per 12m mast	R 144 000.00

The above costing is a complete solution and involves all aspects of installing the mast.

These costs together with the combination of medium and high mast will form the basis of the cost implications that are required to achieve the required lux levels.

17.16 Lighting Design

Refer to the Rail yard lighting design layout drawing 0.84/40146 in Volume 3 Appendix 20.

Rail Yard lighting design will be done in accordance with Transnet Freight Rail specifications, there are a number of factors that must be considered whilst undertaking yard lighting such as intensity and contrasts.

In the case of intensity, lighting design will take into consideration the work being done in that specific area as certain intensities are most suitable for specific work being performed.

In the case of contrasts, when applying lighting design there will be a specific dark and bright areas unless there are a series of luminaires placed in close proximity which is not a practical way of designing.

These dark areas will be overcome by using a combination of high and medium masts to obtain the acceptable contrast and intensity.

17.17 Lux Levels calculations

Taking into account that TFR lamp requirements are, 400 Watt High Pressure Sodium Discharge Lamps with associated control gear which are normally used and 4 lamps are required at each mast, the following results can be concluded.

The total length of the siding is 3175m and the total length from the first train set to the loco shed is 1405m where lighting is required, therefore by utilizing 25 masts at 25 meters high in a single line formation to provide lighting for the rail area the minimum average of 20 lux can be achieved. Refer to drawing 0.84/40139 in Volume 3 Appendix 6.

Table 8 – Lighting Data

Type of Floodlights	**Type of floodlights**	**Scissor Type**
	Manufacturer / Model	Sectional Poles
	Wattage	400
	Manufacturer / Model	High Pressure Sodium discharge
Illumination Standards Compliance	Compliant with Standards (Yes / No)	Yes
	Standard Used for design	Transnet Freight Rail
Operation Data & Costs	Investment costs	R199 000.00 (25m Mast)
	Hours of Operation (Per Year)	4 380 (12 hours a day for 365 days)
	Number of hours at lower illumination (Per Night)	12 hours
Energy Costs	Cost per kW/h	R1.15

18. FIRE PROTECTION AND DETECTION SERVICES

Introduction and Terms of Reference

This section outlines the conceptual design of the fire services to be provided for the Medupi Rail Yard Project.

The design criteria used are the recommendations presented in the Fire Hazard and Risk Assessment Report. Refer to Volume 3 Appendix 13 for a copy of this report.

18.1 Fire Water

The connection chamber and position was provided by the client. The pressure and flows at the connection points will be confirmed prior to detail design.

The fire water network serving the facilities will be modelled using the Water Mate package.

A detailed calculation report sheet will be generated illustrating the required pipe sizes and pressures at specific nodes. The SANS 1200 will be used to compile a bill of quantities for all the water pipes.

The following design parameters were used as base for the fire water pipeline design:

- Minimum velocity = 0.7m/s

- Maximum velocity = 3.0m/s
- Pipe material – uPVC Class12

18.2 Fire Prevention

Reducing the risk of fire in the first instance is a logical precondition to fire prevention.

Reduction of risk can be accomplished by the Owner/Operator having specific interventions in place such as:

- Comprehensive planned maintenance and inspection plans to reduce the potential for mechanical fault and friction occurrences.
- Housekeeping plans to prevent accumulations of product and debris.
- Operators trained to manage incipient fires.
- Well-trained and equipped fire response teams to manage developed fires.
- Strict control over contractors. An effective hot work permit system should be in place. Flammable liquids and gases should not be permitted in the enclosure.
- Regular fire prevention inspections following suitable check lists.

These considerations have been taken into account in the development of this report.

18.3 Site Wide Protection

Site wide fire protection will be provided in the form of strategically located fire hydrants.

18.4 Fire Monitoring System

The fire detection/manual alarm call points system will be allocated to specific zones and each zone will be provided with an audible alarm and flashing light to assist in determining where the alarm trigger is located.

This system will report to a fire monitoring panel located in the rail yard facility security office and the panel will interface to the CBMS (Central Building Management System) at the Medupi power station.

The fire monitoring panel will consist of an electrical panel with various system status alert alarms and controls and zone status (on/off/alert/ready) indicator lights corresponding to geographical location of the fire zones. This panel has the ability to test/reset the various fire detection system components and interact with other remote monitoring devices or stations.

18.5 Lime Stone and Gypsum Systems

18.5.1 Product Considerations

Lime stone and gypsum and their associated dusts are not pyrophoric and they are sometimes used as inerting agents to decrease the risk of explosive atmospheres for pyrophoric substances such as coal dust.

Therefore special protection systems e.g. spray, fog or deluge systems are not required to protect against ignition of the products themselves.

18.5.2 Equipment Considerations

Research has shown that the most common causes of fire on conveyor and material handling systems are:

- Friction due to a belt losing traction and slipping on the drive roller, or due to a misaligned belt slipping off the rollers and jamming.
- Overheated material from ovens, kilns or dryers that have not been cooled sufficiently before being placed on the belt may also cause belt ignition. This is not the case on this project as product is not handled hot.
- Cutting and welding activities generating hot molten metal particles which can ignite the belt or accumulations of waste below. This is an operational and maintenance management matter.

To mitigate the causes of friction noted above the mechanical design of the loading/unloading systems and conveyors will incorporate the following:

- Design to ensure belt-loading systems discharge onto belts with minimal spillage.
- Belt-alignment and motion-sensing switches will be installed to detect when belts are not running correctly with automatic trips to stop the conveyors in the event of undue misalignment or slowing of the belt.
- Belt tension via automatic belt tensioners or systems will be sufficient to avoid slippage, abnormal wear and strain on drive components.
- Emergency tripwires will be provided along conveyor lengths.
- Conveyor belt over-speed/belt break detection will be provided.
- Fire retardant conveyor belting will be installed.

18.5.3 Fire Protection to Limestone Loading and Gypsum Unloading

Spray or deluge systems are not required at the loading area to protect against the substance itself.

Fixed fire protection is proposed to provide incipient fire protection to mechanical or electrical (e.g. motor drives or MCC panels) equipment or waste build-up by means of strategically placed fire extinguishers and hose reels.

18.5.4 Fire Protection to Limestone and Gypsum Conveyor Systems

The limestone conveyor system consists of:

- 3 x feeder conveyors
- 2 x belt conveyors (one of which is located in a tunnel)

The gypsum conveyor system consists of:

- 2 x belt conveyors

Water spray protection will be provided to head ends of the conveyors to protect against the possibility of a mechanical equipment failure in those areas. (Motor fire, gearbox oil fire etc.)

Further, fixed fire protection in the form of hose reels and fire extinguishers will be provided to provide incipient fire protection to mechanical or electrical (e.g. motor drives conveyor idler bearings) equipment or generally at transition points by means of strategically placed fire extinguishers.

18.5.5 Fire Detection and Alarm Systems to Loading/Unloading Areas and Conveyors

Fire detection will be provided at conveyor head and tail pulleys only.

The detection will be interlocked with the particular conveyor drive to stop the conveyor and any others interlocked to it upon detection of a fire. Strategically placed manual alarm call points will also be provided. All items will report to the fire monitoring panel.

18.6 Office and Operations Tower Building

The office and operations tower building will essentially fall under D3 Classification, Low Risk Industrial in terms of SANS 10-400 National Building Regulations and the fire protection will therefore consist of:

- Fire hose reels
- Fire extinguishers
- Manual alarm call points
- Smoke detection system.
- Audible local alarm and flashing light

Special protection will be provided as follows:

- Rail Yard operations room – gas suppression
- Electronic equipment room – gas suppression

The detection will be interlocked with the particular conveyor drive to stop the conveyor and any others interlocked to it upon detection of a fire. Strategically placed manual alarm call points will also be provided. All detection items will report to the fire monitoring panel.

18.7 Locomotive Shed

A locomotive shed and diesel storage facility will be provided to service the shunting locomotive.

This shed is approximately 600 m² service space for the shunting locomotive and has various offices and store rooms (180 m²) attached to one end of the building.

(Refuelling takes place outside the building at the diesel storage facility.)

Some workshop activities could include welding, grinding and torch cutting. It is assumed that normal workshop protocol will be followed in that these activities will be controlled and take place in suitably screened areas with fire extinguishers at hand.

The following fluids are also stored in small quantities within the building:

Table 9 – Chemicals and Fluids stored in buildings

Product		Usage
1.	Benzene Class 1 Flammable liquid	Cleaning agent
2.	Trichloro-ethylene	Cleaning agent
3.	Carbon tetrachloride	Cleaning agent
4.	Engine oil	Locomotive Engine
5.	Viscous oils	Gear boxes, link drive systems, axle bearing
6.	Hydraulic oil	Track machinery, axle drives, hydraulic gears
7.	Grease	Lubrication
8.	Battery Acid	Top-up batteries
9.	Radiator fluid	Top-up radiator

With the exception of Benzene these are all high flash point non-flammable products which are stored in small quantities.

A local standalone foam deluge system is proposed to provide fire protection to cover the benzene storage area.

This building will typically fall under SANS classification D3 Low Risk Industrial and considering the divisional areas and the activity/storage scenario already described, sprinklers cannot be justified.

In this case the fire protection and detection system will consist of the following:

- Fire hydrants
- Fire hose reels
- Fire extinguishers
- Local standalone foam deluge (benzine storage)
- Manual alarm call points
- Smoke detection system in rooms
- Fire detection within the workshop area

Strategically placed manual alarm call points will also be provided. All items will report to the fire monitoring panel.

18.8 Diesel Storage

A diesel storage facility will be provided to refuel the shunting locomotive.

This will consist of a storage tank in a bunded area alongside a covered road tanker decanting area.

