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

CONTENTS

Annexes

SECTION A. General description of project activity

A.1 Title of the project activity:

EnviroServ Chloorkop Landfill Gas Recovery Project.
Revision 5.
05/02/2007

A.2. Description of the project activity:

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The EnviroServ Chloorkop Landfill Site has been used for the disposal of municipal solid waste since 1997, receiving 1 500 to 1 700 tons of waste per day (or approximately 396 000 to 448 800 tons per annum; assuming 22 workdays per month). This is based on recorded tonnage data from 1997 to December 2006 with a gap in 2002. Waste accepted includes general (or domestic) waste, garden waste, soil and builder's rubble.

To date, four cells have been constructed and used for the disposal of waste.

The objective of the project is to extract landfill gas at the Site and combust the landfill gas by flaring. Landfill gas consists of approximately 50% methane, which has a global warming potential 21 times greater than CO_2. Through the destruction of methane, the emissions of greenhouse gas are reduced.

The project will involve the installation of vertical wells and horizontal collectors for the extraction of landfill gas. Vertical wells will be installed by augering into the existing waste body when a cell reaches final grade. Horizontal collectors involve the excavation of trenches into the waste at intermediate intervals before a cell reaches final grade. In both cases, perforated piping will be installed in gravel backfill for collection of landfill gas under a vacuum. The vertical wells and horizontal piping will be connected to one or more headers and a blower for centralized gas collection; the collected gas will be combusted using one or more flares. Vertical wells and pipework will go out on civil tender to a contractor, whilst the horizontal wells will be constructed by Enviroserv. The flare and ancillary equipment will be put out to tender.

It is the intention of EnviroServ to develop a project for utilisation of the landfill gas after better definition of gas quantity and quality, and the investigation of the economic viability and feasibility of alternative uses of the captured gas. Potential uses include direct use for industrial process heating off-site or the generation of electricity for onsite use, sale to a nearby industry, or to the grid.

Project Participants' view on how the CDM project activity contributes to sustainable development

The project contributes to sustainable development in multiple ways:

1. The project will result in foreign direct investment through the purchase of certified emission reductions by one or more overseas buyers. In addition, the project will contribute to economic

development by creating new markets and/or strengthening existing markets within the country for goods and services required by the project.

2. The project will generate jobs, which would not otherwise exist and build capacity, which would not otherwise occur. Landfill personnel will receive training related to the gas recovery operation, which they would not receive otherwise. The project intends to utilise the gas provided that a feasible and viable utilisation project can be developed. Such utilisation will provide additional contribution to sustainable development in the country.

3. The project will reduce pollution. The collection and destruction of methane gas will reduce greenhouse gas emissions and reduce the impact of the landfill operation on air quality. In addition, labour conditions and safety on the Site will be improved due to the reduction in the risk of fire and explosion at the landfill. The capture and destruction of landfill gas trace components will contribute to an improvement in odour nuisances and local air pollution.

4. This CDM project, which will be developed and operated in a careful manner in accordance with the laws and regulations of South Africa, will help to demonstrate to the overseas emissions trading market that South Africa is a prime destination for CDM projects. This will help to attract additional and sustainable foreign direct investment into the country.

A.3. Project participants:

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Name of Party involved ((host) indicated a host Party)	Private and/or public entity(ies) project participants (as applicable)	Kindly indicate if the Party involved wishes to be considered as a project participant (Yes/No)
South Africa (host)	EnviroServ (Pty)Ltd – Private	No
Japan	Japan Carbon Finance Ltd – Private	No

A.4. Technical description of the project activity:

A.4.1. Location of the project activity:

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EnviroServ Chloorkop Landfill, Ekurhuleni Metropolitan Municipality, South Africa

A.4.1.1. Host Party(ies):

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South Africa

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

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Gauteng Province

A.4.1.3. City/Town/Community etc:

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Ekurhuleni Metropolitan Municipality

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

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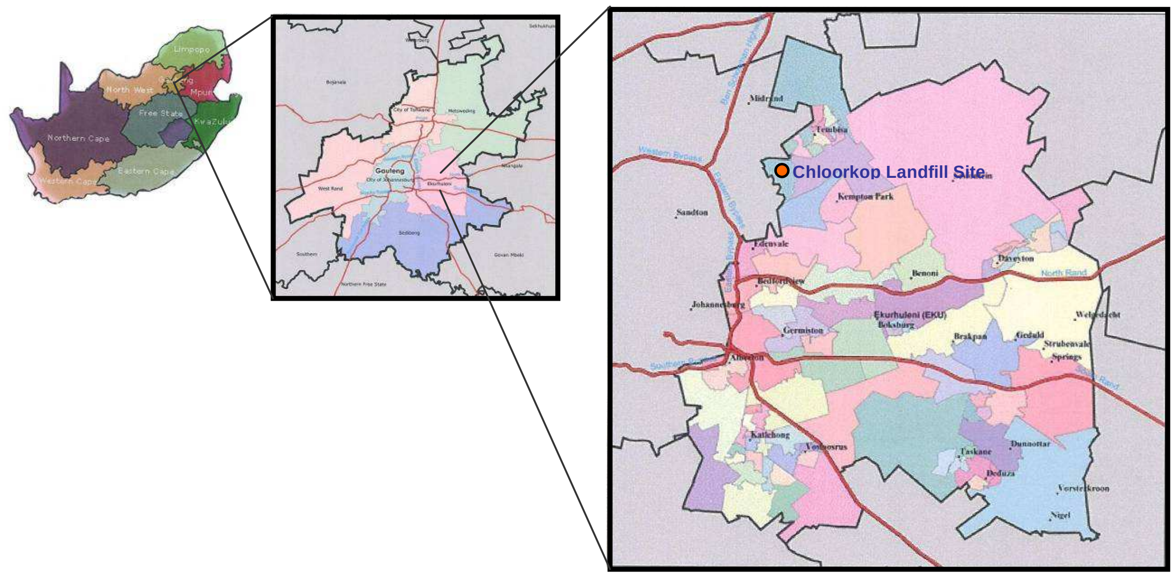
The EnviroServ Chloorkop Landfill Site is situated in the Northern Service Delivery Area of the Ekurhuleni Metropolitan Municipality, which is located in the eastern part of the Gauteng Province. It is approximately 13km from the Johannesburg International Airport, 7 km from the Buccleuch Interchange and 7 km from the Allandale off-ramp from the N1. The closest residential area is Phomolong to the east and Klipfontein View to the west (approximately 0.5 km). The Site is surrounded by industrial areas to the north, south and east.



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

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Waste management, scope 13.

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

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The technology to be employed by the project activity is the installation of vertical wells and horizontal collectors to extract the landfill gas, which will then be flared. The EnviroServ Chloorkop Landfill currently consists of four cells (Cells 1 – 4) where waste has been deposited since 1997. Cell 4 was constructed in 2005 and commissioned for disposal in February 2006. In the period through 2012, another two cells (Cells 5 and 6) will be constructed. Cell 6 will be the final cell of the current Site.

In 2005, six (6) full-scale vertical extraction wells were installed in the existing Cells 1-2. These were constructed for an initial pilot project, which received exemption from the Environmental Impact Assessment (EIA) Regulations from the Gauteng Department of Agriculture, Conservation and Environment (GDACE). The purpose of the pilot project was to provide a better definition of gas quantity and quality.

These pilot wells will be supplemented by additional vertical wells in Cells 1-3 as the existing outer slopes are covered with additional waste and final soil cover. During the development of Cells 4, 5 and 6, horizontal collectors for gas extraction will be installed at two elevations within the waste mass. The captured landfill gas will be destroyed by combustion in a flare. The flare(s) will be a high temperature enclosed flare, which will include:

- condensate knock-out
- blower
- flow control mechanism
- flame arrestor
- burner
- flame detector.

