CLEAN DEVELOPMENT MECHANISM
PROJECT DESIGN DOCUMENT FORM (CDM-PDD)
Version 03 - in effect as of: 28 July 2006

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SECTION A. General description of project activity

A.1. Title of the project activity:

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The Capture and Utilisation of Methane at the Gold Fields’ owned Beatrix Mine in South Africa
Version 4.0
Date: 2 October 2008

A.2. Description of the project activity:

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Purpose:

The Beatrix Mine (referred to as Beatrix from here on) is owned by Gold Fields and located in the Free State Province of South Africa. Beatrix is a gold mine. The mining activity releases underground methane. The origin of this methane is unknown. Methane is highly explosive and a safety hazard. Currently, the underground mine methane is diluted with ventilation air to below its explosion limits and released into the atmosphere through ventilation shafts.

Aside from underground mine methane, methane is also released from numerous exploration boreholes. Since the start of the drilling program in the 1950s, a number of boreholes have intersected methane-carrying geological structures. During the development of this project, 488 holes were identified in the Gold Fields mining area. Only 38 of the identified boreholes are still venting methane at detectable levels. Five of these boreholes, geographically far apart from each other, are venting methane at rates that justify the implementation of greenhouse gas reduction projects.

Mine Methane:

The proposed project will pipe the underground mine methane up the main Beatrix shaft (Number 1 Shaft) and to the surface where is will be flared and used to generate electricity. The project will be implemented in two phases:

1. The first phase will be the installation of a flaring system. At this stage, all the mine methane will be flared. The first phase, or flaring of all the mine methane, will occur in May 2009.
2. The second phase will be the installation of the power plant in January 2010. In phase two, the mine methane will be used to generate electricity and any excess methane will be flared.

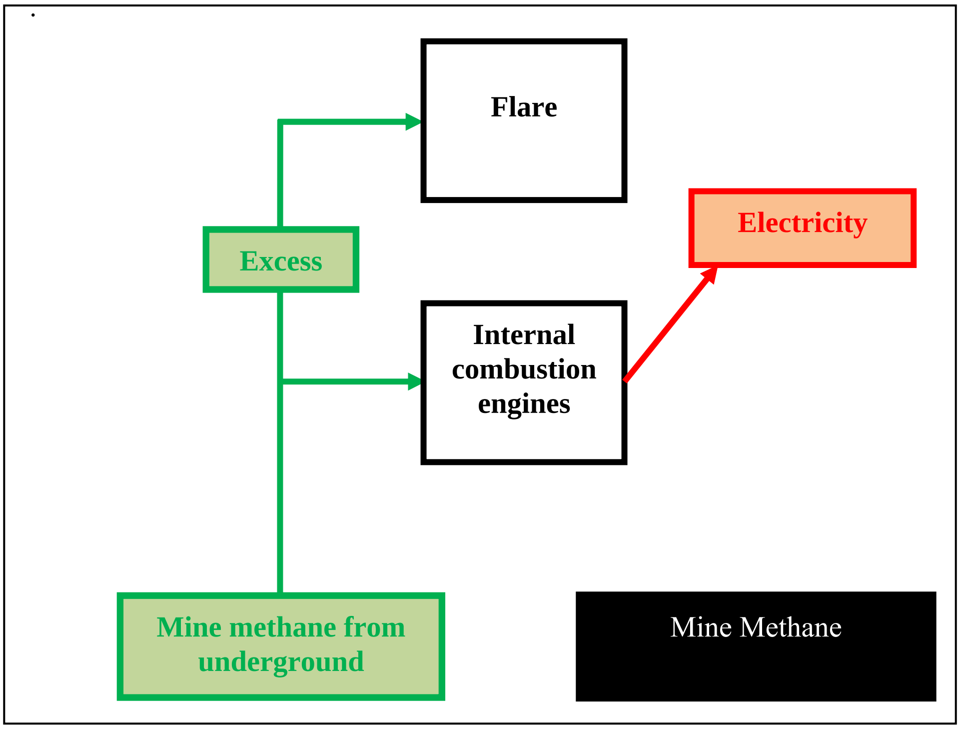

Figure 1: Proposed project activity – Underground Mine Methane

Currently, Beatrix does not self-generate electricity. Beatrix does have stand-by emergency generators, which they use to bring the miners to surface when there is no grid electricity. The generators are only used as emergency power. Under normal circumstances, Beatrix gets all of its electricity from the national grid.

In the project activity, electricity will be generated by combusting the mine methane in internal combustion engines. The electricity generated will displace grid electricity. The excess methane, remaining after electricity production, will be flared.

The electricity generation and flaring plant will be built, owned and operated by Exxaro On-Site Pty Ltd. The electricity produced will be used by the Beatrix Mine.

Non-Mine Methane:

The non-mine methane released from five exploration boreholes, geographically far apart from each other, will be flared as part of the project activity.

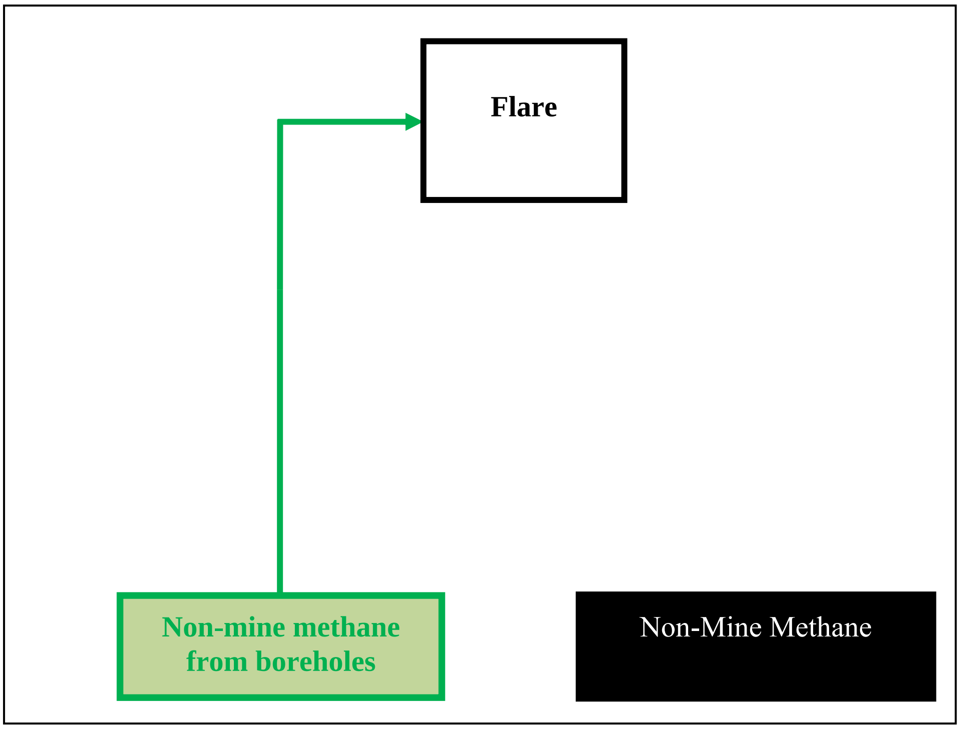

Figure 2: Proposed project activity-Non-Mine Methane from Boreholes

The flares used to flare the methane released from the boreholes will be built, owned and operated by Exxaro On-Site Pty Ltd.

GHG Reduction:

The use of this underground mine methane will reduce the amount of electricity Beatrix needs to import from the national grid. The South African grid electricity is generated predominantly from low grade coal. The use of coal and, more specifically, low grade coal means that the production of grid electricity is emissions-intensive.

The proposed project will destroy both the underground mine methane and the non-mine methane released from the boreholes. The destruction of this methane will result in the elimination of methane released directly into the atmosphere. Since methane has 21 times the global warming potential of carbon dioxide, the project will result in a reduction of GHG emissions.

Contribution to Sustainable Development:

The project makes positive contributions to sustainable development. The South African Designated National Authority (DNA) evaluates sustainability in three categories: Economic, environmental and social. The contribution of the project towards sustainable development is discussed in terms of these three categories:

- **Economic:** The project will contribute to foreign reserve earnings for South Africa via the carbon credit sales revenue.

The carbon credits obtained from the destruction of methane will be owned by Gold Fields. The revenue from carbon credits will decrease the volatility of the normal earnings profile of the mine. The current earnings profile of the mine changes with the fluctuating gold price and the cyclical changes associated with the South African currency.

- **Environmental:** At a regional level, the project will have a positive impact on the environment. This positive impact relates to a reduction in the generation of coal-based electricity and its associated environmental consequences. These consequences include: the impact of coal mining, the utilisation of scarce water resources, SO_2 emissions and the impacts associated with the disposal of coal ash.

  The project will result in a reduction of greenhouse gas emissions by eliminating the release of methane, which has a global warming potential of 21 times that of carbon dioxide.

- **Social:** The project will create jobs in both the construction and operations phase.

  The project will destroy the underground mine methane and the methane released from boreholes. Methane has always been a huge safety risk since it is a highly explosive gas. The destruction of the methane will result in a safer working environment for the personnel at Beatrix.

  Gold Fields have committed to contributing a percentage (R0.20 per ton of CO_2e and 0.5% of pre-tax profit) of their carbon credit revenue to The Gold Fields Foundation. This is similar to the contribution Gold Fields makes out of gold mining revenue in terms of its social sustainable development obligations as dictated by the South African mining legislative framework relating to sustainable development.

  The Gold Fields Foundation is involved in a number of projects aimed at the social upliftment of the local communities. These projects target local economic development with a positive environmental impact. Examples of these projects include:

  - Golden Oils – a community based, indigenous plant essential oil project
  - Bulk water supply to the Lejweleputswa District
  - Land and housing project in Masilonyana
  - Beatrix day-care facilities

A.3. Project participants:

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Name of Party involved (*) ((host) indicates a host Party)	Private and/or public entity(ies) project participants (*) (as applicable)	Kindly indicate if the Party involved wishes to be considered as project participant (Yes/No)
Republic of South Africa (host)	Gold Fields Ltd	No
	Exxaro Ltd	
	Promethium Carbon (Pty) Ltd	
(*) In accordance with the CDM modalities and procedures, at the time of making the CDM-PDD public at the stage of validation, a Party involved may or may not have provided its approval. At the time of requesting registration, the approval by the Party(ies) involved is required.		

Note: *When the PDD is filled in support of a proposed new methodology (forms CDM-NBM and CDM-NMM),* at least the host Party(ies) and any known project participant (e.g. those proposing a new methodology) shall be identified.

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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A.4.1.1. Host Party(ies):

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The host party is the Republic of South Africa.

A.4.1.2. Region/State/Province etc.:

>>

The project is located in the Free State Province.

A.4.1.3. City/Town/Community etc.:

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Beatrix mine is situated south of Virginia in an area known as the "Welkom Gold Fields." Beatrix mine is in the Theunissen district of the Free State. Beatrix falls under Masilonyana Local Municipality and Lejweleputswa District Municipality.

A.4.1.4. Details of physical location, including information allowing the unique identification of this project activity (maximum one page):

>>

The proposed project will be located on Leeuwbult 52, which is a farm in the district of Theunissen near Virginia. The location of the project is represented below.

Figure 3: Map of southern Africa

This map was extracted from www.nationsonline.org website

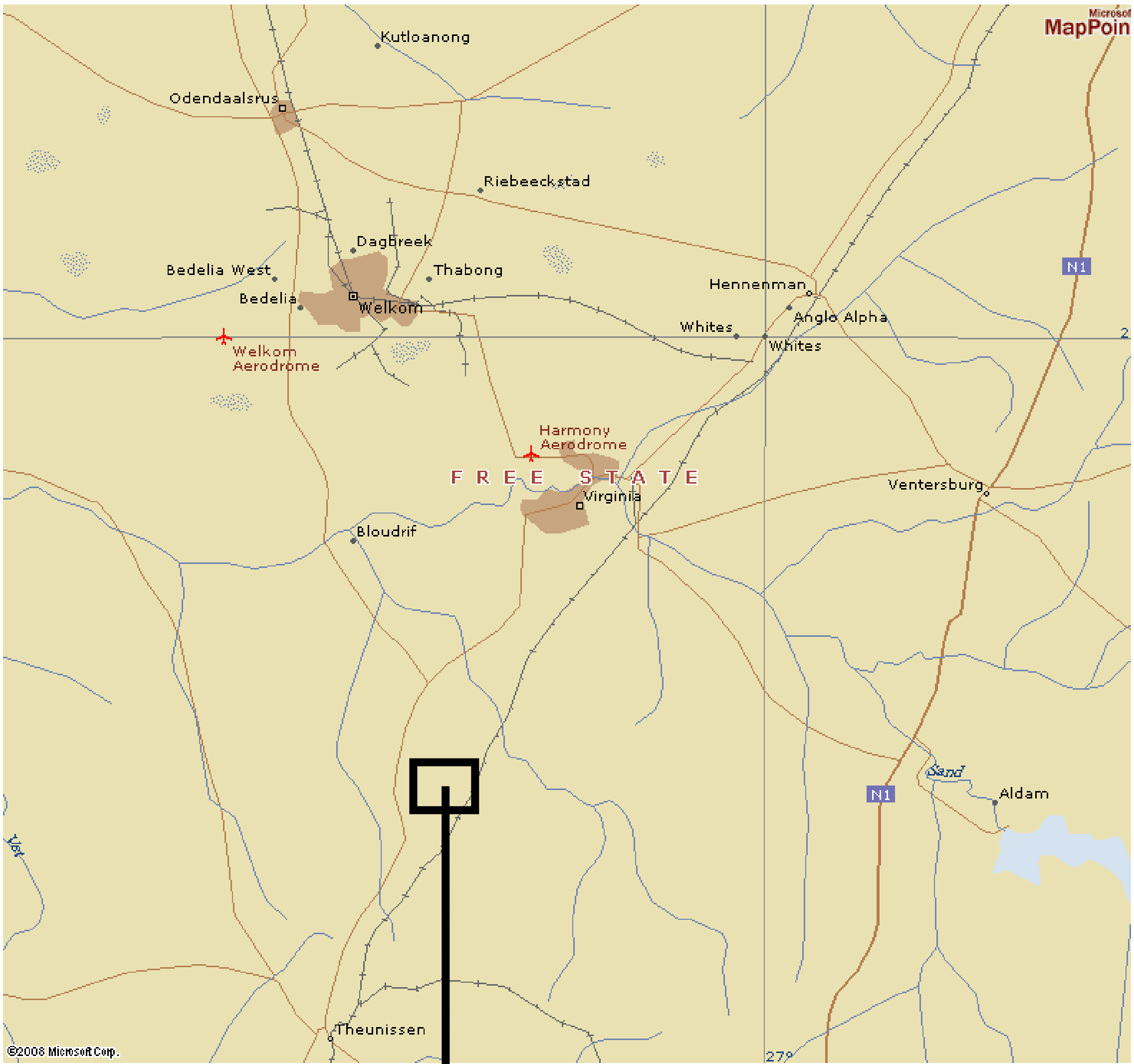

Figure 4: Map of the Free State

Project Location

This map was extracted from http://encarta.msn.com/map_701512555/free_state.html

The plant that will use and destroy the underground mine methane will be located at Beatrix mine. The GPS coordinates are:
S 28°15'44"
E 26°47'06"

The project will flare the methane released from five boreholes. These boreholes are:

Name	GPS Coordinates
DBE1	S 28 11.066 E 26 45.488
EX1	S28 16.334 E 26 44.612
ST23	S28 11.995 E 26 44.312
1400	S28 13.323 E 26 44.607
2264	S28 13.908 E 26 47.078

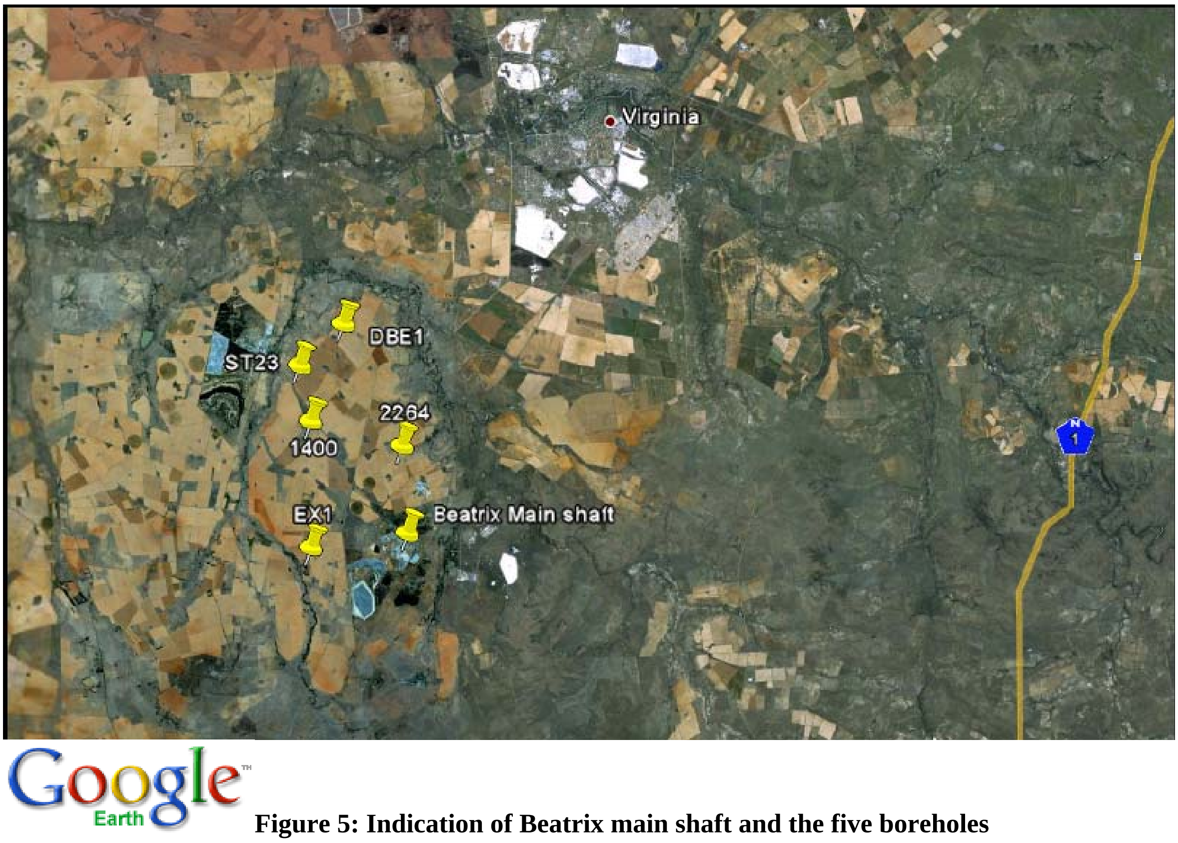

Figure 5: Indication of Beatrix main shaft and the five boreholes

A.4.2. Category(ies) of project activity:

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The project category is:

Sectoral Scope 10: Fugitive emissions from fuels (solid, oil and gas)

A.4.3. Technology to be employed by the project activity:

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Background on the Occurrence of Methane

The methane is found in geological faults and liberated when the fault is encountered during the mining activity. The origin of the methane in these faults is unknown. Scientific research into the origin of the methane indicates that is comes from a deep-seated source and that it may be of biological origin. More information on the research done into the source of the methane can be found in Annex 3. Annex 3 describes the location of the geological faults in greater detail.

Methane from gold mines is different to methane from coal mines. The methane from gold mines is not released homogeneously whereas the methane from coal mines is released homogeneously. Coal mine methane is a direct result of coal mining (i.e. if more coal is mined then more methane will be released). This is not the case with gold mine methane. Hence, it is difficult to determine how much methane will be released and how long that methane source will continue to release methane. This presents many challenges for projects proposing to use the gold mine methane.

<u>The Use and Destruction of the Underground Mine Methane</u>

The underground mine methane will be captured by:

1. Sealing off an area into which the methane is released and piping the methane from that area to the surface, and/or
2. Piping the methane from underground boreholes to the surface.

Currently, the methane is diluted by piping compressed air into the rock face at the geological faults where methane is released. In the project, these same pipes will be used to extract the methane from the faults. The extracted methane will then be piped approximately 3.5km underground. The methane will be brought up the main shaft.

The mine methane will be piped to surface. There will be 5 monitoring stations underground, which are in place to measure the flowrate of the methane. A diagram of the underground mine methane extraction system can be seen below.

