Enabling Activities to Facilitate Early Action on the Implementation of the Stockholm Convention on Persistent Organic Pollutants

Final Report

Identification and Quantification of Dioxins and Furans

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List of abbreviations and acronyms

AGOA	-	Africa's Growth and Opportunity Act
APCS	-	Air Pollution Control System
BoS	-	Bureau of Statistics
CHAL		Christian Health Association of Lesotho
Co	-	Company
GDP	-	Gross Domestic Product
GEF	-	Global Environment Facility
HCB	-	Hexachlorobenzene
IEC	-	Information, Education and Communication
IMF	-	International Monitory Fund
LPG	-	Liquefied Petroleum Gas
LRA	-	Lesotho Revenue Authority
NA	-	Not Applicable
ND	-	No Data
NIP	-	National Implementation Plan
OIC	-	Officer-in-Charge
PCB's	-	Polychlorinated biphenyls
PCDD	-	Polychlorinated dibenzo-*para*-dioxins
PCDF	-	Polychlorinated dibenzo furans
PCP	-	Pentachlorophenol
POP's	-	Persistent Organic Pollutants
PVC	-	Polyvinyl chloride

RSA	-	Republic of South Africa
SACU	-	Southern African Customs Union
SADC	-	Southern African Development Community
UN	-	United Nations
WASCO	-	Water and Sewerage Company

Signs and units

g	-	grams
Kg	-	kilogram
L	-	litre
m	-	meter
TEQ	-	Toxic Equivalent

Executive Summary

Based on the classification of the "Standardized Toolkit for Identification and Quantification of Dioxins and Furan Releases", the main categories were identified, and those relevant to Lesotho were picked. Out of the 10 categories, 9 categories were deemed existent in the country; these are presented in table 1 below.

Table 1: Main categories, identifying categories relevant to Lesotho.

Category	Source Category	Relevance to Lesotho
1	Waste Incineration	Yes
2	Ferrous and Non-Ferrous Metal Production	**No**
3	Power Generation and Heating	Yes
4	Production of Mineral Products	Yes
5	Transportation	Yes
6	Uncontrolled Combustion Processes	Yes
7	Production of Chemicals and Consumer Goods	Yes
8	Miscellaneous	Yes
9	Disposal/Land filling	Yes
10	Identification of Potential Hot-Spots	Yes

It was further realized that the burning of waste in many areas is regarded as incineration, which in real technical terms it is not. However, due to lack of another category, the process of burning, particularly medical waste has been treated as incineration. All hospitals in the country were found to have medium technology incinerators.

The category of Power Generation and Heating was considered only as far as household heating and cooking is concerned, and here statistical data from demographic analyses were used to quantify amounts of fuel consumed, hence the emission rates of dioxins and furans.

Transport category was dealt with in two ways, namely, motor vehicle counts, as per the registers of the Traffic Department, and through compiled statistical data on total imports of hydrocarbon fuels.

Activities in the Production of Mineral Products are quiet low, considering that it only applies to Brick production and Asphalt mixing. There are various data gaps in this area and this are discussed in detail in the report.

Regarding uncontrolled combustion processes, there is a serious problem of quantification as there is no way of assessing the frequency of burning. This deals with biomass burning as well as burning of waste, both of which are evidently common in Lesotho. The best option seemed to be a statistical estimation based on probabilistic aspects.

Production of chemicals is non-existent in the country. However the use of chemicals is applicable. This category is therefore considered only in so far as the use of chemicals and consumer goods is concerned. The subcategory deals with textile production since Petroleum industry is covered in transport. In this regard, customs records for a full year export of textile were used as the basis.

There are of course other diverse activities, which were considered under miscellaneous. In this category, the crematorium is not yet in operation, but there are dry cleaners and a lot of tobacco smoking. Emission from biomass has also been considered, and the drying of biomass was extrapolated from the household-heating category.

Under the category of Disposal, landfills and waste dumps, generation rates were estimated using urban demographic statistical data. As part of the study, it was noted that there exists a number of illegal dumpsites, some of which may have been missed, and this encompasses open water dumping as well as composting.

Sewage treatment activity calculations were based on the estimates of generated sewage as adopted by Water and Sewage Company (WASCO). The estimated amount of sewage generated is based on the total water consumption and treatment facilities flow rates.

In all areas visited where activities existed, the extent of contamination, as well as the capacity to manage the activity was used as the basis of proclaiming such areas as hotspots. In as far as by-products are concerned; this was restricted to dumps of wastes/residue from all categories mentioned above.

The total by-products emissions for Lesotho are estimated at 62.0 g-TEQ/a in air, 95.7 g-TEQ/a on products and 121.6 g-TEQ as residues, while emissions on land and water are negligible as shown in **figure 1** below.

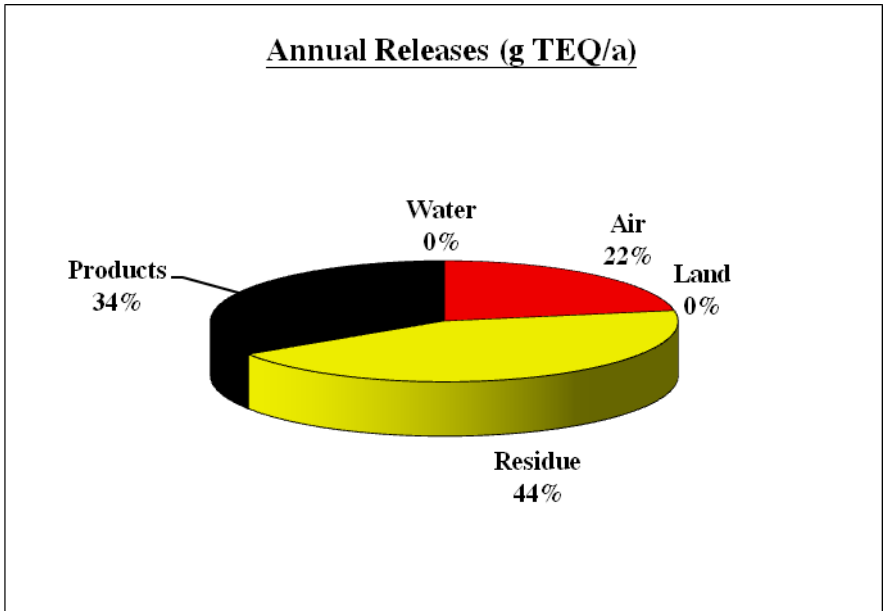

Figure 1: *Graphical presentation of the overall annual releases of dioxins and furans for Lesotho*.

From figure 1 above, release from land and water are far negligible, and represents about 0.0%, hence why it appears as zero on the pie chart. On the

other hand, the bigger portion is contributed by residues that are left after burning waste at illegal and controlled dumping sites.

The dioxins and furans formed through various processes escape into the environment through different pathways/media namely: air, land and water. The escape into the air is brought about by combustion and high temperature thermal process, whereas on land it occurs by adsorption, absorption and leaching on or into the soil. The introduction of dioxins and furans to water could happen in a number of ways. This includes discharge of effluent or contamination with leachate and chemicals containing dioxins and furans. Of the three media, air is the most affected by these releases followed by water and then land. This can be explained by indicating that a lot of waste is burnt due to poor waste management system resulting in gaseous emissions. With water in second place, the contaminants are introduced through effluent from sewage treatment works, leachate from waste disposal sites all of which are operated in an inefficient manner. The land receives little pollution partly because Lesotho does not practice massive organic farming whereby sludge is used to condition the soil.

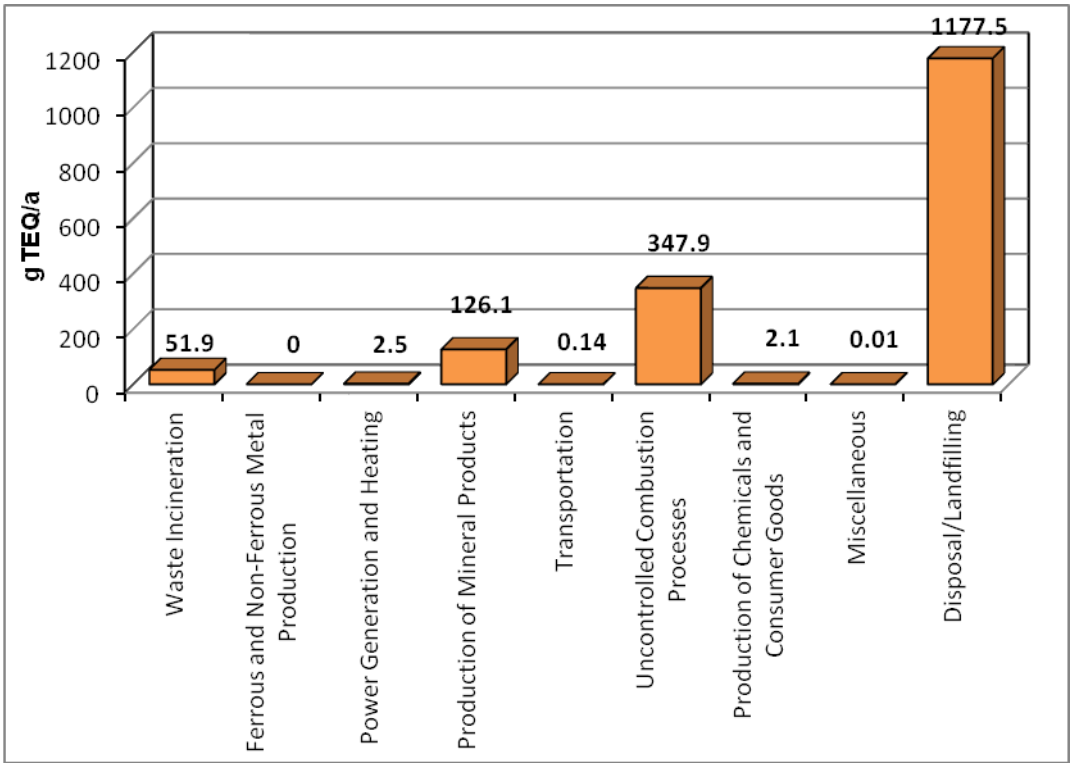

Figure 2: *Graphical presentation of unintentional release of dioxins and furans emissions by main category.*

From **figure 2**, unintentional release of dioxins and furans, by main category, is dominated by waste disposal or landfilling, which is followed by uncontrolled combustion. The other categories produce insignificant releases. From this analysis, it is obvious that when preparing the National Implementation Plan for Management of POPs, with respect to dioxins and furans, dumpsites and landfills should be given the top priority. It is therefore conclusive that dumpsites, landfills and uncontrolled combustion are considered as hotspots. In terms of dumpsites, special attention needs to be given to Ha Tšosane and Maputsoe dumpsites, which cater for all sorts of waste, including industrial waste.