Fire protection considerations for the fuel storage facility are as follows:

- Fuel type – diesel fuel considered combustible but not flammable
- Plant layout and geographic location
- Maximum storage capacity of the installation – 28000 liter;
- Individual storage vessel size and shape – one tank horizontal type
- Location of the storage facility – relatively isolated no high risk areas nearby.
- Low level of occupancy
- The tank is located within a bunded area.
- Size of the covered decanting area.

In this case the fire protection and detection system for this area will consist of the following:

- Fire hydrants
- Fire hose reels
- Fire extinguishers
- Manual alarm call points
- Fire detection within the tank and fuel offloading areas.

Strategically placed manual alarm call points will also be provided. All items will report to the fire monitoring panel.

18.9 Electrical Works

Electrical infrastructure will also require fire protection and detection systems.

The following services will be provided:

Substations (1 off)

- Fire extinguishers
- Smoke detection

Transformers (2 sets)

- Water deluge system
- Hydrants
- Fire detection

Strategically placed manual alarm call points will also be provided. All items will report to the fire monitoring panel.

19. FENCING AND SECURITY FENCING REQUIREMENTS

The decision was made by Eskom to move their existing security fence from its current position to the northern boundary of the rail way yard. The decision was made not to provide access to the Medupi plant from the rail way yard due to National Key-point Security issues. The existing service road fence will be used as the boundary fence to the rail yard. The only requirements will be to provide a new access gate and security office at the existing service road fence to the rail yard.

A typical detail drawing will be issued for the construction of the new access gate at the security office. The SANS 1200 will be used to measure the quantities for the new access gate and any additional work that would be required to accommodate the new gate in the existing service road fence.

Provision was made for a diamond mesh security fence, 2.4m high with corner end straining and gate posts according to Eskom specifications. The security gate will be designed as a double leaf gate with a 6m opening.

It must be noted that the connection to the existing fire water network will be outside the newly relocated Medupi Power Plant security fence boundary.

Refer to drawing 0.84/40141 in Volume 3 Appendix 8 for the proposed fencing layout.

20. COSTING EVALUATION

20.1 Capital Costs

Table 10 – CAPEX costing summary

TOTAL RAILWAY YARD	ZAR		83 420 900,00
RAILWAY YARD INFRASTRUCTURE	ZAR	61 376 900,00	
RAIL WAY YARD (IN-MOTION WEIGHBRIDGE)	ZAR	1 056 000,00	
ROLLINGSTOCK (SHUNT LOCOMOTIVE)	ZAR	20 988 000,00	
TOTAL CIVIL SERVICES and INFRASTRUCTURE	ZAR		104 111 810,00
CIVIL SERVICES	ZAR	104 111 810,00	
TOTAL ELECTRICAL CONTROL & INSTRUMENTATION	ZAR		4 975 000,00
YARD AREA LIGHTING	ZAR	4 975 000,00	
TOTAL STRUCTURAL AND BUILDING SERVICES	ZAR		12 051 250,00
DIESEL LOCO SHED	ZAR	7 391 250,00	
ADMINSTRATION BUILDING	ZAR	3 412 500,00	
SECURITY OFFICE	ZAR	250 000,00	
FUEL STORAGE AND DISPENSING	ZAR	997 500,00	
TOTAL FIRE PROTECTION AND PREVENTION	ZAR		28 200 000,00
FIRE PROTECTION AND PREVENTION	ZAR	28 200 000,00	
TOTAL CAPEX ESTIMATE MEDUPI RAIL YARD AND ASSOCIATED INFRASTRUCTURE	**ZAR**		**232 758 960,00**

The above CAPEX costing summary excludes engineering, procurement and construction management costs. The costing accuracy is +-30 % with a base date of January 2015. Refer to Volume 3 Appendix 18 for a detailed breakdown of the above costing summary.

20.2 Operational Costs

Table 11– Rail Yard Operating Cost (OPEX)

RAIL OPERATIONS	
DESCRIPTION	**AMOUNT (ZAR)**
Annual salaries for staff (Train operations only)	2 200 000.00
Annual maintenance cost – shunt locomotive	865 500.00
Annual fuel consumption (36642.86 liters @ R11 per lt)	403 100.00
ADD CONTINGENCIES (10%)	346 900.00
SUB TOTAL RAIL OPERATIONS	**3 815 500.00**
RAIL INFRASTRUCTURE MAINTENANCE	
DESCRIPTION	**AMOUNT**
Patrolling (2 x permanent patrolman)	280 000.00
Maintenance (P&G's and consumables)	240 000.00
ADD CONTINGENCIES (10%)	52 000.00
SUB TOTAL RAIL INFRASTRUCTURE MAINTENANCE	**572 000.00**
SUMMARY ANNUAL TOTAL OPEX	**4 387 500.00**

The costing accuracy of the OPEX cost above is +-30 % with a base date of January 2015.

21. DEVELOPMENT TEAM

The following people were involved in the development of this document:

21.1 Rail

- Dietricht Bredenkamp (Technical Director: Projects)
- Danie van der Schyff (Rail Operations Specialist)
- Leon Onverwacht (Civil Engineer: Civil)
- Neels Cronje (Rail Operations Specialist)
- Piet Koekemoer (Senior Engineering Technician: Perway Design)

21.2 Civil Infrastructure

- L. Geldenhuys (Civils Lead Project Director)
- PJJ Basson (Civils Project Manager)
- WF Küsel (Civils Lead Engineer)
- C Prinsloo (Design Reviews)
- W Bekker (Civils CAD Operator)

21.3 Electrical Control and Instrumentation

- Shekar Inderlall (Electrical Engineer)
- Mike Da Silva (Electrical, Control & Instrumentation)
- Amantha Maharaj (Electrical Engineer-Design Review)

21.4 Buildings and Structural

- Errol Tromp (Structural Engineer)
- Johan Duvenhage (Architect)

21.5 Fire Protection Services

- Roger Bosch (Mechanical Engineer)

22. REVISIONS

Rev.	Status	Issued by	Date
01	Issued for review	Francois Retief	4/12/2014
02	Updated with Electrical and C&I changes	Francois Retief	29/1/2015
03	Updated with all MDR changes including C&I issues from 19 February 2015	Francois Retief	20/2/2015
04	Updated with final C&I issues after meeting held on 27 February 2015	Francois Retief	13/3/2015

Bosch Holdings Consortium

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONCEPT DESIGN REPORT VOLUME 2

MATERIALS HANDLING

Report reference number:1184-099-4-100-R-0001-Rev04 Concept Vol2 Materials Handling

Revision: 04

Total pages: 34

Report submitted by:

Bosch Holdings Consortium

13 March 2015

Bosch Holdings Consortium

BOSCH HOLDINGS	7E Thabile Engineering	Thabo Consulting	NEMAI CONSULTING

CONCEPT DESIGN REPORT FOR THE MEDUPI RAIL SIDING DOCUMENT APPROVAL		
CONSULTANT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM CIVIL ENGINEERING --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM BMH DEPARTMENT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM ELECTRICAL ENGINEERING --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM C&I DEPARTMENT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM LPS (FIRE ENGINEERING) DEPARTMENT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM CHEMICAL DEPARTMENT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
MEDUPI ARRANGMENT DESIGN --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
MEDUPI POWER STATION --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE
ESKOM PED DEPARTMENT --- NAME	--------------------------------------- SIGNATURE	------------------------------ DATE

	COMMENTS	ORIGINATOR
1		
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Abbreviations

Abbreviation	Description
A	amps
AC / ac	Alternating Current
CCTV	Closed Circuit Television
C&I	Control and Instrumentation
CMS	Control and Monitoring System
COLTO	Committee of Land Transport Officials
CSW	Continuous Surface Wave
CTC	Centralized traffic control
DC	Direct Current
DCP	Dynamic Cone Penetrometer
FGD	Flue Gas Desulphurisation
HMI	Human Machine Interface
HVAC	Heating Ventilation and Air Conditioning
km/h	kilometres per hour
kV	Kilo Volts
kVA	Kilo Volt Amperes
kW	KiloWatts
l/s	litres per second
LAN	Local Area Network
m/s	metres per second
m^3	cubic metres
MAP	Mean annual precipitation
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
mm	millimetres
OPC	Open Platform Communications
ORS	Owner's Requirement Specification
PIS	Plant Information System
PLC	Programmable logic controller
SCADA	Supervisory control and data acquisition
SQL	Structured Query Language
t	Ton

Abbreviation	Description
t/a or tpa	Tons per annum
t/h or tph	Tons per hour
TFR	Transnet Freight Rail
UPS	Uninterrupted Power Supply
uPVC	Unplasticized Poly Vinyl Chloride
V	Volts

LIST OF TABLES

1. INTRODUCTION

This concept study develops the preferred options identified in the Options report for the Medupi rail siding. This document provides an overview of the engineering processes followed and the system design status at the end of the concept phase. The document describes the results of technical assessments and compliance with stakeholder requirements, technical risks identified, lessons learned during the design process and outstanding issues for this design phase. This document further provides references to approve the design output documentation.

The rail yard will handle bulk limestone, used as a sorbent, for use in the retrofitted FGD plant. Depending on market demand, bulk gypsum will also be despatched via the rail yard.

The scope of the new rail yard is to provide the Medupi Power Station with a rail yard solution and rail operations that will ensure that the yard is capable to receive and off-load 1,200,000 t/a of Limestone and to load and despatch 400,000 t/a of FGD Gypsum.

This report covers the Concept Design of the proposed Materials Handling system that will be required to off-load the Limestone and load the Gypsum. The next phase of the Materials Handling part of the project will be the basic design phase which will complete the project.