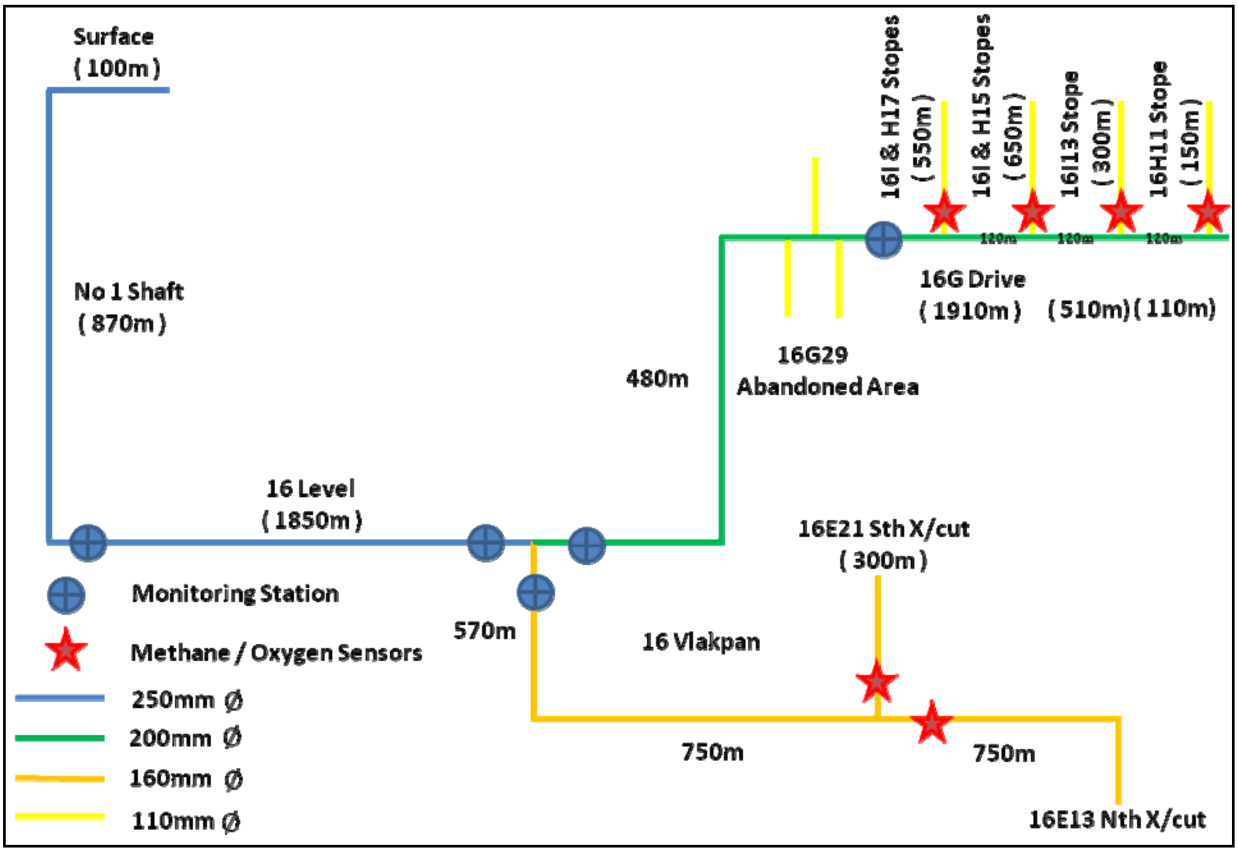

Figure 6: The underground piping and monitoring system for methane extraction.

This will be done in cases where such methane can safely and practically be captured. Changing conditions underground may change the viability of different methane sources over time.

These methane removal methods are within the applicability criteria as described in AM0064; Version 02; EB42.

AM0064 is applicable when the captured methane is used for the production of electricity, motive power and/or thermal energy and/or destroyed through flaring. In this project activity, the captured underground mine methane will be used for:

Electricity generation: The captured mine methane will be used for electricity generation. This electricity will be generated in internal combustion engines.

Flaring: Excess methane remaining after electricity generation will be flared in enclosed flares. This is necessitated by the fact that the flowrate of mine methane varies. None of the captured methane will be released back into the atmosphere

The project will be implemented in two phases:

1. The first phase will be the installation of a flaring system. At this stage, all the mine methane will be flared. The first phase, or flaring of all the mine methane, will occur in May 2009.

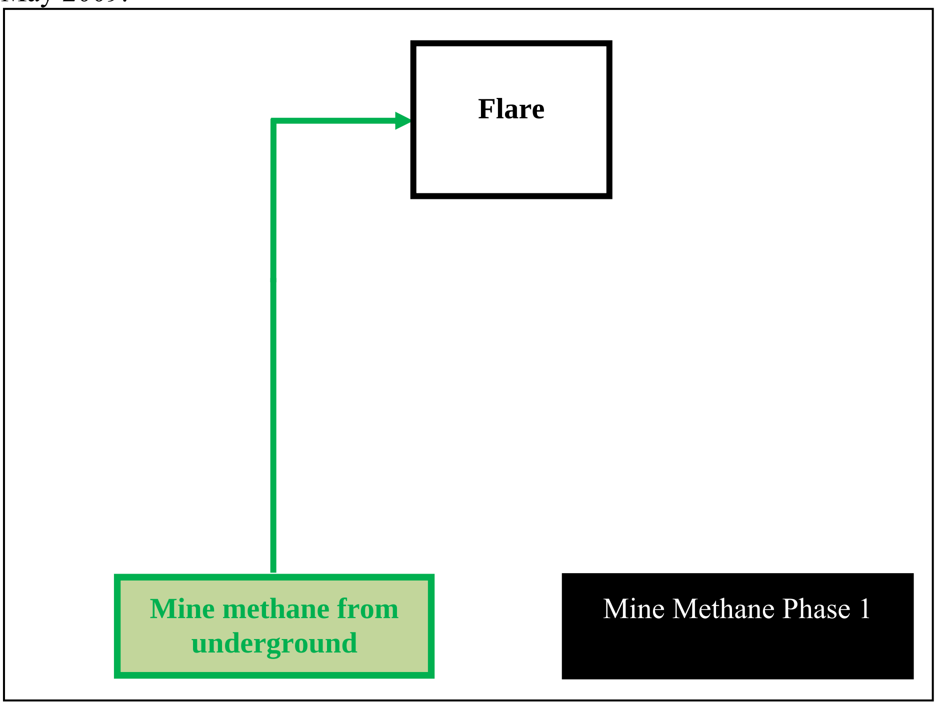

Figure 7: Phase 1

2. The second phase will be the installation of the power plant. In phase two, the mine methane will be used to generate electricity and any excess methane will be flared. Phase two is projected to occur in January 2010.

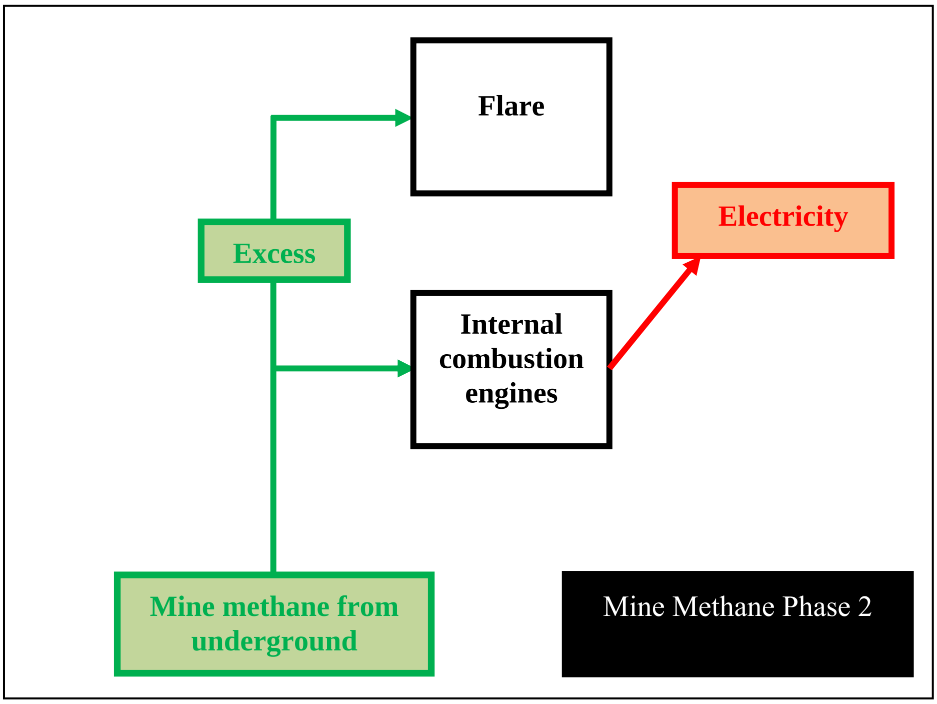

Figure 8: Phase 2

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The reason for this two phased approach is that the lead time for the internal combustion engines is longer than the lead time for the flares.

The Destruction of the Non-Mine Methane Released from the Boreholes

The methane released from five exploration boreholes, geographically far apart from each other, will be flared. The flowrate and composition of the gas released from each of these boreholes is:

Borehole Name	Gas Flowrate (l/s)	Methane Concentration (vol %)
DBE1	32.46	98
EX1	75.32	99
ST23	102.90	99
1400	29.54	95
2264	13.61	97

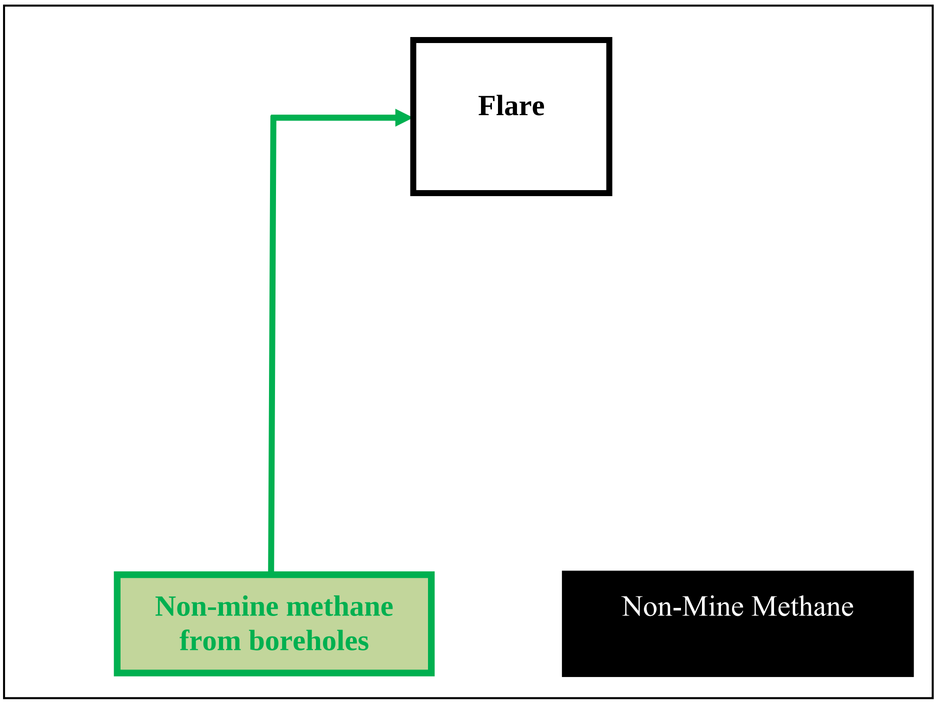

Figure 9: The destruction of non-mine methane from the boreholes

The boreholes are simple holes in the ground that were drilled for exploration purposes. All the boreholes considered in this project activity were drilled before 2001. Pictures of the boreholes included in this project can be seen below:

Hole EX1

Hole ST23

1400

DBE1

2264

Figure 10: Pictures of the non-mine methane boreholes

A.4.4. Estimated amount of emission reductions over the chosen crediting period:

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The estimated amount of emission reduction over the chosen crediting period is represented below:

Table 1: Summary of emission reductions

Years	**Annual estimation of emission reductions in tonnes of CO2e***
1 May 2009 – 31 Dec 2009	160,092
1 Jan 2010 – 31 Dec 2010	326,512
1 Jan 2011 – 31 Dec 2011	326,512
1 Jan 2012 – 31 Dec 2012	326,512
1 Jan 2013 – 31 Dec 2013	326,512
1 Jan 2014 – 31 Dec 2014	326,512
1 Jan 2015 – 31 Dec 2015	326,512
1 Jan 2016 – 31 Apr 2016	116,009
Total estimated reductions (tonnes of CO2e)	**2,235,172**
Total number of crediting years	**7 (renewable twice)**
Annual average over the crediting period of estimated reductions (tonnes of CO2e)	

*The emission reductions are less in 2009 than in subsequent years because of the project implementation plan. The project will be implemented in two phases as discussed in Section A.4.3.

Due to the variation of mine methane, the emission reduction figures in the table above were calculated based on measurements taken during the development of the project. There is no guarantee that the underground methane emission rate will stay constant. The methane emission rate may increase or decrease, depending on changing geological conditions. Should this happen, the emission reduction by the project will vary accordingly.

A.4.5. Public funding of the project activity:

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No public funding has been used or will be used in the development and implementation of this project.

SECTION B. Application of a baseline and monitoring methodology

B.1. Title and reference of the approved baseline and monitoring methodology applied to the project activity:

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This PDD is compiled using the approved baseline and monitoring methodology AM0064:

“Methodology for methane capture and utilization or destruction in underground, hard rock, precious and base metal mines”

Version 02, EB 42

This PDD refers to the following tools:

- “Tool to calculate baseline, project and/or leakage emissions from electricity consumption” Version 01;
- “Combined tool to identify the baseline scenario and demonstrate additionality” Version 02.2;

- "Tool to determine project emissions from flaring gases containing methane" Annex 13, EB28;
- "Tool to calculate the emission factor for an electricity system" Version 01.1.

No fossil fuel is used to capture, transport or use the methane. Hence, the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" Version 02 is not used in the PDD.

B.2. Justification of the choice of the methodology and why it is applicable to the project activity:

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AM0064 was specifically developed by Promethium Carbon (Pty) Ltd., South Africa for the Beatrix mine methane capture and destruction project.

A discussion of the applicability of AM0064 as applied to the Beatrix Underground Methane Capture Project follows:

Table 2: Discussion of the applicability of AM0064 for mine methane

Discussion of the Applicability conditions of AM0064 for mine methane capture and utilization or destruction as applied to the Beatrix Underground Methane Capture Project		
Applicability criteria as in AM0064	**Project activity at Beatrix mine**	**Was the Applicability condition of AM0064 met?**
The applicability conditions apply to project activities that involve capture, utilisation or destruction of methane from any operating mine, excluding mines where coal is extracted.	Methane will be captured, utilized and destroyed. Beatrix is not a coal mine.	Yes
Mine methane can be captured from the following: *• Underground boreholes in the mine, where mine methane can be captured from:* *- Development ends including shafts, access drives, ore passes or other developments;* *- Existing infrastructure such as shafts, access drives, raises and winzes;* *- Working areas including working stopes and worked out stopes; or* *- Any other area opened up for the development of the mine or the extraction of ore;* *• Surface wells drilled into sealed off areas where the mine methane is accumulated;* *• Gas drainage galleries or other infrastructure using mine methane capture techniques, including capture of gas from sealed areas;* *• Ventilation air.*	Methane will be captured from underground boreholes, gas drainage galleries and sealed areas as described in AM0064. Surface well drainage from sealed off areas where mine methane is accumulated could be considered if future methane sources are identified due to continued mining. Ventilation air methane will not be used.	Yes
The mine methane can be removed from the mine, in which the project activity is implemented, in two ways: *1. By sealing off an area into which the methane is released and piping it from that area, and/or* *2. By piping the methane from underground boreholes.*	Both these removal methods will be used in the Beatrix project.	Yes
For the purposes of this component, drainage to surface boreholes is only allowed in the following	Depending on future mine development, methane	Yes

cases: *• Where a hole is drilled from the surface to an underground mining area where mine methane is allowed to accumulate. For safety reasons, such an area will be isolated (sealed off) from the rest of the workings by walls. Methane will be drained into these areas with the purpose of taking it to the surface via the borehole.* *• Where a hole is drilled from the surface to an underground mining area and a pipe into which mine methane has been collected is connected to the opening of the borehole where it intersects the mining area. In this case the borehole is used to convey mine methane to surface rather than to install a pipe column in the shaft.*	may be drained to surface through boreholes drilled into underground mining areas where methane is allowed to accumulate as required by AM0064. Methane extraction, from surface boreholes, that does not comply with the requirements of AM0064 will not be done.	
The methodology is applicable under the following conditions: *• The captured mine methane is utilised to produce electricity, motive power and/or thermal energy and/or destroyed through flaring;* *•Prior to the start of the project activity all mine methane was released into the atmosphere or partially used for heat generation;* *• The methodology applies to both new and existing mining activities;* *• Project participants must be able to supply the necessary data for ex-ante projections of methane demand in the case where part of mine methane was used for the heat generation prior to the start of the project activity.*	Captured methane will be used for electricity generation. No prior use of the methane exists and all methane is diluted in the ventilation air. Beatrix is an existing mining operation.	Yes
This component of the methodology does not apply to project activities that: *• Operate in coal mines;* *• Operate in open cast mines;* *• Capture methane from abandoned or decommissioned mines;* *• Capture/use methane from surface boreholes that do not intersect mining areas/developments underground;* *• Use CO2 or any other fluid/gas to enhance methane drainage.*	Beatrix mine is not a coal mine and is not an open cast mine. Beatrix is, furthermore, an operating mine and not an abandoned or decommissioned mine. Future surface borehole methane extraction will only be done for mining areas/developments underground. No CO_2 will be used for enhanced methane drainage.	Yes
In addition, the applicability conditions included in the tools referred to above apply.	All tools that AM0064 refers to were adhered to.	Yes

Finally, for mine methane capture and utilization or destruction, this methodology is only applicable to project activities where the identified baseline scenario is a partial or total atmospheric release of mine methane. In case of a partial atmospheric release, some mine methane is flared and/or used for the heat generation only.	The baseline selection section will illustrate that atmospheric methane release is the baseline scenario.	Yes

Table 3: Discussion of the applicability of AM0064 for non-mine methane

Discussion of the Applicability condition of AM0064 for non-mine methane capture and destruction as applied to the Beatrix Underground Methane Capture Project		
Applicability criteria as in AM0064	**Project activity at Beatrix mine**	**Was the Applicability condition of AM0064 met?**
These conditions below are applicable to project activities that capture and destroy methane released from geological structures, e.g. methane released directly from holes bored to geological formations specifically for mineral exploration and prospecting activities.	Methane will be captured, and destroyed. The methane released is the result of a geological structure.	Yes
Abandoned or decommissioned mines, as well as open cast mines are excluded. Coal extraction mines or oil shale, as well as boreholes or wells opened for gas/oil exploration or extraction do not qualify under this methodology.	Beatrix is an operating mine. Beatrix is not a coal mine and is in no way involved in gas/oil exploration.	Yes
Project participants are able to demonstrate that the methane captured would have been emitted to the atmosphere in the absence of the project activity using historic records kept on exploration and prospecting activities, current safety procedures and ventilation design diagrams. The exploration plans shall be available as required evidence.	For safety reasons no boreholes may be blocked. Therefore, the boreholes will continue to release methane as is currently the case.	Yes
Only methane emitted from structures (mineral exploration and prospecting activities, adits, boreholes, etc.) designed and installed solely for prospecting of minerals6 qualifies; pre mining drainage related to minerals for which the mine was developed and is being operated does not qualify. Dedicated methane or natural gas extraction is excluded.	The boreholes were drilled solely for the prospecting of gold and not as pre-mining drainage. Information regarding the exploration borehole in terms of the descriptive log and detailed geological analysis is available.	Yes
This methodology is applicable to the following cases: *(i) Structures installed, or boreholes drilled before 2001: or* *(ii) Structures installed, or boreholes drilled after 2001 with a minimum of 5 years prior*	The boreholes were all drilled before 2001.	Yes

to project registration, where it could be demonstrated that the structures or the boreholes where part of a exploration plan.		
Project activities shall capture and destroy methane within the project boundary. That means, there will be no transportation, distribution or selling of methane or natural gas to users outside the mining site.	The methane will be destroyed on site and will not be transported or distributed outside the mining property. The small volumes of methane and remote locations do not justify any piping installation or other use of the gas.	Yes
The measures that would increase the amount of methane emissions from the boreholes beyond the natural release as would occur in the baseline are excluded. This means forced extraction by pumping or the use of CO2 or any other fluid/gas to enhance methane drainage is excluded. If a flare is used, the lowest possible fan capacity should be established under which flare can properly operate.	No measures to increase the amount of methane emissions will be used. In cases where the methane pressure in the borehole is sufficient (at least 80mbar), no fan will be installed on the flare at that borehole. If a fan is required, the suction pressure of the fan will not be less than atmospheric pressure.	Yes
The methodology is not applicable to project activities generating non-mine methane if a combustion facility is used for heat and/or electricity generation.	The unpredictability of the gas flow rate, the low estimated flow rates, as well as the distance to any consumer does not justify the generation of heat or electricity from this borehole. If at any stage power generation using the non-mine methane becomes viable, a deviation will be applied for.	Yes
In addition, the applicability conditions included in the tools referred to above apply.	All tools that AM0064 refers to were adhered to.	Yes
Finally, for non-mine methane capture and destruction, the methodology is only applicable if the identified baseline scenario is a total atmospheric release of methane.	The baseline scenario is a total atmospheric release of methane.	Yes

B.3. Description of the sources and gases included in the project boundary:

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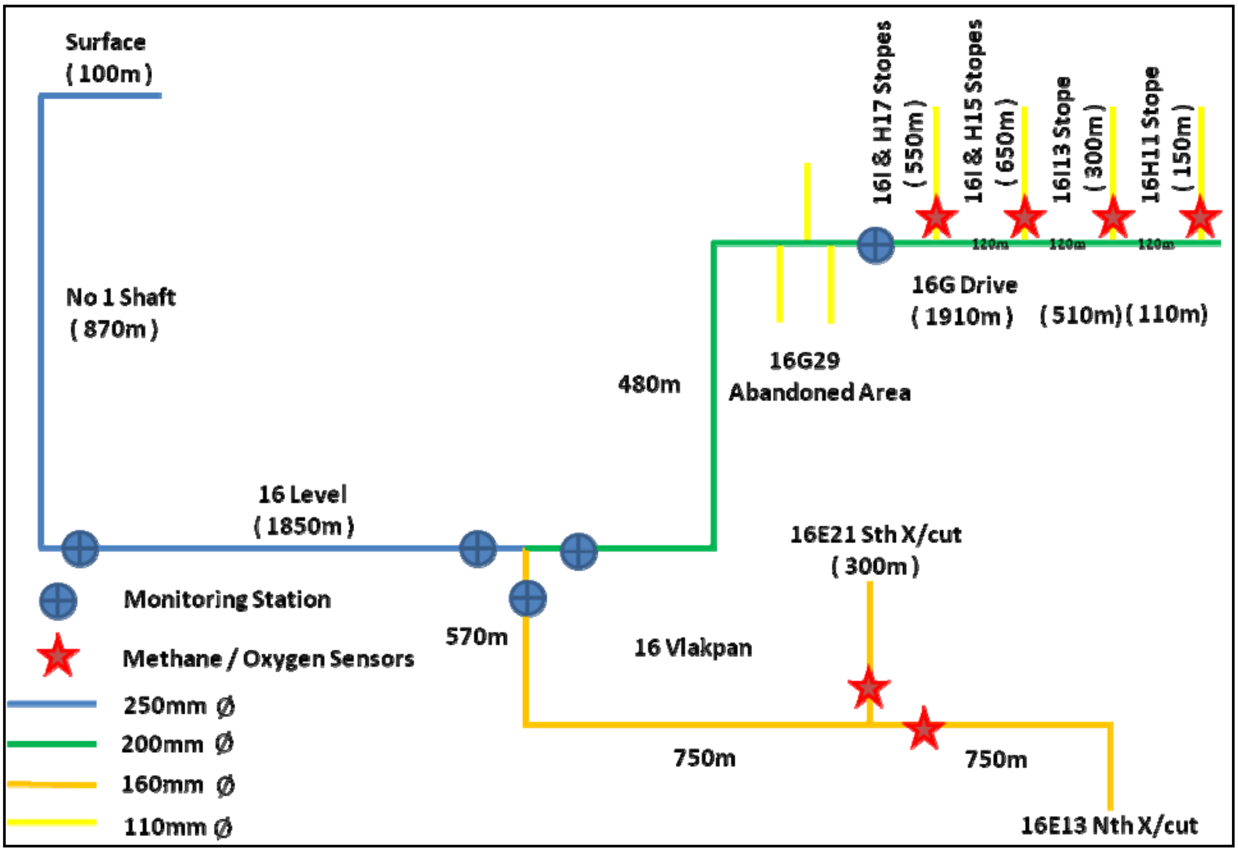
The *spatial extent* of the project boundary comprises:

- All equipment installed and used as part of the project activity for the extraction of the methane at the project site.
- Flaring, captive power and thermal generation facilities installed and used as part of the project activity.
- Power plants connected to the electricity grid, where the project activity exports or imports power from the grid, as per the definition of an electricity system in the latest approved version of the "Tool to calculate the emissions factor for an electricity system."