In comparison with other countries (from the toolkit), Lesotho exceeds Uruguay and Jordan in all categories, but is far less than Philippines and Brunei Darussalam, in terms of dioxin and furan releases. A comparison that is understandable, considering the economic levels of these countries. This

therefore indicates a direct correlation of emissions with economic level/activity of the country.

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1.0 Introduction

1.1 General

In the past man used to live in harmony with the nature, such that the environment was able to assimilate the pollution that emanated from his activities. In addition, the amount of pollution and the complexity of pollutants, due to limited industrial development by then, the environment was able to assimilate the pollution arising from various anthropogenic activities and sources. In contrast, in the modern world nature can no longer provide for all man's needs due to his rapidly changing lifestyle. In the process of this changing lifestyle, a lot of his activities have contributed to adverse effects to both human health and the environment.

In the past two to three decades, it was only then that environmental issues were given serious attention at the global level. Amongst the other international environmental conventions or treaties that were set up, of relevance to this subject is the Stockholm Convention on Persistent Organic Pollutants (POPs).

The convention deals with a group of compounds that take a long time to degrade in the natural environment and also bioaccumulates in fatty tissues. They have serious impact on human health as they induce birth defects, cancer and immune deficiencies. In order to protect environmental degradation and safeguard human health was established. The Convention was opened for signature, by Governments, in May 2001. The Convention regulates twelve POPs, which are grouped into pesticides, industrial chemicals and two unintentional by-products emanating from combustion of chlorine-containing products (particularly plastic or polyvinyl chlorine). Annex C of the Convention lists three unintentional by-products (e.g. HCB, PCB's and PCDD/F).

Purpose

The Stockholm Convention was set up to:

- Take international legally binding action (elimination, restricted use, reduction of emissions) against certain persistent organic pollutants.
- Protect human health and environment from potential harm

Dioxins and Furans, more precisely polychlorinated dibenzo-*p*- dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are two of the twelve Persistent Organic Pollutants (POPs) covered by the Stockholm Convention on Persistent Organic Pollutants (POPs). PCDD/PCDF, together with polychlorinated biphenyls (PCB) and hexachlorobenzene (HCB) are unintentional by-products. All POPs as they appear in Annex C (HCB, PCB's PCDD/F) require "continuing minimization and, where feasible, ultimate elimination" (UNEP, 2004).

In view of the foregoing, a project was formulated under Global Environment Facility (GEF) with specific focus on:

- Pesticides
- Polychlorinated biphenyls
- Dioxins and Furans
- Health, awareness and legal aspects on POPs

The aim of this component of the project is to identify and estimate emission quantities of dioxins and furan as released to different media. This data will form the basis upon which the National Implementation Plan (NIP) for Lesotho will be developed.

1.2 Socio-Economic status of Lesotho

Lesotho is a small country with a population of just above 2 million. About 75% of the country is mountainous or foothills and 80% of the population live in the rural areas. The country is demarcated into ten administrative districts, each with its administrative center, which are becoming rather urbanised.

1.2.1 Population distribution

Lesotho is further divided into four ecological zones, namely, Lowlands, Foothills, Mountains and Senqu valley. These zones differ in terms of topography, altitude, climate, number of people and population concentration. Three quarters of the country is mountainous, and the other three zones share the remaining one-quarter. The lowlands have gained a good share of population while the mountains; foothills and Senqu valley effectively lost a share of theirs. The population density, as per 2001 demographic survey, estimates about 71 persons per square kilometer (km^2). This population density estimate includes the mountain areas, which of course are not populated. Therefore, in the lowlands, particularly the urban centers, the population density can be expected to be higher. In fact density on arable land is 531 people per square kilometer, which is a better indicator of distribution of population affected by by-products.

1.2.2 Economic situation

Falling within the category of the 'least developed countries', Lesotho is currently faced with deeper development problems than was the case at the time of independence. The basic challenge facing the country centres on the fundamental need to provide a substantial basis for a better quality of life for all Basotho.

Despite the intensified focus on poverty reduction, the proportion of Basotho households living below the poverty line is estimated at 50 percent of the population. The majority of this population does not have adequate access to basic human needs, with about 40 percent of the labour force currently in search of gainful employment. Preliminary estimates have indicated that, in order to make a significant impact on unemployment figures, approximately 40 000 new jobs will need to be created annually for a sustained period.

Development strategies implemented by the government and involving either five or three-year rolling plans have previously articulated policy direction for

socioeconomic development. Such multipronged policies pursued in the past have not been able to achieve the primary objective of improving the livelihoods of the people of Lesotho. With a pronounced slump recorded in the past decade, economic growth has been erratic and performance has been marked by highly unsustainable short-term successes:

- In first plan period of 1970/1 – 1974/5, GDP average growth of 8 %, attributable to sound performance in agricultural sector;
- In the second plan period of 1975/6 – 1979/80, GDP average growth of 7% resulted from increased diamond mining, large volumes of external assistance, migrant worker remittances, and increase in SACU revenues;
- In period of 1980 – 1990, low GDP growth rate of 3.9% was noted;
- In period of 1990 – 1999, slight rise in GDP growth to 4.2%. This favourable performance was attributable to construction of Lesotho Highlands Water Project as well rapid expansion of manufacturing sector. However, political disturbances in 1998 saw negative GDP growth; and
- Since 1998, when civil and political unrest contributed to an economic recession, Lesotho's economy contracted by 11.5 percent, as measured by real gross national product. With recovery to the level prior to this event expected to be slow, the projected growth rate for 2001/02 stands at only 1.7 percent.

Negative impacts of the economy during these periods resulted from various factors. These included erratic agricultural performance with low levels of job creation, declining migrant labour remittances due to progressive retrenchments, winding down of Lesotho Highlands Water project operational activities, attainment of full production capacity in manufacturing, and a steady increase in population with ever-growing numbers of job seekers. Operational difficulties were also experienced in the country's utility sectors, further discouraging foreign investors and resulting in huge backlogs of unserviced customers.

The 2001/2002 budget proposal were directed at implementing the government's poverty reduction and growth strategy, which is supported by the International Monitory Fund (IMF) through its Poverty Reduction and Growth Facility as well as other development partners. Structural adjustment is focusing investment in those sectors that would have a positive impact on poverty reduction. With priorities carefully identified, resources have been allocated to programmes directed at such reduction, as well as the provision of general public services, building up to reserves for the future, and short to medium-term investments.

Reflecting the present sharp slowdown in global activity and increasing volatility in financial markets, net private investment in emerging market economies is expected to slump significantly during 2001. As with many Africans already resigned to poverty, disease and marginalisation, Lesotho faces a challenging and uncertain external environment.

Lesotho's national income is derived from both domestic economic activity and migrant labour remittances. In order to offset adverse development in the South African mining industry, more investments need to be made in the domestic economy. The country's economy has traditionally been based on subsistence agriculture and animal husbandry, as well as small-scale industries that include clothing, footwear, textiles, food processing and construction. The small but expanding manufacturing base depends largely on farm products to support the milling, canning and jute industries.

Economic sectors such as manufacturing and telecommunications are beginning to show good signs of growth, but much needs to be done to build on this progress. Lesotho's major natural resource is human and water. Water is often referred to as 'white gold' by the Basotho people. Completion of construction phases in the Lesotho Highlands Water Project (LHWP) and establishment of major hydropower facilities are seeing the sale of water to South Africa, generating royalties that are an important source of income for Lesotho.

Along with other developing countries, Lesotho faces a number of risks and threats to its political and socioeconomic development. Through a new national vision, such weakness and issues are being isolated and an effort made to turn them into national capacity. Development objectives of an environment of macroeconomic and political stability, characterized by a sound and coherent policy framework.

Based on free market principles and private ownership, the Lesotho economy presents a relatively open business climate. The government's response to the negative economic developments lies in the formulation of a series of initiatives to correct the growing macroeconomic imbalances and lay the foundation for renewed economic growth:

- Accelerated divestiture of state-owned enterprises;
- Improvement in the domestic financial intervention;
- Increased diversification of the revenue base; and
- Containing of government expenditure through public sector reforms.

2.0 Methodology

When applying the screening matrix the study focused on main source categories and their sub-categories that are applicable to Lesotho. The only category not applicable to Lesotho is Category 2: Ferrous and Non-Ferrous Metal Production. In order to gather the necessary information to assist in compilation of inventories, a number of field visits were undertaken.

2.1 General objective

The objective of the exercise is to identify and quantify Dioxins and Furans sources and their releases in order to develop their inventories in Lesotho. The inventories will then facilitate the development of National Implementation Plan (NIP).