The commercial utilisation of the captured gas will be fully investigated after better definition of gas quantity and quality, as well as after consultation with prospective gas users/customers. Some possible uses of the gas to be fully investigated include generation of electricity for onsite use, sale to a nearby industry, or to the national grid; or direct off-site use of the gas as a replacement for other fossil fuels. Emission reductions as a result of fuel displacement are not included in the project activity and therefore the after use of the captured landfill gas is not considered as part of the project activity.

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

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The estimated emission reductions during the crediting period are as follows:

Years	**Annual estimation of emission reductions in tonnes of CO_2 e**
2007	23 380
2008	107 694
2009	119 204
2010	187 615
2011	254 042
2012	323 360
2013	303 437
Total estimated reductions (tonnes of CO_2 e)	**1 318 732**
Total number of crediting years	**7**
Annual average over the crediting period of estimated reductions (tonnes of CO_2 e)	**188 390**

A.4.5. Public funding of the project activity:

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There is no public funding of the project activity.

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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Version 02 of AM0011 – Landfill gas recovery with electricity generation or no capture or destruction of methane in the baseline scenario.

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

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AM0011 is applicable to projects where:

- The baseline is atmospheric release of the landfill gas;
- There are no regulations governing the landfill gas emissions;
- The captured gas is used to evaporate leachate, generate electricity for on-site use and/or is flared;
- Emissions reductions associated with generation of the displaced electricity do not generate credits.

At the EnviroServ Chloorkop Landfill the baseline is the continuation of the current practice of atmospheric release of the landfill gas (LFG).

The South African environmental guidelines for landfill management are published in a set of documents collectively known as the Minimum Requirements. These guidelines are implemented through landfill permits issued by the Department of Environmental Affairs and Tourism (prior to January 2006 these permits were issued by the Department of Water Affairs and Forestry).

The current guideline relevant to landfills, the *Minimum Requirements for Waste Disposal by Landfill (second edition, 1998)*, are not prescriptive on gas management and do not require gas capture and flaring. Permit Holders of hazardous and large landfills are however required to do gas monitoring and are required to report to the Department if gas levels exceed 1% and to implement venting systems if methane concentrations exceed 5% in air. These requirements are therefore related to health and safety requirements.

The *Minimum Requirements* documents are reviewed every 4-5 years. In the draft third edition that was published for comment in October 2005, the requirements regarding gas management remained unchanged (i.e. gas capturing and flaring is not required). From ongoing discussions with the authorities, it is not foreseen that this requirement will change.

There are no local regulations, which prescribe the capturing and flaring of landfill gas.

The EnviroServ Chloorkop Landfill Gas Project proposes to flare the captured landfill gas and will not claim emission reductions associated with potential other uses such as the generation of electricity. The project complies with the applicability criteria of the approved methodology.

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

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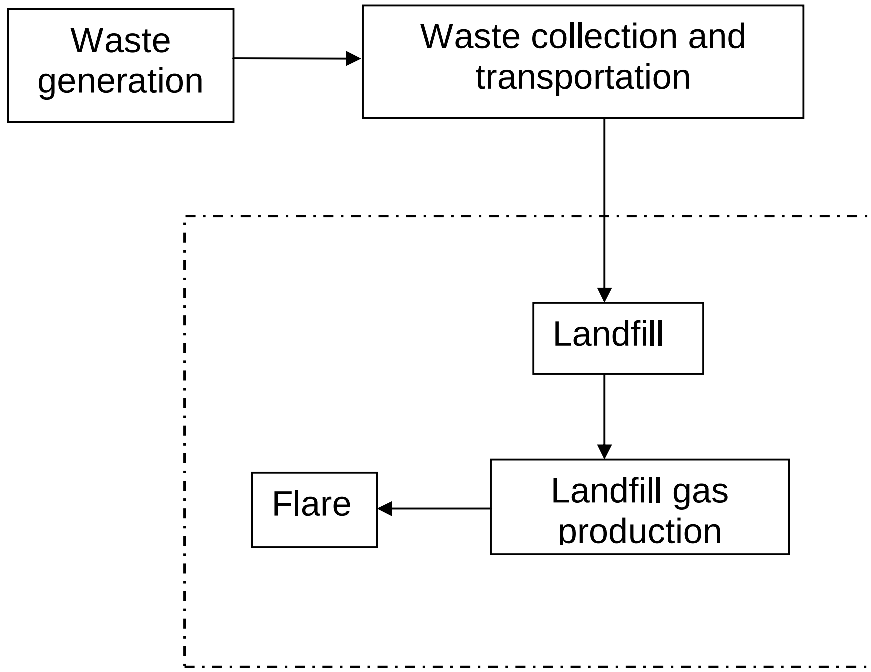
The project boundary of the CDM project activity is the EnviroServ Chloorkop Landfill Site where landfill gas will be captured and destroyed. It consists of the 23 hectare landfill, consisting of a total of six cells, two stormwater dams and a leachate dam, as well as the proposed gas extraction system. This system will include vertical gas extraction wells, horizontal gas collectors, gas collection headers, and blowers/flares for efficient gas collection and combustion. In due course, after further definition of gas quantity and quality, a gas utilisation project is envisioned as discussed above.

The following project activities and emission sources are considered within the project boundaries:

	Source	Gas	Included?	Justification/explanation
Baseline	Landfill (waste body)	CO_2	No	Not considered – part of the natural carbon cycle
		CH_4	Yes	Main component of landfill gas
		N_20	No	Not applicable
Project Activity	Landfill gas capturing and flaring	CO_2	No	Not considered – part of the natural carbon cycle
		CH_4	Yes	Main component of landfill gas
		N_20	No	Not applicable
	Electricity consumption of blowers	CO_2	No	Not considered – part of the natural carbon cycle
		CH_4	Yes	Main component of landfill gas
		N_20	No	Not applicable

The project boundary is indicated in the diagram below.



The emissions from the transport of the waste to the landfill are not taken into account. These emissions are not affected by the project activity and are similar to transport emissions under the baseline scenario.

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

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Methodology AM0011 identifies the baseline as atmospheric release of the landfill gas.

At the EnviroServ Chloorkop Landfill the baseline is the continuation of the current practice of atmospheric release of the landfill gas (LFG).

The South African environmental guidelines for landfill management are published in a set of documents collectively known as the Minimum Requirements. These guidelines are implemented through landfill permits issued by the Department of Environmental Affairs and Tourism (prior to January 2006 these permits were issued by the Department of Water Affairs and Forestry).

The current guideline relevant to landfills, the *Minimum Requirements for Waste Disposal by Landfill (second edition, 1998)*, are not prescriptive on gas management and do not require gas capture and flaring. Permit Holders of hazardous and large landfills are however required to do gas monitoring and

are required to report to the Department if gas levels exceed 1% and to implement venting systems if methane concentrations exceed 5% in air. These requirements are therefore related to health and safety requirements.

There are no local regulations, which prescribe the capturing and flaring of landfill gas.

The EnviroServ Chloorkop Landfill Gas Project proposes to flare the captured landfill gas and will not claim emission reductions associated with potential other uses such as the generation of electricity.

The project complies with the applicability criteria of the approved methodology:

- The baseline is atmospheric release of the landfill gas;
- There are no regulations governing the landfill gas emissions;
- The captured gas is used to evaporate leachate, generate electricity for on-site use and/or is flared;
- Emissions reductions associated with generation of the displaced electricity do not generate credits.

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): >>

Following the guidance of AM0011 the reduction of GHG emissions is demonstrated in two steps. In the first step this PDD describes the additionality of the project. The baseline determination is the second step in this process.

AM0011 proposes a four-step process to demonstrate additionality:

1. Assessment of legal requirements
2. Investment analysis
3. Barrier and common practice analysis (in case project does not pass step 2)
4. Check on credibility of the baseline

Step 1 – Assessment of legal requirements

In South Africa the establishment and operation of landfills is governed by the documents entitled *Minimum Requirements for Waste Disposal by Landfill* through a permitting system in terms of the Environment Conservation Act (Act 73 of 1989). The authority in charge of permitting and enforcement must apply the Minimum Requirements when granting a landfill permit.