The boundary for the capture of mine methane includes:

- Piping of the methane to the surface
- Underground monitoring stations for the methane

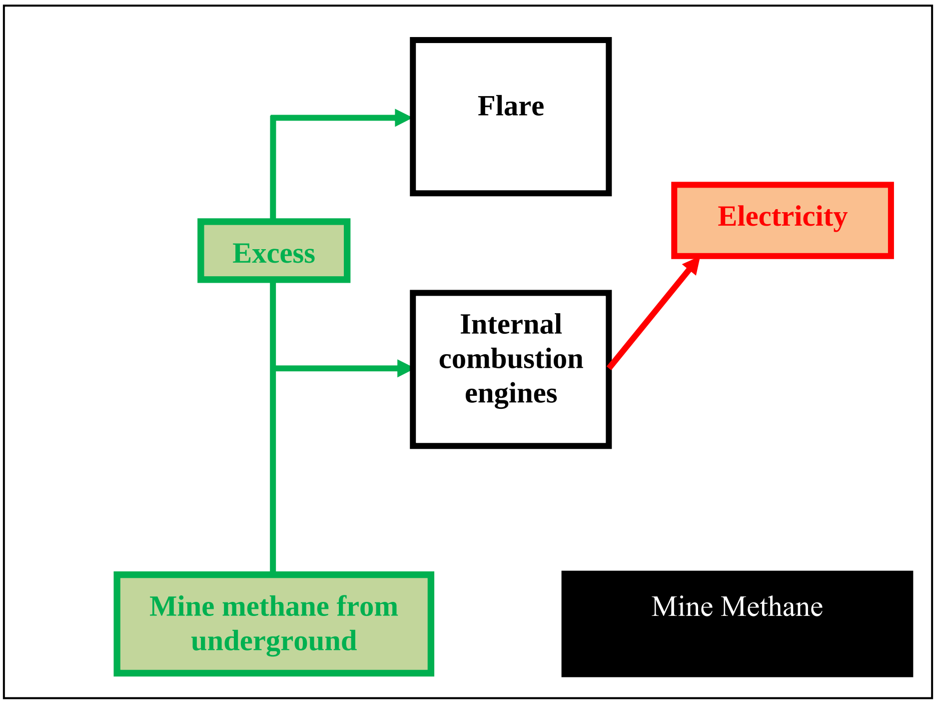
A diagram of the boundary for the capture of mine methane can be seen below:



The boundary for the destruction and utilisation of mine methane includes:

- The piping of methane on the surface to the flare and internal combustion engines
- The fan on the surface used to increase the pressure of the methane
- The flare
- The internal combustion engines
- The Instrumentation on the surface, which is in place for monitoring

A diagram of the boundary for the destruction and utilisation of mine methane can be seen below:



The boundary for the destruction of non-mine methane includes:

- Piping of methane to the flare
- The flare

A diagram of the boundary for the destruction of non-mine methane can be seen below:

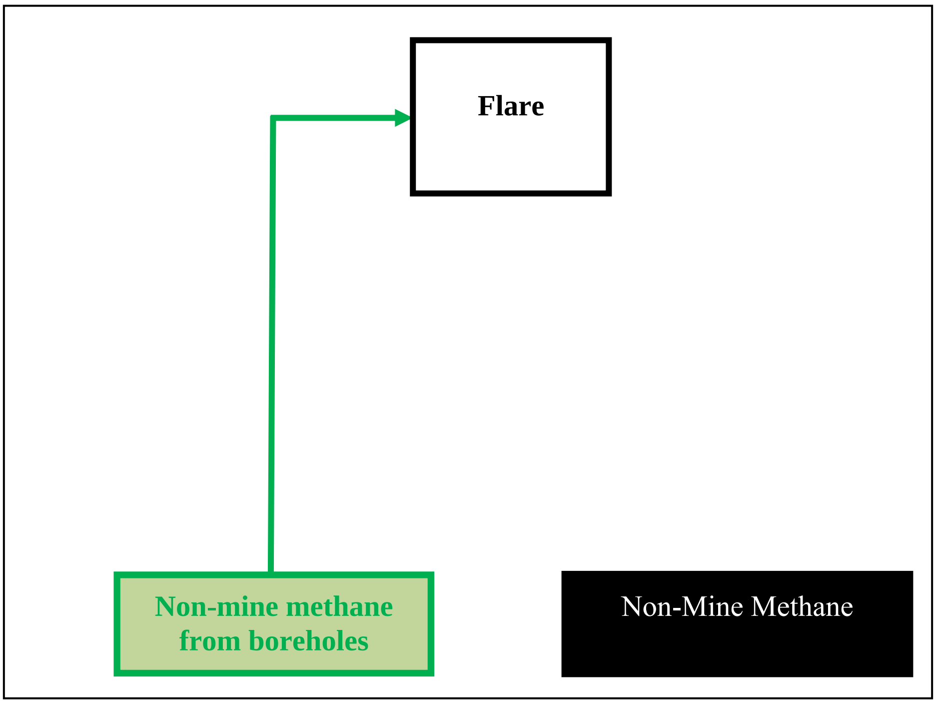


Table 4 illustrates which emissions sources are included and which are excluded from the project boundary for determination of both baseline and project emissions.

Table 4: Overview on emissions sources included in or excluded from the project boundary

	Source	Gas	Included?	Justification / Explanation
Baseline	Venting of methane	CO_2	No	Excluded.
		CH_4	Yes	Main emission source. However, certain sources of mine methane may not be included, as noted in the applicability conditions.
		N_2O	No	Excluded.
	Emissions from use or destruction of methane in the baseline	CO_2	Yes	Emissions from any flaring or use for heat generation in the baseline scenario.
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from electricity generation in the grid	CO_2	Yes	Included if the project activity involves power generation
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
	Emissions from captive power and/or heat generation, and vehicle fuel use	CO_2	Yes	Included if the project activity involves power/heat generation or use of mine methane as vehicle fuel
		CH_4	No	Excluded for simplification. This is conservative.
		N_2O	No	Excluded for simplification. This is conservative.
Project activity	On-site fuel consumption due to the project activity, including transport of the gas	CO_2	Yes	Fuel consumption by all equipment used by the project activity should be accounted for.
		CH_4	No	Excluded for simplification. This emission source is assumed to be negligible.
		N_2O	No	Excluded for simplification. This emission source is assumed to be negligible.
	Emissions from methane combustion	CO_2	Yes	Emissions from the combustion of methane in a flare or heat/power generation.
		CH_4	No	Excluded for simplification.
		N_2O	No	Excluded for simplification.
	Emissions from NMHC destruction	CO_2	Yes	Emissions from the combustion of NMHC in a flare, or heat/power generation, if NMHC accounts for more than 1% by volume of extracted mine methane.
		CH_4	No	Excluded for simplification.
		N_2O	No	Excluded for simplification.
	Fugitive emissions of unburned methane	CO_2	No	Excluded.
		CH_4	Yes	Small amounts of methane will remain unburned in flares or heat/power generation.
		N_2O	No	Excluded.
	Fugitive methane emissions from on-site equipment	CO_2	No	Excluded for simplification. This emission source is assumed to be very small.
		CH_4	No	
		N_2O	No	

	Fugitive methane emissions from gas supply pipeline or in relation to use in vehicles	CO_2	No	Excluded for simplification. However taken into account among other potential leakage effects (see leakage section).
		CH_4	No	
		N_2O	No	
	Accidental methane release	CO_2	No	Excluded for simplification. This emission source is assumed to be very small.
		CH_4	No	
		N_2O	No	

B.4. Description of how the baseline scenario is identified and description of the identified baseline scenario:

>>
The "Combined tool to identify the baseline scenario and demonstration of additionality" (version 02.2) was used to identify the baseline scenario in the following manner:

Step 1: Identification of alternative scenarios

Sub-Step 1a: Define alternative scenarios to the proposed CDM project activity

<u>**Alternative Scenarios for Mine Methane**</u>

The identified alternative baseline scenarios are:

A Diluting the methane to safe and acceptable levels with ventilation air is technically feasible. The ventilation air methane (VAM) can then be:
  i. Vented to atmosphere as VAM;
  ii. Destroyed or used in technology that can use VAM rather than venting it;

B Capturing of methane and extraction from underground boreholes or sealed off areas. The captured methane can then be:
  i. Captured and vented above ground in a safe location
  ii. Flared above ground
  iii. Used for additional grid or captive power generation
  iv. Fed into gas pipeline (to be used as fuel for vehicles or heat/power generation);
  v. Used for electricity generation with the excess flared
  vi. Used for electricity generation with the excess flared without being registered as a CDM project activity. This is the proposed project activity for the destruction and utilisation of mine methane without CDM.

The baseline scenario alternatives include all possible options to generate electricity:

D For the generation of electricity:
  i. Electricity can be imported from the national grid
  ii. Electricity can be generated from fossil fuels other than mine methane
  iii. Electricity can be generated from methane
  iv. Electricity can be generated from renewable energies

Alternative Scenarios for Non-Mine Methane

The baseline scenario alternatives for non-mine methane capture and destruction include all possible options that are technically feasible to handle mine methane to comply with safety regulations. These options are:

E Technically feasible options for the handling of the non-mine methane:

i. Vented to atmosphere;
ii. Destroyed or used in technology that can use methane rather than venting it;
iii. Flared;
iv. Used for additional grid or captive power generation;
v. Fed into gas pipeline (to be used as fuel for vehicles or heat/power generation);
vi. Flaring without being registered as a CDM project activity. This is the proposed project activity for the destruction of non-mine methane without CDM.

Sub-Step 1b: Consistency with mandatory applicable laws and regulations:

All options comply with the mandatory applicable laws and regulations.

National and Sectoral Policies and Regulations Relevant to Determining the Baseline Scenario

There are no policies that require Beatrix mine to use the mine methane that is currently being diluted and vented as VAM. More relevant to the project activity is the Power Conservation Project (PCP), which, at the time of writing the PDD, is in the process of being developed by Eskom, in concert with Municipalities, Government, and customers.

The PCP is a demand side project aimed at stabilising the supply/demand balances in the system. According to Eskom, the details of the PCP are still being refined, but one of the criteria used in designing the PCP is to signal efficient use of electricity. Once this PCP is legislated, it will require the Beatrix mine to commit to reducing their grid electricity consumption. The relevance of this PCP, in the selection of the baseline scenario, is discussed below:

In EB 22 Annex 3, the Board differentiates between two types of national and/or sectoral policies that need to be taken into account when establishing the baseline scenario (paragraph 6). The second type is relevant to the PCP since it concerns energy efficiency:

Paragraph 6 (b): *National and/or sectoral policies or regulations that give comparative advantages to less emissions-intensive technologies over more emissions-intensive technologies (e.g. public subsidies to promote the diffusion of renewable energy or to finance energy efficiency programs). These policies are E- type policies that decrease GHG emissions.*

The Board then goes on to state that policies applicable under paragraph 6 (b) need not be taken into account when establishing the baseline scenario if they have been implemented since the adoption by the COP of the CDM M&P (decision 17/CP.7, 11 November 2001).

The PCP is still in development, but will, more than likely, be legislated before project implementation. However, this is after the 11 November 2001 and, as such, the PCP need not be taken into account when establishing the baseline scenario for the Beatrix mine.

STEP 2: Barrier analysis

Sub-step 2a: Identify barriers that would prevent the implementation of alternative scenarios:

A list of the alternative scenarios and the investment, technological barriers and barriers due to prevailing practice that they face is presented in Table 5.

Sub-step 2b: Eliminate alternative scenarios which are prevented by the identified barriers:

Table 5 indicates whether the identified alternative scenarios are prevented by the identified barriers.

Table 5: Alternative scenarios and related barriers

Alternative scenarios	***Sub-step 2a***			***Sub-step 2b***
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
A i. Vented to atmosphere as VAM	No barriers	No barriers	No barriers	NO
A ii. Using / destroying ventilation air methane rather than venting it	Will require capital expenditure that is not required in the business as usual case. This has not been quantified due to the unavailability of technology. Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	Ventilation air methane destruction equipment is not common in South Africa. Many technologies require a stable methane concentration in the ventilation air in order to use this air. The methane at gold mines is variable. Therefore, it the ventilation air methane is difficult to use. Training personnel to operate and maintain this equipment is also a barrier.	The destruction and/or use of methane is/are not done at South African gold mines. It is not part of the normal operation of the gold mines.	YES
B i. Captured and vented above ground in a safe location	This option of mine methane will not yield financial or other benefits over and above the business as usual case sufficient to justify the capital expenditure.	No barriers	This is not normally done in gold mines as there is no financial or other benefit that justifies the implementation of this option.	YES

Table 5: Alternative scenarios and related barriers

Alternative scenarios	***Sub-step 2a***			***Sub-step 2b***
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
B ii. Flaring of mine methane	This option will not yield financial or other benefits over and above the business as usual case sufficient to justify the capital expenditure.	No barriers	This is not normally done in gold mines as there is no financial or other benefit that justifies the implementation of this option.	YES
B iii. Use the methane for additional grid or captive power generation	Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	The power generation equipment is not common in South Africa and will need to be imported from Europe. The combustion engines require highly skilled staff and this will require training the relevant personnel at additional cost.	No gold mine in South Africa generates power from mine methane.	YES
B iv. The methane is fed into gas pipeline	The closest natural gas pipeline is 178 km from the mine. The cost of connecting over this distance is prohibitive. Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	No barriers	There is no pipeline of this nature within a 178 km (Beatrix to Sasolburg)	YES

Table 5: Alternative scenarios and related barriers

Alternative scenarios	***Sub-step 2a***			***Sub-step 2b***
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
B v. Used for electricity generation with the excess flared	Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	The power generation equipment is not common in South Africa and will need to be imported from Europe. The combustion engines require highly skilled staff and this will require training the relevant personnel at additional cost.	No gold mine in South Africa generates power from mine methane.	YES
B vi. Used for electricity generation with the excess flared without being registered as a CDM project activity.	Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	The power generation equipment is not common in South Africa and will need to be imported from Europe. The combustion engines require highly skilled staff and this will require training the relevant personnel at additional cost.	No gold mine in South Africa generates power from mine methane.	YES
D i. Electricity can be imported from the national grid	No barriers	No barriers	No barriers	NO
D ii. Electricity can be generated from fossil fuels other than mine methane	Will require capital expenditure. Additional capital would be needed to secure a supply of fossil fuels.	No barriers	No barriers	YES

Table 5: Alternative scenarios and related barriers

Alternative scenarios	***Sub-step 2a***			***Sub-step 2b***
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
D iii. Electricity can be generated from mine methane	Will require capital expenditure. Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	The power generation equipment is not common in South Africa and will need to be imported from Europe. The combustion engines require highly skilled staff and this will require training the relevant personnel at additional cost.	No gold mine in South Africa generates electricity or heat from mine methane.	YES
D iv. Electricity can be generated from renewable energies	Will require capital expenditure. Renewable energy like wind turbines is expensive.	The technologies are not common in South Africa and will most likely need to be imported from Europe.		YES
E i. Vented to atmosphere	No barriers	No barriers	No barriers	NO
E ii. Destroyed or used in technology that can use methane rather than venting it	Will require capital expenditure. Due to the large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	Non-mine methane destruction equipment is not common in South Africa.	This is not normally done in gold mines as there is no financial or other benefit that justifies the implementation of this option.	YES
E iii. Flared	This option will not yield financial or other benefits over and above the business as usual case sufficient to justify the capital expenditure.	No barriers	This is not normally done in gold mines as there is no financial or other benefit that justifies the implementation of this option.	YES

Table 5: Alternative scenarios and related barriers

Alternative scenarios	***Sub-step 2a***			***Sub-step 2b***
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
E iv. Used for additional grid or captive power generation	Will require capital expenditure. Due to the low flowrate and large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	The power generation equipment is not common in South Africa and will need to be imported from Europe. The combustion engines require highly skilled staff and this will require training the relevant personnel at additional cost.	This is not normally done in gold mines as there is no financial or other benefit that justifies the implementation of this option.	YES
E v. Fed into gas pipeline (to be used as fuel for vehicles or heat/power generation).	The closest natural gas pipeline is 178 km from the mine. The cost of connecting over this distance is prohibitive. Due to the low flow rate and large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	No barriers	There is no pipeline of this nature within a 178 (Beatrix to Sasolburg)	YES

Table 5: Alternative scenarios and related barriers

Alternative scenarios	*Sub-step 2a*			*Sub-step 2b*
	Investment barriers	Technological barriers	Barriers due to prevailing practice	Is this scenario prevented by the identified barriers?
E vi. Flaring without being registered as a CDM project activity.	Due to the low flowrate and large uncertainty associated with the methane resource, no capital can be committed if the repayment of the capital is reliant on the future availability of methane.	No barrier	No barrier	YES

Table 5 above shows that the only alternative scenario, which does not face financial barriers, technological barriers and/or barriers due to prevailing practice, is the continuation of business as usual. In the business as usual scenario, the mine methane is diluted to acceptable and safe limits and vented as ventilation air methane. The electricity is sourced from the national grid. The heat is generated from electrical energy sourced from the national grid.

The non-mine methane is vented to the atmosphere.

Simply continuing with this practice has the following advantages:

- It conforms to all legal requirements provided that the mine methane is diluted sufficiently;
- No technological barriers exists as this is the accepted industry practice;
- No capital expenditure is required since the ventilation system currently in use at the Beatrix mine adequately dilutes the methane to an acceptable level; and,
- Electricity from the national grid is inexpensive

Baseline scenario

The alternative scenario that does not face any barriers is the baseline scenario. Hence, the baseline scenario for Beatrix is the continuation of the current practice, which is to dilute and vent the mine and non-mine methane and import electricity from the grid. The baseline for the project is:

A i. The mine methane is vented to the atmosphere as VAM
D i. Electricity can be imported from the national grid
E i. The non-mine methane is vented to atmosphere.

Step 3: Investment Analysis

This is covered by the barrier analysis in step 2.

Step 4: Common practice analysis

Globally, various projects are at different stages of development to utilize coal mine methane (CMM) for power generation. These projects are being developed as CDM projects. At least six of these projects are being executed in China. The proposed Beatrix project is a deviation from these projects since Beatrix is a gold mine and the methane released is not related to the amount of gold mined.

Beatrix will be the first gold mine to use the methane for electricity generation in South Africa. All methane from South African gold mines is simply diluted and vented.

The internal combustion engines that will be used in the project activity have been used at only two other CDM registered projects in South Africa. These projects are:

- PetroSA Biogas to Energy Project (Project 0446); and
- Durban Landfill Gas-to-Electricity Project – Mariannhill and La Mercy (Project 0545).

B.5. Description of how the anthropogenic emissions of GHG by sources are reduced below those that would have occurred in the absence of the registered CDM project activity (assessment and demonstration of additionality):

>>
The “Combined tool to identify the baseline scenario and demonstration of additionality” (version 02.2) was used to demonstrate that the proposed project activity is additional.

Table 5 lists the alternatives scenarios and the barriers that these scenarios face. Apart from the identified baseline, the alternatives scenarios, including the proposed project activity, face barriers. Therefore, all the other alternative scenarios, including the proposed project activity, are additional.