2. SCOPE OF CONCEPT DESIGN

The Concept Study carries forward the results of the Options Report (1184-099-4-100-R-0001 REV02) which has been approved by Eskom. The objectives of the concept design is to select the optimum rail off-loading facilities for limestone, rail loading facilities for gypsum and to generate a materials handling layout and concept to optimally integrate these systems into the rail yard and to the stockpile areas.

For the limestone materials handling, the scope of work is from the tippler to the stacking conveyor; the battery limit at the stockyard is the underside of the transfer chute to the stacking conveyor. For gypsum materials handling, the scope of this project covers from the stock pile to the rail wagon loading facility; the battery limit at the stock yard is the top of the reclaim hoppers.

The required throughput rates are 1,200,000 t/a and 400,000 t/a for limestone and gypsum respectively. The rail simulations have been completed and the rail infrastructure will be specified to handle these throughputs, this is described in the Concept Design Report Volume 1.

The two tippler technologies that have been identified for the concept design stage are the unit train rotary type tippler and the “Rotaside” type tippler (also called a Side tippler).

The required electrical control and instrumentation scope of work for the Medupi rail yard project will be all electrical power supplied to the bulk material handling equipment, lighting for the rail yard, electrical feed for signalling and all other equipment that requires a power source.

The electrical system is expected to provide all equipment within the rail yard boundaries with electrical power. 3 Phase power will be required since different equipment operate at different voltages. Consideration to existing equipment and systems being implemented at Medupi power station will be considered where the rail yard can integrate with the larger system installed.

3. KEY DESIGN ASSUMPTIONS

3.1 Bulk Materials Handling

The following assumptions have been made regarding the materials handling system:

- 342 annual operational days per annum (365 days less 5 days holiday and 18 days shut down for maintenance);
- A 12 hour duration train drop-off and collect cycle;

- The CAR wagons utilised for Limestone will be equipped with rotary couplers (necessary for the Rotary type tippler only);
- Capacities of downstream materials handling equipment in the case of Limestone, and upstream materials handling equipment in the case Gypsum will be sufficient in order not to constrain the unloading/loading facilities.

3.2 Bulk Material Properties

The following design inputs were utilised for the concept design:

The following properties of limestone have been assumed and utilised in the generation of the concept design.

Description	Value	Unit
Limestone throughput	1,200,000	t/a
Low bulk density (volumetric capacity)	1360	kg/m^3
High bulk density (structural capacity)	1840	kg/m^3

Table 1: Properties of limestone

The following properties of gypsum have been assumed and utilised in the generation of the concept design.

Description	Value	Unit
Gypsum throughput	400,000	t/a
Low bulk density (volumetric capacity)	1000	kg/m^3
High bulk density (structural capacity)	1840	kg/m^3

Table 2: Properties of gypsum

3.3 Bulk Earthworks

The following assumptions have been made regarding bulk earthworks:

The bulk earthworks layer works will be designed to accommodate a 26t axle load. It is assumed that the existing stock piles will be cleared before the commencement of construction. A letter dated 6 August 2014 from Eskom requested the design team to review all earthwork designs due to the quality of stockpiles deteriorating from G5 to G6 and G7 to COLTO classifications. For the concept design stage it is assumed that all materials G7 and higher will be imported from commercial sources.

The design and costing of the bulk earthworks in the Concept Design Report Volume 2 (Materials Handling) will only include excavation and backfilling for the materials handling facilities. All other bulk earthworks and layer works will be covered in the Concept Design Report Volume 1(Rail Yard).

See TRH4 Table 13 for material grading specifications.

3.4 Service Road

The service road design and costing will be covered in the Concept Design Report Volume 1 (Rail Yard and Services).

3.5 Stormwater

The following assumptions have been made regarding stormwater:

The stormwater will be modelled with a MAP 437mm as discussed with Eskom. It is assumed that the Medupi stormwater master plan including structure sizes will be available for the detail design stage. The dirty stormwater from the Gypsum loading facility will be drained into a new pollution control dam that will be designed by the FGD project team. The design and costing will be covered in the Concept Design Report Volume 1 (Rail Yard and Services).

3.6 Potable Water

For the design and costing of the potable water system refer to the Concept Design Report Volume 1 (Rail Yard and Services).

3.7 Fire Water

For the design and costing of the fire water system refer to the Concept Design Report Volume 1 (Rail Yard and Services).

3.8 Fencing

The following assumptions have been made regarding fencing:

The existing three tier national key-point fence will be moved by Eskom to the north of the rail way site prior to construction. The existing service road fence will be used as the rail yard boundary fence.

3.9 Electrical

The following assumptions have been made regarding the electrical system:

- Electrical power will be distributed into the rail yard utilizing the 6.6kV limestone handling substation.
- Maximum of 5MVA will be required to run the rail yard.
- Cabling will be selected to have a volt drop better than 5%
- Existing mini-sub to be used for high mast lighting
- Yard Lighting required will be at a 20 Lux minimum average
- Future signalling will be required post 2020
- Future Electrification of Transnet freight rail line's will be required

4. DESIGN APPROACH

4.1 Design inputs

4.1.1 Stakeholder Requirements

The stakeholder's requirements for the project was captured in the Stakeholders Requirements Definitions (SRD) report (200-130118) that was supplied to the client and signed off on 17 June 2014.

4.1.2 Design Criteria Report

This document (200-130171) was compiled by the Consultant and signed off by the client of 17 June 2014.

4.2 Design Process

Various rail yard options were considered at the options study phase of the project, each of which required a different concept for the materials handling infrastructure.

The options study determined the rail yard operating philosophy and the requirement to utilise the CAR type rail wagon with a tippler for off-loading of the limestone. Refer to the options study report (1184-099-4-100-R-0001-Rev02) in Volume 3 Appendix 15. The type of tippler will be selected as part of the concept design phase and is affected by the required throughput/cycle times, capital and operational costs and the type of rail cars available. The life-cycle costs are further discussed in the tippler lifecycle costing report in Volume 3 Appendix 14.

4.3 Design Outputs

The outputs of the concept design phase of the Materials handling part of the project are the two conceptual layouts as described in drawings 0.84/40136 (Refer to Volume 3 Appendix 3) and 0.84/40137 (Refer to Volume 3 Appendix 4). In addition to this a lifecycle cost analysis has been developed to assist with the concept selection for the tippler (Refer to Volume 3 Appendix 14).

4.4 Design Verification

A site visit was conducted with the project design team and Eskom Technical Staff on 15 October 2014. Existing services and Eskom design requirements were verified on site. The site visit was concluded with a technical meeting addressing any outstanding information required. The design verifications were reviewed on an ongoing basis as part of the regular meetings held between the design team and the Eskom Technical review team.

4.5 Codes and Standards

Various international and South African standards will need to be applied in the design of the system; these will be specified in the relevant technical specifications for each type of equipment. The following codes and standards have been used and considered in the development of this concept design:

4.5.1 Informative standards

- ISO 9001 Quality Management Systems;
- ISO 5048 - Continuous mechanical handling equipment - Belt conveyors with carrying idlers - Calculation of operating power and tensile forces;
- The Guidelines for Human Settlement Planning and Design (Roads, Water and Sanitation);
- TRH17: Geometric design of rural roads (Geometric Design);
- TRH14: Guidelines for road construction materials; and
- TRH4: Structural design of flexible pavements for interurban and rural roads.

4.5.2 Normative standards

- Occupational Health and Safety Act 85/1993;

- South African National Building Regulations;
- SANS 10160 - The General Procedures and Loadings to be Adopted in the Design of Buildings;
- SANS 10100 The Structural Use of Concrete;
- Part 1: Design.
- Part 2: Materials and Execution of Work.
- SANS 10161 The Design of Foundations for Buildings;
- SANS 10162 The Structural Use of Steel;
- Part 1: Limit States Design of Hot-Rolled Steelwork.
- Part 2: Limit States Design of Cold-Formed Steelwork.
- Part 3: Allowable Stress Design.
- Part 4: The Design of Cold Formed Stainless Steel Structural Members.
- SANS 10389-1 : 2003 Exterior lighting
- SANS 10142-1: The wiring of premises
- SANS-10198 Selection, handling and installation of electric power cables not exceeding 33kV
- SANS-60439 Low-voltage switchgear and control gear assemblies
- SANS-10114 Artificial lighting of interiors
- SANS- 62305 Protection against lightning
- SANS 1200 (Bill of Quantities and cost estimates)

4.5.3 Client standards

- 240-55864499: Specification for Belt Conveying Systems Standard
- 240-54937439: Fire Protection/Detection Assessment
- 240-54937450: Fire Protection & Life Safety Design Standard
- 240-56737448: Fire Detection and Life Safety Design
- 240-56227516: Specification for switchgear and associated equipment for voltages up to and including AC 1090 V and DC 1200 V
- 200-11757: Earthing and lightning protection standard
- 200-11768: Station cabling and racking standard
- Eskom's Distribution Specification – Part 22: Medium-Voltage miniature substations for systems with nominal voltages of 11kV and 22KV- Document reference DSP 34-1621

4.5.4 Other Stakeholders Standards

- Transnet Specification CEE-0003_ISS_90 will be applied to the luminaires for street lighting and yard lighting
- Transnet specification CEE-0018_ISS_90 will be applied to the high mast lighting of outdoor areas
- Transnet S410 Specifications (Services roads and rail way layer works)

5. SYSTEM DESCRIPTION

5.1 Process Description

5.1.1 Limestone rail wagon off-loading

This section discusses the rail wagon off-loading operation of limestone. The rail yard operation is described in detail in the Concept Design Report Volume 1 (Rail Yard and Services). The two concepts that have been developed for limestone off-loading are described below.