The Minimum Requirements prescribe “best practice” in the operation of landfills but are not prescriptive on the measures to be implemented as best practice. The permit granted to the EnviroServ Chloorkop Landfill in 1997 (permit number 16/2/7/A230/D17/Z1/P280 dated 30 October 1997) by the relevant authority, the Department of Water Affairs and Forestry (DWAF), incorporates and confirms this best practice. These documents are not prescriptive regarding the extraction and destruction of landfill gas, but require that monitoring be done to determine if there is a safety concern. In terms of condition 6.1.1, the Permit Holder is therefore required to implement adequate measures to the satisfaction of the Regional Director of the Department of Water Affairs and Forestry to ventilate or

prevent lateral migration of methane gas so that the build-up of dangerous concentrations is prevented. The permit does not prescribe what measures should be implemented. Sections 6.1.2 and 6.1.3 requires that monitoring of flammable gas and carbon dioxide should be conducted. Such monitoring has been done by EnviroServ over the past years, but no landfill gas recovery has been implemented, as it was not required by the authorities.

The EnviroServ Chloorkop Landfill has been operating in compliance with the DWAF permit since 1997. The landfill is pursuing a high sanitary standard and is amongst the best landfills in the country. The landfill design has been optimised to minimise negative effects to the environment. It has been equipped with both a storm water and a leachate collection system. Collected stormwater is recycled on the landfill to reduce dust nuisance, as the climate at Chloorkop is semi-arid.

In South Africa the operation of each landfill is overseen by a site-specific *Monitoring Committee* made up of local, provincial, and national authorities, as well as neighbours and other stakeholders. The Monitoring Committee meets at least once a year to discuss any operational problems or issues, and to monitor compliance with permit conditions. In the case of the EnviroServ Chloorkop Site, the Monitoring Committee and EnviroServ maintain a very cooperative relationship. The EnviroServ Chloorkop Landfill has been complying with requirements suggested by the committee, and the committee has endorsed the current operation of the landfill.

Therefore the current practice at the Chloorkop Landfill complies both with national South African legal guidelines, as well as with local requirements.

The project activity passes step 1 of the additionality test.

Step 2: Investment analysis

This step is to identify a number of alternative business scenarios for the EnviroServ Chloorkop Landfill and evaluate the economic feasibility if **the CDM would not be in place**. This step is to demonstrate the most attractive business case.

No	Scenario	Notes/comments	Assessment
1	No LFG capture (current scenario)	Zero cost.	Likely.
2	Modified amount of LFG is extracted	Significantly less LFG recovery would decrease project viability. No technical basis for assuming significantly more LFG.	Unlikely
3	Air or O_2 injection in the landfill	Was not considered as this can result in internal landfill fires, severe site management difficulties, and high levels of air pollution from the off-gases of uncontrolled subsurface combustion. In	Unlikely

		addition, injecting pure O_2 into a landfill site would be prohibitively expensive.	
4	Changed or changing waste composition	The Chloorkop site is licensed to receive municipal waste until its anticipated closure date in 2012. Therefore, it cannot accept hazardous waste or other types of waste.	Unlikely and prohibited by current regulations.
5	Another on-site LFG use	No realistic potential on-site gas use is known at this time.	Unlikely
6.	Another off-site LFG use	Potential off-site gas use not realistic due to current lack of gas infrastructure and interest by potential gas users in vicinity of site	Unlikely
7.	Project is deferred for five years	Emission reductions have no current value post-2012.	Unlikely
8.	Combinations of the above (2-7).	Since all individual scenarios are unlikely, then the combinations thereof are also unlikely.	Unlikely.
9	LFG capture and utilisation:		
9a	Supply to off-site buyer for use as fuel gas	Limited gas infrastructure in South Africa. Potential buyers limited.	Unlikely.
9b	Electricity generation and supply to national grid	Low electricity prices in South Africa.	Unlikely.
10	LFG capture and flaring (project scenario)	Estimated costs USD 2.4 million.	Unlikely.

Internal rate of return (IRR) and net present value (NPV) financial models were generated for the following scenarios:

- Scenario 10: LFG capture and flaring with the income from the sale of CERs
- Scenario 9: LFG capture and flaring without the income from the sale of CERs
- Scenario 9a: LFG capture and supply to off-site buyer for use as fuel gas, excluding income from sale of CERs
- Scenario 9b: LFG capture with electricity generation and supply to national grid, excluding income from the sale of CERs

The models were developed for duration of years i.e. from 1 July 2007 to 2013 to encompass the remaining term of the CDM. The hurdle rate for profitability and the discount rate for the NPV calculations were taken as the risk free government bond rate (8.75% pa) plus a risk premium of 5% i.e. a total rate of 13.75%.

The results of the models are as follows:

Scenario	IRR	NPV
10: Flaring – with income from sale of CERs	26.2%	0.9M US$
9: Flaring – without income from sale of CERs	Negative	-2.9M US$
9a: Sale of fuel gas to off-site industry	Negative	-1.8M US$
9b: Electricity generation and supply to national grid	Negative	-3.6M US$

These results show that scenario 2 is only financially viable with the income from the sale of CERs. The other scenarios are not financially viable. It is therefore clear that the continuation of the current practice is the economically most attractive course of action if the project could not benefit from the CDM.

The project activity passes step 2 of the additionality test.

EnviroServ will explore the possibility and use of the captured gas, and will explore the use of the benefits of the CERs sold to implement downstream use(s) of the captured gas. EnviroServ will not claim CERs associated with these activities should they prove feasible.

Step 3 – Barrier analysis

Not applicable.

Step 4 – Check on credibility of the baseline

According to AM0011 the DOE should check the credibility of the baseline during validation. The following arguments support this credibility:

- Financing: the baseline scenario is the continuation of the current practice. For EnviroServ as the landfill owner, this is a financially feasible scenario. As discussed above, EnviroServ Chloorkop landfill has been in operation in compliance with its permit since initial waste placement in 1997. The operation of the landfill is financed by waste disposal fees that EnviroServ collects from the municipalities and other parties from which it receives waste.
- Local support: local stakeholders have endorsed the operation of the landfill in its current mode. In South Africa, the involvement of local stakeholders in the operation of a landfill site is well organised. Large landfill sites, including the EnviroServ Chloorkop landfill, have a *Monitoring Committee* which consists of the relevant authorities (local, provincial, and national) and stakeholders including neighbours, surrounding communities, and businesses. This committee meets at least once a year and is also consulted when EnviroServ is considering changes at the landfill. EnviroServ and the Monitoring Committee maintain a cooperative relationship. The Monitoring Committee has endorsed and continues to endorse the current operation of the EnviroServ Chloorkop Landfill.
- Physical obstructions: the area of the Chloorkop landfill is owned by EnviroServ. Currently approximately half of the area of the landfill is used for filling cells 1 – 4. The current operation will continue until anticipated closure in 2017.

- Enforcement of legislation: as discussed above in step 1 of the additionality test, relevant legislation has been enforced in past operations, is currently enforced, and will be enforced in the future. No legislation is anticipated that will require the combustion of landfill gas. This aspect will be monitored on an annual basis.

Conclusion: the project activity passes step 4 of the additionality test. Hence the proposed project activity is considered to be additional.

B.6. Emission reductions:

B.6.1. Explanation of methodological choices:

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According to methodology AM0011, the emission reduction achieved during a given year is the amount of methane destroyed during the year times the approved Global Warming potential value for methane.