2.2 Study area

The study area covered all districts, with main focus on the administrative centres where the largest population dwells and higher proportion of waste is being generated. The urban/administrative centers may therefore be listed as thus: Mokhotlong, Botha Bothe, Leribe, Berea, Maseru, Mafeteng, Mohale's Hoek, Quthing, Qacha's Nek, Thaba-Tseka, Semonkong, Roma and Maputsoe.

2.3 Method of data and information gathering

2.3.1 Interviews

Interviews were held with relevant stakeholders to secure information appropriate to the study. The consulted stakeholders included, but not confined to officers from the following institutions: Water and Sewerage Authority (WASCO), Public Health, Sub-Accountancy, District Secretaries, Town Clerks, etc. The list of institutions and names of people consulted during the study is provided under acknowledgements. The proprietors were also interviewed regarding the type, use, handling, quantities and acquisition of the solvent or chemical used for dry-cleaning purpose.

2.3.2 Data gathering

The Dioxins and Furans task team was responsible for quantifying the amount of waste disposed of at legal and illegal waste dumpsites, amount waste generated by health facilities (private and government), as well as stabilization ponds operated by WASCO.

During the information/data gathering the team interviewed the persons manning the dumpsites. Data on waste generated by sewage ponds were obtained from the records on the capacity of the different plants, date of commissioning and the daily amount of sewage discharged into the treatment ponds per day.

Data on domestic waste generated and disposed at illegal and legal dumpsites was estimated based on the population size of the Urban Areas and Development Centres.

Some of the data was sourced from the relevant reports acquired from the different sources as listed in section 2.3.5 below.

2.3.3 Physical assessment

Physical assessment was accomplished by making physical site visits to all the relevant sources of wastes generating dioxins and furans. Data was generated from physical site visits to WASCO sewage ponds, Lesotho Correctional Services sewage ponds, artisanal clay brick manufacturers and dumpsites (both legal and illegal). Where data was not readily available from the visited waste sources, estimates of waste disposed or generated was estimated from the information provided by the persons on site.

Physical site visits also assisted in identifying various streams of waste, acquiring geographical location of waste site (in the form of coordinates) and the different sources of different streams of waste.

2.3.4 Records review

Records reviewed as part of the study are vehicle registers at Traffic Departments and Sub-Accountancy of each district with the purpose of categorizing them into different engine capacities and the type of fuel used. The Ministry of Trade and Industry (MTI) provided information regarding the distribution of dry-cleans throughout the country.

2.3.5 Reports

The following reports were reviewed and pertinent information obtained from such reports includes, but not confined to:

- **Health reports** - provided information on tobacco-smoking, healthcare waste, which is ultimately incinerated and other general waste destined for the dumpsites;
- **Statistical reports** – provided information on demographics, household energy consumption and population;
- **Energy reports** – provided data on imported fuel with particular reference to petro-chemical products, such as petrol, diesel, coal, paraffin, LPG, etc; and
- **Lesotho Revenue Authority reports** – provided information on textile exports, with the view to estimating the amount of textile waste generated in the form off-cuts. It is estimated that of the total raw textile material used, only ten percent (10%) of it goes into waste. The estimate is as provided by the textile industry.

3.0 Full country Inventory

The full country inventory is summarized in table 2 below. Annual releases have been calculated following the default emission factors and the data presented in section 5 and elaborated in section 4.

Table 2: By-products emissions, summary for main categories

Cat.	Source Categories	Annual Releases (g TEQ/a)					Totals
		Air	Water	Land	Products	Residue	
1	Waste Incineration	51.60				0.3	51.9
2	Ferrous and Non-Ferrous Metal Production	N/A					
3	Power Generation and Heating	2.525					2.5
4	Production of Mineral Products		126.070				126.1
5	Transportation	0.142					0.1
6	Uncontrolled Combustion Processes	238.011				109.9	347.9

Cat.	Source Categories	Annual Releases (g TEQ/a)					Totals
		Air	Water	Land	Products	Residue	
7	Production of Chemicals and Consumer Goods				2.131		2.1
8	Miscellaneous	0.001				0.01	0.0
9	Disposal/Landfilling		22.999			1154.5	1177.5
1-9	**Total**	**292.3**	**149.1**		**2.1**	**1264.6**	**1708.1**

4.0 Process-by-Process Analysis

Formation of dioxins and furans require *inter alia* presence of Carbon, Chlorine, Oxygen and low temperature (below 800 °c). Favourable conditions for the formation of dioxins and furans are optimal presence of catalysts, such as Copper, Iron and Aluminum.

The PCDD and PCDF releases arise from four types of sources. Three of these are process related:

- Chemical production processes – particularly where chlorinated solvents are used for bleaching;
- Thermal and combustion processes – including incineration of waste, combustion of solid and liquid fuels and the thermal processing of metals; and
- Biogenic processes, which may form PCDD/PCDF from precursors such as pentachlorophenol.

The fourth is related to previous formation:

- Reservoir sources such as historic dumps of contaminated wastes and soils and sediments, which have accumulated PCDD/PCDF over extended periods.

Releases to air include off-gases from:

- Combustion processes;

- Metal processing operations;
- Drying and Baking operations, smoke houses, etc; and
- Other industrial thermal processes.

Releases to water can occur with the discharge of wastewater, run-off from contaminated sites, leachate from waste dumps, dumping of wastes, application of dioxin-contaminated chemicals (e.g. pesticides), etc.

Sources releasing PCDD/PCDF to land can be divided into three classes:

- Contaminated product applied to the land directly; and
- Residue from a process left on or applied to land,
- Or deposited into land via environmental processes.

The following analysis encompasses the situation in all districts through the information acquired during field visits. The analysis and findings will then narrow down on specific waste disposal sites.

4.1 Waste Incineration

The category identifies seven sub-categories. In Lesotho, the only applicable sub-category is medical waste incineration. An attempt by the CHAL and Health sectors has been to erect medical waste incinerators at all major Hospitals in the country. These exist parallel with brick built kilns, which are simple and manually and openly operated. All of the medium technology incinerators installed are no longer properly functioning. They have the same problem of non-functioning fuel jet sprayer. As a result, they are operated manually by applying some diesel on the waste and igniting with matches. This therefore results in incomplete combustion process. The burning temperatures cannot even decompose tougher material like sharps (needles). Instead, combustion is sustained by already burning materials. The medium technology incinerators, at their time of normal functioning were operated by unskilled personnel who do not and had never undergone any induction or training relevant to the field. The same applies

to the kilns, which are currently used to burn medical waste. This may be one of the factors contributing to poor maintenance of kilns and incinerators.

During the data collection, it was evident that the Hospitals have never neither quantified nor estimated medical waste generated. All visited hospitals do not have waste management programme. In this regard, to obtain information on medical waste generated, an attempt was made to let Health Inspectors collect and quantify waste over a period of one month. The data was then extrapolated to cover annual waste generated. While this option is still being pursued, the group decided to engage some published standardized medical waste generation based on empirical studies. This mode makes use of Hospital capacities in terms of beds and occupancy. SA Incinerator Company (Pty) Ltd published amounts of wastes that can be expected to be generated by various facilities. **Table 3** below indicates those values.

Table 3: **Waste expected to be generated per Facility**

Classification	Building types	Quantities of waste produced per day
Industrial Buildings	Factories	Survey must be made
	Warehouses	1 kg per 10 m^2
Commercial Buildings	Office Buildings	0,5 kg per 10 m^2
	Department stores	1,8 kg per 10 m^2
	Shopping centres	Study of plans or survey required
	Supermarkets	4 kg per 10 m^2
	Restaurants	1 kg per meal
	Banks	Study of plans or survey required
Residential	Private homes	2,25 kg basic and 0,5 kg per bedroom
	Flats	2 kg per bedroom
Schools	High schools	3,5 kg per room and 0,12 kg per pupil
	Universities	Survey required
Institutions	Hospitals	2,5 kg per bed
	Nurses or interns homes	1,5 kg per person
	Homes for aged	1,5 kg per person
	Rest homes	1,5 kg per person
Hotels, etc.	Hotels – 1st class	1,5 kg per room and 1 kg per meal
	Hotels – medium class	0,75 kg per room and 0,5 kg per meal
	Motels	1 kg per room
	Caravan parks	3 to 4 kg per caravan
Miscel-laneous	Veterinary hospitals	
	Industrial plants	Study of plans or survey required
	Municipalities	

THE S.A. INCINERATOR CO. HAS SURVEYS ON MINE HOSTELS, ABATTOIRS A, B, C & D GRADE AND HOSPITALS IN MORE DETAIL THAN IS SHOWN HERE.

Based on **table 3** above, the value of 2.5kg per bed was used. Since the goal is to estimate the worst-case scenario, 100% occupancy was assumed more so because some other clinics do exist whose information was not available. Therefore, the information could be inclusive.

4.2 Power Generation, heating and cooking

Category 3 identifies five subcategories, of which only two are considered relevant for Lesotho. These are household heating and cooking with biomass and household heating and cooking with fossil fuels. Power generation in this country is solely hydro driven. Available data in these areas is for the number of households, their average size as well as the percentages relating to type of fuel used. There are no quantities used. For fossil fuels, namely paraffin, LPG and coal, import quantities were used to estimate the total for the country-all households. Some empirical measurements were done to measure the amount of wood that is used by a household per day. Further considering that cooking is a daily chore, the amount of 2.5kg virgin wood was multiplied by the number of households constituting the percentage that uses wood. The other way was to use the energy output of the fuels which were provided by the department of energy. The higher of the two is considered.