Option 1 – Rotaside Type Tippler (Side Tippler)

The rail wagons are manually uncoupled, and a sidearm charger will then position the individual rail wagon within the tippler. The side tippler will then off-load the rail wagon into the under-ground hoppers and return the empty rail wagon to the rail. The side arm charger will then reposition the empty rail wagon beyond the tippler before collecting the next full rail wagon.

Option 2 - Unit Rotary Type Tippler

In the rotary type tippler the rail wagons remain coupled, and a sidearm charger will position the rail wagons within the tippler. The rotary tippler will then rotate about the axis of the rail wagon couplers to discharge the limestone into the under-ground hoppers. The tippler will then rotate back and return the empty rail wagon to the rail.

While the tippler is in operation, the side arm charger will traverse back and attach at the next coupling. Once the rail wagon is empty and has been returned to the rail, the side arm charger will traverse forward in order to move the empty wagon out and the next full wagon into the tippler.

5.1.2 Limestone material handling

Limestone from the Tippler will be dumped into the feed hoppers below the tippler. Belt feeders or apron feeders will feed to a horizontal conveyor, in the vault beneath the tippler, which will discharge to an inclined belt conveyor. The inclined belt conveyor will discharge to the limestone stacking conveyor and in turn the downstream equipment.

5.1.3 Gypsum rail wagon loading

This section discusses the rail wagon loading operation of gypsum. The rail yard operation is described in detail in the Concept Design Report Volume 1 (Rail Yard and Services).

The rail wagons will be shunted to the gypsum loading facility, and then moved to within the loading station by a rail wagon positioner. An overhead feed bin will discharge to the rail wagons as they are manipulated by the side arm charger.

5.1.4 Gypsum material handling

Gypsum will be manually reclaimed from the stockpile by wheeled or track-type loaders feeding to reclaim hoppers. The reclaim hoppers will discharge to two gypsum reclaim belt conveyors, one of these will discharge to an inclined belt conveyor which will discharge to the feed bin described above, the other gypsum reclaim belt conveyor does not form part of the scope of this project.

5.2 System Components

5.2.1 Limestone handling

The limestone handling system will consist of the following equipment:

- Rail wagon tippler – Rotary or “Rotaside” type tippler.

- Hoppers – the hoppers to which the tippler discharges. These will be equipped with either belt or apron feeders.
- Horizontal limestone belt conveyor – located in the tippler vault.
- Inclined limestone belt conveyor –discharges the limestone to the stacking belt conveyor.

5.2.2 Gypsum handling

The limestone handling system will consist of the following equipment:

- Gypsum reclaim hoppers – receive gypsum from mobile reclaim equipment and discharge to the gypsum reclaim belt conveyor.
- Gypsum reclaim belt conveyor – discharges to the Inclined gypsum belt conveyor.
- Inclined gypsum belt conveyor – discharges to the bin at the loading facility.
- Gypsum bin – an overhead bin feeding the rail wagons with a controlled discharge.

5.3 Control and Instrumentation System

Refer to drawing 0.84/43218 (Volume 3 Appendix 22) for the conceptual control system network architecture.

The Control system for the Medupi rail yard will be a standalone system where maintenance, spare keeping and monitoring will be handled from the main plant local to the rail yard.

Allowance will be made for the Control systems of the Medupi rail yard, to integrate to the other systems in the Medupi power station plant's system. The standards and specifications will be in line with the current requirements for Control and Instruments systems installed at Medupi power station.

The Automation technology to be considered will be Programmable Logic Controllers and by implementing similar Architectures the required standardisation will be achieved across Medupi Power Station

There will be a requirement for a Plant Information System (PIS) that will make near real time and historical plant information available to third party applications.. All PIS databases will be accessible by third party software applications on the Clients by means of SQL series. These third party applications will only be able to read data from the PIS databases

Control and instrumentation cables will be armoured for outdoor applications. All cables will be shielded, with a minimum conductor section of 0.5 mm2. Cables above ground are to be laid in trays or on ladder racks and will be segregated from power cables in accordance with International standards. Cables will be labelled and conductors will be identified at terminations by ferrule number or suitable proprietary method.

Instrumentation will be provided from reputable vendors. Where possible instrumentation will be similar to current specifications installed at the main power plant

Instrumentation will be provided with the necessary ingress protection for the location. Instrumentation located outdoors will be protected with sunshades.

Instruments measurement principles will be properly chosen to meet the following requirements:

- Medium
- Servicing without interrupting process
- Installation possibilities and accessibility
- Ambient and process conditions
- Operational ranges and accuracy

An option would be to use the Siemens PLC.. This technology is currently being used at Medupi power station's main plant. Using SIMATIC WinCC which is a SCADA and HMI system from Siemens, monitoring and controlling physical processes in Medupi Rail yard can be done successfully.

5.4 Maintenance Concept

The maintenance of the rail yard and shunt locomotive will be undertaken by a contractor (Transnet) to the same standards as clearly covered in the Transnet and OEM maintenance manuals. All other maintenance will be the responsibility of Eskom or a suitable subcontactor appointed by Eskom.

The bulk materials handling equipment will require scheduled maintenance as per common maintenance practices for a tippler station and its associated equipment. Mechanical equipment will be designed/selected to have a sufficient design life to allow adequate maintenance intervals and equipment availability provided that reasonable maintenance procedures are adhered to. Maintenance access to the equipment on the southern side of the main Medupi security fence will be via the road entrance at the south-western end of the rail yard and it is suggested that maintenance of this facility is treated as a standalone activity from the remainder of the plant.

The electrical, control & instrumentation systems for the Medupi rail yard will be a standalone where maintenance, spares holding and monitoring should be individual procedures separate from the main plant.

When designing the electrical, control & instrumentation for Medupi rail yard, integration to the main Medupi power station plant's system will be considered where equipment used and specifications to be installed will be in line with systems already installed at Medupi power station. Making provision for integration will assist with less down time at the rail yard if faults arise.

Physical buttons on control panels and operating desk are known as hardwired I/O's, they can easily be traced by wirings done on their terminals. Buttons implemented on SCADA/HMI screens to operate logic are considered as soft I/O's. They can be traced by checking in the logic.

Current control equipment installed in Medupi power station are Siemens PLC, this technology will be considered when specifying equipment for Medupi rail yard. By implementing this philosophy, a maintained standard will be achieved across the Medupi Power station.

5.5 Operating Concept

5.5.1 Limestone handling

The side arm charger will position the rail wagon within the tippler. The rail wagon clamps will be actuated and ensure the wagon is adequately secured before the tippler will lift the individual rail wagon over the underground hopper. The tippler will then return to the horizontal position before the rail wagon clamps are released and the side arm charger pushes the rail wagon out of the tippler. The side arm charger will then place the next full rail wagon within the tippler.

Each of the hoppers will be discharged by a belt or apron feeder which will discharge to a short belt conveyor running parallel to the rail line. This belt conveyor will discharge to a second belt conveyor which will feed the stacker conveyor.

The "Rotaside" type tippler station is likely to require 4 shunters to operate the yard while the rotary type tippler is estimated to require 2 shunters.

The tippler will be controlled from a control cabin at the tippler building and will be monitored from the Rail Yard operations room in the administration building by means of a CCTV camera system. In addition to this, the shunters and the operators should be equipped with radio communications equipment.

5.5.2 Gypsum handling

Mobile earthmoving equipment will reclaim from the gypsum stockpile and discharge to hoppers which will discharge to the reclaim belt conveyor. The gypsum is then transferred to the inclined gypsum conveyor which will feed a bin which straddles the gypsum loading area in order to load the rail wagons. The rail wagons will be manipulated and positioned by means of a rail wagon positioner arrangement and the feed to them will be controlled by a gate at the underside of the feed bin.

The gypsum loading station will be controlled and monitored directly from the administration building area and will be equipped with CCTV cameras in order to provide visual feedback to the operators in the Rail yard operations room.

5.5.3 Rail yard operations room requirements

When considering a Rail yard operations room there are a number of factors and equipment that need to be taken into account which must be all under a common roof which creates a central Rail yard operations room which aims to achieve the following:

- Improved communications between operational staff
- Reduced manpower costs in terms of supervision requirements
- Reduced construction costs
- Providing one central point of focus for the entire rail yard operations

There are two critical factors that must be considered when a Rail yard operations room is designed:

- Equipment and tools to perform the task
- The human factor

The human factor is to ensure that operators manning the system must be in an environment conducive for the task at hand e.g. lighting design, air-conditioning design must be considered.

The main areas of focus for the operator evaluation are as follows:

- Controls
- Visual Displays
- Work Space
- Seating
- Communications
- Movement around the control console
- Documentation requirements
- Emergency Requirements
- Personal belongings
- Bathrooms
- Kitchen area
- Relaxation area
- Thermal comfort
- Lighting
- Auditory Environment

The control of Gypsum loading will also be done from this room where two control desks will be available. The ablution facility will be shared with the admin building.

5.6 Safety Concept

General safety requirements for the mechanical equipment are as follows:

- Standard guarding, emergency stop and interlock principles will be specified to allow for a safe working environment for all personnel accessing the plant.
- All rotating equipment will be effectively guarded as required by the Occupational Health and Safety Act 85/1993;
- All equipment will be specified to include emergency stop facilities, including belt conveyors which will be equipped with pull wire trip switches on all accessible sides.

General safety regarding access to mechanical equipment:

- The tippler “vault” will have a minimum of two separate points of entry/exit.
- The tunnel from the tippler “vault” along the Inclined Limestone Belt Conveyor will have sufficient access for maintenance as well as the required escape routes. A barrier will be provided between the rail yard area and the Medupi power station area within the tunnel with access to the conveyor on either side of this barrier.
- Elevated sections of conveyor belts will have a walkway on either side.
- The Inclined Gypsum Belt Conveyor will be equipped with a suitable barrier between the rail yard area and the Medupi power station area and suitable access will be provided to the conveyor on either side of the barrier.