The emission reductions are therefore calculated from the measured flows and methane content as follows:

$$ER_y = MDproject_y \ x \ GWP\_CH_4$$

$$MDproject_y = \Sigma Q * C$$

where

ERy	yearly emission reductions (t CO_2e)
MD $project_y$	tons of methane (t CH_4)
GWP_CH_4	The approved Global Warming Potential of methane fir the first commitment period is 21 tCO_2e/tCH_4
Q	volume of landfill gas extracted and destroyed in a year (m^3). At the start of the project all landfill gas will be flared. At a later stage a part of the landfill gas extracted may be applied for power or heat generation, or another use
C	methane concentration in the landfill gas (t/m^3)

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

(Copy this table for each data and parameter)

Data / Parameter:	Lo
Data unit:	Nm^3 landfill gas/kg organic C.
Description:	Theoretical landfill gas generation potential based on the biodegradable organic carbon content of specific waste fractions.
Source of data used:	Van Zanten, B., and Scheepers, M., 1994, Modelling of Landfill Gas Potentials, Report prepared for International Energy Agency (IEA) Expert Working Group on Landfill Gas, published by Technical University of Lulea, Sweden.
Value applied:	1.87
Justification of the choice of data or description of measurement methods and procedures actually applied :	A comprehensive field validation study was performed in the Netherlands in the mid-1990s in which zero order, first order, first order multicomponent, and second order kinetic models for landfill gas generation were compared for 9 full scale Dutch landfills where extensive information on waste inputs and gas recovery was available. This study concluded that a multicomponent model based on the biodegradable organic carbon content of specific waste fractions yielded the smallest deviation from actual field generation and recovery data (+ or – 18-22%).
Any comment:	Many widely-available models for landfill gas generation were developed for regulatory or national inventory purposes, may not have been field validated, and are not appropriate for site-specific landfill gas generation modeling.

Data / Parameter:	k
Data unit:	1/year
Description:	kinetic constant 0.07 (putresible "rapidly" biodegradable fraction of landfilled waste) or 0.04 ("slowly" biodegradable paper fraction of landfilled waste).
Source of data used:	Pipatti, R., and Vieira, S., 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, EXCEL spreadsheet IPCC_ Waste_Model_sb24.
Value applied:	either 0.07 (for "rapidly" biodegradable putresible fraction of landfilled waste) or 0.04 (for "slowly" biodegradable paper fraction of landfilled waste).
Justification of the choice of data or description of measurement methods and procedures actually applied :	The value of 0.07 is the minimum values for k for "dry tropical climate" for the rapidly degradable putresible fraction consisting mainly of food waste while 0.04 is the minimum values for k for "dry tropical climate" for the slowly degradable paper fraction. Using the minimum values adds conservatism to this calculation. See Annex 3 for additional information.
Any comment:	

B.6.3 Ex-ante calculation of emission reductions:

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According to methodology AM0011, the (ex ante) emission reduction estimates are made by projecting the future greenhouse gas emissions of the landfill using a first order kinetic model. These estimates are for reference purposes only, since the emission reductions will be determined (ex post) by metering of the actual quantity of methane captured and used for leachate evaporation, electricity generation or flaring once the project activity is operational.

Baseline emissions

An estimation of the potential landfill gas production has been performed by Landfills +, Inc. using the methodology of Van Zanten and Scheepers (1994)[1]. This methodology is based on a multicomponent first order kinetic model validated at full-scale landfills. Rather than using the total waste mass, this modelling is based on the biodegradable organic carbon content of various waste fractions. The following assumptions were used for the Chloorkop modelling. *(Please note that details of the assumptions for the Baseline information are given in Annex 3)*:

Year	methane production (Nm^3/hr)	methane recovered (Nm^3/hr)	methane emitted to air (Nm^3/hr)	CO_2e/year
2007	2965	-	2965	389 663
2008	3222	-	3222	423 404
2009	3463	-	3463	455 078
2010	3490	-	3490	484 816
2011	3902	-	3902	512 740
2012	4102	-	4102	538 967
2013	3849		3849	505 728
Total				3 310 396

Leakage

AM0011 supposes zero leakages from the project activity.

Predicted emission reductions

The predicted emissions reductions are based on a conservative calculation for the expected mass of methane that can be recovered from the Chloorkop Landfill during the period 2007-2013. Please note that the assumptions for this conservative calculation are described in Annex 3. The baseline emissions are the theoretical total mass of methane produced in the Chloorkop Landfill based on a first order kinetic calculation using the methodology of Van Zanten and Scheepers (1994).

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[1] *Van Zanten, B., and Scheepers, M., 1994, Modelling of Landfill Gas Potentials, Report prepared for International Energy Agency (IEA) Expert Working Group on Landfill Gas, published by Technical University of Lulea, Sweden}*

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

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Year	Estimation of project activity emission (tonnes of CO_2 e)	Estimation of baseline emission (tonnes of CO_2 e)	Estimation of leakage (tonnes of CO_2 e)	Estimation of overall emission reductions (tonnes of CO_2 e)
2007	366 283	389 663	0	23 380
2008	315 710	423 404	0	107 694
2009	335 874	455 078	0	119 204
2010	297 201	484 816	0	187 615
2011	258 699	512 740	0	254 042
2012	215 587	538 967	0	323 360
2013	202 291	505 728	0	303 437
Total (tonnes of CO_2 e)	1 991 645	3 310 396		1 318 732

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

B.7.1 Data and parameters monitored:

(Copy this table for each data and parameter)	
Data / Parameter:	**Q**
Data unit:	m^3
Description:	Total amount of landfill gas collected
Source of data to be used:	Measured value converted to NTP to give Nm^3.
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Expected emission reductions were calculated with the assumption that 75% of the theoretical landfill gas generation could be recovered from the mass of domestic waste in place with active gas extraction in a particular year. (Non-domestic waste was subtracted from the total waste mass before theoretical gas production modeling.) The recovered gas was assumed to contain 40% CH_4 (v/v). Then 50% of the estimated theoretical CH_4 was used to provide a conservative estimation of potential CERs. The 75% recovery figure is conservative based on field determination of the landfill CH_4 mass balance at field scale for 9 landfill cells at 3 sites in France, which was published in 2006 in the peer-reviewed journal, Waste Management *[see Spokas, K., J. Bogner, J. Chanton, M. Morcet, C. Aran, C. Graff, Y. Moreau-le-Golvan, N. Bureau, and I. Hebe, 2006: Methane mass balance at three landfill sites: what is the efficiency of capture by gas collection systems? Waste Management(Elsevier), 26, 516-525.]* Through a combination of intensive field measurements using multiple methods for emissions measurements and supporting laboratory studies, high rates of CH_4 recovery were documented at sites with final soil cover. For

	example, it was shown that only about 1-2 % of the CH_4 production was being emitted and about 97% was being recovered with an active gas extraction system at Montreuil-sur-Barse in eastern France (near Troyes). At Lapouyade (near Bordeaux in southwestern France), a minimum of 94% of the CH_4 production was being recovered at two cells with engineered gas recovery, but for a cell without recovery, 92% of the CH_4 production was being emitted. Based on this study, the default capture rate currently being using by ADEME (the French environment agency) for sites with final soil cover is 85%. This study quantified the following mass balance for each of 9 full-scale field cells at 3 sites with different design and management practices, applying the following mass balance equation to each cell: CH_4 Production = CH_4 Recovered + CH_4 Emitted + Lateral CH_4 Migration + CH_4 Oxidized + ΔCH_4 Storage (all units = mass t^{-1}; from Bogner and Spokas, 1993) *[See Bogner, J., Spokas, K., 1993. Landfill CH_4: rates, fates, and role in global carbon cycle, Chemosphere 26, 366-386.]* The Chloorkop landfill has controlled placement of waste in engineered cells with daily, intermediate, and final cover. Gas collection will be initiated in cells at final grade using vertical wells and then extended with horizontal collectors in areas still undergoing active filling. Gas collection can only be initiated from horizontals after they are covered by approx. 10 m. waste, consistent with best international practice. Thus, given the well-engineered site, 75% can be considered realistic and conservative.
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer. Data will be aggregated monthly and yearly
QA/QC procedures to be applied:	Flow meters will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	The specific type and manufacturer of the flow meter and the calibration procedures to be used will be determined through a tender process yet to be completed. The typical accuracy of thermal mass flow meters is ± 5% or better.