4.3 Production of Mineral Products

The only activities within the country relevant to the category are brick production and asphalt mixing. Loti brick is the only company engaged in extensive brick production. The other sector is an informal one where individuals mould and bake lower grade bricks in their backyards. While this sector may not be negligible, they utilize coal ash, first and second hand and finally use coal to bake. Therefore the contribution is covered by the total coal consumption in the country.

Asphalt is used for road construction and would consist of rock chips, sand, fillers bound together in bitumen. There is only one such plant at Ha Tikoe, Maseru, which is a small size operation without cleaning system for gaseous emissions (stack emission). There is no data regarding the amounts of bitumen used, the production is as per the demand of the civil construction industry. However, data on bitumen that was imported into the country is available. This was used to estimate the total asphalt mixing in the country.

4.4 Transport

Data in this category was obtained from the Department of Energy in terms of total imports/consumption of all petroleum products, for the years 2010-2017. An average of these years was taken to reflect annual consumption. A further attempt was made to classify or rather to evaluate the ratios of 2 stroke engines to 4 stroke engines. This was done by direct count of all currently registered vehicles in all districts. The counting was done through the review of vehicle registers in the districts. The absorption factor for unleaded gasoline was estimated to 10% of the total gasoline consumption, based on consumption since 1998 when it was first introduced. The greatest difficulty with 2 stroke engines is that their registration is not legally binding. These are lawn mowers, boats, chain saws, generators etc. As a result they were not quantified. A consideration that their emission factors are much higher than the 4 stroke counterparts, and due to their proximity to users, thereby reflecting a higher risk, their estimated consumption ratio was set at 0.01% in the country.

4.5 Uncontrolled Combustion Processes

In this category, the main consideration was that of waste burning and accidental fires. Biomass burning is covered under household heating and cooking, this includes post harvest residue burning which augments the wood reserve. Even then, regarding accidental fires, there is no data whatsoever and these occurrences are rare in Lesotho. Waste burning was treated as a common activity, it occurs at every dumpsite, in many households and even commercial sites. Since there seem to be no other way of quantifying in a formal sense, some empirical estimates were made. During the country field surveys, a proportion of the dumpsite where there was evidence of burning was recorded relative to the whole dumpsite. It was therefore generally estimated that at least 50% of all generated waste is burnt.

4.6 Production of Chemicals and Consumer Goods

There is neither chemical industry in Lesotho nor any petroleum refinery. Leather tanning has since been closed down. Therefore, the only relevant subcategory is that of textile production which is increasing. Data from customs was in dozens of individual company exports. Once again conversion of those dozens to mass was an empirical exercise of weighing individual products and averaging them to one mass that was used for the year 2003. Releases in products are calculated as upper bound and lower bound limits for the product, simply because there is no way of concluding the final concentration in the final product.

4.7 Miscellaneous

Processes that could not be classified in the main source categories fall here. Of the five identified in the toolkit, dry cleaning and tobacco smoking are considered to be significant. The dry cleaning process uses chloro-hydrocarbon, the total of which is used up and enters the fabric or lost as residue. All dry cleaning establishments gave their consumption in terms of time taken to use up a 200 L per annum. This was converted to mass (using the established density) over a year and emission factor applied.

4.8 Disposal and Land filling

All five subcategories of disposal are relevant for Lesotho. However there is really no way of estimating open water dumping, which is an illegal activity by few desperate people far from the waste dumps. It is also difficult to assess the extent of composting, particularly with the knowledge that people burn everything. Waste oil is not yet treated but sometimes it is burnt for various reasons. The values for waste oil are those calculated based on all oil imported in the country. Eventually all of it is disposed of and destined for air, water, land and residue.

Regarding the sewage, the volumes were available for all stabilization ponds. However, there are no measurements of the rate of inflow. WASA estimates the sewer production through water consumption per connected household. The algorithm used is 80%, which is assumed to end in sewage ponds. There is however a great part of the population, even in urban areas, which is not connected to the sewer line, who use pit latrines and septic tanks. This scenario makes it difficult to estimate the residue. However, the total water consumption in the country was used in this way and the estimate as such, is that of the sewage residue that produces PCDDs/Fs.

5.0 Detailed Supporting data

This section outlines raw data as collected from the source. Sources are noted in the section above.

Category 1: Waste Incineration

Subcategory: Medical waste incineration

Estimated Annual Waste containerization, collection, treatment & disposal before all new refurbished World Bank incinerators coming into use			
Hospital Name	**No. of beds**	**Healthcare waste Kg (including sharps from Health centres)**	**Healthcare waste kg (hospital only)**
Berea Govnt Hospital	49	6, 700	6, 300
Maluti Hospital	63	8,800	8,000
Seboche Hospital	39	4,900	5,000
Botha Bothe Govnt Hospital	45	6,300	5,700
Mamohau Mission Hospital	20	3,800	2,600
Motebang (Leribe) Hospital	101	13,900	12,900
Mafeteng Govnt Hospital	48	7,600	6,100
Botšabelo Leprosy Hospital	3	-	400
Maseru Private Hospital	14	-	1,800
Mohlomi Mental Hospital	23	-	2,900
Queen Elizabeth II Hospital	450	72,000	57,500

Estimated Annual Waste containerization, collection, treatment & disposal before all new refurbished World Bank incinerators coming into use			
Hospital Name	**No. of beds**	**Healthcare waste Kg (including sharps from Health centres)**	**Healthcare waste kg (hospital only)**
Scott Mission Hospital	65	6,500	8,100
St. Joseph's Mission Hospital	51	7,400	6,500
Makoanyane Military Hospital	16	1,900	2,000
Ntšekhe Hospital	42	6,600	5,400
Mokhotlong Govnt Hospital	42	6,100	5,400
Machabeng (Qacha's Nek)	40	5,400	5,100
Tebellong Hospital	18	2,600	2,300
Quthing Govnt Hospital	51	6,900	6,500
St. James Mission (Mantšonyane)	24	3,400	3,100
Paray Mission Hospital	38	5,700	4,900
TOTAL	**1,242**	**176,500**	**158,500**

Extract from COWI Lesotho Healthcare Waste Study Report 2010

Medical waste from hospitals was estimated from the hospital beds capacity. In all hospitals, except Mafeteng Hospital, incinerators were not operational. Some hospitals (such as Quthing, Thaba-Tseka and Mafeteng) managed to collect data on the amounts of waste generated over a period of a week and some extrapolations were made based on the data gathered. The only form of incineration on medical waste was by means of manually operated kilns. The dimensions of these kilns were taken and used in estimating the quantities of medical waste burned.

Category 2: Ferrous and non-Ferrous Metal Production

This category is not applicable to Lesotho, as Lesotho does not manufacture any of the mentioned products.

Category 3: Power Generation and Heating/Cooking

Subcategory: Household heating and cooking and Domestic Heating

Subcategory		Number of households	Energy consumption per household per day (MJ)	Duration (Days)	Aggregate Amount (MJ/a)	TJ/annum
Household heating & cooking	Virgin wood					
	Cow dung					
	Crop residue					
Domestic heating	Coal fired stoves					
	Natural gas fired stoves					
Total						

The Category of Power Generation and Heating was considered only as far as Household heating and cooking and here statistical data from demographic analyses were engaged. The heating values obtained from the department of energy were used for the various fuel sources. For animal waste the value is MJ/Kg, for crop residue, MJ/Kg and for virgin wood it is MJ/Kg remained as data gap on account of time limitations.

Category 4: Production of Mineral Products

Subcategory: Brick production

Subcategory	Material used	Duration	Tonnes/annum
Loti Brick	Clay & coal	Annual	76, 369. 920
Artisanal bricks	Clay & coal dust	Annual	102, 048. 000

Subcategory	Material used	Duration	Tonnes/annum
Totals			178, 417. 920

Activities in the Production of Mineral Products are quiet low considering that it only applies to brick production and Asphalt mixing. There are various data gaps in this area.

Category 5: Transport

Fuel type		Annual Consumption (L)	Density Kg/L	Quantity (t/a)
Gasoline	Leaded	195,388	0.74	144.58712
	Unleaded	567,968	0.74	420,296.32
Diesel		540,964	0.85	36,366
Paraffin		235,904		
Industrial/Heavy oil		No data		
Jet oil		No data		

Transport category was dealt with in two directions, namely vehicular counts as per registers of the traffic departments and through the total import statistics of hydrocarbon fuels.

Category 6: Uncontrolled Combustion Processes

The two subcategories here have been dealt with reference to data in other categories. Biomass combustion uses data on Household heating, category 3, while waste burning falls under category 9 (disposal).

Category 7: Production and Use of Chemicals and Consumer Goods

Subcategory: Textile production

Use of consumer goods was estimated from the Bureau of Statistics data of export textiles for the year 2010- 2017 even though it was expressed in monetary terms.

Category 8: **Miscellaneous**

Subcategory: Tobacco

Reference was made from Bureau of Statistics data on tobacco imports to extrapolate number of cigarettes imported into the country

Subcategory: Dry Cleaning

The subcategories here are tobacco smoking and dry cleaning, the data of which has been captured from the trade data as well as visits to the operating dry cleaners.

The rationale behind this is that most of textile used is heavy textile, which is often hand-washed with water and is mostly used fairly over the winter period. As such, it is expected that the amounts of heavy textile dry-cleaned is relatively low compared to normal textile.

Category 9: **Disposal**

Subcategory: Landfill leachate

All the subcategories in this group needed some data generation, as there is no ready data whatsoever. Some of the data in the form of estimation of relative amounts of waste disposed within a period of one month was collected at all district centers.