General safety design and installation requirements for the electrical system will be as follows:

- No electrical equipment should be mounted on removable walkways or structures.
- Live parts of electrical equipment mounted in enclosures should be shrouded or shielded to prevent unintentional contact (IP2X) by personnel.
- All enclosures and devices with switch disconnecting properties (MCB’s, MCCB, switch-disconnectors) must, where applicable have provision for securing by means of padlocks.
- All electrical installations should be such that they are "fail safe", i.e. the failure of the Plant or any circuit, stops the associated drive in a safe state.

General safety design and installation requirements for the lighting system will be as follows:

- All areas where lighting is required should be designed with personnel safety as the first criteria.
- Lighting design and installations should be completed in such a manner as to ensure that lighting provided does not have an adverse effect on any employee’s performance while performing their duties. These criteria must comply with the OHS Act.
- Unwanted lighting and glare should be considered to ensure that all employee’s safety whilst walking or performing specific tasks is not compromised.

6. SITING

6.1 Site Selection

The rail yard site selection was governed by the following:

- The decision to use the existing rail way network to deliver limestone to the power station.

- The position and layout of the FGD plant.
- Available space within the existing Medupi Power Station fence boundaries.
- The availability of existing services such as potable water, fire water and stormwater drainage structures.

6.2 Site Characteristics

The general topography of the site can be classified as flat terrain that slopes from the south west to the north east with a slope between 0.5% and 1%. For the construction of the rail yard a large amount of bush clearing will be required as approved by the Environmental Impact Assessment.

Stockpiles on the northern side of the proposed rail yard area are currently in use for other construction projects in Medupi. These stockpiles are to be removed before the commencement of the rail yard construction.

The bulk earthworks for the proposed rail way embankment will require large quantities of fill material. Due to the shortage of material on site all fill material G7 and higher will be imported from commercial sources.

6.3 Site Layout

Refer to the Main Concept layout drawing no. 0.84/4041 in Volume 3 Appendix 1.

7. BUILDINGS AND SERVICES

Please refer to the Concept Design Report Volume 1 (Rail Yard and Services).

8. MECHANICAL DESIGN

8.1 Limestone off-loading

A typical cycle time through a Side tippler arrangement with a side arm charger is 180 to 300 seconds per rail wagon, including positioning of the rail wagon within the tippler. In order to position the uncoupled rail wagons within the tippler, the side arm charger can traverse through the tippler assembly.

A typical cycle time through a Rotary tippler arrangement with a side arm charger is 75 to 180 seconds per rail wagon, including positioning of the rail wagon within the tippler. For this type of tippler the side arm charger cannot traverse through the tippler assembly and will move and position the train from the inlet side to the tippler.

The required feed rate onto the inclined belt conveyor will be set by the tippler cycle time, this equates to an average offloading rate of 1200 t/h for the Side tippler and 2880 t/h for the Rotary type tippler. In order to reduce the design conveying rate of the bulk materials handling equipment it is suggested that a delay is placed between the tippling operations of the rotary tippler, if applicable; this will require a longer off-loading cycle, which can be accommodated within the required 12 hour turnaround time, but will allow lower costs for the bulk materials handling equipment. The hoppers, feeders and conveyors will be adequately sized to suit the capacity of the selected concept.

The Side Tippler (Refer to drawing 0.84/40137 in Volume 3 Appendix 4) is the preferred limestone off-loading concept due to the lower estimated overall lifecycle cost. Refer to Volume 3 Appendix 14 for the report that compares the lifecycle cost of the Rotary and the Side tippler. The required off-loading time does not place a high demand on the tippler station, so the additional expense of a rotary type tippler station is not warranted to achieve a higher cycle time.

The tippler will be equipped with a side arm charger arrangement for the effective handling and positioning of the rail wagons at the tippler station.

8.2 Limestone materials handling

The options study for the rail yard determined the positions of the limestone off-loading facility. This position, along with the position of the limestone stockpile, provides the constraints within which the limestone handling equipment layout has been developed. With these constraints considered, and in order to achieve the simplest layout with the least possible number of transfer points, the conveyor route as described in drawings 0.84/40136 (Volume 3 Appendix 3) and 0.84/40137 (Volume 3 Appendix 4) has been developed for the limestone handling.

8.3 Gypsum loading

An overhead surge bin, which will straddle the rail at the gypsum loading point, is required to provide control and surge capacity before loading into the rail wagons. Additionally, the surge bin will allow for the reclaim operation from the gypsum pile to continue while the changeover between the train sections is made. The expected time between train sections is approximately 9.5 minutes and this will be allowed for as a minimum.

Due to the available 12 hour turnaround time a high speed train loading operation is not required, a lower speed operation allows lower capacity equipment as well as a smaller bin feeding to the rail wagons. There is however a minimum practical speed at which the rail wagon positioning and filling operations can occur and it is suggested that the rail wagon positioner is set to stop for a set time between each rail wagon. This will allow the surge bin capacity as well as the required gypsum reclaim rate to be significantly lower, reducing the required equipment capacities. However, due to the flow characteristics of gypsum, a minimum practical size surge bin will be required.

8.4 Gypsum materials handling

The options study for the rail yard determined the position of the gypsum loading facility. This position, along with the gypsum stockpile location, provides the constraints within which the gypsum handling equipment layout has been developed.

The gypsum stockpile will be manually reclaimed by mobile wheeled or tracked loaders feeding reclaim hoppers which will feed onto two gypsum reclaim belt conveyors. One of these gypsum reclaim belt conveyors will discharge to an inclined conveyor feeding a single elevated surge bin which will provide the necessary buffer capacity before the gypsum is discharged to the receiving rail wagons. The second gypsum reclaim belt conveyor will discharge to another belt conveyor which will feed onto either of the two overland ash conveyors; this is required for the use-case when the gypsum will be discharged to the ash dumps. The gypsum loading station will be equipped with a wagon positioner arrangement for the effective handling and positioning of the rail wagons.

9. ELECTRICAL DESIGN

9.1 Power supply into the rail yard

Currently there is a planned 6.6kV limestone handling plant substation as part of the FGD plant where the supply for the rail yard will come from. An option would be to utilize either the 6.6kV or 11kV existing substation for electrical feed into the yard.

Relay rooms are required to feed local control points and yard equipment. In the yards substation there will be a transformer which steps down the incoming voltage from 6.6kV to 400V for LV equipment and 220 volts ac or 110 volts dc for control and instrumentation. DC will be generated by means of a UPS with a battery backup, the required DC voltage will be tapped off from the UPS.

9.2 Power for the yard lighting and facilities

Currently the existing rail yard operations will be in accordance with Transnet Freight Rail. Therefore lighting in the rail yard will be as per TFR's standards.

Power will be distributed from the main substation in the rail yard into a yard lighting mini substation/kiosk, or an existing mini-sub.

9.3 Power for Rail System (signalling and yard automation)

Currently there will be no signalling required for rail operation and is not applicable for the current design, since train movements on the current network are authorised by means of radio train orders.

Provision will be made for a Rail yard operations room to monitor and control yard movements from a central point in the yard.

9.4 Cable Route selection

Refer to the drawing Substations & Cable Routes 0.84/40138 in Volume 3 Appendix 5.

The risk to plant and personnel due to the failure of cable and connection failures is an important consideration. The most important items that are considered during the design phase are the size (length and effective area) of the cables, the type of cable used for the application, cable route, cable supporting and the fire risk of the cables. The cable route will be the most practical and economical route available and where possible cables will be installed on the northern and western sides of the street.

Electrical services will be kept on the opposite side of the road to telecommunication and water services where practically possible.

The types of cable mainly used for new installations are the flame retardant PVC cables and the halogen free (HF) cables. The most important difference in the properties of these two cable types is the high emission of acid gas (hydrogen chloride) from PVC cables in the case of fire whereas no hydrogen chloride gas is released from the halogen free cables. The hydrogen chloride (HCL) gas in combination with other toxic gases that are produced from the burning of PVC. This acid gas is also responsible for the corrosion to steel reinforcement of concrete, steel structures and electronic equipment printed circuit boards. The cables shall be XLPE insulated with flame-retardant reduced halogen emission PVC outer sheath (emit a mass of not more than 15% halogen). Acceptance criteria for insulation shall be in accordance with SANS 1411-2.

Cables shall be manufactured in accordance with SANS 1339 and SANS 1411 Parts 1, 2, 4 and 7.

In the cable size range of 35 mm^2 to 185 mm^2 3½ core cables with a neutral core approximately ½ of the cross sectional area of the phase conductors shall be used. Cabling will be selected to have a volt drop better than 5%.

9.5 Electrical Power Requirements

As mentioned previously there is an already planned 6.6kV/400V substation that has been considered where electrical power will be distributed into the rail yard. All electrical, control and instrumentation equipment are rated at different voltage levels therefore Three-phase electrical power must be supplied into the rail yard.

Electrical power will be distributed from either 6.6kV, 11kV existing substation or the planned 6.6kV limestone handling substation into the main substation locally to the rail yard. Thereafter the voltage will be stepped down and distributed to various equipment on the rail and bulk material handling side.

9.6 Switchgear general specifications

9.6.1 General

- Switchgear should be supplied in accordance with specification 240-56227516
- Provisions will be made for UPS's in the substation for the switchgear control voltage

9.6.2 Circuit breakers

Circuit Breakers will be of the three pole, single mechanism type, with spring operating mechanism. Spring charging will be done by means of an 110V DC electric motor.