Data / Parameter:	
Data unit:	%, g/m^3 Field gas chromatographs or infrared analytical instruments measure a volumetric mixing ratio for CH_4 in the LFG at field conditions, this mixing ratio is converted to a mass per unit volume at NTP using site-specific temperature and pressure measurements taken concurrently.
Description:	Methane fraction in landfill gas
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected	40% (v/v) Landfill gas which is undiluted with air typically contains 50-60% (v/v) CH_4; therefore an assumption of 40% of theoretical LFG being recovered is

emission reductions in section B.5	conservative.
Description of measurement methods and procedures to be applied:	Measured by semi-continuous gas quality analyser. The % - reading will be calculated to a g/m^3 unit by using the molecular mass of methane and relevant temperature and pressure measurements in the appropriate gas law equations.
QA/QC procedures to be applied:	Gas analyzer will be subject to regular maintenance and calibration to ensure accuracy. See comment below.
Any comment:	The specific type and manufacturer of the gas analyzer and the calibration procedures to be used will be determined through a tender process yet to be completed.

Data / Parameter:	**$LFG_{leachate,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas used for leachate evaporation
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	This parameter becomes relevant only after implementation of destruction methods other than flaring

Data / Parameter:	**$LFG_{electricity,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas used for electricity generation
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer Data will be aggregated monthly and yearly.
QA/QC procedures to	Flow meters will be subject to regular maintenance and calibration to ensure

be applied:	accuracy.
Any comment:	This parameter becomes relevant only after implementation of destruction methods other than flaring

Data / Parameter:	**$LFG_{flared,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas flared
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100% The destruction efficiency of enclosed flared at 1000 deg. C or greater which are combusting CH4 is typically >99%. Therefore, 100% was assumed.
Description of measurement methods and procedures to be applied:	A source test on the enclosed flare will be done twice per year to verify destruction efficiency. The flow (and CH_4 content) of the LFG will be monitored continuously with a flow meter by the project developer as discussed for previous parameters. Data will be aggregated monthly and yearly. In accordance with good international practice, destruction efficiency will also be correlated to flare parameters using site-specific data.
QA/QC procedures to be applied:	Flow meters will be subject to regular maintenance and calibration to ensure accuracy. See comment below.
Any comment:	The specific type and manufacturer of the enclosed flare, flow meter, gas analyzer and the calibration procedures to be used will be determined through a tender process yet to be completed.

Data / Parameter:	**$LFG_{app\ i,y}$**
Data unit:	m^3
Description:	Total amount of landfill gas destroyed in application (e.g. boiler, engine)
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a flow meter by the project developer Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flow meters will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	This parameter becomes relevant only after implementation of destruction methods other than flaring

Data / Parameter:	**FE**
Data unit:	%
Description:	Flare efficiency (combustion efficiency)
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	100% The destruction efficiency of enclosed flares at 1000 deg. C or greater which are combusting CH4 is typically >99%. Therefore, 100% was assumed
Description of measurement methods and procedures to be applied:	The efficiency of the enclosed flare (% of methane completely oxidized by combustion in the flare) will be determined on a quarterly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare shall be applicable for the period up to the next measurement. In case the quarterly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used. Efficiency will be quantified using a source test for unburned hydrocarbons at the enclosed flare under steady state conditions. Procedures will conform to South African and international best practice, but the specific test procedures will be developed in conjunction with sampling ports and other flare-specific considerations
QA/QC procedures to be applied:	Regular maintenance will ensure optimal operation of flares. Flare efficiency will be determined quarterly. If there is significant deviation from the previous reading, the test will be repeated and conditions corrected as needed. If this testing is not performed, the default value of 90% will be assumed.
Any comment:	The specific type and manufacturer of the enclosed flare will be determined through a tender process yet to be completed. It should be noted that enclosed flares are highly efficient for destruction of hydrocarbons and typically give >99% destruction efficiency for CH_4.

Data / Parameter:	**T_{LFG}**
Data unit:	°C
Description:	Temperature of landfill gas
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NTP
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a thermometer by the project developer. Data will be aggregated monthly and yearly.

QA/QC procedures to be applied:	Thermometers will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	This parameter is measured as a QA/QC check

Data / Parameter:	**P_{LFG}**
Data unit:	Pa
Description:	Pressure of landfill gas
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NTP
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a pressure meter. Data will be aggregated monthly and yearly
QA/QC procedures to be applied:	Pressure transducer(s) will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	This parameter is measured as a QA/QC check

Data / Parameter:	**Flare hours**
Data unit:	hours
Description:	Flare working hours
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	Continuous (24 hours/day)
Description of measurement methods and procedures to be applied:	Data will be monitored continuously by the project developer using a clock. Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Clock will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	

Data / Parameter:	**Flare temperature**
Data unit:	°C
Description:	Temperature of flare
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously by the project developer using a thermometer. Data will be aggregated monthly and yearly.
QA/QC procedures to be applied:	Flare thermometer will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	

Data / Parameter:	**EL**
Data unit:	kWh
Description:	Electricity generated
Source of data to be used:	Measured value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	NA
Description of measurement methods and procedures to be applied:	Data will be monitored continuously with a kWh meter
QA/QC procedures to be applied:	Meter will be subject to regular maintenance and calibration to ensure accuracy.
Any comment:	Only applicable if there is any electricity generation in future

Data / Parameter:	EL_{IMP}
Data unit:	kWh
Description:	Electricity consumed by project (blowers)
Source of data to be used:	Measured and calculated value
Value of data applied for the purpose of calculating expected emission reductions in section B.5	0
Description of measurement methods and procedures to be applied:	Measure operating time of blower. Multiply by blower capacity. Multiply by SA grid combined margin to calculate electricity consumed.
QA/QC procedures to be applied:	
Any comment:	Not required in terms of AM0011. Will however be monitored to assess the significance of emissions

B.7.2 Description of the monitoring plan:

>>

The amount of methane will be determined by monitoring the amount of landfill gas, the temperature and pressure of the landfill gas and the percentage methane in the landfill gas.

The regulatory framework will be monitored on an annual basis. In case upcoming regulations in South Africa mandate methane capture and destruction during the crediting period, the baseline scenario and emissions shall be adapted accordingly.

Monitoring as required in terms of the EIA authorisation will also be conducted.

To assure correct monitoring, staff training will involve the following:
To assure correct monitoring, at least two persons will be trained regarding:

- General knowledge of equipment used in the landfill and for landfill gas extraction and monitoring;
- Specialized training with reading and recording data;
- Specialized training regarding calibration of equipment;
- Environmental safety and health, including emergency situations.

Chosen trainees will have a good understanding of the processes and installation technology of the landfill gas extraction.
Verification and training will be initiated in parallel with the first well installations.
An operations and maintenance manual will be developed for the EnviroServ Chloorkop Landfill Recovery Gas Project which is inclusive of environmental safety and health. This manual will include:

- Detailed information on operations
- As-built drawings
- Maintenance procedures
- Equipment drawings and specifications
- Methodologies for monitoring, maintenance of monitoring equipment, and equipment calibration
- Environmental safety and health guidelines and procedures.

Parameters that will be monitored and the frequency of monitoring are described in section B7.1.

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)

>>

Date of completion: 5 October 2006 (Updated 3 February 2007)

Consultant (not to be considered as a project participant):

Climate Focus BV

Rodezand 34
3011 AN ROTTERDAM
The Netherlands
Contact: Mr Adriaan KORTHUIS
Email: cdmchloorkop@climatefocus.com

In conjunction with:

Landfills Plus Inc.