The additionality of the proposed project activity is further illustrated by the barriers listed below:

A complete list of barriers that would prevent the proposed project activity from occurring are listed below:

Investment barriers *inter alia*:

- Codes such as the mineral resource quantification code of the JSE Securities Exchange (where Gold Fields is listed) or other international codes such as JORC are required by the investment community. When considering these codes, it is clear that the investment of capital in the available methane resources is not justifiable. This is because of the unpredictable nature of the methane occurrence. The proposed project, which involves the use of methane, therefore, is very difficult to fund in terms of conventional mining finance.
- The unquantifiable and unpredictable nature of the mine methane makes debt funding of the proposed project extremely difficult.
- Return on investment for a methane utilization project is low, particularly on a perceived risk-adjusted basis, in comparison with the alternative uses of this available capital.
- Financial projections for the proposed project suggest that, even under optimistic assumptions, the cost to generate electricity will be higher than the average cost of electricity from the national provider (Eskom).
- The proposed project will require capital expenditure that would not be required in the continuation of the baseline.

Technological barriers, *inter alia*:

- The unpredictability of methane supply is a barrier to the project activity. The flowrate of the methane is expected to vary and the continuation of the release of methane is not a certainty. This poses risks in terms of plant capacity and investment.

- The internal combustion engines require specialist labour and infrastructure

Barriers due to prevailing practice, *inter alia*:

- The project activity is the "first of its kind" in South Africa.
- The internal combustion engines, which will be used in the proposed project, have been proven in other similar applications in other parts of the world. However, to date, these internal combustion engines have not been operated on gold mine methane.
- Generating electricity is not part of the normal skill set of a mining activity.
- Largely because of the low cost of electricity and technological barriers, most mine operators in South Africa have not really considered the possibility of generating electricity from mine methane. Due to the delocalization of the methane sources and the unpredictability of the methane supply, it is not ideal for use as a fuel source and has not, to date, been used as fuel source.
- There is no legislative pressure to use the energy content from the methane. South African laws only make provision for safety issues regarding methane venting. Even where utilization has been identified as a priority, current legal policies offer little or no incentive for using mine methane to generate electricity.
- There is no policy or regulations preventing the release of methane in South Africa. In terms of the Mines Health and Safety Act employers and employees are obliged to identify hazards and eliminate, control or minimise the risk to health and safety. Operational experience on Beatrix has led the management to believe that the sealing off of surface holes forces methane that would have escaped on surface to escape into working areas. This increases the risk of workers in these working areas. The sealing of surface holes is therefore not allowed by management.

Registering the proposed project activity as a CDM project will alleviate the identified barriers in the following ways:

Alleviating the Investment barriers *inter alia*:
The carbon credit revenue will lower the financial risks associated with the project and, therefore, aid in overcoming the identified investment barriers.

The only financial benefit that this project will have, without carbon credit revenue, is the displacement of electricity by using mine methane. As was stated earlier, the relatively cheap price of South African grid electricity does not make the use of mine methane attractive. The carbon credit revenue will make the use of mine methane feasible.

Alleviating the Technological barriers, *inter alia*:
The technological barriers are linked to the operators of the technology. The additional revenue can also be used to cover the costs associated with the training of staff required to operate the specialised equipment.

Alleviating the Barriers due to prevailing practice, *inter alia*:
As was stated, this project is the "first of its kind" in South Africa. The additional carbon credit revenue will make the project attractive to investors despite this risk.

Additionality of project activity
The proposed project activity is additional. This is demonstrated by the barrier analysis. Investment, technological and common practice barriers were identified. These barriers are overcome by the registration of the project as a CDM project. Therefore, the proposed capture and

use of the Beatrix mine methane and the destruction of the Beatrix non-mine methane satisfies the CDM additionality criteria.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

>>
The emission reduction (ER), baseline emission (BE), project emission (PE) and leakage emissions (LE) are calculated as set out below:

Baseline emissions for mine methane capture and utilization or destruction

$$BE_y = BE_{MD,y} + BE_{MR,y} + BE_{Use,y} \quad \textbf{(1)}$$

Where:

BE_y	Baseline emissions in year y (tCO_2e/yr)
$BE_{MD,y}$	Baseline emissions from the destruction of methane in the baseline scenario in year y (tCO_2e/yr)
$BE_{MR,y}$	Baseline emissions from the release of methane into the atmosphere in year y that is avoided by the project activity (tCO_2e/yr)
$BE_{Use,y}$	Baseline emissions from the production of power and/or heat displaced by the project activity in year y (tCO_2e/yr)

In the baseline, no methane is used for any heat or electricity generation. Methane destruction in the baseline only occurs if the gas is ignited by accident. This accidental methane destruction is not desirable and is stopped as soon as possible for safety reasons. (This leads to $BE_{MD,y} = 0$.)

In the baseline, all methane was simply vented to atmosphere as ventilation air methane. The baseline emissions due to the ventilation of the methane will be captured in the $BE_{MR,y}$.

In the proposed project activity, the methane will be used to generate electricity. Excess methane will be flared. The generation of electricity will displace grid electricity used in the baseline. This will be captured in the $BE_{Use,y}$ term.

Equation 1 becomes:

$$BE_y = BE_{MR,y} + BE_{Use,y} \quad \textbf{(1.1)}$$

Baseline emissions from the release of methane into the atmosphere:

Baseline emissions from the venting of methane were calculated as follows:

$$BE_{MR,y} = GWP_{CH4} \times \sum_i \left[\left(MM_{PR,i,y} - MM_{BL,i,y} \right) + \left(VAM_{PR,i,y} - VAM_{BL,i,y} \right) \right] \quad \textbf{(6)}$$

Where:

$BE_{MR,y}$	Baseline emissions from the release of methane into the atmosphere in year y that is avoided by the project activity (tCO_2e/yr)
GWP_{CH4}	Global Warming Potential of methane
$MM_{PR,i,y}$	Mine methane captured, sent to and destroyed by use i in the project activity in year y (tCH_4/yr)
$MM_{BL,i,y}$	Mine methane that would have been captured, sent to and destroyed by use i in the baseline scenario in year y (tCH_4/yr)
$VAM_{PR,i,y}$	VAM captured, sent to and destroyed by use i in the project activity in year y (tCH_4)

$VAM_{BL,i,y}$ VAM that would have been captured, sent to and destroyed by use i in the baseline scenario in year y (tCH_4)

No ventilation air methane (VAM) is used in the baseline (BL) or in the project case (PR). The result is that:

$VAM_{PR,i,y} = 0$
$VAM_{BL,i,y} = 0$

No mine methane (MM) is captured and used in the baseline (BL). The result is:

$MM_{BL,i,y} = 0$

Combustion engines, absorption chillers and flaring of excess methane will take place in the project case (PR). Therefore, including the uses of methane, Equation 6 simplifies to equation 6.1:

$$BE_{MR,y} = GWP_{CH4} \times \left(MM_{PR,engine,y} + MM_{PR,flare,y} \right) \qquad \textbf{(6.1)}$$

Where:

$MM_{PR,engine,y}$ Mine methane captured, sent to and destroyed by internal combustion engines in the project activity in year y (tCH_4/yr)
$MM_{PR,flare,y}$ Mine methane captured, sent to and destroyed by flare in the project activity in year y (tCO_2e/yr)

<u>*Baseline emissions from power generation by project activity:*</u>

The proposed project activity will generate electricity. The electricity generated will displace electricity that was sourced from the national grid in the baseline. No captive power generation occurred in the baseline. Equation 7 originally stated:

$$BE_{Use,y} = GEN_y \times EF_{ELEC,y} + HEAT_y \times EF_{HEAT,y} + VFUEL_y \times EF_{V,y} + ABS_y \times \frac{COP_{ABS}}{COP_{ELEC}} \times EF_{ELEC,y}$$

(7)

Where:

$BE_{Use,y}$ Baseline emissions from the production of power or heat replaced by the project activity in year y (tCO_2e/yr)
GEN_y Electricity generated by the project activity in year y (MWh)
$EF_{ELEC,y}$ Emission factor for electricity generation (grid, captive or a combination) replaced by the project activity (tCO_2/MWh)
$HEAT_y$ Heat generation by project activity in year y (GJ)
$EF_{HEAT,y}$ Emission factor for heat generation replaced by the project activity (tCO_2/GJ)
$VFUEL_y$ Vehicle fuel provided by the project activity in year y (GJ)
$EF_{V,y}$ Emission factor for vehicle operation replaced by the project activity (tCO_2/GJ)
ABS_y Chilling produced in project activity by absorption chillers in year y (MWh)
COP_{ABS} Coefficient of performance of the absorption chiller (MW thermal input / MW thermal output)
COP_{ELEC} Coefficient of performance of the electrical chillers used in the baseline Chillers (MW electrical input / MW thermal output)

Since only electricity is generated, equation 7 simplifies to:

$$BE_{Use,y} = GEN_y \times EF_{ELEC,y} \quad \textbf{(7.1)}$$

The project activity will displace grid electricity.

The emission factor for the grid electricity was calculated in accordance with the latest approved version of the "Tool for calculation of emission factor for electricity systems," Version 01.1. (The calculations are presented in the Annex 4.)

Equation 9 is presented below:

$$EF_{ELEC,y} = s_{grid,y} \times EF_{grid,y} + s_{captive} \times EF_{captive,y} \quad \textbf{(9)}$$

Where:

$EF_{ELEC,y}$	CO_2 baseline emission factor for the electricity displaced due to the project activity during the year y (tCO_2/MWh)
$EF_{grid,y}$	CO_2 baseline emission factor for the grid electricity displaced due to the project activity during the year y (tCO_2/MWh)
$EF_{captive,y}$	CO_2 baseline emission factor for the captive electricity displaced due to the project activity during the year y (tCO_2/MWh)
s_{grid} (%)	Share of the electricity demand supplied by the grid imports over the last 3 years
$s_{captive}$ (%)	Share of facility electricity demand supplied by captive power over the last 3 years

Taking in consideration that all electricity in the baseline is sourced from the grid:

S_{grid} = 100%
$S_{captive}$ = 0%

The project activity will not replace any new or existing captive generation electricity generation. The result is that:

$EF_{captive,y}$ = 0

This implies that Equation 9 can be simplified to Equation 7.2:

$$EF_{ELEC,y} = EF_{grid,y} \quad \textbf{(7.2)}$$

Where:

$EF_{ELEC,y}$	Emission factor for electricity generation (grid, captive or a combination) replaced by the project activity (tCO_2/MWh)
$EF_{grid,y}$	CO_2 baseline emission factor for the grid electricity displaced due to the project activity during the year y (tCO_2/MWh)

Baseline emissions for non-mine methane capture and destruction:

Historically, all methane from exploration boreholes was emitted to atmosphere.

$$BE_y = \sum_{h=1}^{8760} TM_{RG,h} \times \frac{GWP_{CH4}}{1000} \quad \textbf{(12)}$$

BE_y	Baseline emissions in year y (tCO2e)
GWP_{CH4}	Global warming potential for methane (value of 21)
$TM_{RG,h}$	Mass flow rate of methane in the residual gas (in the tool it is defined as the gas stream flowing to the flare) in the hour h (kg/h)
1/1000	Factor to convert kg/year to ton/year

<u>Project emissions due to project activities recovering mine methane</u>

Project emissions are defined by the following equation:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \quad \textbf{(13)}$$

Where:

PE_y	Project emissions in year y (tCO_2e/yr)
$PE_{ME,y}$	Project emissions from energy use to capture and use methane in year y(tCO_2e/yr)
$PE_{MD,y}$	Project emissions from methane destroyed in year y (tCO_2e/yr)
$PE_{UM,y}$	Project emissions from un-combusted methane in year y (tCO_2e/yr)

<u>Project emissions from the use of additional energy required for MM/VAM capture and utilisation</u>

Additional energy was required to capture, transport and compress, use or destruct the mine methane. Project emissions from the use of this energy were calculated as follows:

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y} \quad \textbf{(14)}$$

Where:

$PE_{ELEC,y}$	Project emissions from the use of electricity for capture, transportation, compression and utilisation or destruction of MM/VAM in year y (tCO_2e/yr). Calculated in accordance with the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption"
$PE_{FF,y}$	Project emissions from the combustion of fossil fuels for capture, transportation, compression and utilisation or destruction of MM/VAM in year y (tCO_2e/yr). Calculated in accordance with the latest approved version of the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion"

No fossil fuel will be used for the capture, transportation, compression, utilisation or destruction of MM/VAM in the project activity. Hence, $PE_{FF,y} = 0$.

The mine methane captured will be pumped to surface. The pumping will be done by using an electrical blower. To calculate $PE_{ELEC,y}$, AM0064 states that the *"Tool to calculate baseline, project and/or leakage emissions from electricity consumption"* (Version 01) must be used. The application of this tool can be seen in Annex 4.

<u>Project emissions from the combustion of MM/VAM</u>

AM0064 states that when the captured mine methane is burned in a flare, heat or power plant, or oxidized in a catalytic oxidation unit, emissions from combustion are released. (In addition, if non methane hydro carbons (NMHC) account for more than 1% by volume of the extracted MM or more than 0.1% by volume of the extracted VAM, combustion emissions from these gases should also be included.) The project emissions (PE) from mine methane destruction (MD) are then accounted for as follows:

$$PE_{MD,y} = \left(MD_{FL,y} + MD_{OX,y} + MD_{ELEC,y} + MD_{HEAT,y} + MD_{GAS,y}\right) \times \left(CEF_{CH4} + r \times CEF_{NMHC}\right) \quad \textbf{(15)}$$

Where:

$PE_{MD,y}$	Project emissions from MM/VAM destroyed in year y (tCO_2e/yr)
$MD_{FL,y}$	Amount of methane destroyed through flaring in year y (tCH_4/yr)
$MD_{OX,y}$	Amount of methane destroyed through catalytic oxidation in year y (tCH_4/yr)
$MD_{ELEC,y}$	Amount of methane destroyed through power generation in year y (tCO_2e/yr)
$MD_{HEAT,y}$	Amount of methane destroyed through heat generation in year y (tCO_2e/yr)
$MD_{GAS,y}$	Amount of methane destroyed after being supplied to gas grid or for vehicle use in year y (tCH_4)
CEF_{CH4}	Carbon emission factor for combusted methane (2.75 tCO_2/tCH_4)
CEF_{NMHC}	Carbon emission factor for combusted non methane hydrocarbons (the concentration varies and, therefore, to be obtained through periodical analysis of captured methane) ($tCO_2/tNMHC$)
r	Relative proportion of NMHC compared to methane $r=PC_{NMHC}/PC_{CH4}$
PC_{CH4}	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
PC_{NMHC}	NMHC concentration (in mass) in extracted gas (%)

No mine methane will be:

- Destroyed through catalytic oxidation ($MD_{OX,y} = 0$)
- Supplied to a gas grid or used as vehicle fuel ($MD_{GAS,y} = 0$)
- Destroyed through heat generation ($MD_{HEAT,y} = 0$)

Equation 15 then simplifies to Equation 15.1:

$$PE_{MD,y} = \left(MD_{FL,y} + MD_{ELEC,y}\right) \times \left(CEF_{CH4} + r \times CEF_{NMHC}\right) \quad \textbf{(15.1)}$$

Furthermore, gas analysis indicated that non-methane hydrocarbons (NMHCs) accounts for 0.22% of the composition. Therefore, the NMHCs are below the 1% threshold and are negligible. Therefore, they are excluded. Equation 14.1 is simplified further to Equation 14.2:

$$PE_{MD,y} = \left(MD_{FL,y} + MD_{ELEC,y}\right) \times \left(CEF_{CH4}\right) \quad \textbf{(15.2)}$$

AM0064 states that the amount of methane destroyed by each application depends on the efficiency of combustion in that application.

Firstly, the mine methane destroyed by the flare is determined:

$$MD_{FL,y} = MMES_{FL,y} - \frac{PE_{flare,y}}{GWP_{CH4}} \quad \textbf{(16)}$$

Where:

$MD_{FL,y}$ Amount of methane destroyed through flaring in year y (tCH_4)

$MMES_{FL,y}$ Amount of methane measured sent to flare in year y (tCH_4)

$PE_{flare,y}$ Project emissions of non-combusted CH_4, expressed in terms of tCO_2e, from flaring of the residual gas stream in year y (tCO_2e)

GWP_{CH4} Global warming potential of methane (21 tCO_2/tCH_4)

The project emissions of non-combusted CH_4 expressed in terms of CO_2e from flaring of the residual gas stream ($PE_{flare,y}$) was calculated following the procedures described in the "*Tool to determine project emissions from flaring gases containing methane*" (Version: not stated. Origin: EB 28, Annex 13). The calculations of the project emissions of non-combusted CH_4 can be found in Annex 4.

Secondly, the mine methane destroyed through electricity generation is determined:

$$MD_{ELEC,y} = MMES_{ELEC,y} \times Eff_{ELEC} \qquad \textbf{(20)}$$

Where:

$MMES_{ELEC,y}$ Amount of methane measured sent to power plant in year y (tCH_4)

Eff_{ELEC} Efficiency of methane destruction/oxidation in power plant

Project emissions from un-combusted methane

$$PE_{UM,y} = \left[GWP_{CH4} \times \sum_i MMES_{i,y} \times (1 - Eff_i) \right] + PE_{flare,y} + PE_{OX,y} \times GWP_{CH4} \qquad \textbf{(23)}$$

Where:

$PE_{UM,y}$ Project emissions from un-combusted methane in year y (tCO_2e)

GWP_{CH4} Global warming potential of methane (21 tCO_2e/tCH_4)

$MMES_{i,y}$ Methane measured sent to use i in year y (tCH4)

Eff_i Efficiency of methane destruction in use i (%)

$PE_{flare,y}$ Project emissions of non-combusted CH_4, expressed in terms of tCO_2e, from the residual gas stream (tCO_2e)

$PE_{OX,y}$ Project emissions of non oxidized CH4 from catalytic oxidation of the VAM stream in year y (tCH_4)

As applied to this project, Equation 23 becomes:

$$PE_{UM,y} = \left[GWP_{CH4} \times MMES_{ELEC} \times (1 - Eff_{ELEC}) \right] + PE_{flare,y} \qquad \textbf{(23.1)}$$

Where:

$MMES_{ELEC,y}$ Amount of methane measured sent to power plant in year y (tCH_4)

Eff_{ELEC} Efficiency of methane destruction/oxidation in power plant

Project emissions due to project activities recovering non-mine methane:

Project emissions are defined by the following equation:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y} \quad \textbf{(24)}$$

Where:

PE_y	Project emissions in year y (tCO_2e/yr)
$PE_{ME,y}$	Project emissions from energy use to capture and use methane in year y(tCO_2e/yr)
$PE_{MD,y}$	Project emissions from methane destroyed in year y (tCO_2e/yr)
$PE_{UM,y}$	Project emissions from un-combusted methane in year y (tCO_2e/yr)

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y} \quad \textbf{(25)}$$

Where:

$PE_{ELEC,y}$	Project emissions from the use of electricity for the operation of the facilities installed by the project in year y calculated in accordance with the latest approved version of the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (tCO_2)
$PE_{FF,y}$	Project emissions from the combustion of fossil fuels for the operation of the facilities installed by the project in year y (tCO_2e/yr). Calculated in accordance with the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (tCO_2e)

There is no electricity used for the operation of the borehole flares and instrumentation. Each of the flares is equipped with a solar panel. There is no fossil fuel consumption for the operation of the non-mine methane facilities. Hence,

$$PE_{ME,y} = 0$$

Project emissions from methane destroyed (combusted methane) in year *y* ($PE_{MD,y}$) was determined as follows:

$$PE_{MD,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(\eta_{flare,h}\right) \times \frac{CEF_{CH4}}{1000} \quad \textbf{(26)}$$

CEF_{CH4}	Carbon emission factor for combusted methane (2.75 tCO_2/tCH_4)
η_{flare}	Flare efficiency in hour h, according to the "Tool to determine project emissions from flaring gases containing methane"
$TM_{RG,h}$	Mass flow rate of methane in the residual gas (in the tool it is defined as the gas stream flowing to the flare) in the hour h (kg/h)
1/1000	Factor to convert kg/year to ton/year

Project emissions in year y from un-combusted methane in accordance with the "Tool to determine project emission from flaring gases containing methane." were determined as follows:

$$PE_{UM,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1000}$$

(27)

GWP_{CH4}	Global warming potential for methane (value of 21)
η_{flare}	Flare efficiency in hour h, according to the "Tool to determine project emissions from flaring gases containing methane"
$TM_{RG,h}$	Mass flow rate of methane in the residual gas (in the tool it is defined as the gas stream flowing to the flare) in the hour h (kg/h)
1/1000	Factor to convert kg/year to ton/year

<u>Leakage due to project activities recovering mine methane</u>

AM0064 states that ***"Leakage may occur if the project activity prevents MM/VAM from being used to meet the baseline thermal energy demand, whether as a result of physical constraints on delivery, or price changes."*** It was stated, during the baseline selection process, that no mine methane (MM) is used in the baseline in the current situation.