The circuit breakers will be in accordance with the requirements of IEC 62271.Testing of the breakers will be done in accordance with IEC 60060.

9.6.3 Isolating switches

The isolating switches should be of the centre rotating, side break type with manual operating mechanisms. All shaft movements should be facilitated by means of roller or ball bearings.

The centre insulator should rotate with the contact arm. Contacts will be silver plated and spring loaded.

The isolating switches should be in accordance with the requirements of IEC 62271.

Testing of the isolating switches should be done in accordance with IEC 62271.

Insulators used for isolators, should be tested in accordance with IEC 60168 and IEC 62217.

9.6.4 Current Transformers

Current transformers should comply with the requirements as stipulated in IEC 60044.

Insulated bushing material should be of porcelain or silicon rubber or composites and should be tested in accordance with IEC 60168 and IEC 62217.

Testing should be done in accordance with IEC 60060.

Multiple cores should be provided for the different protection requirements as well as for metering.

9.6.5 Voltage Transformers

Voltage transformers should comply with the requirements as laid down in IEC 60044.

Insulating bushings should be porcelain or composite rubber or composites and should be tested in accordance with IEC 60168 and IEC 62217.

Voltage transformers should be of the inductive type.

Testing should be done in accordance with IEC 60060

9.6.6 Surge Arrestors

The arrester will be capable of absorbing lightning and switching surges without damage to the equipment.

Testing should be done in accordance with IEC 60060.

9.7 Concept design description and equipment

Electrical power provided, shall be bulk, dual, AC supplies to low and medium voltage switchboards situated in electrical substations. Circuits on these boards will be provided for the power supplies to the

Plant i.e. motors, cubicles, power distribution boxes, variable speed drives etc. as per the power supplies required.

A dual supply auxiliary power system switchgear philosophy will be adhered to for ancillary plant i.e. when one board is isolated for maintenance purposes; only the electrical equipment supplied from that switchboard are out of operation, the Plant being fed from the other supplies shall remain in operation.

All concepts shall be in accordance with Eskoms standards and similar to the Medupi main plant, if not the same, philosophies shall be adhered to at all times when considering electrical infrastructure at the Medupi rail yard.

9.7.1 Power Conditioning

9.7.1.1 AC Power supply conditions

9.7.1.1.1 Normal AC supply conditions

Extremes of these parameters can occur simultaneously:

- Voltage: ± 5 percent
- Frequency: ± 2.5 percent
- Voltage unbalance: Negative Phase Sequence (NPS) voltage up to 0.02 of nominal Positive Phase Sequence (PPS) voltage
- The Zero Phase Sequence Voltage component can be up to 1% of the PPS component.
- The harmonic distortion of the supply voltage under normal operation will be as follows:
- The Total Harmonic Distortion (THD) of the voltage can be up to 5% of the fundamental component.
- The voltage waveform can contain harmonic components up to the 100th harmonic.
- The amplitude of any individual component can be up to 1% of the fundamental component.

Where variable speed drives are provided the harmonic current values as prescribed in this paragraph shall be adhered to. For all operating conditions, individual harmonic currents shall not exceed (these are measured at the electrical supply boards):

- rms amplitude of 100/n percent, where n is the harmonic number.
- sub-harmonic currents shall not exceed the RMS amplitude of 100n percent, where n is the fraction given by the sub-harmonic frequency divided by the fundamental frequency.

9.7.1.1.2 Abnormal AC power conditions

The supply voltage frequency can reach limits of up to 52.5 Hz and fall as low as 47.5 Hz. This condition can last for up to 1 minute.The amplitude and duration of temporary abnormal voltage conditions which can occur on the power supply are as follows:

- Short duration abnormal conditions: Short duration undervoltage conditions arise either due to a loss of supply or the supply voltage being depressed due to a short circuit on the network.
- Loss of power supply: When the supply is disconnected, the supply voltage either drops rapidly to 0% of nominal value or is sustained at low amplitude at a reduced frequency because of back generation of electrical drives. The initial voltage amplitude during these conditions is less than 80% of nominal value and decays with a time constant of up to 1.5 seconds. The time duration from loss of supply until supply restoration is between 1 second and 2.5 seconds.

- Short circuits: Depression of supply voltage due to short circuits can result in voltages as low as 0% of nominal value. The duration of the drop can be up to 1 second.
- Overvoltages: Overvoltages with amplitudes of 110% of nominal value can occur for up to 10 seconds.
- Medium duration power supply deviations: Voltage depressions of medium duration can be caused by the switching of load, such as starting induction motors. The supply voltage can fall as low as 75% of nominal value and the duration of this depression can be up to 15 seconds.
- Power swings: An alternative source of this abnormal condition is when power swings occur after a severe disturbance on the network. The supply voltage amplitude will oscillate at a frequency between 0.2 and 2 Hz. In this case, the voltage can fall as low as 65% of nominal and can rise up to 110% of nominal during a swing. The voltage will not fall below 70% for longer than 0.5 seconds. However, these oscillations, or repeated abnormal voltage conditions, can continue for up to 60 seconds.
- Long duration power supply deviations: Long duration abnormal supply voltage conditions usually originate from operating the plant at its limits. The supply voltage can be up to 110% of nominal value and can drop as low as 90% of nominal value. The duration of such abnormal conditions is up to 6 hours.

The following lightning and switching surge conditions can occur on the power supply system:

- Lightning impulse: Phase-to-earth and/or phase-to-phase lightning impulses with a front time of 1.2 µs, a time-to-half-value of 50 µs, a peak value up to that indicated in the Switchgear Parameter Table and with both positive and negative polarities, as described in IEC 60060-1.
- Switching impulse: Phase-to-earth and/or phase-to-phase switching impulses with a front time of 250 µs, a time-to-half-value of 2500 µs, a peak value up to that indicated in the table in paragraph 5.1 and with both positive and negative polarities, as described in IEC 60060-1.

9.7.2 Earthing and Lightning

The earth mat under the civil foundations shall be designed in accordance with IEC 61024, IEEE 80 and IEEE 142. The design calculations use the lightning density information applicable to the site, soil sample resistivity results and the building physical parameters

Provision shall be made to enable the earthing of items of plant and Plant to an earth mat, either directly to the power station main earth mat, or to a separate earth mat that is then again connected to the main station earth mat (at two points).

The earthing of moving equipment, stackers, and conveyors shall be in accordance with the earthing and lightning protection standard 84ELEC001.

9.7.3 Electric Motors & Variable Speed drives

Electric motors shall comply with specification GGS 0802. Three phase motors shall be preferred over single phase motors. No 400 V motor exceeds a rating of 132 kW. A specific concession to this requirement may be granted by the Engineer after review. A soft start facility may be utilised, provided that the maximum starting current does not exceed 1500 A.

DC or uninterruptible power supplies (UPS) shall be fitted to the AC control supply of the 400 V boards to keep the motor contactor operating coils energised during voltage depressions lower than 0.85 Vn and lasting up to 1 second. The electrical motors therefore run during such abnormal power supply voltage variations.

All motors shall be supplied and installed with all items necessary for their correct operation. This includes mounting plates, bolts, jacking bolts, shims, couplings, auxiliary lubrication and cooling equipment.

Electric motors shall be supplied from individual switchgear circuits each having its own protection and situated in its own compartment. Where more than one motor is supplied from a distribution board each one shall be individually protected.

All motors shall undergo a routine test at the factory before delivery to site.

The variable speed drives shall have all the necessary ancillary plant for a complete working installation. The associated Plant (as applicable) include motors, power transformers, power line converters, DC link reactors, power load inverters and electronic control cubicles for control, monitoring, alarm and protective functions.

The equipment shall be self-contained, with all the necessary auxiliary and control AC/DC supplies derived within the equipment.

9.8 Single Line Diagram

The single line diagram (refer to drawing 0.84-40147 in Volume 3 Appendix 21) shows a high level concept layout of the rail yard area where the main supply will be from the Eskom planned lime stone handling plant which feeds the rail yard and services as well as the bulk material handling area. A redundancy principal of 100% will be used which means at any giving point the rail yard will have a spare supply which will be able to carry the entire load of the rail yard. Two 6.6kV boards will further step down to 400V where the low voltage will be distributed from to various equipment ie. FGD plant, Limestone handling, Rail yard operations room, admin building and possible the rail area lighting.

9.9 Electrical Equipment List

Electrical Equipment List-Medupi Rail Yard				
Rail yard Substation	**Rail yard & Services**	**Bulk Material Handling**	**Admin Building**	**Operations Building**
Distribution board	**Weighbridge-Building**	**Limestone BMH**	Distribution board	Distribution board
Plug Points	Distribution board	Power supply for IP cameras	Plug Points	Plug Points
Power supply for IP cameras	Plug Points	Power supply for motors & VSD		Monitors
Sensors(fire)	Power supply for IP cameras	Power supply for auxiliaries	Mini substation	
	Mini-substation	Power supply for all C&I	***Lighting inside & outside***	***Lighting inside & outside***
Lighting inside & outside	***C&I***	Mini-substation	Cabling	Cabling
Cabling	Cabling	***C&I***	Lamps /florescent	Lamps /florescent
Lamps /florescent	Trenching	C&I equipment(load cells, sensors, etc.)	Power supply	Power supply
Power supply	Instruments(load cells, sensors, etc.)	Cabling		
	Power supplies	Trenching	***Air-conditioning***	***Air-conditioning***
Air-conditioning			Cabling	Cabling
Cabling	***Lighting inside & outside***	**FGD Gypsum BMH**	Air conditioning Unit	Air conditioning Unit
Air conditioning Unit	Cabling	Power supply for IP cameras	Power supply	Power supply
Power supply	Lamps /florescent	Power supply for motors & VSD		
	Power supply	Power supply for auxiliaries	***Electrical Rooms***	
Transformer(11kV/415v or 6.6kV/415v)		Power supply for all C&I	Power Room	
Cables to Transformer	***Air-conditioning***	mini-substation	Server Room	
Trenching	Cabling	***C&I***		
Bund wall	Air conditioning Unit	C&I equipment(load cells, sensors, etc.)		
Earthing	Power supply	Cabling		
Auxiliaries		Trenching		
Switchgear	***Yard Lighting***			
Circuit breaker	Distribution board			
Isolator	Cabling			
Current transformers	Luminaires + auxiliaries			
Voltage transformers	Masts			
metering units CT+VT	Trenching			
	Day/night sensors			
Panels				
Transformer protection panels				
Metering panels				
Equipment panels				

Table 3: Electrical equipment list

10. CONTROL AND INSTRUMENTATION DESIGN

10.1 Introduction

Control and instrumentation will be required for both the bulk material handling as well the rail yard and services.