1144 N President St
Wheaton, Illinois 60187 USA
Contact: Jean E. BOGNER, PhD
Email: jbogner@landfillsplus.com

Jones & Wagener Consulting Civil Engineers

PO Box 1434
Rivonia
2128
SOUTH AFRICA
Contact: Mr Jonathan Shamrock
Email: shamrock@jaws.co.za

Ardeer Engineering (Pty)Ltd

PO Box 14
Modderfontein
1645
SOUTH AFRICA
Contact: Mr John Skews
Email: SkewsJ@ardeer.co.za

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 starting date for project implementation will depend on the timing of the approval of the project as a CDM project. The anticipated starting date is July 1, 2007.

The initial installation of six vertical wells in Cells 1-2 as the piloting phase of the project was completed in October 2005.

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

>>
Landfill gas will be produced at the Site for more than 20 years, and the gas extraction and combustion system will remain in place until no longer required.

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:

>>
01/07/2007.

C.2.1.2. Length of the first crediting period:

>>
7 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:

>>

Pollution and degradation will be avoided and the collection and destruction of methane gas will reduce greenhouse gas emissions and reduce the impact of the landfill operation on air quality. This includes odour nuisances, local air pollution, and stratospheric ozone destruction. In addition, labour conditions and safety on the Site will be improved.

The Gauteng Department of Agriculture, Conservation and Environment (GDACE), is the relevant provincial South African authority required an Environmental Impact Assessment (EIA) for this project. As agreed with the authorities at the start of the project, a Scoping Report was prepared with a focus on air quality issues.

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:

>>

Although the project is expected to have a nett positive impact, the competent authority (GDACE) required that an environmental impact assessment be conducted. A detailed Scoping Report was compiled by Synergistics Environmental Services. The main findings and conclusions were as follows:

Findings*:*

No fatal flaws or negative impacts of high significance were identified. The scoping assessment concluded that the benefits of the project far outweigh its costs. The overall benefits of the project include:

- *Direct foreign investment in South Africa through the purchase of CERs by an overseas buyer (the JCF).*
- *The recovery and combustion of methane gas that will result in an improvement of air quality and the reduction of greenhouse gas, thus contributing to more sustainable landfill practices.*
- *There will be a reduction in the ozone depletion potential of the waste disposal facility.*
- *The destruction of the trace gases in landfill gas that will contribute to the reduction of local odour nuisances and an improvement of the air quality.*
- *The reduced ozone depletion potentials and global warming potentials will have positive transboundary impacts as these are global phenomena.*
- *Promotion of local economic development through the creation of a new market and/or strengthening the existing market in South Africa for the equipment and materials required by the project (i.e. piping and flares).*

- *Improved protection of the groundwater resource in the vicinity of the waste disposal facility since the gas extraction wells will be equipped for leachate removal.*
- *EnviroServ's site personnel will receive training related to the gas recovery operation, which they would not receive in the absence of the project.*
- *The project will be developed in accordance with the laws and regulations of South Africa, which would demonstrate to the overseas emissions trading market that South Africa is a prime destination for further CDM projects, thereby attracting additional and sustainable foreign investment into the country.*
- *As a case study, the project may eventually lead to future reductions of greenhouse gas emissions in South Africa through the promotion of future CDM projects.*
- *EnviroServ is committed to investigate the feasibility of future downstream utilisation of the gas or the heat energy generated by the flaring process – this provides the option to create and utilise landfill gas and/or landfill gas energy, which is a renewable source of energy.*
- *EnviroServ is committed to assist with the establishment of a social benefit project.*

Conclusions

The scoping assessment concluded that the project is desirable from an environmental point of view and that it would contribute to sustainable landfill practices.

No information gaps or need for further studies have been identified and, to date, IAPs have not raised any concerns or issues regarding the project. IAPs were provided with the opportunity to review the scoping report (Version 0) for a period of 30 days. No comments were received.

SECTION E. Stakeholders' comments

>>

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

>>

Stakeholder consultation to date has included the following:

<u>Pilot project (2005):</u>

- Letters and the Briefing Paper describing the pilot project and inviting Interested and Affected Parties (I&APs) to become involved were faxed and e-mailed to the Chloorkop Monitoring Committee members and other I&APs on 24 March 2005. The closing date for comments was 19 May 2005.
  - ⇒ The Ekurhuleni Department of Environmental Health sent a letter stating that there was no objection to the proposed project.

  - ⇒ No further comments were received.
- The Pilot Project was discussed at the meeting of the Chloorkop Monitoring Committee held on 16 May 2005.
  - ⇒ No comments were raised regarding the landfill gas extraction project.
- A meeting to discuss the pilot project and expected future phased of the project was held on 17 November 2005. This included a site visit to the pilot project installation.
  - ⇒ The only comment received was a request to share information about CDM projects for landfills owned by the Local Authority.

<u>Full-scale project:</u>
As part of the EIA process the following public consultation was undertaken:

- Advertising the project in a local newspaper on 2 February 2006, inviting Interested and Affected Parties to register with the public consultation office.
- A briefing document with details regarding the proposed project was distributed to the Chloorkop Monitoring Committee during February 2006 and other registered I&APs on request.
- The draft Scoping Report was made available for a period of 30 days (7 April to 8 May 2006) for comment by stakeholders. The availability of the report was advertised in a local newspaper on 30 March 2006 and written notification was sent to the members of the Chloorkop Landfill Monitoring Committee.
- A meeting was held on 18 April 2006 at which the outcome of the impact assessment was discussed. This meeting was advertised in the advertisement placed in the local newspaper on 30 March 2006 and the Monitoring Committee members and registered Interested and Affected Parties were notified by telephone or fax. Only one community member attended the meeting and her main concern was the odours arising from the landfill site and the potential impact of the project on odours.
- No written comments were received from the stakeholders on the Scoping Report.

E.2. Summary of the comments received:

>>
Only one comment was received at the Monitoring Committee meeting held on 18 April 2006. The concern was related to odours from the landfill site.

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

>>
A detailed air quality assessment was done as part of the Scoping Process of the EIA. Odours are expected to improve as a result of the Chloorkop Landfill Gas Recovery project.

Annex 1

CONTACT INFORMATION ON PARTICIPANTS IN THE PROJECT ACTIVITY

Organization:	Japan Carbon Finance Ltd.
Street/P.O.Box:	1-3, KUDANKITA 4-CHOME
Building:	
City:	CHIYODA-KU, TOKYO
State/Region:	
Postfix/ZIP:	102-0073
Country:	Japan
Telephone:	+81-3-5212-8880
FAX:	+81-3-5212-8886
E-Mail:	y-ito@jcarbon.co.jp
URL:	
Represented by:	Mr. Yusuke Ito
Title:	Deal Manager, Carbon Finance Department
Salutation:	Mr.
Last Name:	Ito
Middle Name:	
First Name:	Yusuke
Department:	Carbon Finance Department
Mobile:	+81-90-6538-2951
Direct FAX:	+81-3-5212-8886
Direct tel:	+81-3-5212-8880
Personal E-Mail:	y-ito@jcarbon.co.jp

Organization:	EnviroServ (Pty) Ltd
Street/P.O.Box:	PO Box 232
Building:	
City:	Bedfordview
State/Region:	Gauteng Province
Postfix/ZIP:	2008
Country:	South Africa
Telephone:	+27 11 456 5400
FAX:	+27 11 453 9048
E-Mail:	esmeg@snviroserv.co.za
URL:	www.enviroserv.co.za
Represented by:	Ms Esmé Gombault
Title:	Director
Salutation:	Ms
Last Name:	Gombault
Middle Name:	
First Name:	Esmé

Department:	
Mobile:	+27 82 779 6276
Direct FAX:	+27 11 453 9048
Direct tel:	+27 11 456 5400
Personal E-Mail:	esmeg@enviroserv.co.za

Annex 2

INFORMATION REGARDING PUBLIC FUNDING

Not applicable.

Annex 3

BASELINE INFORMATION

An estimation of the potential landfill gas production has been performed by Landfills +, Inc. using the methodology of Van Zanten and Scheepers (1994). This methodology is based on a multicomponent first order kinetic model validated at full-scale landfills. Rather than using the total waste mass, this modelling is based on the biodegradable organic carbon content of various waste fractions.