On the basis of Lesotho Population Census 2010 the per capita waste generation was estimated at 0.5kg per capita and when this value is multiplied by current urban population (837201) it gives 152, 789.183 tonnes of waste generated per year. This amount is inclusive of all commercial and industrial waste. Most of this waste is destined to dump sites, both legal and illegal. These sites are far from

being landfills and as such rain water drains and leaches directly through them. The amount of rainfall influences the dispersion and concentration of pollutants (dioxins and furans) in both surface runoff and groundwater. In areas with highest rainfall, it would be expected that the contamination would be spread over a wide area but with less concentration. On the other hand where there is less rainfall, pollution would be confined to a small area but in high concentrations. So both instances are detrimental depending on the dosage. It is also worth considering the amount of solid waste that is being drenched by rain for the larger the quantities the more would be the leachate generated.

Subcategory: Sewage/Sewage Treatment

Area	**Type of Treatment**	**Capacity**	**Commissioned**	**Projected full capacity (2010 – 2017)**
MASOWE	Treatment plant	6000m³/d (not yet at full capacity)	Dec 2013	8,760,000 m³
Agric College	Treatment plant	7060m³/d (not yet at full capacity)	July 2013	7,730,700 m³
Ratjomose	Treatment plant	10000m³/d	1980-1993	29,200,000 m³
Industrial Area	Ponds			
Morija				
Mafeteng				
Mohale's Hoek				
Quthing	Lagoon Ponds	80m³/d from Machabeng Hospital (in 2006 study)		233,600 m³
Qacha's Nek				
Thaba Tseka				
Roma				
TY				
Mapoteng				
Maputsoe	Lagoon ponds	103m³/d (in 2006 study)		300,760 m³
Lhotse	Lagoon Ponds	223m³/d (in 2006 study)		651,160 m³
Botha Bothe	Lagoon Ponds	170m³/d (in 2006 study)		496,400 m³

Mokhotlong				-
				47,372,620 m^3
				47,372,620,000ℓ

Maseru has 188, 550m of Sewage Pipeline. 78% of Maseru population uses on site sanitation facilities. The ponds in the districts were initially made to cater for hospitals, however when the towns grew WASCO was given the mandate of operating the ponds, and since then other entities connected to the sewage line.

Type of sanitation facility	**Number of households**
Simple pit latrine	3,842
VIP latrine	6,407
Conservancy Tank	1,591
WASCO Sewer line	53
Biogas / DEWATS	71
No Toilet or latrines at all	487

MASOWE and Agric College ponds have not yet produced significant sludge, the dry beds are empty.

6.0 Data Gaps

6.1 Waste Incineration

- Medical waste data needs to be regenerated. If hospitals could have waste management programme, again for their own performance and environmental aspects and planning. This would go a long a way in assisting in the development of national waste management programmes. Therefore, this data should be regenerated.

6.2 Power Generation and Heating

- The information on exact use of fossil fuels for various categories could not be obtained hence the approach was to use demographics to calculate the percentages. There is a need to further breakdown the data sheets to incorporate all the consumption pathways.
- There are omissions of available data for the years 2012-2013 and 2017.
- There is a sharp increase in the use of gas in the year 2015/16 with no explanation for the rise.

6.3 Production of Mineral Products

This category centers on the production of bricks of which it was found out that the technologies prescribed were not available. The challenge that remains is the development of air quality monitoring standards upon which the data could be generated.

6.4 Transportation

- Statistics on registered vehicles and other fuel consuming machinery from Traffic Department does not cover the fuel type of the car, at least on the register where it was easily accessible. This data would go a long way even on other emission estimates and planning. Statistics on government and foreign missions vehicles is also not available. In addition, a reasonable number of locally used cars still uses foreign registration, mostly RSA registered cars. Statistics on the number of such cars is not available.
- Annual quantities for grease, paraffin, jet oil, motor oil, and solvents could not be calculated because their specific gravities or densities could not be found particularly from the toolkit.

6.5 Uncontrolled Combustion Processes

Information covering classes within this sub-category is not available from the relevant ministries or departments, which were supposed to generate such information.

6.6 Production of Chemicals and Consumer Goods

- The country is not involved in the production of chemicals. However there is an increase in the development of textile activities. The quantification of waste was done on the assumption that 10% of total textile material ends up as off-cuts. There is therefore a need to put in place a waste measurement mechanism in order to establish right quantities.

6.7 Miscellaneous

Processes, such as drying of biomass, operation of cremation and smoke houses do not exist in the country. Therefore, totals for their annual consumption could not be determined.

6.8 Disposal/Landfill

- Amounts of waste that is burnt in households is a real problem, this can only be estimated using some statistical algorithm that would be acceptable.
- Water is one medium that is vulnerable to contamination by dioxins and furans, hence the importance of knowing the amount of leachate produced from a waste disposal facility.

  The quantity of leachate can be computed using Water Balance formulae as follows:

  $Q\ (m^3/year) = P + S - R - aW$

  Where Q = Leachate

P = Precipitation

S = Surface seepage into the landfill

R = Surface run off from the landfill

a = absorptive capacity of waste (m^3/tonne)

W = Weight of waste deposited (tonnes/year)

Unsaturated waste = 35 – 45%

Saturated waste = 50 – 60%

The current practice of waste disposal is such that waste is either discarded indiscriminately or on controlled and illegal dumpsites. In this, an attempt to quantify leachate quantities using the above equation, it was realised that the volumes of surface water entering and leaving the dumpsites were not quantified. Thus, without this information the amount of leachate generated could not be determined.

Other factors to consider, besides the water balance, is the geological characteristics specific for each dumpsite, rate of surface water evaporation from the dumpsites and soil porosity. Geological properties determine the soil characteristics and profile, hence the permeability of the soil. Different soils have different porosity; as such the leaching effect is also likely to differ too. For instance clay soil expands when wet, thereby obstructing percolation of leachate into the ground.

As a result, the information on annual average rainfall of different urban centres could not be of any use, in terms of estimating the amount of leachate caused by rainwater. However, a direct relationship is expected to exist between rainfall and the amount of leachate from dumpsites. In that respect, it suffices to indicate that more leaching effect is expected at highland areas with high precipitation (e.g. Mokhotlong, Qacha’s Nek,

Botha Bothe and Leribe), and leaching is expected to be the least within places with lower rainfall (e.g. Mafeteng and Quthing).

6.9 Potential Hotspots

The previous topics under this chapter were essentially identifying data gaps on activities/processes, which are sources of dioxins and furans. Under this heading, the focus is on the magnitude and severity of the problem. It has been acknowledged that there was no information on the following:

- The amounts of different media (soil, water, air) contaminated with dioxins and furans.
- The rate at which these gases are generated from the identified sources.
- The impact on human health and the environment.

In all areas visited where activities existed, the extent of contamination, as well as the capacity to manage the activity was used as the basis of proclaiming such areas as hotspots. Therefore, from the analysis of our data the study reveals that the biggest contributors of dioxins and furans, as depicted in **figure 1 and 2** above, are:

- Disposal/landfilling (solid waste disposal at dumpsites and sewage sludge from WASCO treatment facilities); and
- Uncontrolled combustion.

The hotspot for dioxins and furans is solid waste disposal at two dumpsites, Ha-Tšosane and Maputsoe (Ha Nyenye). The two sites contribute significantly due to industrial development within the two areas. This is followed by uncontrolled combustion. However, this is not considered to be a hotspot, but due to its relative contribution (in relation to solid waste disposal) it becomes one of the areas which are a cause for concern and therefore needs to be included in the list of priority areas to be addressed by NIP.

7.0 Assessment and Projections

7.1 By products assessments

On the basis of the data analysis, an overall analysis of the status of the country regarding the level of byproducts emissions indicates that the major sources are Uncontrolled combustion and Disposal/land filling. The highest emission is seen as the residue from the sewage ponds in all urban centers. This is so due to non-removal of sludge. The assessment with regard to the most affected people is difficult since the overall population around such hotspots is not known. It was evident from the fieldwork that waste management in Lesotho leaves a lot to be desired. The question is what can we do?

The major contribution of emissions by sewage disposal, may not really indicate the real residue as the ponds are always covered/full, thus it may not be considered as a hot sport.

In the overall, data exists in various places, but in forms not corresponding to the application hereof, and therefore was of no help in this study.

7.2 Survey Analysis

7.2.1 Waste management

Solid waste

In all districts in general terms, the office of the Town Clerk is responsible for the collection and disposal of solid waste for the whole of District town centre. Waste is collected from both businesses and private households, most of which are civil servants residences, though the trend has now changed due to the observed growth of some of our towns.

Waste is collected and disposed of at dumpsites, which have been semi-official for lack of proper planning. These are normally abandoned quarries, which have

not been rehabilitated. There are always other unofficial dumpsites, where individual citizens, mainly businesspersons dump their refuse whenever the Town Clerks' office fails to collect and dispose of the waste.

The Local Government attempts to collect almost on daily basis. However, at times waste piles for up to a week due to transport problems, that is when the Town Council's truck/tractor is broken.

Sewage management

Sewer lines

Water and Sewage Company is countrywide and apart from delivering running water to the town centers, they also maintain the sewage ponds. It was discovered that most of the sewage/stabilization ponds were old as they have been established in the 1980's, not very well maintained and overburdened with load. Despite this fact, not all establishments within the towns are connected to the sewer line. It was often reported that the capacity of the existing line is too low even for current connections, which the authors estimated at less than 15% of all potential establishments.

The sewage ponds ranged from 4 to 6 in number, and arranged in two ways; In series and in parallel (Mokhotlong).

- The sewage delivered by the sewer line into the sewage ponds undergoes a natural treatment process, involving microbiological digestion;
- The resulting sewage effluent from the last pond is then released and flows down the donga or the nearby river; and
- In some cases, as was the case with Mohales-Hoek, well-points for drawing water to be purified for drinking are downstream of the point where effluent from sewage treatment facilities enters the river or stream.