The scope of the C&I project includes the following:

- SCADA and Control System
- Monitoring and Control for Bulk Materials Handling, Rail-yard Equipment
- Interface to Weighbridge standalone systems
- Plant Information system
- Building Management system including lighting management, CCTV, Access control, Intercom/ PA and Fire Detection systems
- Interface to Medupi Power plant
- Field Equipment

The C&I Architecture drawing 0.84/43218 (Refer to Volume 3 Appendix 22) will include a standalone PLC & SCADA system to the Medupi Power plant Control System with an interface to the Medupi Power plant Control system.

The facility control and instrumentation will provide services for the integrated monitoring and control of the Medupi Rail Yard to achieve a Facility-wide integrated system. There will be a local Plant Information System (PIS) which provide facilities for storing and transfer of information to the main power plant concerning the performance of the system, production, facility conditions and performance and provide data in order to obtain the required parameters.

The PIS information as well as information from the BMS can be accessed by the Medupi Power plant control room through the PIS interface and CBMS respectively.

Centralised operation will be deemed to include all actions that will normally be undertaken to accomplish normal and emergency start-up, routine loaded operations, and normal and emergency facility shutdown.

All local controls, control panels and other Human Machine Interfaces (HMI) located inside and outside the CCR, namely in equipment rooms, switchgear rooms or local to the Facility, will in general be regarded as operational facilities and the SCADA and/ or Control and Monitoring System will interface to these facilities and monitor all such operations.

A high-level computer system (HMI) will be provided with multiple operating stations and integrated with the control system to perform local control and monitoring, and for automatic comprehensive data logging and archiving with detailed analysis and reporting for maintenance management. On-line condition monitoring will be provided for equipment.

The communications between SCADA and the PLC as well as the Interfaces to the main power plant are considered to be redundant. This would achieve the best availability at this level however once the plants total availability requirements are confirmed the level of redundancy in all systems including PLC will be addressed. Due to the nature of operations its currently not foreseen to have redundancy at the Field level that requires control by the PLC's therefore no redundancy in the PLC's was allowed for.

10.2 Bulk material handling

Looking at the bulk material handling side, I/O systems required can include the following:

- Over speed trip of the tippler
- Thermal motor protection
- Blocked chute detection
- Belt drift switches
- Emergency stop and pull-wire trip switches
- Belt under-speed switches

10.3 Yard Control System

Yard control will be by means of local and remote control, where all control and instrumentation equipment signals required will be taken back to the Rail yard operations room.

10.4 Surveillance

Surveillance will be required for both security measures and monitoring of the rail yard & bulk material handling area. These cameras may monitor the rail yard, railway line, weighbridge as well as the specific areas of the BMH area.

IP cameras will be considered as opposed to analogue cameras due to the resolution and picture quality as well as the type of footage that is required; For example yard monitoring for security may require cameras that can be controlled by moving 360 degrees as well as zooming capability, whereas monitoring of the rail way line or conveyors maybe require cameras with fixed lenses that have no zooming capabilities.

All footage will be displayed in the Rail yard operations room in the rail yard where dedicated screens will be provided for viewing.

Long term Storage of footage will be provided and easily retrievable via a high resolution DVR.

11. SERVICE ROAD REQUIREMENTS

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

The existing rail way is serviced by a 6m gravel road. It is proposed that the new service road connect to this gravel road at the existing rail way crossing. It is proposed that the service road will be designed on the same platform as the rail way to provide level access to all facilities.

The road alignment is determined by the rail way layout. The road centreline is placed 6m from the rail centreline. The road will be designed and modelled using AutoCAD Civil3D.

Road cross and longitudinal sections will be generated for the service road. This will be accompanied by a detailed layout drawing with setting out data. The SANS 1200 will be used to compile a complete bill of quantities for the service road.

The service road will be designed to the following specifications:

- 6m wide gravel road
- Cross fall between 1:15 and 1:40
- Layer works as specified in the Transnet S410 specifications
- Geometric design to travel with reasonable ease with a 7t truck

- Maximum local depressions and bump of 50mm
- The road centreline will be placed 6m from the outside rail centreline
- Cut and fill slopes at 1:2

The service road will be designed as a 6m wide gravel ring road to service all facilities in the rail yard. The start position will be at the existing service road rail way crossing. The road layer works will be designed to the same standard as the rail way layer works. The road will have a cross fall between 1:15 and 1:40 for storm water drainage. No formal storm water drainage will be installed for the proposed gravel road. Guard rails will be installed on areas of fill more than 0.5m high.

The service road design and costing is covered in the Concept Design Report Volume 1 (Rail Yard and Services).

12. STORMWATER AND DIRTY WATER REQUIREMENTS

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

The portion north of the rail way line drains to an earth lined channel at the north side of the rail yard. This channel drains from west to east and exits at a newly upgraded stormwater culvert. The size and capacity of the new culvert should be verified during detail design.

The clean rail way stormwater will be collected using concrete channels and underground pipes to drain into a new proposed earth lined channel that will drain to the newly upgraded culvert. This culvert size will be evaluated using the 1:20 year peak flow to determine the required culvert size due to the increased run off from the rail way yard.

The dirty stormwater from the gypsum loading facility will be collected into an independent concrete channel and underground pipe network that will drain to the proposed pollution control dam that will be designed by the FGD project team. The estimated run off contribution to the pollution control dam will be $0.05m^3/s$ for a 1:20 year return period.

The topographical survey will be used to determine catchment areas and flow paths with the assumed 437mm MAP. The rail way drainage and earth lined channels will be modelled in a Hydro cube model using the rational method for different return periods. The rational method will be used for all the 1:2 and 1:20 year return periods. All required structure sizes will be evaluated and sized accordingly

The Hydro cube analysis will provide peak flow values for the chosen return periods. Pipe, channel and culvert sizes will be determined from this analysis. The SANS 1200 will be used to compile a bill of quantities for stormwater structures.

13. CIVILS SERVICES AND REQUIREMENTS

13.1 Bulk Earthworks

The topographical survey and a site visit clarified numerous stockpiles on the proposed rail way site. It is assumed that all the stockpiles will be removed prior to construction. The bulk earthworks below the rail way main layer works will be constructed using G9 material.

From the topographical survey and final approved rail way layout an AutoCAD Civil3D model will be used to generate setting out data and measurement of quantities.

A detailed bulk earthworks layout drawing with setting out data and cross sections will be issued during detail design stage. Bulk earthworks quantities will be used to compile a SANS 1200 bill of quantities. The layer works will be constructed as per typical section on drawing 0.84/40141 in Volume 3 Appendix 8.

The positions and placement of the platform for the rail way layer works and bulk earthworks was determined by the final approved rail way layout. The platform was designed to ensure that the new toe line will not overlap the existing service road fence.

A letter dated 6 August 2014 from Eskom requested the design team to review all earthwork designs due to the quality of stockpiles deteriorating from G5 to G6 and G7 to COLTO classifications. For the concept design stage it is assumed that all materials G7 and higher will be imported from commercial sources. With the final geotechnical report outstanding it was assumed (on advice from the Geotechnical Engineer) that the insitu material could be collapsible and would have to be compacted by an impact roller to ensure proper support.

The platform will be designed to accommodate the limestone unloading facility, locomotive shed, diesel storage and the gypsum loading facility on the same level as the rail way lines. The security office and accommodation building will be provided with separate platforms.

The bulk earthworks and rail way layer works will be designed according to the Transnet S410 specifications. All cut and fill slopes for the earthworks will be designed to 1:2. The bulk earthworks will consist of G9 material compacted to 93% MOD AASHTO in layers of 150mm. The rail way layer works will be designed for a 26t axle load to specifications.

The cost for bulk earthworks in this report only includes the excavation and backfilling cost to all materials handling facilities. All other bulk earthworks and rail way layer works will be measured in the Concept Design Report Volume 1 (Rail Yard and Services).

13.2 Potable water

Refer to drawing 0.84/40141 in Volume 3 Appendix 8.

Medupi is served by an existing independent potable water network. The connection chamber and position was provided by the client. It was assumed that the connection to the existing network will provide sufficient pressure and flow required for serving the buildings. The pressure and flows at the connection points will be confirmed prior to detail design.

The potable water network serving the facilities will be modelled during the detail design using the Water Mate package.

A detailed calculation report sheet will be generated during detail design illustrating the required pipe sizes and pressures at specific nodes. The SANS 1200 will be used to compile a bill of quantities for all the water pipes.

The potable water network will serve the security office, locomotive workshop and administration building with a stand tap and ablution facilities. Provision will also be made to serve the materials offloading facility and the gypsum loading facility with stand taps.