The following **assumptions** were used for the Chloorkop modelling:

1. Potential landfill gas (LFG) yield

Landfill gas (LFG) potential yield assumed to be 1.87 Nm^3 landfill gas/kg organic C.

{Reference: *Van Zanten, B., and Scheepers, M., 1994, Modelling of Landfill Gas Potentials, Report prepared for International Energy Agency (IEA) Expert Working Group on Landfill Gas, published by Technical University of Lulea, Sweden.*

2. Total annual LFG production

For each fraction, LFG production in Nm^3 in year t =

1.87*tonnes wastes*1000 (kg/tonne)*organic C fraction*k*e^{-kt}

where k= kinetic constant (1/yr)
and t= time (yr)

The LFG production for each year from the waste inputs for each year was summed to provide the total annual LFG production.

{Reference: *Van Zanten, B., and Scheepers, M., 1994, Modelling of Landfill Gas Potentials, Report prepared for International Energy Agency (IEA) Expert Working Group on Landfill Gas, published by Technical University of Lulea, Sweden}*

This first order multicomponent model was compared with zero order, first order single component, and second order models in a validation study at 9 full-scale landfills in the Netherlands with detailed waste input data, showing the best fit to field LFG production.

3. Kinetic constants

Two fractions were used as the basis for estimating LFG generation from the domestic waste received at the EnviroServ Chloorkop Landfill Site. Only general/domestic waste was assumed

to be biodegradable. Non-domestic waste was subtracted from total waste inputs. Monthly waste inputs from 2005 were projected until closure in 2012. The assumed kinetic constants are given below:

	k (1/yr)
Domestic putresibles	0.07
Domestic paper	0.04

{*Reference*: Minimum values for k for "dry tropical climate" for rapidly degradable putresible fraction consisting mainly of food waste and slowly degradable paper fraction.
Pipatti, R., and Vieira, S., 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste, EXCEL spreadsheet IPCC_ Waste_Model_sb24.
Range for default values from this model are shown below:

Range for k for "dry tropical climate"	**Fraction**
0.07–0.10	Rapidly Degradable: Food, sewage sludge
0.04–0.06	Slowly Degradable: Paper/textile waste

Assumptions for biodegradable organic C content of waste fractions

	dry fraction	Organic C (fraction dry)	k (1/yr)
Domestic putresibles	0.50	0.80	0.07
Domestic paper	0.75	0.40	0.04

Only general/domestic waste assumed to be biodegradable.

Only included gas production in a given year from waste in place that could be "welled" in that year for gas production estimates for the Chloorkop CDM project.

4. Waste inputs

Information on the amount of waste received on the site for 1997 to 2003 was obtained from the Site operator. Data were unavailable for 2002, so data from 2001 and 2003 were averaged. The fraction of general/domestic waste for individual years ranged from 0.8 (2004) – 0.97 (1998). Information for 2005 was based on the monthly average for Jan-Feb. 2005 projected to the end of 2005. Waste inputs for 2006-2012 were assumed to be the same as for 2005 with general/domestic waste = 0.80 of total waste. The fraction of general/domestic waste has been decreasing slightly due to increased inputs of builders' rubble. The Chloorkop Landfill is scheduled to close at the end of 2012. Thus, the assumed waste inputs for 2006-2012 combined with previous years were cross-checked with available remaining airspace using a density of 1.1t/m3 (average historical density).

General (domestic) waste inputs as follows:

Year	Domestic Waste	Waste Total
1997	16412	16412
1998	137125	137125
1999	198239	198239
2000	312867	312867
2001	338733	338733
2002	327923	327923
2003	317114	317114
2004	279566	349457
2005	344429	430536
2006	344429	430536
2007	344429	430536
2008	344429	430536
2009	344429	430536
2010	344429	430536
2011	344429	430536
2012	344429	430536

Cumulative mass of waste= 4683409.41 tonnes and 4257644.92 m^3

Tonnages used

Month	General Waste	Builders Rubble	Clean Ash	Clean Soil	To Cover	To Stockpile
Jan-03	25,977	801	48	814	1,662	0
Feb-03	20,960	3,929	15	1,043	4,986	0
Mar-03	20,326	6,090	10	381	6,481	0
Apr-03	19,333	3,828		452	4,281	0
May-03	21,271	5,061	34	1,705	6,800	0
Jun-03	25,791	324	0	0	324	0
Jul-03	19,138	4,851	25	889	5,765	0
Aug-03	19,121	2,359	29	781	3,169	0
Sep-03	19,888	5,508	17	161	5,685	0
Oct-03	23,971	6,153	11	1,827	7,991	0
Nov-03	22,797	6,286	5	1,819	8,110	0
Dec-03	21,842	2,538	65	1,714	4,318	0
Jan-04	47,513	10,337	123	438	10,898	0
Feb-04	21,756	6,416	16	5,447	11,880	0
Mar-04	26,643	5,877	97	5,001	10,975	0
Apr-04	20,942	3,432	11	3,106	6,549	0
May-04	21,138	4,181	447	1,414	6,043	0
Jun-04	20,118	7,355	653	1,388	9,396	0
Jul-04	19,180	14,764	3	548	15,314	0
Aug-04	18,521	6,267	245	1,504	8,016	0
Sep-04	21,414	7,469	525	449	8,442	0
Oct-04	30,637	476	34	520	1,030	0
Nov-04	24,865	5,597	5	299	5,900	0

Dec-04	26,116	3,597	16	180	3,793	0
Jan-05	27,669	4,610	48	4,207	7,865	1,000
Feb-05	24,173	6,130	36	5,383	9,549	2,000
Mar-05	23,262	4,643	45	3,006	5,693	2,000
Apr-05	24,703	4,415	67	3,225	4,706	3,000
May-05	20,671	7,183	91	3,661	7,936	3,000
Jun-05	22,556	8,948	107	3,209	8,264	4,000
Jul-05	19,287	11,445	114	12,205	19,764	4,000
Aug-05	22,514	5,769	157	1,694	3,619	4,000
Sep-05	23,784	6,997	128	1,062	4,186	4,000
Oct-05	25,077	12,518	101	2,677	9,296	6,000
Nov-05	28,693	11,292	116	2,755	8,163	6,000
Dec-05	28,582	6,315	113	3,627	4,054	6,000
Jan-06	29,366	4,080	90	3,206	1,376	6,000
Feb-06	27,401	3,552	85	6,442	4,078	6,000
Mar-06	27,568	3,976	136	5,464	575	9,000
Apr-06	23,248	4,701	95	8,674	4,471	9,000
May-06	25,350	9,387	130	10,945	11,462	9,000
Jun-06	22,651	10,852	197	7,162	6,033	12,178
Jul-06	22,685	8,683	110	4,008	3,583	9,218
Aug-06	25,267	12,930	408	6,264	3,682	15,920
Sep-06	24,985	14,323	210	6,854	3,479	17,908
Oct-06	31,047	30,784	398	8,406	4,018	35,570
Nov-06	36,978	5,174	286	25,184	5,124	25,520
Dec-06	34,130	4,039	223	11,427	6,132	9,557
TOTAL	**1,180,907**	**326,244**	**5,922**	**182,622**	**304,916**	**209,871**