Such displacement resulting in leakage does not occur and the project activity does not ***"cause increased emissions outside the project boundary associated with meeting thermal energy demand with other fuels."***

AM0064 states that ***"because of likely day-to-day fluctuations in MM/VAM extraction rates, to ensure a conservative result, CERs should not be calculated solely from annual data. Any CERs generated from methane destruction should be calculated using daily logs, or monthly logs if daily data are not available, of project-case demand for MM/VAM for nonthermal uses compared against estimates of the baseline MM/VAM demand for thermal uses. For each day (or month) of the crediting period, this form of leakage must be calculated if:"***

$$ME_k - \left(MMES_{ELEC,k} + MMES_{HEAT,k}\right) < TH_k \qquad \textbf{(28)}$$

Where:

ME_k	Methane extracted on day k (tCH_4)
$MMES_{HEAT,k}$	Methane measured sent to new heat generation uses on day k in the project scenario that would not have been sent in the baseline scenario on day k (tCH_4)
$MMES_{ELEC,k}$	Methane measured sent to power plant on day k (tCH_4)
TH_k	Methane used to serve thermal energy demand in the baseline for day k (tCH_4)

No mine methane is used in the baseline ($TH_k = 0$) and

It is furthermore not possible for the sum of methane sent to heat generation equipment ($MMES_{HEAT,k}$) and the methane sent to electricity generation equipment ($MMES_{ELEC,k}$) to be more than the methane extracted (ME_k). The result is that:

$$ME_k - \left(MMES_{ELEC,k} + MMES_{HEAT,k}\right) \geq 0 \qquad \textbf{(28.1)}$$

Taking into consideration that $TH_k = 0$, the implication is that no leakage occurs in this project activity. Equation 27 then becomes:

$$LE_y = Q_{AF} \times NCV_{AF} \times EF_{AF} \times OXID \quad \textbf{(32)}$$

Where:

LE_y	Leakage emissions in year y (tCO_2e/yr)
$Q_{AF,y}$	Quantity of alternative fuels displaced by the project activity in year y (tonnes or m^3)
NCV_{AF}	Net calorific value for alternative fuels (GJ/tonne or m3)
EF_{AF}	Emissions factor for alternative fuel (tCO_2/GJ) sourced from IPCC
OXID	Oxidation efficiency of combustion (%), sourced from IPCC

Since $Q_{AF,y}$ is zero. The result is that:

$LE_y = 0$ **(32.1)**

<u>Leakage due to project activities recovering non-mine methane:</u>

No leakage is considered as in accordance with AM0064 version 02.

<u>Emission reductions</u>

The emission reduction ER_y by the project activity during a given year y is the difference between the baseline emissions (BE_y) and project emissions (PE_y). The leakage emissions (LE_y) in this project activity are zero as no activity which uses methane occurred in the baseline. No baseline methane application was thus displaced. The emission reduction is calculated as below:

$$ER_y = BE_y - PE_y - LE_y \quad \textbf{(33)}$$

Where:

ER_y	Emission reductions in year y (tCO_2e/yr)
BE_y	Baseline emissions in year y (tCO_2e/yr)
PE_y	Project emissions in year y (tCO_2e/yr)
LE_y	Leakage emissions in year y (tCO_2e/yr)

B.6.2. Data and parameters that are available at validation:

The following table with values is reproduced from the flaring tool:

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_c	kg/kmol (g/mol)	Atomic mass of carbon	12
AM_h	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_o	kg/kmol (g/mol)	Atomic mass of oxygen	16
AM_n	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_n	Pa	Atmospheric pressure at normal conditions	101 325
Ru	$Pa.m^3/kmol.K$	Universal ideal gas constant	8 314.472
T_n	K	Temperature at normal conditions	273.15
MF_{O2}	Dimensionless	O2 volumetric fraction of air	0.21
GWP_{CH4}	t_{CO2}/t_{CH4}	Global warming potential of methane	21
MV_n	$m^3/Kmol$	Volume of one mole of any ideal gas at normal	22.414

Data / Parameter:	s_{grid}
Data unit:	percentage
Description:	Percentage of the electricity demand supplied by the grid imports for the 3 years preceding the implementation of the project.
Source of data used:	Current and historical mining operations at Beatrix mine.
Value applied:	100%
Justification of the choice of data or description of measurement methods and procedures actually applied :	No captive electricity generation occurs in the baseline. Historically, all electricity is sourced from the national grid.
Any comment:	

Data / Parameter:	$s_{captive}$
Data unit:	percentage
Description:	Percentage of the electricity demand supplied by captive electricity generation for the 3 years preceding the implementation of the project.
Source of data used:	Current and historical mining operations at Beatrix mine.
Value applied:	0%
Justification of the choice of data or description of	No captive electricity generation occurs in the baseline. Historically, all electricity is sourced from the national grid.

measurement methods and procedures actually applied :	
Any comment:	

Data / Parameter:	CEF_{CH4}
Data unit:	tCO_2/tCH_4
Description:	Carbon emission factor for combusted methane
Source of data used:	As stated in AM0064
Value applied:	2.75
Justification of the choice of data or description of measurement methods and procedures actually applied :	Ex ante value stated in AM0064
Any comment:	44/16 = 2.75 tCO_2e/tCH_4

Data / Parameter:	Eff_{ELEC}
Data unit:	Percentage
Description:	Efficiency of methane destruction/oxidation in power plant
Source of data used:	IPCC default value as stated in AM0064
Value applied:	99.5%
Justification of the choice of data or description of measurement methods and procedures actually applied :	IPCC default value as stated in AM0064
Any comment:	

Data / Parameter:	TH_{BL}
Data unit:	tCH_4
Description:	Average annual thermal demand over the past 5 years (tCH_4)
Source of data used:	Current and historical mining operations at Beatrix mine
Value applied:	0
Justification of the choice of data or description of measurement methods and procedures actually applied :	Historically the baseline scenario had no thermal demand.
Any comment:	

B.6.3. Ex-ante calculation of emission reductions:

>>

The calculations presented in this section were based on:

- A project start date (i.e. implementation of the flare) of 1 May 2008;
- Flaring occurs in the first phase of the project, which runs from May to December 2008;
- Electricity generation and flaring occur in the second phase of the project, which runs from January 2009 to the end of the crediting period.

Baseline emissions for mine methane capture and utilization or destruction

Equation 1:

$$BE_y = BE_{MD,y} + BE_{MR,y} + BE_{Use,y}$$

Year	BE_y	$BE_{MD,y}$	$BE_{MR,y}$	$BE_{Use,y}$
1 May 2009 – 31 Dec 2009	132,940.96	0	132,940.96	-
1 Jan 2010 – 31 Dec 2010	272,412.90	0	226,745.09	45,667.81
1 Jan 2011 – 31 Dec 2011	272,412.90	0	226,745.09	45,667.81
1 Jan 2012 – 31 Dec 2012	272,412.90	0	226,745.09	45,667.81
1 Jan 2013 – 31 Dec 2013	272,412.90	0	226,745.09	45,667.81
1 Jan 2014 – 31 Dec 2014	272,412.90	0	226,745.09	45,667.81
1 Jan 2015 – 31 Dec 2015	272,412.90	0	226,745.09	45,667.81
1 Jan 2016 – 31 Apr 2016	90,804.30	0	75,581.70	15,222.60

Equation 3:

$$r = \frac{PC_{NMHC}}{PC_{CH4}}$$

Year	r	PC_{NMHC}	PC_{CH4}
1 May 2009 – 31 Dec 2009	0.00466	0.37%	79%
1 Jan 2010 – 31 Dec 2010	0.00466	0.37%	79%
1 Jan 2011 – 31 Dec 2011	0.00466	0.37%	79%
1 Jan 2012 – 31 Dec 2012	0.00466	0.37%	79%
1 Jan 2013 – 31 Dec 2013	0.00466	0.37%	79%
1 Jan 2014 – 31 Dec 2014	0.00466	0.37%	79%
1 Jan 2015 – 31 Dec 2015	0.00466	0.37%	79%
1 Jan 2016 – 31 Apr 2016	0.00466	0.37%	79%

Equation 6:

$$BE_{MR,y} = GWP_{CH4} \times \left(MM_{PR,engine,y} + MM_{PR,flare,y}\right)$$

Year	$BE_{MR,y}$	GWP_{CH4}	$MM_{PR,engine,y}$	$MM_{PR,flare,y}$
1 May 2009 – 31 Dec 2009	132,940.96	21		6,330.52
1 Jan 2010 – 31 Dec 2010	226,745.09	21	8,595.16	2,202.22
1 Jan 2011 – 31 Dec 2011	226,745.09	21	8,595.16	2,202.22
1 Jan 2012 – 31 Dec 2012	226,745.09	21	8,595.16	2,202.22

1 Jan 2013 – 31 Dec 2013	226,745.09	21	8,595.16	2,202.22
1 Jan 2014 – 31 Dec 2014	226,745.09	21	8,595.16	2,202.22
1 Jan 2015 – 31 Dec 2015	226,745.09	21	8,595.16	2,202.22
1 Jan 2016 – 31 Apr 2016	75,581.70	21	2,865.05	734.07

Equation 7:

$$BE_{Use,y} = GEN_y \times EF_{ELEC,y}$$

Year	$BE_{Use,y}$	GEN_y	$EF_{ELEC,y}$
1 May 2009 – 31 Dec 2009	-	-	1.02
1 Jan 2010 – 31 Dec 2010	45,667.81	44,772.36	1.02
1 Jan 2011 – 31 Dec 2011	45,667.81	44,772.36	1.02
1 Jan 2012 – 31 Dec 2012	45,667.81	44,772.36	1.02
1 Jan 2013 – 31 Dec 2013	45,667.81	44,772.36	1.02
1 Jan 2014 – 31 Dec 2014	45,667.81	44,772.36	1.02
1 Jan 2015 – 31 Dec 2015	45,667.81	44,772.36	1.02
1 Jan 2016 – 31 Apr 2016	15,222.60	14,924.12	1.02

Equation 9:

$$EF_{ELEC,y} = s_{grid} \times EF_{grid,y} + s_{captive} \times EF_{captive,y}$$

Year	$EF_{ELEC,y}$	s_{grid}	$EF_{grid,y}$	$s_{captive}$	$EF_{captive,y}$
1 May 2009 – 31 Dec 2009	1.02	1	1.02	0	0
1 Jan 2010 – 31 Dec 2010	1.02	1	1.02	0	0
1 Jan 2011 – 31 Dec 2011	1.02	1	1.02	0	0
1 Jan 2012 – 31 Dec 2012	1.02	1	1.02	0	0
1 Jan 2013 – 31 Dec 2013	1.02	1	1.02	0	0
1 Jan 2014 – 31 Dec 2014	1.02	1	1.02	0	0
1 Jan 2015 – 31 Dec 2015	1.02	1	1.02	0	0
1 Jan 2016 – 31 Apr 2016	1.02	1	1.02	0	0

<u>Baseline emissions for non-mine methane capture and destruction:</u>

Equation 12:

$$BE_y = \sum_{h=1}^{8760} TM_{RG,h} \times \frac{GWP_{CH4}}{1000}$$

Year	BE_y	$TM_{RG,h}$	GWP_{CH4}
1 May 2009 – 31 Dec 2009	68,872.43	638.56	21
1 Jan 2010 – 31 Dec 2010	117,469.33	638.56	21
1 Jan 2011 – 31 Dec 2011	117,469.33	638.56	21
1 Jan 2012 – 31 Dec 2012	117,469.33	638.56	21
1 Jan 2013 – 31 Dec 2013	117,469.33	638.56	21

1 Jan 2014 – 31 Dec 2014	117,469.33	638.56	21
1 Jan 2015 – 31 Dec 2015	117,469.33	638.56	21
1 Jan 2016 – 31 Apr 2016	48,596.90	638.56	21

Project emissions due to project activities recovering mine methane

Equation 13:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y}$$

Year	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
1 May 2009 – 31 Dec 2009	26,717.37	1,732.08	16,267.29	8,718.00
1 Jan 2010 – 31 Dec 2010	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2011 – 31 Dec 2011	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2012 – 31 Dec 2012	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2013 – 31 Dec 2013	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2014 – 31 Dec 2014	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2015 – 31 Dec 2015	37,778.78	4,666.05	29,177.48	3,935.25
1 Jan 2016 – 31 Apr 2016	12,804.74	1,555.35	9,693.91	1,555.48

Equation 14:

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y}$$

Year	$PE_{ME,y}$	$PE_{ELEC,y}$	$PE_{FF,y}$
1 May 2009 – 31 Dec 2009	1,732.08	1,732.08	0
1 Jan 2010 – 31 Dec 2010	4,666.05	4,666.05	0
1 Jan 2011 – 31 Dec 2011	4,666.05	4,666.05	0
1 Jan 2012 – 31 Dec 2012	4,666.05	4,666.05	0
1 Jan 2013 – 31 Dec 2013	4,666.05	4,666.05	0
1 Jan 2014 – 31 Dec 2014	4,666.05	4,666.05	0
1 Jan 2015 – 31 Dec 2015	4,666.05	4,666.05	0
1 Jan 2016 – 31 Apr 2016	1,555.35	1,555.35	0

Equation 15:

$$PE_{MD,y} = \left(MD_{FL,y} + MD_{ELEC,y}\right) \times \left(CEF_{CH4} + r \times CEF_{NMHC}\right)$$

Year	$PE_{MD,y}$	$MD_{FL,y}$	$MD_{ELEC,y}$	CEF_{CH4}
1 May 2009 – 31 Dec 2009	16,267.29	5,915.38	-	2.75
1 Jan 2010 – 31 Dec 2010	29,177.48	2,057.80	8,552.19	2.75
1 Jan 2011 – 31 Dec 2011	29,177.48	2,057.80	8,552.19	2.75
1 Jan 2012 – 31 Dec 2012	29,177.48	2,057.80	8,552.19	2.75
1 Jan 2013 – 31 Dec 2013	29,177.48	2,057.80	8,552.19	2.75
1 Jan 2014 – 31 Dec 2014	29,177.48	2,057.80	8,552.19	2.75
1 Jan 2015 – 31 Dec 2015	29,177.48	2,057.80	8,552.19	2.75

1 Jan 2016 – 31 Apr 2016	9,693.91	674.33	2,850.73	2.75

Equation 16:

$$MD_{FL,y} = MMES_{FL,y} - \frac{PE_{flare,y}}{GWP_{CH4}}$$

Year	$MD_{FL,y}$	$MMES_{FL,y}$	$PE_{flare,y}$	GWP_{CH4}
1 May 2009 – 31 Dec 2009	5,915.38	6,330.52	8,718.00	21
1 Jan 2010 – 31 Dec 2010	2,057.80	2,202.22	3,032.76	21
1 Jan 2011 – 31 Dec 2011	2,057.80	2,202.22	3,032.76	21
1 Jan 2012 – 31 Dec 2012	2,057.80	2,202.22	3,032.76	21
1 Jan 2013 – 31 Dec 2013	2,057.80	2,202.22	3,032.76	21
1 Jan 2014 – 31 Dec 2014	2,057.80	2,202.22	3,032.76	21
1 Jan 2015 – 31 Dec 2015	2,057.80	2,202.22	3,032.76	21
1 Jan 2016 – 31 Apr 2016	674.33	734.07	1,254.65	21

Equation 20:

$$MD_{ELEC,y} = MMES_{ELEC,y} \times Eff_{ELEC}$$

Year	$MD_{ELEC,y}$	$MMES_{ELEC,y}$	Eff_{ELEC}
1 May 2009 – 31 Dec 2009	-	-	99.5%
1 Jan 2010 – 31 Dec 2010	8,552.19	8,595.16	99.5%
1 Jan 2011 – 31 Dec 2011	8,552.19	8,595.16	99.5%
1 Jan 2012 – 31 Dec 2012	8,552.19	8,595.16	99.5%
1 Jan 2013 – 31 Dec 2013	8,552.19	8,595.16	99.5%
1 Jan 2014 – 31 Dec 2014	8,552.19	8,595.16	99.5%
1 Jan 2015 – 31 Dec 2015	8,552.19	8,595.16	99.5%
1 Jan 2016 – 31 Apr 2016	2,850.73	2,865.05	99.5%

Equation 23:

$$PE_{UM,y} = \left[GWP_{CH4} \times MMES_{ELEC} \times \left(1 - Eff_{ELEC}\right)\right] + PE_{flare,y}$$

Year	$PE_{UM,y}$	$MMES_{ELEC,y}$	Eff_{ELEC}	$PE_{flare,y}$	$PE_{OX,y}$	GWP_{CH4}
1 May 2009 – 31 Dec 2009	8,718.00	-	99.5%	8,718.00	0	21
1 Jan 2010 – 31 Dec 2010	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2011 – 31 Dec 2011	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2012 – 31 Dec 2012	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2013 – 31 Dec 2013	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2014 – 31 Dec 2014	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2015 – 31 Dec 2015	3,935.25	8,595.16	99.5%	3,032.76	0	21
1 Jan 2016 – 31 Apr 2016	1,555.48	2,865.05	99.5%	1,254.65	0	21

<u>**Project emissions due to project activities recovering non-mine methane:**</u>

Equation 24:

$$PE_y = PE_{ME,y} + PE_{MD,y} + PE_{UM,y}$$

Year	PE_y	$PE_{ME,y}$	$PE_{MD,y}$	$PE_{UM,y}$
1 May 2009 – 31 Dec 2009	15,004.35	0	8,117	6,887.24
1 Jan 2010 – 31 Dec 2010	25,591.53	0	13,845	11,746.93
1 Jan 2011 – 31 Dec 2011	25,591.53	0	13,845	11,746.93
1 Jan 2012 – 31 Dec 2012	25,591.53	0	13,845	11,746.93
1 Jan 2013 – 31 Dec 2013	25,591.53	0	13,845	11,746.93
1 Jan 2014 – 31 Dec 2014	25,591.53	0	13,845	11,746.93
1 Jan 2015 – 31 Dec 2015	25,591.53	0	13,845	11,746.93
1 Jan 2016 – 31 Apr 2016	10,587.18	0	5,727	4,859.69

Equation 25:

$$PE_{ME,y} = PE_{ELEC,y} + PE_{FF,y}$$

Year	$PE_{ME,y}$	$PE_{ELEC,y}$	$PE_{FF,y}$
1 May 2009 – 31 Dec 2009	0	0	0
1 Jan 2010 – 31 Dec 2010	0	0	0
1 Jan 2011 – 31 Dec 2011	0	0	0
1 Jan 2012 – 31 Dec 2012	0	0	0
1 Jan 2013 – 31 Dec 2013	0	0	0
1 Jan 2014 – 31 Dec 2014	0	0	0
1 Jan 2015 – 31 Dec 2015	0	0	0
1 Jan 2016 – 31 Apr 2016	0	0	0

Equation 26:

$$PE_{MD,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(\eta_{flare,h}\right) \times \frac{CEF_{CH4}}{1000}$$

Year	$PE_{MD,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	CEF_{CH4}
1 May 2009 – 31 Dec 2009	8,117	638.56	0.90	2.75
1 Jan 2010 – 31 Dec 2010	13,845	638.56	0.90	2.75
1 Jan 2011 – 31 Dec 2011	13,845	638.56	0.90	2.75
1 Jan 2012 – 31 Dec 2012	13,845	638.56	0.90	2.75
1 Jan 2013 – 31 Dec 2013	13,845	638.56	0.90	2.75
1 Jan 2014 – 31 Dec 2014	13,845	638.56	0.90	2.75
1 Jan 2015 – 31 Dec 2015	13,845	638.56	0.90	2.75
1 Jan 2016 – 31 Apr 2016	5,727	638.56	0.90	2.75

Equation 27:

$$PE_{UM,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1000}$$

Year	$PE_{UM,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
1 May 2009 – 31 Dec 2009	6,887.24	638.56	0.90	21
1 Jan 2010 – 31 Dec 2010	11,746.93	638.56	0.90	21
1 Jan 2011 – 31 Dec 2011	11,746.93	638.56	0.90	21
1 Jan 2012 – 31 Dec 2012	11,746.93	638.56	0.90	21
1 Jan 2013 – 31 Dec 2013	11,746.93	638.56	0.90	21
1 Jan 2014 – 31 Dec 2014	11,746.93	638.56	0.90	21
1 Jan 2015 – 31 Dec 2015	11,746.93	638.56	0.90	21
1 Jan 2016 – 31 Apr 2016	4,859.69	638.56	0.90	21

Leakage due to project activities recovering mine methane

Equation 28:

$$ME_k - \left(MMES_{ELEC,k} + MMES_{HEAT,k}\right) < TH_k$$

Year	ME_k	$MMES_{ELEC,k}$	$MMES_{HEAT,k}$	LHS	TH_k
1 May 2009 – 31 Dec 2009	29.58	0	0	29.58	0
1 Jan 2010 – 31 Dec 2010	29.58	23.55	0	6.03	0
1 Jan 2011 – 31 Dec 2011	29.58	23.55	0	6.03	0
1 Jan 2012 – 31 Dec 2012	29.58	23.55	0	6.03	0
1 Jan 2013 – 31 Dec 2013	29.58	23.55	0	6.03	0
1 Jan 2014 – 31 Dec 2014	29.58	23.55	0	6.03	0
1 Jan 2015 – 31 Dec 2015	29.58	23.55	0	6.03	0
1 Jan 2016 – 31 Apr 2016	29.58	23.55	0	6.03	0

Emission reductions

Equation 33:

$$ER_y = BE_y - PE_y - LE_y$$

Year	ER_y	BE_y	PE_y	LE_y
1 May 2009 – 31 Dec 2009	160,092	201,813	41,722	0
1 Jan 2010 – 31 Dec 2010	326,512	389,882	63,370	0
1 Jan 2011 – 31 Dec 2011	326,512	389,882	63,370	0
1 Jan 2012 – 31 Dec 2012	326,512	389,882	63,370	0
1 Jan 2013 – 31 Dec 2013	326,512	389,882	63,370	0
1 Jan 2014 – 31 Dec 2014	326,512	389,882	63,370	0
1 Jan 2015 – 31 Dec 2015	326,512	389,882	63,370	0
1 Jan 2016 – 31 Apr 2016	116,009	139,401	23,392	0

B.6.4 Summary of the ex-ante estimation of emission reductions:

>>

Year	Estimation of project activity emissions (tonnes of CO_2 e)	Estimation of baseline emissions (tonnes of CO_2 e)	Estimation of leakage (tonnes of CO_2 e)	Estimation of overall emission reductions (tonnes of CO_2 e)
1 May 2009 – 31 Dec 2009	41,722	201,813	0	160,092
1 Jan 2010 – 31 Dec 2010	63,370	389,882	0	326,512
1 Jan 2011 – 31 Dec 2011	63,370	389,882	0	326,512
1 Jan 2012 – 31 Dec 2012	63,370	389,882	0	326,512
1 Jan 2013 – 31 Dec 2013	63,370	389,882	0	326,512
1 Jan 2014 – 31 Dec 2014	63,370	389,882	0	326,512
1 Jan 2015 – 31 Dec 2015	63,370	389,882	0	326,512
1 Jan 2016 – 31 Apr 2016	23,392	139,401	0	116,009
1 May 2009 – 31 Dec 2009	41,722	201,813	0	160,092
Total (tonnes of CO_2 e)	**445,336**	**2,680,508**	**0**	**2,235,172**

B.7. Application of the monitoring methodology and description of the monitoring plan:

The operations manager/ personnel have overall responsibility for the maintenance and calibration of the equipment. Equipment will be calibrated and maintained in accordance with national and international standards.