The following design parameters, which resulted in an estimated peak flow of 0.5l/s, were used as base for the potable water design:

- Population – 18 people
- Unit demand – 80 litres/person/day
- Peak Factor – 4
- Pipe material – 50mm uPVC Class12

It is proposed to install 50mm uPVC class 12 pipes to all buildings in the rail yard. All pipe sizes will be re-evaluated when pressures and flows are known at the connection point. The final pipeline positions and valve placement will be conducted after the approval of the layout plan.

The potable water design and costing will be covered in the Concept Design Report Volume 1 (Rail Yard and Services).

13.3 Civil Works relating to Electrical

- Lighting Foundations
- Lighting Cable trenching
- Control cable trenching

All excavation, trenching and concrete work will be done to SANS 1200 specifications.

14. GEOTECHNICAL AND HYDROLOGICAL STUDIES

The following scope of work is proposed:

14.1 Desk study review

- A desk study review will be undertaken of all the available geotechnical and geological information pertaining to the site including published geological maps and geological and geotechnical reports.

14.2 Fieldwork will include the following

- Test Pits
- Dynamic Core Penetrometer (DCP) Tests
- Continuous Surface Wave (CSW) Tests
- Construction Material Sampling
- Laboratory Testing

14.3 Geotechnical Report

A geotechnical report will be compiled presenting the information obtained during the site investigation including the prevailing site conditions, stratigraphy, material classification and characterisation, geotechnical parameters, preliminary foundation recommendations and recommendations for infill investigations if required. A factual interim report will be issued about one week after the completion of all fieldwork presenting the recorded soil profiles, DCP results and CSW logs but a final interpretive report will only be issued a week after receiving all laboratory results. Rockland will however endeavour to supply the design team with information as it becomes available to allow the design process to proceed with least interruption.

15. FIRE PROTECTION REQUIREMENTS

This is discussed in Concept Design Report Volume 1 (Rail Yard and Services).

16. STRUCTURAL REQUIREMENTS

The structural work pertaining to bulk materials handling includes the tippler station, the gypsum loading station and all bulk materials handling support structures and transfer towers. The Side tippler or “Rotaside” tippler structure will consist of a concrete basement formed approximately 11m below ground level, with concrete retaining walls surrounding the perimeter of the basement. Access will be via concrete staircases. The steelwork inserts required to support the tippler will be cast integrally with the concrete structure. A suspended concrete slab with the required cut outs, to suit mechanical requirements, will be formed at floor level. The structure will be covered with a steel portal roof structure and mild steel sheeting. This is to prevent the ingress of rainwater into the basement, and provide all weather access for offloading operations.

Limestone will be conveyed below ground in a concrete tunnel, which daylights as the conveyor climbs at the specified gradient. Thereafter, the conveyors will be supported on concrete sleepers at ground level, spaced at approximately 2,5m intervals.

As the conveyors leading into the transfer towers rise above grade, small box girders with walkways on one side will support the conveyor and span between steel trestles. The steel trestles will be located at approximately 15m centres, and will be founded on concrete foundations on engineered layerworks.

Transfer towers will consist of braced steel structures, with mentis grating forming the access floors at the various required levels within the transfer houses. Access will be via steel staircases, and facilitate “walk on” access between conveyor walkways and transfer tower floor levels.

Each transfer tower will have the minimum number of fire escape routes as required by legislation. Similarly, the conveyor tunnel will be fitted with a transverse fire escape tunnel and concrete framed stair well.

17. TECHNOLOGY REQUIREMENTS

17.1 Maturity of Selected Technology

The use of both rotary unit wagon tipplers and “rotaside” type tipplers is common in industry. This has been the case for a number of years, and the technology used for this type of equipment is well developed. The same applies to the general bulk materials handling equipment that will be used such as belt or apron feeders, hoppers, belt conveyors and overhead feed bins as well as to auxiliary equipment such as standalone dust separation equipment.

17.2 New Technology Required

No new or immature technologies have been selected as part of the design for this concept study.

18. COSTING EVALUATION

18.1 Capital costs

TOTAL LIMESTONE HANDLING - SIDE TIPPLER OPTION				177 616 324
	BMH EQUIPMENT	ZAR	132 242 324	
	CIVIL WORKS	ZAR	3 430 000	
	STRUCTURAL WORKS	ZAR	41 944 000	
TOTAL LIMESTONE HANDLING - ROTARY TIPPLER OPTION				178 739 324
	BMH EQUIPMENT	ZAR	111 117 324	
	CIVIL WORKS	ZAR	11 241 000	
	STRUCTURAL WORKS	ZAR	56 381 000	
TOTAL GYPSUM HANDLING				62 442 000
	BMH EQUIPMENT	ZAR	59 280 000	
	CIVIL WORKS	ZAR	INCLUDED IN STRUCTURAL	

STRUCTURAL WORKS	ZAR	3 162 000	
TOTAL ELECTRICAL CONTROL & INSTRUMENTATION			8 589 000
ELECTRICAL	ZAR	1 924 000	
CONTROL AND INSTRUMENTATION	ZAR	6 665 000	
TOTAL CAPEX ESTIMATE BULK MATERIALS HANDLING AND ASSOCIATED INFRASTRUCTURE - SIDE TIPPLER OPTION	**ZAR**		**248 647 324,00**
TOTAL CAPEX ESTIMATE BULK MATERIALS HANDLING AND ASSOCIATED INFRASTRUCTURE - ROTARY TIPPLER OPTION	**ZAR**		**249 770 324,00**

Table 4: CAPEX costing summary – materials handling

The above CAPEX costing summary excludes engineering, procurement and construction management costs. The costing accuracy is +-40 % with a base date of January 2015. Refer to Volume 3 Appendix 19 for a detailed breakdown of the above costing summary.

18.2 Life-Cycle Cost Assessment

A lifecycle cost assessment was conducted to provide a comparison of the overall costs to the Client between the Rotary and Side tippler options.

The assessment shows that the overall lifecycle costs of the Side tippler will be significantly lower than for the Rotary tippler. Refer to Volume 3 Appendix 14 for the detailed life cycle cost analysis report.

19. DEVELOPMENT TEAM

The following people were involved in the development of this document:

19.1 Material handling/Mechanical

- Darius Bezuidenhoudt (Mechanical Engineer)
- Dave Chappelow (Bulk materials handling consultant)

19.2 Civil Infrastructure

- L. Geldenhuys (Civils Lead Project Director)
- PJJ Basson (Civils Project Manager)
- WF Küsel (Civils Lead Engineer)
- C Prinsloo (Design Reviews)
- W Bekker (Civils CAD Operator)

19.3 Electrical Control and Instrumentation

- Shekar Inderlall (Electrical Engineer)

- Mike Da Silva (Electrical, Control & Instrumentation)
- Amantha Maharaj (Electrical Engineer-Design Review)

19.4 Buildings and Structural

- Errol Tromp (Structural Engineer)
- Johan Duvenhage (Architect)

19.5 Fire Protection Services

- Roger Bosch (Mechanical Engineer)

20. REVISIONS

Rev.	Status	Issued by	Date
01	Issued for review	Francois Retief	4/12/2014
02	Updated with Electrical and C&I changes	Francois Retief	29/1/2015
03	Updated with all MDR changes including C&I issues from 19 February 2015	Francois Retief	20/2/2015
04	Updated with final C&I issues after meeting held on 27 February 2015	Francois Retief	13/3/2015

Bosch Holdings Consortium

BOSCH HOLDINGS	Thabile Engineering	Thabo Consulting	NEMAI CONSULTING

ESKOM HOLDINGS SOC LTD

TASK 203 – BASIC AND DETAILED DESIGN OF MEDUPI RAIL YARD AND OFFLOADING FACILITY

CONTRACT NUMBER: 4600051676

ORDER NUMBER: 4501833635

BOSCH HOLDINGS CONSORTIUM PROJECT NUMBER: P1184-099-1

MEDUPI RAIL YARD AND OFFLOADING FACILITY
CONCEPT REPORT VOLUME 3
APPENDICES

Report reference number: 1184-099-4-100-R-0001-Rev04 Concept Vol3 Appendices Revision: 04 Total pages: 03

Report submitted by:

Bosch Holdings Consortium

13 March 2015

CONTROLLED DISCLOSURE

Appendix	Description	Drawing number
1	Main Concept layout drawing	0.84/40134
2	Rail Plan and Profile drawing	0.84/40135
3	BMH layout drawing for Rotary Tippler	0.84/40136
4	BMH layout drawing for Side Tippler	0.84/40137
5	Substation & Cable Routes	0.84/40138
6	Lighting Design - Shunting Neck	0.84/40139
7	Lighting Design - Staging Yard	0.84/40140
8	Civil services Concept layout drawing	0.84/40141
9	Administration & Operations Tower Building - Plans	0.84/40142
10	Administration & Operations Tower Building - Elevations & View	0.84/40143
11	Security Office – Plan, Elevations & View	0.84/40144
12	Loco Workshop, Utilities and Ablutions – Plan & Elevations	0.84/40145
13	Fire hazard and risk assessment report	-
14	Rotary and Side Tippler lifecycle costing report	-
15	Options Study report	-
16	Simulation report	-
17	ON-TRACK Technology - Massize T4 installation detail	-
18	Costing detail Volume 1 (Rail Yard and Services)	-
19	Costing detail Volume 2 (Materials handling)	-
20	Rail lighting layout drawing	0.84/40146
21	Single line diagram - Electrical	0.84/40147
22	Concept control network architecture - typical	0.84/43218

23	Materials handling Process Flow Diagram (PFD)	0.84/43219