Sewage tanker emptying services

- Sewage that comes by the tanker is emptied in the ponds and the effluent thereof most probably ends up in the neighbouring streams, which are generally tributaries to rivers that finally drain into Mohokare (Caledon) or Senqu (Orange) Rivers, the RSA-Lesotho water systems, contravening the "SADC Protocol on Shared Water Resources".

Medical waste disposal

Ministry of Health is mandated to provide both curative and preventive services nationwide. However, given the demands which exceed the government capacity to satisfy such needs, other stakeholders are also involved in the delivery of health services. Stakeholders referred to here are private doctors and Christian Health Association of Lesotho which operate some clinics and hospitals.

Currently, there are approximately 21 hospitals, 192 health centres. The potential sources of dioxins and furans within these facilities could be found in the following categories of medical waste:

- Biological waste (human tissue)
- Infectious waste (dressing, swabs)
- Sharps (syringes, cartridges)
- Chemical wastes (chemicals & pharmaceuticals)

Given the hazardous nature of medical waste, it requires strict management, which entails the following steps:

- Segregation
- Storage
- Handling
- Transport
- Treatment
- Disposal

During the survey it was found that the above captioned procedural steps were not satisfactorily adhered to due to a number of constraints which are not limited to following:

- Low awareness on the importance of proper management of medical waste.
- Inadequate resources (financial & technical) and human.

For these reasons and others there was no standing monitoring programme on waste generation rates and even the disposal was into medium size incinerators with moderate temperature control, which were also badly sited in relation to proximity to habitable premises. In all the areas that were visited there was a general complaint on health and safety of the workers and the general public with regard to emissions.

On account of poor waste management, some partially treated medical wastes get access to dumping sites where it is burnt thus giving off dioxins and furans. Some sites are located within built up areas in which case communities living in the vicinity of such areas are at high risk of being exposed to dioxins and furan emissions.

7.2.2 Registered motor vehicles and other fuel consuming machinery

At the onset, the teams agreed to collect most of the data in two complementary ways. The reason was that since data if available at any point may very well be in a much tougher form, which may require intensive manipulation in analysis. Records of the registered vehicles in all districts were referenced, and enumeration undertaken. This was a lower level attempt to estimate the petroleum fuel consumption in the country. This data to date has only been used to estimate the proportion of 2 stroke engines to 4 stroke engines.

7.2.3 Dry clean services

Dry cleaning seemed to be a dying business in the early 90's when people changed to jeans and other cotton based textile. A lot of them closed down and a few that are still operational are centered in Maseru. There is only one Dry Clean in Mafeteng (Likhoele Dry Cleaners), which serves Mafeteng, Mohales-Hoek and Quthing. In total we talk of about two or so dry cleaners only.

This industry uses, Perklone (tetrachloroethylene – UN No. 1897, Class 6.1) as the cleaning agent.

- The chemical is supplied without Material Safety Data Sheet. Information on the containers briefly covers warnings, cautions and whom to call in case of emergency.
- The chemical is supplied in either 20 or 200ℓ drums by SASOL Chemicals in Randburg.
- On the average the Dry Cleaners use about 200ℓper annum.
- During the washing process, Perklone is used without water. After continued use, dirty Perklone is distilled internally for reuse.

Steam boilers in the Dry Clean business are currently powered by electricity. The use of coal as a source of fuel has ceased usage.

7.3 Projections

Since the overall environmental management issues are still at infancy stage in Lesotho, and the country is committed to implementing all sustainable development goals; it is a very hopeful situation that plastic materials, used/waste oils and the overall waste management systems are going to be initiated, such that the countries emission contribution will be decreased.

8.0 Sites contaminated with dioxins and furans

Land serves as a sink for dioxins and furans generated through various processes as by-products, which later enter the food chain through uptake by plants and animals. They are released to land in three ways, namely: direct

application of products contaminated with dioxins and furans, to residues from a process left on or applied to land or dioxins and furans deposited to land through environmental processes. Examples of land exposure to dioxins and furans are:

- Use of dioxins and furans contaminated products, e.g. pesticides, wood preservatives;
- Use of sewage sludge or compost to improve soil fertility; and
- Direct disposal of dioxins and furans containing waste on land, e.g. ashes from open burning of waste at dumpsites.

As part of study, the findings revealed the residue disposal in view of exposure to dioxins and furans to be the cause for concern, particularly at all dumpsites where waste is burned.

Topping the list of dumpsites considered as hotspots, are the busiest dumpsites of Maseru and Maputsoe. Maseru (Tšosane dumpsite) and Maputsoe dumpsites also cater for industrial waste. The whole waste management of the county is a potential source to a larger degree than any other activity. In the other districts, there is a lot of illegal dumping which becomes a serious source of contamination into waters. The overall assessment of contaminated sites shall appear on the overall report when all other groups' reports have been reviewed.

9.0 Conclusion

The total by-products emissions for Lesotho are estimated at 62 g-TEQ/a in air, 0 g-TEQ in waters, 95.7 g-TEQ/a on products and 121.6 g-TEQ as residues, while emissions on land are negligible. A detailed record of emission is appended as A**nnex 2**.

The study depicts a close correlation between emissions with economic level/activity of the studied areas. The estimated emissions herein present a rough picture of emission of dioxins and furans generated by different activities in the country. The study adopted a worst-case scenario. Meaning, if a more

accurate and comprehensive study would probably give a lower value(s). Precautionary principle has been applied due to lack of formal data. As such, higher estimates have been used rather than ignoring the situation.

The identified possible shortcomings in data collected are outlined per category as:

Category 1 – The hospital data sourced from the COWI Report does not have data on healthcare waste generated by Queen 'Mamohato Memorial Hospital and a number of new clinics have been opened since the COWI study report of 2013. Due to time constraints, the team was unable to visit the hospital and also to verify the total number of clinics in the country.

Category 2 – Not applicable to this study.

Category 3 – There is no data on household and cooking biomass, though we know our rural area heavily depend on it.

Category 5 – The 50ppm diesel amounting 92, 997L cannot be accounted for as there is no provision in the UNEP toolkit as well as the conversion factor into mass.

Category 6 – Collected data on veldt fires could not be used due to lack of conversion factor.

Category 7 – Not applicable because the activity of chemical production in the country is insignificant.

Category 8 – The data pertaining to chemicals used in dry-cleaning was unreliable due to lack of well-documented records.

Category 9 – Data on daily handling capacity for Qacha's Nek, Thaba-Tseka, Roma, Teyateyaneng, Mapoteng and Mokhotlong sewage ponds was not available from the sewage ponds operator and from the data sourced from the Department of Water Affairs.

Category 10 – There is no primary data on contaminated sites and the study could not identify any potential contaminated sites. Dumpsites are the only potential contaminated site and are covered in category 9.

10.0 Recommendations

It may not be easy to relatively evaluate the levels of emissions that are acceptable. Some of the sources cannot be eliminated. For those that can be, it would be prudent for Lesotho to minimize emissions from such sources. In the foregoing analysis, these recommendations are made, as points of intervention.

- There is a need to establish an effective or standardized waste management system in Lesotho, both for monitoring and control purposes.
- Substitution of products that are known to be precursors of dioxins and furans with those that are non-precursors should be considered. That is to say, use of plastic materials should be discouraged.
- There is a need for awareness-raising throughout all the sectors with regard to Information, Education and Communication (IEC) about dioxins and furans. This would go a long way in minimizing uncontrolled combustion, particularly that of waste in the backyards.
- There is a need to have countrywide readily accessible and up-to-date database for registration of vehicles and other fuel-consuming machinery.
- There is a need to develop or put in place appropriate legislation for regulating various emissions.
- Build capacity to monitor the emissions through human resources development and upgrading of the existing infrastructure (laboratories).

11.0 Work plan for interventions

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Intervention Area 3.3.1 Institutional and regulatory strengthening measure			
Objectives			
To develop Integrated Waste Management Strategy to ensure significant reduction in the releases of dioxins and furans			
Strategies			
To develop Integrated Waste Management Strategy to ensure significant reduction in the releases of dioxins and furans			
Strengthen Environment Act 2008 and other relevant legislations			
Activities			
Develop document on Integrated Waste Management Strategy to cover reduction of dioxins and furans releases from major source categories.	Policy document in place	1 year	GOL: M 45,000
Organize workshops involving interested and affected parties, stakeholders, NGOs, government sectors, academia, community leaders to make input on the development of air quality standards incorporating reduction of dioxins and furans.	Workshop proceedings available	3 months	GOL: M 20,000
Develop regulations under the Environment Act 2008 to address reduction of the release of dioxins and furans.	Regulations in place	1 year	GOL : M 10,000
Develop advert discouraging smoking in public places	Advert on discouraging smoking in public places in place	6 months	GOL: M 4,500
Intervention Area 3.3.7 Measures to reduce releases from unintentional production			
Objective			
To implement measures and procedures for the identified source categories that will significantly reduce releases of dioxins and furans			
Strategy			
Develop/formulate a legal framework for major activities (vehicle, factories) that emit dioxins and furans			
Activities			
Update the inventories register by 2020	Updated register available	4 months	GOL : M 25,000