Promethium Carbon will be responsible for the recording and archiving of the data and emission reduction calculations. Electronic records will be kept and stored both on site and off site by Promethium Carbon.

Refer to the monitoring plan.

B.7.1 Data and parameters monitored:

<u>Mine methane capture and utilization or destruction</u>

Data / Parameter:	$EF_{grid,y}$
Data unit:	tCO_2/MWh
Description:	CO_2 baseline emission factor for the grid electricity displaced due to the project activity during the year y (tCO_2/MWh)
Source of data to be used:	Answer of applied tool. See Justification below.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	1.02
Description of measurement methods and procedures to be	The project activity will displace grid electricity. The emission factor for the grid electricity will be calculated in accordance with the latest approved version of the "Tool for calculation of emission factor for electricity systems," version 01.1.

applied:	The emission factor will be calculated ex post and updated using the latest publically available information. Eskom has verbally committed to annually update the information required for the tool.
QA/QC procedures to be applied:	
Any comment:	This is the same as $EF_{ELEC,y}$ since no captive power in the baseline scenario. Furthermore from the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (Version 01.1) $EF_{grid,y}$ is also equal to $EF_{EL,j,y}$. (Scenario C.1. that results in Scenario A: Option A.1.)

Data / Parameter:	$MM_{PR,engine,y}$ or $MMES_{ELEC,y}$
Data unit:	tCH_4/yr
Description:	Mine methane captured, sent to and destroyed by internal combustion engines in the project activity in year y
Source of data to be used:	As measured by calibrated flow meters on piping going to the combustion engines
Value of data applied for the purpose of calculating expected emission reductions in section B.5	8,595.16 tCH_4/year
Description of measurement methods and procedures to be applied:	Continuous monitoring will be logged electronically. Hourly measurements will be archived.
QA/QC procedures to be applied:	The measuring equipment must be calibrated to manufacturer's standards and required recalibration frequency.
Any comment:	

Data / Parameter:	$MM_{PR,flare,y}$ or $MMES_{FL,y}$
Data unit:	tCH_4/yr
Description:	Mine methane captured, sent to and destroyed by flare in the project activity in year y
Source of data to be used:	As measured by calibrated flow meters on piping going to the flare
Value of data applied for the purpose of calculating expected emission reductions in section B.5	2,202.22 tCH_4/year
Description of measurement methods and procedures to be applied:	Continuous monitoring will be logged electronically with a memory cycle of 1 minute. The gas volume is measured by the instrument in Nm^3/hr and the temperature and pressure are measured.
QA/QC procedures to be applied:	The measuring equipment must be calibrated to manufacturer's standards and required recalibration frequency
Any comment:	

Data / Parameter:	GEN_y

Data unit:	MWh
Description:	Electricity generated by the project activity in year y
Source of data to be used:	The electrical output, in MWh, will be measured after the electricity generation equipment.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	44,772.36MWh
Description of measurement methods and procedures to be applied:	The electricity output will be measured after the electricity output. This output will be logged electronically. Continuous monitoring will be done.
QA/QC procedures to be applied:	The measuring instrument must be calibrated to manufacturer's specifications.
Any comment:	

Data / Parameter:	PC_{CH4}
Data unit:	%
Description:	Concentration (in mass) of methane in extracted gas (%), measured on wet basis
Source of data to be used:	Concentration meters, optical and calorific, will be used.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	79%
Description of measurement methods and procedures to be applied:	Electronic measurements will be logged hourly.
QA/QC procedures to be applied:	Maintenance of concentration meters will be done according to manufacturer's specification.
Any comment:	

Data / Parameter:	PC_{NMHC}
Data unit:	%
Description:	NMHC concentration (in mass) in extracted gas
Source of data to be used:	Concentration meters, optical and calorific, will be used.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.37%
Description of measurement methods and procedures to be	Electronic measurements will be logged annually

applied:	
QA/QC procedures to be applied:	
Any comment:	

Data / Parameter:	$EC_{PJ,,y}$
Data unit:	MWh/y
Description:	Quantity of electricity consumed by the project electricity consumption source in year *y*
Source of data to be used:	As measured by calibrated electricity meters.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	4,441.32 MWh/year
Description of measurement methods and procedures to be applied:	The electricity consumption of the electricity generating equipment and auxiliaries will be measured. The continuous monitored data will be logged electronically.
QA/QC procedures to be applied:	The measuring equipment must be calibrated to manufacturer's standards and required recalibration frequency
Any comment:	

Data / Parameter:	TDL_y
Data unit:	-
Description:	Average technical transmission and distribution losses for providing electricity to source in year y
Source of data to be used:	A default value of 3% was used because the scenario presented below was found to be applicable to the project (verbatim text in italics): *(b) project and leakage electricity consumption sources if the electricity consumption by all project and leakage electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies is smaller than the electricity consumption of all baseline electricity consumption sources to which scenario A or scenario C (cases C.I or C.III) applies.*
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Default 3% as stated in "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*"
Description of measurement methods and procedures to be applied:	The tool will be checked annually for updates and new default values.
QA/QC procedures to be applied:	Annually. In the absence of data from the relevant year, most recent figures should be used, but not older than 5 years. If these figures are not available, then default values, as stated in the tool, will be used.
Any comment:	

Data / Parameter:	$FV_{RG,h}$
Data unit:	m^3/h
Description:	Volumetric flow rate of the residual gas in dry basis at normal conditions in the hour *h*
Source of data to be used:	Measurements will be taken using a flow meter
Value of data applied for the purpose of calculating expected emission reductions in section B.5	403.84 m^3/h
Description of measurement methods and procedures to be applied:	The same basis (dry or wet) will be considered for this measurement and the measurement of volumetric fraction of all components in the residual gas ($fv_{i,h}$) if the residual gas temperature exceeds 60 ºC. The measurements will be reported in Nm^3/hr. The instrument will have a pressure and a temperature component.
QA/QC procedures to be applied:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation.
Any comment:	

Data / Parameter:	$fv_{i,h}$
Data unit:	-
Description:	Volumetric fraction of component i in the residual gas in the hour *h* Where i is CH_4,CO,CO_2,O_2,H_2,N_2
Source of data to be used:	Initial gas analyses before project start. Thereafter measurements will be taken by project participants using a continuous gas analyser.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	$fv_{CH4,h}$ = 0.87 (value from initial measurement) $fv_{CO,h}$ = 0.00 (value from initial measurement) $fv_{CO2,h}$ = 0.00 (value from initial measurement) $fv_{O2,h}$ = 0.02 (value from initial measurement) $fv_{H2,h}$ = 0.00 (value from initial measurement) $fv_{N2,h}$ = 0.11 (value from initial measurement)
Description of measurement methods and procedures to be applied:	The same basis (dry or wet) is considered for this measurement and the measurement of the volumetric flow rate of the residual gas ($FV_{RG,h}$) when the residual gas temperature exceeds 60 ºC
QA/QC procedures to be applied:	Analysers will be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check will be performed by comparison with a standard certified gas.
Any comment:	

Data / Parameter:	$fv_{CH4,FG,h}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h
Source of data to be used:	Measurements by project participants using a continuous gas analyser
Value of data applied	2,265.73 mg/m^3

for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. in conel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.
QA/QC procedures to be applied:	Analysers must be periodically calibrated according to manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m3 simply multiply by 0.716. 1% equals 10 000 ppmv.

Data / Parameter:	$t_{O2,h}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas of the flare in the hour h
Source of data to be used:	Measurements by the project participants using a continuous gas analyser
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0.01
Description of measurement methods and procedures to be applied:	Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes). An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow. Continuously. Values to be averaged hourly or at a shorter time interval
QA/QC procedures to be applied:	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas.
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency.

Data / Parameter:	T_{flare}
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurements by project participants
Value of data applied	600 °C

for the purpose of calculating expected emission reductions in section B.5	
Description of measurement methods and procedures to be applied:	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating. The temperature should be measured continuously.
QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

<u>Non-mine methane capture and destruction</u>

Data / Parameter:	$TM_{RG,h}$
Data unit:	Kg/h
Description:	Mass flow rate of methane in the residual gas in the hour h
Source of data to be used:	Mass flow measuring devices installed at the boreholes
Value of data applied for the purpose of calculating expected emission reductions in section B.5	638.56 kg/h
Description of measurement methods and procedures to be applied:	Monitoring will be done continuously
QA/QC procedures to be applied:	A zero check and a typical value check should be performed annually by comparing the borehole gas with a standard gas.
Any comment:	

Data / Parameter:	Tflare
Data unit:	°C
Description:	Temperature in the exhaust gas of the flare
Source of data to be used:	Measurements by project participants
Value of data applied for the purpose of calculating expected emission reductions in section B.5	600 °C
Description of measurement methods and procedures to be applied:	Measure the temperature of the exhaust gas stream in the flare by a Type N thermocouple. A temperature above 500 ºC indicates that a significant amount of gases are still being burnt and that the flare is operating. The temperature should be measured continuously.

QA/QC procedures to be applied:	Thermocouples should be replaced or calibrated every year.
Any comment:	An excessively high temperature at the sampling point (above 700 ºC) may be an indication that the flare is not being adequately operated or that its capacity is not adequate to the actual flow.

B.7.2. Description of the monitoring plan:

>>

The onsite monitoring as well as calibration/verification of measurement equipment will be the responsibility of the operations manager. The data will be collected on site and archived both on site and off site. Promethium Carbon will be responsible for calculating the emission reductions and drafting of the emission reduction report. Further detail on the monitoring of the project can be seen in the monitoring plan.

B.8. Date of completion of the application of the baseline study and monitoring methodology and the name of the responsible person(s)/entity(ies):

>>

Both the baseline study and the monitoring methodology were developed by Promethium Carbon (Pty) Ltd and completed in October 2008.

SECTION C. Duration of the project activity / crediting period

C.1. Duration of the project activity:

C.1.1. Starting date of the project activity:

>>

The first phase of the project, the installation of the flares, is expected to start in May 2009.

C.1.2. Expected operational lifetime of the project activity:

>>

The life time of the mine as well as the proposed equipment (if well maintained) exceeds the 21 year period of this project activity.

C.2. Choice of the crediting period and related information:

C.2.1. Renewable crediting period:

C.2.1.1. Starting date of the first crediting period:

>>

1 May 2009

C.2.1.2. Length of the first crediting period:

>>

Seven years

C.2.2. Fixed crediting period:

C.2.2.1. Starting date:

>>

Not applicable

C.2.2.2. Length:

>>
Not applicable

SECTION D. Environmental impacts

>>

D.1. Documentation on the analysis of the environmental impacts, including transboundary impacts:

>>
The project does not involve any activity that is listed in terms of the National Environmental Management Act and, as such, does not require an environmental impact assessment or a basic assessment.

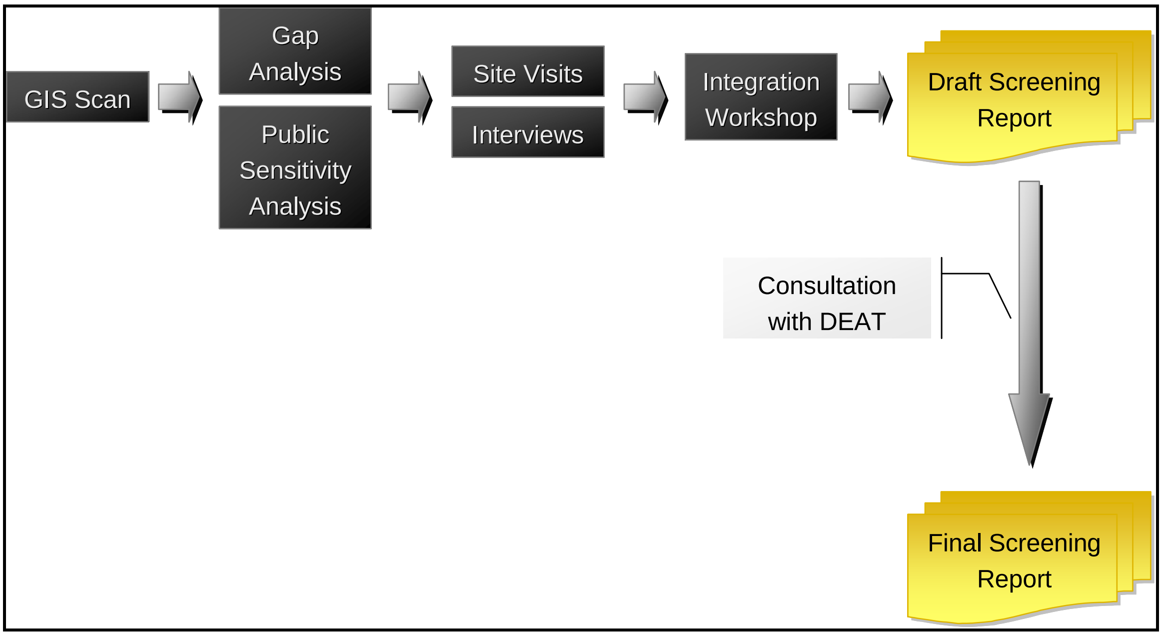
The project will need to be included in the Environmental Management Programme Report (EMPR) of the Beatrix mine. Following meetings with the regional director of The Department of Minerals and Energy (DME) for Welkom, the project will need to be included as an addendum to the EMPR. DEAT expects this process to take four months.

D.2. If environmental impacts are considered significant by the project participants or the host Party, please provide conclusions and all references to support documentation of an environmental impact assessment undertaken in accordance with the procedures as required by the host Party:

>>
The project participants contracted Strategic Environmental Focus (SEF) to compile a screening report on the project. The objectives of the screening report were:

- To make recommendations on the appropriate environmental authorisation processes to be undertaken for the establishment of the cogeneration plant;
- To provide advanced warning of any potential environmental issues or sensitivities at the existing site, which may influence the outcome of the environmental authorisation processes; and
- To highlight environmental risks, and to briefly discuss these risks with regards to the legislation governing both the current operations as well as the proposed inclusion of the cogeneration operations on site;

The process followed to realise the objectives of the screening report was:



The results of the screening exercise were:

- There do not appear to be any environmental fatal-flaws associated with the establishment of the proposed cogeneration plant on the existing 'brown-fields" site;
- The proposed cogeneration plant will be installed at an existing "brown-fields" site;
- It will not be necessary to apply for a Water Use License in terms of Section 21, 37(1) or 38(1) of the National Water Act, 1998, as no listed water uses are contemplated for the proposed project. This is given that municipal water (Sedibeng) will be used as top-up water for the cogeneration plant; and
- The proposed development will also require an addendum to the mine's existing EMPR in terms of the Minerals and Petroleum Resources Development Act, 2002(Act No. 28 of 2002) [MPRDA)], therefore requiring that an Environmental Management Plan be submitted for approval to the Department of Minerals and Energy (DME).

Following the screening report, the relevant authorities were consulted to confirm the necessary permits required. As discussed above, the project will have to be included as an addendum to the EMPR of the mine.

SECTION E. Stakeholders' comments

>>

E.1. Brief description how comments by local stakeholders have been invited and compiled:

>>

An advertisement was placed in a local newspaper in both English and Afrikaans. Afrikaans is the language of the area. The advertisement was placed in the Vista newspaper on the 22nd of August 2008. Comments were invited on the project and the closing date for comments was the 15th of September 2008.

The relevant stakeholders, such as the farmers in the area, are updated about the project and its progress on a regular basis. Hennie Pretorius, the Environmental Manager at Beatrix, visits each of the farmers at their farms and up-dates them on the project.

There will also be a stakeholder meeting as required by the process for the addendum to EMPR. Invitations for this meeting will be sent out to the relevant stakeholders. These invitations include the topic to be discussed, such as the project. The farmers must sign the invitation to show that they have been informed even if they do not attend the meeting.

E.2. Summary of the comments received:

>>
Comments on the Advertisement:

There were two responses to the advertisement:

1. The first was a journalist from a regional paper in Bethlehem in the Eastern Free State, who was only interested in Gold Fields paying to have the advert placed in his newspaper as well.
2. The second person was a local businessman from Welkom who enquired about the benefit that the Gold Fields Foundation would derive from the project. The businessman is planning to start a Section 21 company. Ultimately, he wanted to know if his proposed company would gain as a result.

In addition, there were some casual observations along the lines: "We saw the Beatrix methane capture advert in the Vista".

Comments from the visits by Hennie Pretorius:

Comments from the stakeholder consultation:

E.3. Report on how due account was taken of any comments received:

>>
The comments were addressed as follows:

1. Bethlehem is not in the region of Beatrix and would not target any relevant stakeholders for this project. The distance between the project and Bethlehem exceeds 300km.
2. Once the section 21 company is formed, the Gold Fields Foundation will assess its merits as a possible beneficiary of the Foundation.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

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Mobile:	
Direct FAX:	
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Annex 2

INFORMATION REGARDING PUBLIC FUNDING

There is no public funding.

Annex 3

BASELINE INFORMATION

Information about the Occurrence of Methane at a Gold Mine

1. Methane Capturing:

1.1 Methane Occurrence:

The methane in the Beatrix mining area is not liberated homogeneously as is the case in coal beds. Methane is carried in geological faults from unknown reservoir(s) or source(s). Scientific research into the occurrence of the methane indicates that the methane:

(a) seems to come from a deep-seated source, and
(b) may be of biological origin.

Some of the literature sources are listed below:

- Hugo P. J., Helium in the Orange Free State Gold Field, Geological Survey, Republic of South Africa, 1963.
- Takai et al., Archaeal Diversity in Waters from Deep South African Gold Mines, Applied and Environmental Microbiology, December 2001, Vol 67, No 12, pp 5750 – 5760
- England, G L, Rasmussen, B, Krapez, B, Groves, D I, Archaean oil migration in the Witwatersrand Basin of South Africa, Journal of the Geological Society, Mar 2002
- Spangenberg J., Frimmel H. E., Basin-internal derivation of hydrocarbons in the Witwatersrand Basin, South Africa: evidence from bulk and molecular 13C data, Chemical Geology, 2001, 173, 339-355.
- Ward J.A. et al, Microbial hydrocarbon gases in the Witwatersrand Basin, South Africa: Implications for the deep biosphere, Geochimica et Cosmochimica Acta, Vol. 68, No. 15, pp. 3239–3250, 2004.

The conclusion reached by Ward states that: "*... these microbial hydrocarbon gases are the product of in situ methanogenic communities in the deep subsurface of the Witswaterand basin*."

Attempts to reduce the methane hazard in the underground mines, by borehole drainage, were made in the 1960s. These attempts were unsuccessful due to the failure to predict the location of the methane gas in the underground mines. This was documented and made public by the Department of Mines in a geological survey on Helium in the Orange Free State Gold-Field. *The South African Government Printer, Bulletin 39, G.P.-s 3479551-1962-63-1200*

The difficulties in predicting the location of the methane in the Beatrix mine are exacerbated by the lack of detailed major and minor geological fault charts. The major geological fault zones, running through the Beatrix mining area, are depicted in Figure 3. The minor faults are largely uncharted. As the country rock in the area is impermeable, methane is carried exclusively in these discrete faults. The exact location of the methane in these discrete faults is difficult to determine. Hence, the management of methane in the mine can only be done on an *ex post* basis; when the area is mined and the methane is released.