Cover ratio
1 part cover to 3.87 Parts waste

AS consumed June 03 to Nov 06 900,808

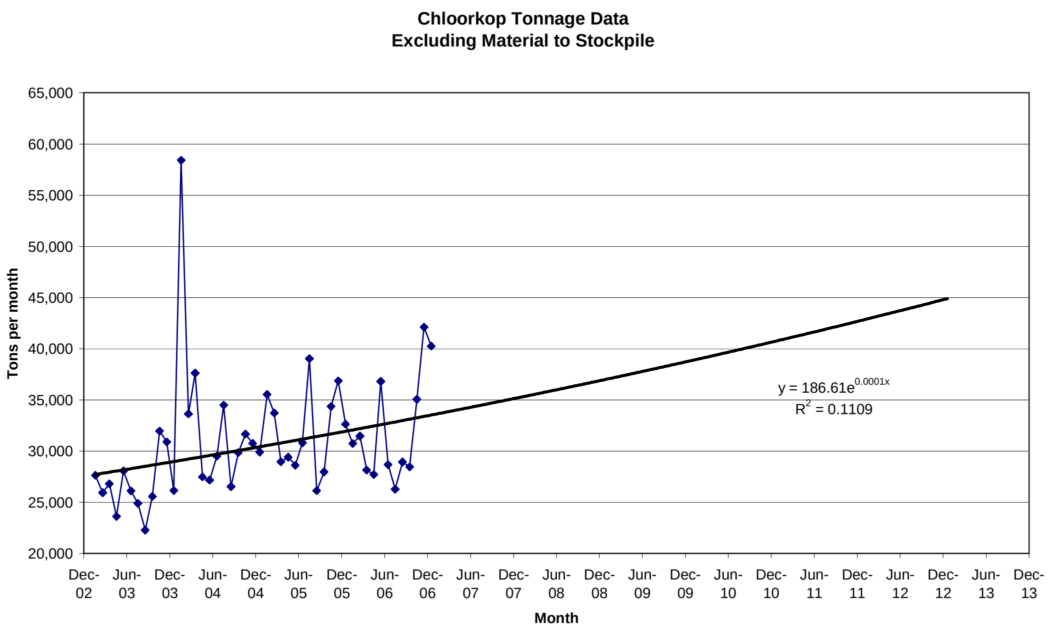
Total Tonnage June 03 to Nov 06 1,287,367

Average density 1.43

Airspace Calculations

Month	Tot AS Consumed	AS Consumed	Tonnage for AS Period	Average Density	Annual Total Tonnage	Annual Domestic	%tage Domestic
Jun-03	1261953						
Dec-03					319988.94	260416.084	81.38
May-04	1435524	173571	346130.36	1.994171607			
Nov-04	1548619	113095	182834.06	1.616641408			
May-05	1678100	129481	186136.24	1.437556398			
Nov-05	1794035	115935	195204.2	1.683738302			
Dec-05					384067.5	290971.98	75.76
May-06	1956741	162706	187530.32	1.152571632			
Nov-06	2162761	206020	189531.896	0.91996843			
Dec-06					384687.896	330675.856	85.96

Graph 1



Comparison of PDD data and most recent data

	PDD information			Site tonnage data		
Year	Domestic waste	Total waste	Percentage Domestic	Recorded Total Tons		Domestic
1997	16,412	16,412	1	16,411		16,411
1998	137,125	137,125	1	137,125		137,125
1999	198,239	198,239	1	198,239		198,239

2000	312,867	312,867	1	312,866		312,866	
2001	338,733	338,733	1	338,732		338,732	
2002	327,923	327,923	1	327,923	*	327,923	
2003	317,114	317,114	1	319,989		319,989	
2004	279,566	349,457	0.8	397,079		317,663	
2005	344,429	430,536	0.8	384,068		307,254	
2006	344,429	430,536	0.8	384,688		307,750	
2007	344,429	430,536	0.8	408,000	**	326,400	
2008	344,429	430,536	0.8	432,000		345,600	
2009	344,429	430,536	0.8	456,000		364,800	
2010	344,429	430,536	0.8	480,000		384,000	
2011	344,429	430,536	0.8	504,000		403,200	
2012	344,429	430,536	0.8	264,000		211,200	site forecast to close in April based on AS consumption rate, use half of the year
2013	344,429	430,536	0.8				
	5,027,838	5,872,694	0.856	5,361,119		4,619,152	

* Data gap, use average between '01 and '03

** Expected closure April 2012 based on latest measured AS consumption data

Tonnage expected based on exponential curve fit to historical tonnage graph

Use June figure as average for year

Year	June	Annual
2007	34000	408000
2008	36000	432000
2009	38000	456000
2010	40000	480000
2011	42000	504000
2012	44000	264000

Total Airspace 4,389,039 This is fixed by site geometry

Total Tonnage	5,361,119	Based on actual up to end 2006, forecast to closure
Calculated density	1.22	
Recorded average density (see Tonnage data sheet)	1.43	
Total tonnage based on recorded density	6,272,485	
Domestic tonnage, assume 80%	5,017,988	

5. Waste fraction characteristics

Chloorkop domestic waste was assumed to be 70% from affluent communities and 30% from non-affluent communities. Assumed waste fraction characteristics were as follows [all mass fractions]:

- **Affluent domestic waste assumed to be 0.45 putresibles [food, garden, etc.] and 0.25 paper.**

  This is based on data from the Benoni area in the Gauteng Province from a study by Shamrock in 1998, which showed that the waste fraction from rich/affluent areas is 0.46 putresibles and 0.24 paper, based on data collected during a comparative study.

- **Non-affluent domestic waste assumed to be 0.20 putresibles and 0.05 paper.**

  This is based on data from the Wattville area from a study by Shamrock in 1998, which showed the waste fraction from poor/non-affluent residential areas is 0.18 putresibles and 0.04 paper.

{Reference: *Shamrock, J.R., 1998, A Comparative Study of the Decomposition Processes and Products of Rich and Poor Refuse in South Africa, M.S. thesis, Faculty of Engineering, University of the Witwatersrand, Johannesburg}.*

The predicted baseline emissions are as follows:

Using the multicomponent first order kinetic mode developed by Van Zanten and Scheepers, the predicted baseline emissions are as follows:

Year	methane production (Nm^3/hr)	CO_2e/year
2007	2965	389 663
2008	3222	423 404
2009	3463	455 078
2010	3490	484 816
2011	3902	512 740
2012	4102	538 967
2013	3849	505 728
Total		3 310 396

Annex 4

MONITORING INFORMATION

The amount of methane will be determined by monitoring the amount of landfill gas, the temperature and pressure of the landfill gas and the percentage methane in the landfill gas.

The regulatory framework will be monitored on an annual basis. Other monitoring as required in terms of the EIA authorisation will also be conducted.

Parameters that will be monitored and the frequency of monitoring are indicated below:

Parameter	Unit	Monitoring frequency	Comment
Amount of landfill gas collected from project wells	m^3	continuous	Measured by a flow meter. Data will be aggregated monthly and yearly
Methane fraction in the landfill gas	% g/m^3	continuous	Measured by continuous gas quality analyser. The % - reading will be calculated to a g/m^3 unit by using the molecular mass of methane and relevant temperature and pressure measurements.
Amount of landfill gas flared	m^3	continuous	Measured by a flow meter. Data will be aggregated monthly and yearly
Combustion efficiency	%	annual	Methane content of flare exhaust gas: The efficiency of the enclosed flare (% of methane completely oxidized by combustion in the flare) will be determined on a yearly basis, with the first measurement to be made at the time of installation. The measured value of the efficiency of the flare shall be applicable for the period up to the next measurement. In case the yearly measurement of efficiency of the flare is not performed, the efficiency of the flare shall be a default value of 90%. If the last measured value of the efficiency of the flare is lower than 90%, then the last lower measured value shall be used.
Combustion efficiency	%	semi-annual, monthly if unstable	Methane content of boiler/engine exhaust gas. Data will be aggregated monthly and yearly
LFG temperature and pressure	°C, Pa	continuous	Thermometer and pressure meter. To monitor the efficiency of the flare. Data will be aggregated monthly and yearly Standard calculations for mass/volume of a given gas at NTP require measurement of gas temperature (in K) and pressure and calculations using standard gas law equations. These measurements and calculations will be performed
Flare working hours	h	continuous	Clock. Data will be aggregated monthly and yearly
Flare temperature	°C	continuous	Thermometer. Data will be aggregated monthly and yearly.

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