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Develop guidelines and standards (air pollution) for major activities (factories, vehicles) which emit dioxins and furans	Guidelines and standards available	2 years	GOL : M 75,000
Organize workshops involving interested and affected parties, stakeholders, NGOs, government sectors, academia, community leaders to make input on the development of air quality standards incorporating reduction of dioxins and furans.	Workshop proceedings available	6 months	GOL: M 30,000
Review of the set bench marks	Targets achieved	Yearly	GOL: M 30,000
Intervention 3.3.8 Measures to reduce releases from stockpiles and wastes			
Objective			
To implement cleanup systems and proper waste management for stockpiles and waste of potential releasers of Dioxins and Furans			
Strategies			
I. Develop guidelines and standards for reducing dioxins and furans from stockpiles and waste			
II. Carry out regular inspections/audits of the stockpiles and waste to ensure compliance with set standards			
Activities			
Develop guidelines for proper management of waste disposal sites	Management guidelines developed and available	6 months	GOL : M 45,000
Set guidelines for remediation/rehabilitation of sites contaminated with dioxins and furans	Rehabilitation guidelines set and available	3 months	GOL : M 45,000
Organize workshops involving interested and affected parties, stakeholders, NGOs, government sectors, academia, community leaders to make input on the development of air quality standards incorporating reduction of dioxins and furans.	Workshop proceedings available	6 months	GOL: M 30,000
Conduct periodic audits of the source categories of dioxins and furans significant to Lesotho once every 2 years	Audit reports available	1 year	GOL: M 230,000

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Draw a maintenance programme for sewage ponds addressing different scenarios.	Sewage ponds maintenance programme in place	3 months	GOL & WASCO: M 120,000
Intervention Area 3.3.9 identification of stockpiles, articles in use and wastes.			
Objective			
To develop a system with guidelines for identification and classification of all source categories from which dioxins and furans are emitted.			
Strategies			
Adopt international and regional guidelines on the harmonisation and classification systems			
Update the Lesotho dioxins and furans inventory in order to develop a system with guidelines to adequately identify all source categories of dioxins and furans			
Activities			
Check documents and statistical records on the amounts of stockpiles, articles in use and wastes that may lead to release of dioxins and furans	Documents and statistical records retrieved and amounts verified	1 month	GOL : M 20,000
Undertake mapping exercise and quantify stockpiles and wastes	Maps produced and records of quantities compiled	1 year	GOL : M 170,000
Intervention Area 3.3.10 Management of stockpiles and appropriate measures for handling and disposal of articles in use			
Objective			
To implement cost-effective and sanitary waste disposal systems			
Strategy			
Adopt internationally set standard operating procedures (SOPs) and manufacturer's codes and guidelines for reduction of dioxins and furans			
Activities			
Promote use of alternatives to plastic bags at chain stores/supermarkets	Use of alternatives (paper bags, bring your own bag etc) mostly practiced	2 years	GOL & Private Sector : M 250, 000
Undertake study tour to Rwanda to learn best practices on plastic use elimination	Tour report	1 week	GOL : M 450,000
Set structures and promote segregation of all different types of waste at points of generation (industries, households and institutions).	Waste separation system in place and effective	5 years	GOL: M 10,000,000 (Local Authorities)

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Advocate for construction and use of technologically cost-effective waste incinerators or equipment (Air Pollution Control System) that will reduce emission of dioxins and furans when treating medical waste.	Analytical reports showing reduced quantities of dioxins and furans in emissions and residues.	3 years	GOL : M 1,000,000
Adopt Polluter-Pays-Principle from Cradle to Grave	Register of polluters available	2 years	GOL : M 50,000
Apprehend those who litter and practice illegal dumping.	Documented records of offenders prosecuted	5 years	GOL : M 150, 000
Construction of 2 regional sanitary landfills.	2 regional sanitary landfills under construction or in operation	8 years	GOL : M 140,000,000
Produce manuals/handbooks that should be used as guidelines for equipment or activities which burn/incinerate waste with the intend to reduce dioxins and furans	200 manual/handbooks available for boilers and incinerators	1 year	GOL : M 65,000
Validate the manuals	Workshop proceedings	1 week	GOL : M 35,000
Intervention Area 3.3.11 Identification of contaminated sites (annex c) and remediation in an environmentally sound manner.			
Objective			
To identify and cleanup sites contaminated with Dioxins and Furans in an environmentally sound manner			
Strategies			
Regular updating of inventories			
Use of Geographical Information Systems (GIS) to map and locate contaminated sites			
Activities			
Conduct assessment of the extent of contamination	Assessment records of findings documented	6 months -	GOL : M 160, 200
Take samples for analysis for levels of dioxins and furans from contaminated sites	Results of analysis documented	6 months	GOL : M 100,000
Compile reports for appropriate cause of action to be taken	Reports with maps compiled	1 month	GOL : M 25,000

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Mobilize organizations/companies with technical capacity to rehabilitate the contaminated sites (-Engage remediation expert to assess the cost of cleaning up the contaminated sites -Engage an expert to carry out the clean up)	Documented records of decontamination and rehabilitation available	1 year	GOL : M 10, 000,000
Intervention Area 3.3.12 Facilitating or undertaking information exchange and stakeholders involvement			
Objective			
To coordinate and strengthen information exchange to reach every person			
Strategy			
Develop information exchange systems and guidelines and involve stakeholders or Interested and Affected Parties to address dioxins and furans			
Activities			
Strengthen coordination mechanism on information dissemination about dioxins and furans	Mechanism or work plan in place for information dissemination	1 year	GOL: M 50, 000
Intervention 3.3.13 Public awareness, information and education			
Objective			
To disseminate information, education and communication to the public in order to increase awareness			
Strategy			
Engage all methods and means of mass communication in the dissemination of POPs issue focusing on dioxins and furans			
Activities			
Develop and introduce brochures, pamphlets, journals, fact-sheets on dioxins and furans for different population groups.	Brochures, pamphlets journals, fact-sheets developed and available quarterly	2 years	GOL : M 190, 000
Organize slots on radio and TV for addressing the nation on dioxins and furans.	Documented records of the number of slots kept Active public participation in phone-in programmes	1 year	GOL : M 125,000
Prepare articles on dioxins and furans for publishing on local newspapers.	Records of articles published in local newspapers available	1 year	GOL : M 30,000

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Produce posters and billboards at public places warning the public about the consequences of burning plastics, paper, rubber, grass, trees, veld fires and any material likely to generate dioxins and furans.	Posters and billboards produced and displayed at strategic public places	1 year	GOL : M 60, 000
Engage with National Curriculum Development Centre in integrating curriculum for lower educational levels to include subject matter on dioxins and furans and include waste management as a subject at lower educational level.	Proceedings from consultative sessions documented and available and developed curriculum	2 years	GOL : M 35,000
Train teachers at lower educational levels on various aspects of dioxins and furans.	Record of participants list	5 years	GOL : M 5,000,000
Encourage schools to engage pupils in extra-curriculum activities such as cleaning campaigns.	Number of extra-curriculum activities organised and carried out recorded and available	1 year	GOL : M 150,000
Promote competitions on clean schools programme	Number of participating schools	5 years	GOL : M 500,000
Intervention Area 3.3.15 Reporting			
Objective			
To report to the Secretariat of the Convention and Government on the achievements in addressing reduction of dioxins and furans			
Strategy			
Periodic update of monitoring data			
Activities			
Prepare a standardized reporting format at local level	Reporting format in place	4 months	GOL : M 18, 000
Compile a national report and submit to the Secretariat of the Convention	Report	Every 2 years	GOL : M 25,000
Intervention Area 3.3.16 Research, development and monitoring			
Objective			
To monitor the levels of dioxins and furans contamination at identified sites			
Strategies			
Focus on dioxins and furans as recommended by any of internationally recognized organisation or institutions, e.g. WHO, UNEP UNITAR etc			
Strengthen the normal surveillance of specialised community groups such as workers			

Dioxins and Furans			
Objectives/Strategies/Activities	**Measures of success**	**Duration**	**Cost**
Activities			
Institute legislation to oblige organizations whose activities may release dioxins and furans to develop Environmental Management Systems.	Legislation enacted and enforced	2 years	GOL: M 65,000
Set standards of exposure levels, exposure limits or Threshold Limit Values of dioxins and furans specific to activities taking place in Lesotho.	Documents on standards and Threshold Limit Values available.	3 years	GOL: M 90,000
Harmonize toxicological and epidemiological methods in order to have internationally comparable results.	Documentation/reports harmonisation methods available	3 years	GOL : M 140,000
Conduct epidemiological studies on the effects of dioxins and furans to communities of Basotho where they are known to be released or potentially available**. (Study groups)**	Reports of epidemiological studies available	5 years	GOL : M 10,000, 000
Intervention Area 3.3.17 Technical and financial assistance			
Objective			
Access all available technical and financial assistance globally- multilaterally and bilaterally			
Strategy			
Develop proposals to solicit support from potential donors			
Activities			
Develop proposals for funding/grants from international organizations for capital and operational budgets on reduction of dioxins and furans.	Proposals developed	1 year	GOL : M 90,000