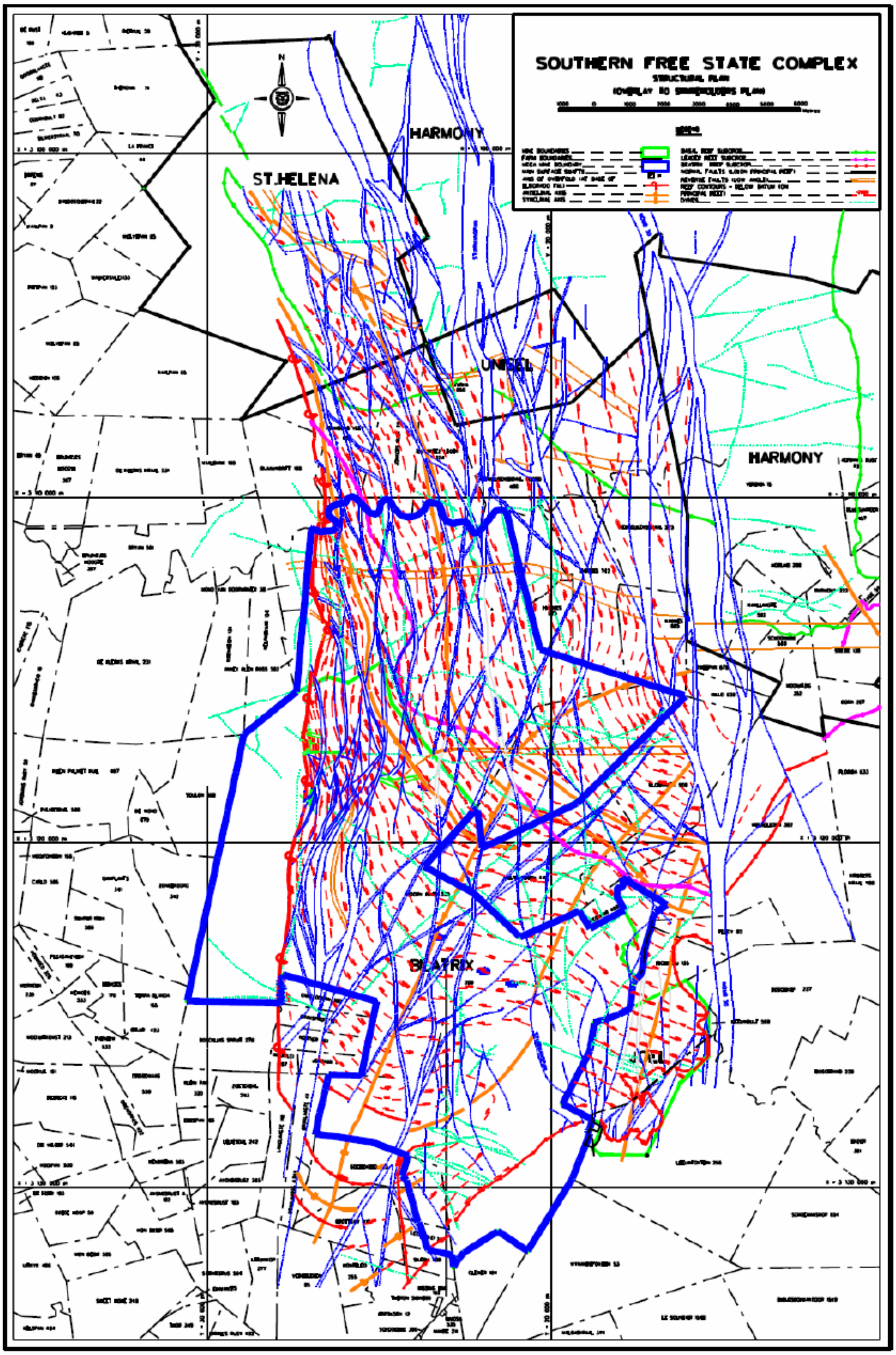

Figure 11: Geological faults in the Beatrix mining area

Historically, methane emissions from mining operations has occurred from the Karoo Supergroup through to the Virginia Formation (refer Figure 12 below) at depths ranging from 300 meters to 3 kilometres.

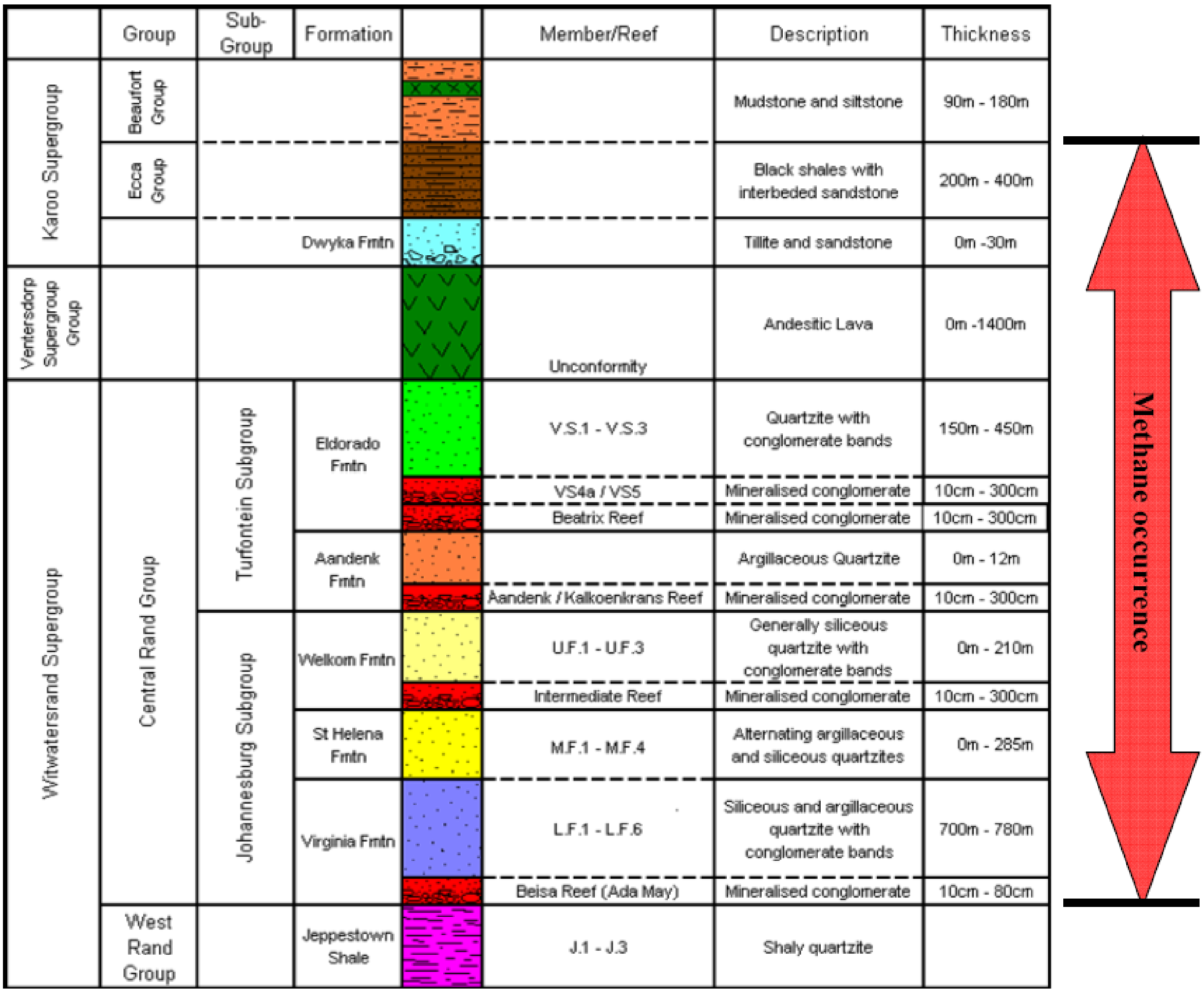

Figure 12: Free State goldfields stratigraphic column

Methane from these geological structures is vented from two main sources: surface boreholes and underground mining areas. This project only deals with methane vented from underground mining areas.

Currently, all of the methane from the underground workings is diluted into the ventilation air and vented to surface through the vent shafts. Examples of these vent shafts can be seen in Figure 13.

The number 1, 2 and 3 Shaft areas of the Beatrix mine are depicted in Figure 13 below. The schematic diagram shows the 3 main shafts, the 2 ventilation shafts and the various levels at which underground mining activity occurs. Clean air travels into the mine through the 1, 2 and 3 Shafts and methane-containing air travels out of the mine through the Vent Shaft and the 2B Vent Shaft.

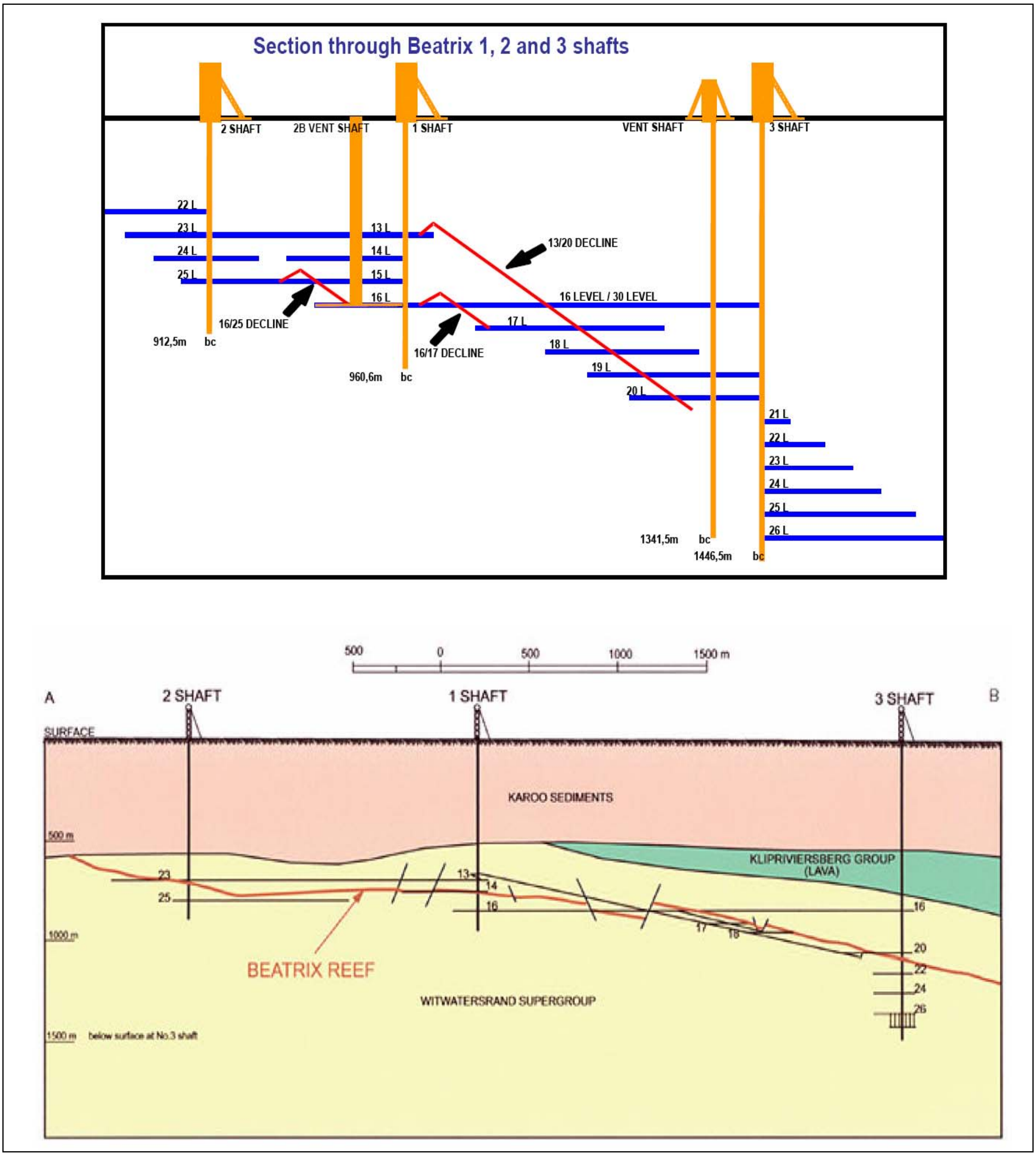

Figure 13: Schematic arrangements of the Beatrix 1, 2 & 3 Shafts ventilation arrangement

Annex 4

MONITORING INFORMATION

From the "Tool to determine project emissions from flaring gases containing methane" (EB 28, Annex 13):

STEP 1: Determination of the mass flow rate of the residual gas that is flared

This step calculates the residual gas mass flow rate in each hour h, based on the volumetric flow rate and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$FM_{RG,h} = \rho_{RG,n,h} \times FV_{RG,h} \qquad \text{(Flaring Tool 1)}$$

Where:

$FM_{RG,h}$	*Mass flow rate of residual gas in hour h (kg/h)*
$\rho_{RG,n,h}$	*Density of residual gas at normal conditions in hour h*
$FV_{RG,h}$	*Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m^3/h)*

And:

$$\rho_{RG,n,h} = \frac{P_n}{\frac{R_u}{MM_{RG,h}} \times T_n} \qquad \text{(Flaring Tool 2)}$$

Where:

$\rho_{RG,n,h}$	*Density of residual gas at normal conditions in hour h*
P_n	*Atmospheric pressure at normal conditions (101,325 Pa)*
R_u	*Universal ideal gas constant (8,314 Pa.m^3/kmol.K)'*
$MM_{RG,h}$	*Molecular mass of the residual gas in hour h (kg/kmol)*
T_n	*Temperature at normal conditions (273.15K)*

And:

$$MM_{RG,h} = \sum_i \left(fv_{i,h} \times MM_i \right) \qquad \text{(Flaring Tool 3)}$$

Where:

$MM_{RG,h}$	*Molecular mass of the residual gas in hour h (kg/kmol)*
$fv_{i,h}$	*Volumetric fraction of component i in the residual gas in the hour h*
MM_i	*Molecular mass of residual gas component i*
i	*The components CH_4, CO, CO_2, O_2, H_2, N_2*

If Flaring Tool 3 is applied to this project activity it becomes:

$$MM_{RG,h} = (fv_{CH4,h} \times MM_{CH4} + fv_{CO} \times MM_{CO} + fv_{CO2} \times MM_{CO2} + fv_{O2} \times MM_{O2}$$
$$+ fv_{H2} \times MM_{H2} + fv_{N2} \times MM_{N2})$$

(Flaring Tool 3.1)

Where:

$fv_{CH4,h}$	Volumetric fraction of methane in the residual gas in the hour h
$fv_{CO,h}$	Volumetric fraction of CO in the residual gas in the hour h
$fv_{CO2,h}$	Volumetric fraction of CO_2 in the residual gas in the hour h
$fv_{O2,h}$	Volumetric fraction of O_2 in the residual gas in the hour h
$fv_{H2,h}$	Volumetric fraction of H_2 in the residual gas in the hour h
$fv_{N2,h}$	Volumetric fraction of N_2 in the residual gas in the hour h
MM_{CH4}	Molecular mass of methane (kg/kmol)
MM_{CO}	Molecular mass of CO (kg/kmol)
MM_{CO2}	Molecular mass of CO_2 (kg/kmol)
MM_{O2}	Molecular mass of O_2 (kg/kmol)
MM_{H2}	Molecular mass of H_2 (kg/kmol)
MM_{N2}	Molecular mass of N_2 (kg/kmol)

STEP 2: Determination of the mass fraction of carbon, hydrogen, oxygen and nitrogen in the residual gas

The mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, were calculated from the volumetric fraction of each component i in the residual gas, as follows:

$$fm_{j,h} = \frac{\sum_i fv_{i,h} \times AM_j \times NA_{j,i}}{MM_{RG,h}}$$

(Flaring Tool 4)

Where:

$fm_{j,h}$	*Mass fraction of element j in the residual gas in hour h*
$fv_{i,h}$	*Volumetric fraction of component i in the residual gas in the hour h*
AM_j	*Atomic mass of element j (kg/kmol)*
$NA_{j,i}$	*Number of atoms of element j in the component i*
$MM_{RG,h}$	*Molecular mass of the residual gas in hour h (kg/kmol)*
j	*The elements carbon, hydrogen, oxygen and nitrogen*
i	*The components CH_4, CO, CO_2, O_2, H_2, N_2*

When applied in this project Flaring Tool equation 4 became:

$$fm_{C,h} = \frac{fv_{CH4,h} \times AM_C \times NA_{C,CH4} + fv_{CO,h} \times AM_C \times NA_{C,CO} + fv_{CO2,h} \times AM_C \times NA_{C,CO2}}{MM_{RG,h}}$$

(Flaring Tool 4.1)

Where:

$fm_{C,h}$	Mass fraction of carbon in the residual gas in hour h
$fv_{CH4,h}$	Volumetric fraction of methane in the residual gas in the hour h
$fv_{CO,h}$	Volumetric fraction of CO in the residual gas in the hour h
$fv_{CO2,h}$	Volumetric fraction of CO_2 in the residual gas in the hour h
AM_C	Atomic mass of carbon (kg/kmol)
$NA_{C,CH4}$	Number of atoms of carbon in methane
$NA_{C,CO}$	Number of atoms of carbon in CO
$NA_{C,CO2}$	Number of atoms of carbon in CO_2

$$fm_{H,h} = \frac{fv_{CH4,h} \times AM_H \times NA_{H,CH4} + fv_{H2,h} \times AM_H \times NA_{H,H2}}{MM_{RG,h}}$$ (Flaring Tool 4.2)

Where:

$fm_{H,h}$	Mass fraction of carbon in the residual gas in hour h
$fv_{CH4,h}$	Volumetric fraction of methane in the residual gas in the hour h
$fv_{H2,h}$	Volumetric fraction of H_2 in the residual gas in the hour h
AM_H	Atomic mass of hydrogen (kg/kmol)
$NA_{H,CH4}$	Number of atoms of hydrogen in methane
$NA_{H,H2}$	Number of atoms of hydrogen in H_2
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)

$$fm_{O,h} = \frac{fv_{CO,h} \times AM_O \times NA_{O,CO} + fv_{CO2h} \times AM_O \times NA_{O,CO2} + fv_{O2,h} \times AM_O \times NA_{O,O2}}{MM_{RG,h}}$$

(Flaring Tool 4.3)

Where:

$fm_{O,h}$	Mass fraction of oxygen in the residual gas in hour h
$fv_{CO,h}$	Volumetric fraction of CO in the residual gas in the hour h
$fv_{CO2,h}$	Volumetric fraction of CO2 in the residual gas in the hour h
$fv_{O2,h}$	Volumetric fraction of O2 in the residual gas in the hour h
AM_O	Atomic mass of oxygen (kg/kmol)
$NA_{O,CO}$	Number of atoms of oxygen in CO
$NA_{O,CO2}$	Number of atoms of oxygen in CO_2
$NA_{O,O2}$	Number of atoms of oxygen inO_2
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)

$$fm_{N,h} = \frac{fv_{N2,h} \times AM_N \times NA_{N,N2}}{MM_{RG,h}}$$ (Flaring Tool 4.4)

Where:

$fm_{N,h}$	Mass fraction of carbon in the residual gas in hour h
$fv_{N2,h}$	Volumetric fraction of methane in the residual gas in the hour h
AM_N	Atomic mass of hydrogen (kg/kmol)
$NA_{N,N2}$	Number of atoms of hydrogen in methane
$MM_{RG,h}$	Molecular mass of the residual gas in hour h (kg/kmol)

STEP 3*: Determination of the volumetric flow rate of the exhaust gas on a dry basis*

This step is only applicable if the methane combustion efficiency of the flare is continuously monitored.

Determine the average volumetric flow rate of the exhaust gas in each hour h based on a stoichiometric calculation of the combustion process, which depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas, as follows:

$$TV_{n,FG,h} = V_{n,FG,h} \times FM_{RG,h} \qquad \text{(Flaring Tool 5)}$$

Where:

$TV_{n,FG,h}$	*Volumetric flow rate of the exhaust gas in basis at normal conditions in hour h (m^3/h)*
$V_{n,FG,h}$	*Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in hour h (m^3/h residual gas)*
$FM_{RG,h}$	*Mass flow rate of the residual gas in hour h (kg residual gas/h)*

$$V_{n,FG,h} = V_{n,CO2,h} + V_{n,O2,h} + V_{n,N2,h} \qquad \text{(Flaring Tool 6)}$$

Where:

$V_{n,FG,h}$	*Volume of the exhaust gas of the flare in dry basis at normal conditions per kg of residual gas in the hour h (m3/kg residual gas)*
$V_{n,CO2,h}$	*Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*
$V_{n,O2,h}$	*Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*
$V_{n,N2,h}$	*Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*

$$V_{n,O2,h} = n_{O2,h} \times MV_n \qquad \text{(Flaring Tool 7)}$$

Where:

$V_{n,O2,h}$	*Quantity of O_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*
$n_{O2,h}$	*Quantity of moles O_2 in the exhaust gas of the flare per kg residual gas flared in hour h (kmol/kg residual gas)*
MV_n	*Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)*

$$V_{n,N2,h} = MV_n \times \left\{ \frac{fm_{N,h}}{200 AM_n} + \left(\frac{1 - MF_{O2}}{MF_{O2}} \right) \times \left[F_h + n_{O2,h} \right] \right\} \qquad \text{(Flaring Tool 8)}$$

Where:

$V_{n,N2,h}$	*Quantity of N_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*

MV_n	*Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)*
$fm_{N,h}$	*Mass fraction of nitrogen in the residual gas in hour h*
AM_n	*Atomic mass of nitrogen (kg/kmol)*
MF_{O2}	*O_2 volumetric fraction of air*
F_h	*Stoichoimetric quantity of moles O_2 required for complete oxidation of one kg residual gas in hour h*
$n_{O2,h}$	*Quantity of moles of O_2 in the exhaust gas of the flare per kg residual gas flared in hour h*

$$V_{n,CO2,h} = \frac{fm_{C,h}}{AM_c} \times MV_v \qquad \textit{(Flaring Tool 9)}$$

Where:

$V_{n,CO2,h}$	*Quantity of CO_2 volume free in the exhaust gas of the flare at normal conditions per kg of residual gas in the hour h (m^3/kg residual gas)*
$fm_{C,h}$	*Mass fraction of carbon in the residual gas in the hour h*
AM_C	*Atomic mass of carbon (kg/kmol)*
MV_n	*Volume of one mole of any ideal gas at normal temperature and pressure (22.4 L/mol)*

$$n_{O2,h} = \frac{t_{O2,h}}{\left(1 - \frac{t_{O2,h}}{MF_{O2}}\right)} \times \left[\frac{fm_{C,h}}{AM_c} + \frac{fm_{N,h}}{2AM_N} + \frac{1 - MF_{O2}}{MF_{O2}} \times F_h\right] \qquad \textit{(Flaring Tool 10)}$$

Where:

$n_{O2,h}$	*Quantity of moles O_2 in the exhaust gas of the flare per kg residual flared in hour h (kmol/kg residual gas)*
$t_{O2,h}$	*Volumetric fraction of O_2 in the exhaust gas in the hour h*
MF_{O2}	*Volumetric fraction of O_2 in the air (0.21)*
$fm_{C,h}$	*Mass fraction of C in the residual gas in hour h*
$fm_{N,h}$	*Mass fraction of N in the residual gas in hour h*
F_h	*Stociometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h (kmol/kg residual gas)*
AM_C	*Atomic mass of C (kg/kmol)*
AM_N	*Atomic mass of N (kg/kmol)*

$$F_h = \frac{fm_{C,h}}{AM_C} + \frac{fm_{H,h}}{4AM_H} - \frac{fm_{o,h}}{2AM_O} \qquad \textit{(Flaring Tool 11)}$$

Where:

F_h	*Stociometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in hour h (kmol/kg residual gas)*
$fm_{C,h}$	*Mass fraction of C in the residual gas in hour h*
$fm_{H,h}$	*Mass fraction of H in the residual gas in hour h*
$fm_{O,h}$	*Mass fraction of O in the residual gas in hour h*
AM_C	*Atomic mass of C (kg/kmol)*

AM_H *Atomic mass of H (kg/kmol)*
AM_O *Atomic mass of O (kg/kmol)*

STEP 4: Determination of methane mass flow rate in the exhaust gas on a dry basis

This step is only applicable if the methane combustion efficiency of the flare is continuously monitored. The combustion efficiency will be measured continuously in this project.