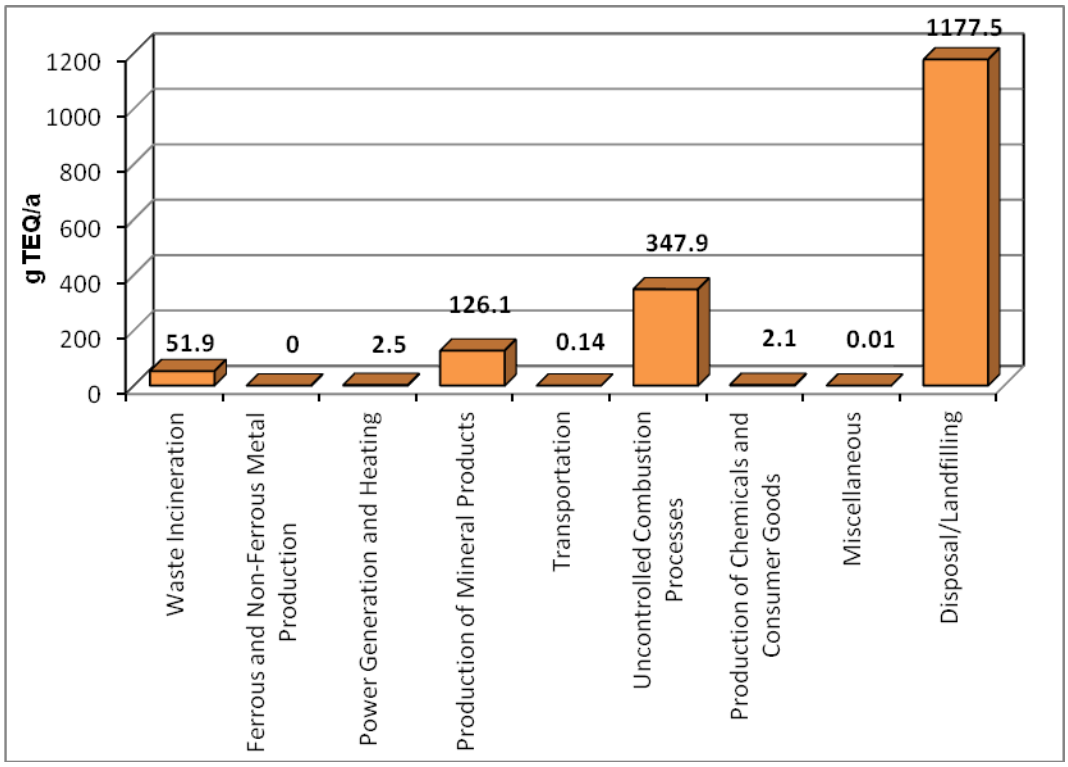
12.0 Annexes

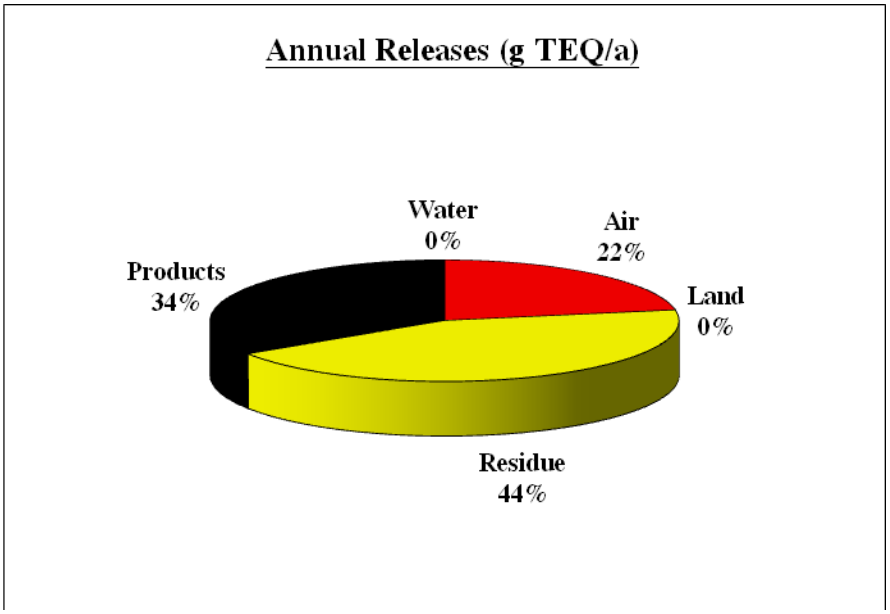
Annex 1: Registered vehicles for 2010 – 2017 period

Year	Engine type	Mkg	BB	Lrb	Berea	Msu	Mft	Mhoek	Qtng	QNek	TTs
2010	4 St P	63	438	226	640	520		333	91	93	115
2010	4 St D	53	80	69	145	140		20	108	51	21
2010	2 St	0	0			0		0	0	0	0
2011	4 St P	95	488	415	594	2307		491	321	118	94
2011	4 St D	40	131	130	790	603		34	42	37	16
2011	2 St	0	1	0	0	13		1	0	0	0
2012	4 St P	124	426	874	626	3059		184	339	163	133
2012	4 St D	79	95	237	74	599		22	32	22	14
2012	2 St	0	0	0	0	13	1	1	0	0	1
2013	4 St P	138	396	1001	498		3737	394	318	200	141
2013	4 St D	52	97	265	107		557	38	72	22	24
2013	2 St	0	0	0	0		0	1	0	0	0
2014	4 St P	143	358	744	740	782	903	344	109	163	145
2014	4 St D	24	94	208	105	610	1013	72	226	24	27
2014	2 St	2	1	0	1	25	196		0	0	0
2015	4 St P	181	369	1083	921	725	3352	403	442	198	162
2015	4 St D	81	125	230	156		934	70	48	28	46
2015	2 St	1	2	1	2		1		0	1	0
2016	4 St P	269	421	1435	883	1557	4040	50	413	224	193
2016	4 St D	49	159	131	97	374	614	14	39	33	48
2016	2 St	0	1	1	0	6	5		0	0	0
2017	4 St P	314	389	1426	859	2475	5004		323	193	265

2017	4 St D	59	100	111	111	422	756		27	28	53
2017	2 St	0	0	0	1	11	12		0	0	0

ANNEX 2: Emission calculations per sub-category: the overall spreadsheet summary





Annex 3: GPS coordinates for Wastewater and solid waste dumpsites

Date	District	Study Area	Coordinates
11-15 September 2017 25 September 2017	**Mafeteng**	WASCO-WWTP	29° 48' 15.88" S 27° 14' 51.60" E Elevation:
		Mafeteng Dumpsite	29° 20' 36.90" S 27° 26' 34.10" E Elevation:
		Water Tank (downhill of the dumpsite)	29° 46' 34.60" S 27° 11' 34.14" E Elevation:
26 September 2017	**Mohale's Hoek**	WASCO-WWTP	29° 08' 41.30" S 27°28' 04.20" E Elevation: 1574m
		Lesotho Correctional Services WWTP	29° 49' 28.30" S 27° 14' 50.40" E
		Mohales-Hoek Dumpsite	30° 09' 39.60" S 27° 25' 14.70" E Elevation: 1467m
		Brick-Making Industry	30° 09' 38.60" S 27° 28' 17.20" E Elevation: 1476m

26 September 2017	**Quthing**	WASCO-WWTP	30° 23' 24.80" S 27° 42' 29.40" E Elevation: 1509m
		Quthing Dumpsite	??
27 September 2017	**Qacha's Nek**	WASCO-WWTP	30° 06' 32.02" S 28° 53' 52.48" E Elevation: 1908m
		Qachas-Nek Dumpsite	30° 04' 48.10" S 28° 37' 36.00" E Elevation: 1750m
27 September 2017	**Semonkong**	WASCO-WWTP	N/A
		Semonkong Dumpsite	29° 51' 04.10" S 28° 03' 25.60" E Elevation: 2274m
14 November 2017	**Mokhotlong**	WASCO-WWTP	29° 18' 13.20" S 27° 29' 55.60" E Elevation:
		Dumpsite (New)	29° 19' 25.20" S 29° 01' 29.30" E Elevation: 2250m
		Dumpsite (Old & being cleared)	29° 16' 45.60" S 29° 04' 46.60" E Elevation: 2118m
15-16 November 2017	**Botha Bothe**	WASCO-WWTP	28° 45' 57.88" S 28° 14' 36.44" E Elevation: 1676m
		LHDA-WWTP (Likileng)	28° 44' 14.13" S 28° 15' 03.98" E Elevation: 1643m
		Dumpsite	28° 44' 17.10" S 28° 16' 35.80" E Elevation: 1721m
15 November 2017	**Leribe (Hlotse)**	WASCO-WWTP	28° 52' 55.18" S 28° 02' 56.60" E Elevation:
		Dumpsite	28° 52' 41.38" S 28° 03' 33.56" E Elevation: 2274m
16 November 2017	**Maputsoe**	WASCO-WWTP	28° 54' 31.77" S 27° 53' 52.05" E Elevation: 1546m

		Dumpsite	28° 54' 34.88" S 27° 54' 00.70" E Elevation:
	Mapoteng	WASCO-WWTP	29° 05' 56.84" S 27° 56' 55.20" E Elevation: 1581m
		Dumpsite	N/A
17 November 2017	**Berea**	WASCO-WWTP	29° 08' 11.3" S 27° 46' 12.5" E Elevation: 1570
		Dumpsite	29° 07' 35.9" S 27° 46' 39.7" E Elevation: 1611m
	Thaba Tseka	WASCO-WWTP 04 November 2017	29° 31' 0.58" S 28° 36' 47.1" E Elevation: 2195m
04 November 2017		Dumpsite	29o 29' 46.3" S 28o 35' 50.1" E Elevation: 2212m
04 November 2017	**Mantšonyane**	WASCO-WWTP	??
		Dumpsite	??
	Mohale	WASCO-WWTP	??
		Dumpsite	??
16 February 2018	**Maseru**	Dumpsite Tsosane	29° 18' 51.75" S 27° 32' 22.30" E
		WASCO-WWTP (Maqalika)	29° 17' 05.59" S 27° 30' 35.13" E
		WASCO-WWTP (Ratjomose)	29° 19' 47.93" S 27° 26' 59.04" E
		WASCO-WWTP (MASOWE)	29° 23' 03.73" S 27° 28' 33.15" E
		WASCO-WWTP (Industrial)	29° 17' 50.98" S 27° 27' 53.99" E
	Katse	WASCO-WWTP	??
		Dumpsites	??
	Ha Lejone	WASCO-WWTP	??
		Dumpsites	??
	Roma	WASCO-WWTP	??
		Dumpsites	??
	Morija	WASCO-WWTP	??
		Dumpsites	??
	Masianokeng/Mazenod	WASCO-WWTP	??
		Dumpsites	??

13.0 References

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