The mass flow of methane in the exhaust gas is based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$TM_{FG,h} = \frac{TV_{n,FG,h} \times fv_{CH4,FG,h}}{1,000,000}$$ *(Flaring Tool 12)*

Where:

$TM_{FG,h}$	*Mass flow rate of methane in the exhaust gas of the flare in dry basis at normal conditions in the hour h (kg/h)*
$TV_{n,FG,h}$	*Volumetric flow rate of the exhaust gas in dry basis at normal conditions in hour h (m^3/h exhaust gas)*
$fv_{CH4,FG,h}$	*Concentration of methane in the exhaust gas of the flare in dry basis at normal conditions in hour h (mg/ m^3)*

STEP 5: Determination of methane mass flow rate in the residual gas on a dry basis

The quantity of methane in the residual gas flowing into the flare is the product of the volumetric flow rate of the residual gas ($FV_{RG,h}$), the volumetric fraction of methane in the residual gas ($fv_{CH4,RG,h}$) and the density of methane ($\rho_{CH4,n,h}$) in the same reference conditions (normal conditions and dry or wet basis).

It is necessary to refer both measurements (flow rate of the residual gas and volumetric fraction of methane in the residual gas) to the same reference condition that may be dry or wet basis. If the residual gas moisture is significant (temperature greater than 60ºC), the measured flow rate of the residual gas that is usually referred to wet basis should be corrected to dry basis due to the fact that the measurement of methane is usually undertaken on a dry basis (i.e. water is removed before sample analysis).

$$TM_{RG,h} = FV_{RG,h} \times fv_{CH4,RG,h} \times \rho_{CH4,n}$$ *(Flaring Tool 13)*

Where:

$TM_{RG,h}$	*Mass flow rate of methane in the residual gas in the hour h (kg/h)*
$FV_{RG,h}$	*Volumetric flow rate of the residual gas in dry basis at normal conditions in hour h (m^3/h)*
$fv_{CH4,RG,h}$	*Volumetric fraction of methane in the residual gas on dry basis in hour h*
$\rho_{CH4,n}$	*Density of methane at normal conditions (0.716 kg/ m^3)*

STEP 6: Determination of the hourly flare efficiency

The determination of the hourly flare efficiency depends on the operation of flare (e.g. temperature), the type of flare used (open or enclosed) and, in case of enclosed flares, the

approach selected by project participants to determine the flare efficiency (default value or continuous monitoring)

This project will use an enclosed, continuously monitored flare for the mine methane.

The non-mine methane flare will only have the monitoring equipment necessary to comply with the 90% default flare efficiency. However, the additional continuous monitoring equipment on the non-mine methane flares will be installed if at some stage the capital becomes available to do so.

The tool states that the in case of enclosed flares and continuous monitoring of the flare efficiency, the flare efficiency in the hour h ($\eta_{flare,h}$) is:

- *0% if the temperature of the exhaust gas of the flare (T_{flare}) is below 500 °C during more than 20 minutes during the hour h.*
- *determined as follows in cases where the temperature of the exhaust gas of the flare (T_{flare}) is above 500 °C for more than 40 minutes during the hour h :*

$$\eta_{flare,h} = 1 - \frac{TM_{FG,h}}{TM_{RG,h}} \qquad \textit{(Flaring Tool 14)}$$

Where:

$\eta_{flare,h}$	*Flare efficiency in the hour h*
$TM_{FG,h}$	*Methane mass flow rate in the exhaust gas averaged in a period of time t (kg/h)*
$TM_{RG,h}$	*Mass flow rate of methane in the residual gas in the hour h (kg/h)*

STEP 7: Calculation of annual project emissions from flaring

Project emissions from flaring are calculated as the sum of emissions from each hour h, based on the methane flow rate in the residual gas (TMRG,h) and the flare efficiency during each hour h ($\eta_{flare,h}$), as follows:

$$PE_{flare,y} = \sum_{h=1}^{8760} TM_{RG,h} \times \left(1 - \eta_{flare,h}\right) \times \frac{GWP_{CH4}}{1{,}000} \qquad \textit{(Flaring Tool 15)}$$

Where:

$PE_{flare,y}$	*Project emissions from flaring the residual gas stream in year y (tCO_2e)*
$TM_{RG,h}$	*Mass flow rate of methane in the residual gas in the hour h (kg/h)*
$\eta_{flare,h}$	*Flare efficiency in hour h*
GWP_{CH4}	*Global warming potential of methane valid for the commitment period (tCO_2e/tCH_4)*

<u>Flaring of Mine Methane</u>

Flaring Tool result of Equation 1:

Year	$FM_{RG,h}$	$\rho_{RG,n,h}$	$FV_{RG,h}$
1	1,556.05	0.785885	1,980.00
2	317.37	0.785885	403.84

3	317.37	0.785885	403.84
4	317.37	0.785885	403.84
5	317.37	0.785885	403.84
6	317.37	0.785885	403.84
7	317.37	0.785885	403.84

Flaring Tool result of Equation 2:

Year	$\rho_{RG,n,h}$	P_n	R_u	$MM_{RG,h}$	T_n
1	0.785885	101,325	8,314	17.61	273.15
2	0.785885	101,325	8,314	17.61	273.15
3	0.785885	101,325	8,314	17.61	273.15
4	0.785885	101,325	8,314	17.61	273.15
5	0.785885	101,325	8,314	17.61	273.15
6	0.785885	101,325	8,314	17.61	273.15
7	0.785885	101,325	8,314	17.61	273.15

Flaring Tool result of Equation 3:

Year	$MM_{RG,h}$	$fv_{CH4,h}$	MM_{CH4}	$fv_{CO,h}$	MM_{CO}	$fv_{CO2,h}$	MM_{CO2}	$fv_{O2,h}$
1	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
2	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
3	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
4	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
5	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
6	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02
7	17.61	0.87	16.04	0	28.01	0.00	44.01	0.02

Year	MM_{O2}	$fv_{H2,h}$	MM_{H2}	$fv_{N2,h}$	MM_{N2}
1	32	0	2.02	0.11	28.02
2	32	0	2.02	0.11	28.02
3	32	0	2.02	0.11	28.02
4	32	0	2.02	0.11	28.02
5	32	0	2.02	0.11	28.02
6	32	0	2.02	0.11	28.02
7	32	0	2.02	0.11	28.02

Flaring Tool result of Equation 4:

Year	$fm_{C,h}$	$fv_{CH4,h}$	AM_C	$NA_{C,CH4}$	$fv_{CO,h}$	$NA_{C,CO}$	$fv_{CO2,h}$	$NA_{C,CO2}$	$MM_{RG,h}$
1	0.59	0.87	12	1	0	1	0	1	17.61
2	0.59	0.87	12	1	0	1	0	1	17.61
3	0.59	0.87	12	1	0	1	0	1	17.61
4	0.59	0.87	12	1	0	1	0	1	17.61
5	0.59	0.87	12	1	0	1	0	1	17.61

6	0.59	0.87	12	1	0	1	0	1	17.61
7	0.59	0.87	12	1	0	1	0	1	17.61

Year	$fm_{H,h}$	$fv_{CH4,h}$	AM_H	$NA_{H,CH4}$	$fv_{H2,h}$	$NA_{H,H2}$	$MM_{RG,h}$
1	0.1994	0.87	1.01	4	0	2	17.61
2	0.20	0.87	1.01	4	0	2	17.61
3	0.20	0.87	1.01	4	0	2	17.61
4	0.20	0.87	1.01	4	0	2	17.61
5	0.20	0.87	1.01	4	0	2	17.61
6	0.20	0.87	1.01	4	0	2	17.61
7	0.1994	0.87	1.01	4	0	2	17.61

Year	$fm_{N,h}$	$fv_{N2,h}$	AM_N	$NA_{N,N2}$	$MM_{RG,h}$
1	0.18	0.11	14.01	2	17.61
2	0.18	0.11	14.01	2	17.61
3	0.18	0.11	14.01	2	17.61
4	0.18	0.11	14.01	2	17.61
5	0.18	0.11	14.01	2	17.61
6	0.18	0.11	14.01	2	17.61
7	0.18	0.11	14.01	2	17.61

Year	$fm_{O,h}$	$fv_{O2,h}$	AM_O	$NA_{O,O2}$	$fv_{CO,h}$	$NA_{O,CO}$	$fv_{CO2,h}$	$NA_{O,CO2}$	$MM_{RG,h}$
1	0.03	0.02	16	2	0	1	0.00	2	17.61
2	0.03	0.02	16	2	0	2	0.00	3	17.61
3	0.03	0.02	16	2	0	3	0.00	4	17.61
4	0.03	0.02	16	2	0	4	0.00	5	17.61
5	0.03	0.02	16	2	0	5	0.00	6	17.61
6	0.03	0.02	16	2	0	6	0.00	7	17.61
7	0.03	0.02	16	2	0	7	0.00	8	17.61

Flaring Tool result of Equation 5:

Year	$TV_{n,FG,h}$	$V_{n,FG,h}$	$FM_{RG,h}$
1	35675.10	22.93	1,556.05
2	7276.25	22.93	317.37
3	7276.25	22.93	317.37
4	7276.25	22.93	317.37
5	7276.25	22.93	317.37
6	7276.25	22.93	317.37
7	7276.25	22.93	317.37

Flaring Tool result of Equation 6:

Year	$V_{n,FG,h}$	$V_{n,CO2,h}$	$V_{n,O2,h}$	$V_{n,N2,h}$

1	22.93	1.10	0.20	21.63
2	22.93	1.10	0.20	21.63
3	22.93	1.10	0.20	21.63
4	22.93	1.10	0.20	21.63
5	22.93	1.10	0.20	21.63
6	22.93	1.10	0.20	21.63
7	22.93	1.10	0.20	21.63

Flaring Tool result of Equation 7:

Year	$V_{n,O2,h}$	$n_{O2,h}$	MV_n
1	0.20	0.01	22.4
2	0.20	0.01	22.4
3	0.20	0.01	22.4
4	0.20	0.01	22.4
5	0.20	0.01	22.4
6	0.20	0.01	22.4
7	0.20	0.01	22.4

Flaring Tool result of Equation 8:

Year	$V_{n,N2,h}$	MV_n	$fm_{N,h}$	AM_n	MF_{O2}	F_h	$n_{O2,h}$
1	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
2	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
3	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
4	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
5	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
6	21.63	22.4	17.75%	14.01	0.21	0.25	0.01
7	21.63	22.4	17.75%	14.01	0.21	0.25	0.01

Flaring Tool result of Equation 9:

Year	$V_{n,CO2,h}$	$fm_{C,h}$	AM_C	MV_n
1	1.10	59%	12	22.4
2	1.10	59%	12	22.4
3	1.10	59%	12	22.4
4	1.10	59%	12	22.4
5	1.10	59%	12	22.4
6	1.10	59%	12	22.4
7	1.10	59%	12	22.4

Flaring Tool result of Equation 10:

Year	$n_{O2,h}$	$t_{O2,h}$	$fm_{C,h}$	AM_C	$fm_{N,h}$	AM_N	MF_{O2}	F_h
1	0.01	1%	59%	12	17.75%	14.01	0.21	0.25
2	0.01	1%	59%	12	17.75%	14.01	0.21	0.25

3	0.01	1%	59%	12	17.75%	14.01	0.21	0.25
4	0.01	1%	59%	12	17.75%	14.01	0.21	0.25
5	0.01	1%	59%	12	17.75%	14.01	0.21	0.25
6	0.01	1%	59%	12	17.75%	14.01	0.21	0.25
7	0.01	1%	59%	12	17.75%	14.01	0.21	0.25

Flaring Tool result of Equation 11:

Year	F_h	$fm_{C,h}$	AM_C	$fm_{H,h}$	AM_H	$fm_{O,h}$	AM_O
1	0.25	59%	12	19.87%	1.01	3%	16
2	0.25	59%	12	19.87%	1.01	3%	16
3	0.25	59%	12	19.87%	1.01	3%	16
4	0.25	59%	12	19.87%	1.01	3%	16
5	0.25	59%	12	19.87%	1.01	3%	16
6	0.25	59%	12	19.87%	1.01	3%	16
7	0.25	59%	12	19.87%	1.01	3%	16

Flaring Tool result of Equation 12:

Year	$TM_{FG,h}$	$TV_{n,FG,h}$	$fv_{CH4,FG,h}$
1	80.83	35675.10	2,265.73
2	16.49	7276.25	2,265.73
3	16.49	7276.25	2,265.73
4	16.49	7276.25	2,265.73
5	16.49	7276.25	2,265.73
6	16.49	7276.25	2,265.73
7	16.49	7276.25	2,265.73

Flaring Tool result of Equation 13:

Year	$TM_{RG,h}$	$FV_{RG,h}$	$fv_{CH4,RG,h}$	$\rho_{CH4,n}$
1	1,232.58	1,980.00	87%	0.716
2	251.40	403.84	87%	0.716
3	251.40	403.84	87%	0.716
4	251.40	403.84	87%	0.716
5	251.40	403.84	87%	0.716
6	251.40	403.84	87%	0.716
7	251.40	403.84	87%	0.716

Flaring Tool result of Equation 14:

Year	$\eta_{flare,h}$	$TM_{FG,h}$	$TM_{RG,h}$
1	0.934422	80.83	1,232.58
2	0.934422	16.49	251.40
3	0.934422	16.49	251.40
4	0.934422	16.49	251.40

5	0.934422	16.49	251.40
6	0.934422	16.49	251.40
7	0.934422	16.49	251.40

Flaring Tool result of Equation 15:

Year	$PE_{flare,y}$	$TM_{RG,h}$	$\eta_{flare,h}$	GWP_{CH4}
1	8,718.00	1,232.58	0.93	21
2	3,032.76	251.40	0.93	21
3	3,032.76	251.40	0.93	21
4	3,032.76	251.40	0.93	21
5	3,032.76	251.40	0.93	21
6	3,032.76	251.40	0.93	21
7	3,032.76	251.40	0.93	21

The "Tool to calculate baseline, project and/or leakage emissions from electricity consumption" (EB 39, Annex 7, Version 01)

Project Emissions from Electricity Consumption for Mine Methane

During the project case, grid electricity and captive electricity (electricity generated by the project) will be required for the capture, transportation, compression and utilisation or destruction of the mine methane ($PE_{ELEC,y}$). In order to calculate $PE_{ELEC,y}$, the "*Tool to calculate baseline, project and/or leakage emissions from electricity consumption*" must be applied. This tool provides the procedure to estimate the project emissions associated with the consumption of electricity.

Applying this tool:

Scenario C applies to the proposed project activity. Scenario C is presented below (verbatim text is in ***italics***):

"Scenario C: Electricity consumption from the grid and (a) fossil fuel fired captive power plant(s).

One or more fossil fuel fired captive power plants operate at the site of the electricity consumption source. The captive power plant(s) can provide electricity to the electricity consumption source. The captive power plant(s) is/are also connected to the electricity grid.

Hence, the electricity consumption source can be provided with electricity from the captive power plant(s) and the grid".

Scenario C was selected as the electricity consumed by the proposed project activity will be sourced either from the grid or from the captive power plant (the project).This captive power plant will be connected to the grid. Hence, it will not be possible to determine how much of the electricity consumed in the project case is sourced from the captive power plant and how much is purchased from the grid.

Furthermore, Case C.I applies (*italic* text is verbatim from the tool):

"Case C.I: Grid electricity. The implementation of the project activity only affects the quantity of electricity that is supplied from the grid and not the operation of the captive power plant. This applies, for example,

- *If at all times during the monitored period the total electricity demand at the site of the captive power plant(s) is, both with the project activity and in the absence of the project activity, larger than the electricity generation capacity of the captive power plant(s); or*
- *If the captive power plant is operated continuously (apart from maintenance) and feeds any excess electricity into the grid, because the revenues for feeding electricity into the grid are above the plant operation costs; or*
- *If the captive power plant is centrally dispatched and the dispatch of the captive power plant is thus outside the control of the project participants."*

Case C.I. applies since the implementation of the project activity will only affect the quantity of electricity that the Beatrix mine imports from the grid and not the operation of the captive power plant. The total electricity demand at the Beatrix mine, which is the site of the captive power plant, is always larger than the electricity generation capacity of the plant.

- The total electricity demand of Beatrix is approximately 864,000MWh/year.
- The total captive generation ability is 5.38 installed MW electrical.

The captive power plant will be operated continuously (apart from maintenance) and the electricity generated by the plant will be dispatched centrally. The dispatch of the electricity will be outside the control of the Gold Fields' Beatrix mine.

Since, Scenario C.I applies to the project activity; the electricity emission factor can be calculated using either Option A1 or Option A2.

Option A1 was selected in order to calculate the electricity emission factor. Option A1 states (verbatim test in italics):

"Option A1: Calculate the combined margin emission factor of the applicable electricity system, using the procedures in the latest approved version of the "Tool to calculate the emission factor for an electricity system" ($EF_{EL,j/k/l,y} = EF_{grid,CM,y}$)."

The identified term, $EF_{grid,CM,y,}$ refers to Step 6 of the "Tool to calculate the emission factor for an electricity system" (version 01), which states (verbatim text in *italics*):

"Step 6. Calculate the combined margin emissions factor

The combined margin emissions factor is calculated as follows:

$$EF_{grid,CM,y} = EF_{grid,OM,y} \times w_{OM} + EF_{grid,BM,y} \times w_{BM}$$

(Equation 13 in the "Tool to calculate the emission factor for an electricity system")

$EF_{grid,BM,y}$	=	*Build margin CO_2 emission factor in year y (tCO_2/MWh)*
$EF_{grid,OM,y}$	=	*Operating margin CO_2 emission factor in year y (tCO_2/MWh)*
w_{OM}	=	*Weighting of operating margin emissions factor (%)*
w_{BM}	=	*Weighting of build margin emissions factor (%)*

- *Wind and solar power generation project activities: w_{OM} = 0.75 and w_{BM} = 0.25 (owing to their intermittent and non-dispatchable nature) for the first crediting period and for subsequent crediting periods.*

- *All other projects: w_{OM} = 0.5 and w_{BM} = 0.5 for the first crediting period, and w_{OM} = 0.25 and w_{BM} = 0.75 for the second and third crediting period, unless otherwise specified in the approved methodology which refers to this tool."*

The default value of w_{OM} = 0.5 and w_{BM} = 0.5 will be used.

The electricity emission factor is then used to determine the project emissions due to electricity consumption by the proposed project activity. These emissions can be determined by applying Equation 1 from the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption," version 01:

$$PE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EL,j,y} \times \left(1 + TDL_{j,y}\right)$$

(Equation 1 from the "Tool to calculate, project and/or leakage emissions from electricity consumption)

Where:

$PE_{EC,y}$	Project emissions from electricity consumption in year y (tCO_2/yr)
$EC_{PJj,y}$	Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year)
$EF_{EL,j,y}$	Emission factor for electricity generation for source j in year y (tCO_2/MWh)
$TDL_{j,y}$	Average technical transmission and distribution losses for providing electricity to source l in year y
j	Sources of electricity consumption in the project
l	Leakage sources of electricity consumption

This equation could then be applied to this project taking into account that the sources of electricity (j) will only be the national grid.

There will be one source of electricity consumption in the project. Hence, 'j' will be one. Applied to this project, Equation 1 becomes:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{EL,y} \times (1 + TDL_{y})$$

A default of 3% was used for the average technical transmission and distribution losses for providing electricity ($TDL_{j,y}$). A default was chosen as there is no recent, accurate and reliable data available within South Africa. The 3% was used since the electricity consumption by the proposed project activity is smaller than the electricity consumption of all the baseline electricity consumption sources.

From "Tool to calculate baseline, project and/or leakage emissions from electricity consumption":

Equation 1:

Year	$PE_{EC,y}$	$EC_{PJ,j,y}$	$EF_{EL,j,y}$	$TDL_{j,y}$

2009	1,732.08	1,648.66	1.02	3%
2010	4,666.05	4,441.32	1.02	3%
2011	4,666.05	4,441.32	1.02	3%
2012	4,666.05	4,441.32	1.02	3%
2013	4,666.05	4,441.32	1.02	3%
2014	4,666.05	4,441.32	1.02	3%
2015	4,666.05	4,441.32	1.02	3%

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