4. STATUS QUO ON THE HEALTH CARE RISK WASTE TREATMENT / DISPOSAL FACILITIES

4.1 Background

An important component of the investigation into the Status Quo of the Health Care Risk Waste Management in Gauteng was to obtain information on the existing waste treatment facilities in the Province. The purpose of this chapter is to determine the:

- Location, types, sizes, capacity and condition of the existing facilities;
- Which facilities are owned by the public and private sectors;
- Operating costs for each facility, where available;
- Which facilities require upgrading or replacement in order to meet current and any future legislative requirements with the associated costs; and
- Spatial representation of the location of the incinerators.

Clearly, the information listed above is essential for Gauteng Province to plan for the future of HCW management. One of the key elements of the National Waste Management Strategy (NWMS) was integrated waste management planning which incorporates HCRW. A number of action plans were developed in the strategy and these included the following: -

- Regulations and guidelines for the compilation of waste management plans, covering *all types of waste*, was to be drafted by the Department of Environment Affairs and Tourism, in consultation with provincial government, and promulgated by the year 2000. Special consideration was to be given to waste management in rural and farming communities.
- For general waste, first generation plans will be compiled by local government in the year 2001, for submission in 2002. Final plans will be submitted and approved in 2003 and be implemented by 2006. Compilation of first generation integrated general waste management plans in the short-term is part of a phasing-in process.
- For hazardous waste (which includes HCRW), first generation plans will be compiled by provincial government in 2001, for submission in 2002. Final plans will be submitted and approved in 2003 and be implemented by 2006.

All I&APs involved in the development of the NWMS identified a number of high priority issues that should be investigated in the short term. The Action Plan on Waste Treatment and Disposal (Department of Environment Affairs and Tourism, 1999) identified certain aspects of the treatment and disposal of "medical waste" that required urgent attention. These were that:

- DEAT will develop guidelines for the safe management of HCW by 2001, which will include guidelines for the separation of waste at source into infectious waste that requires incineration (according to the Human Tissues Act) and non-hazardous HCW that can be disposed of by alternative methods;
- Revised air emission standards for waste incineration facilities will be developed by DEAT by December 2001. The revised air emission standards will consider international standards and South African conditions, and will be graded according to the size of the facilities and the type of waste incinerated;

- DEAT will undertake monitoring and auditing of all waste incineration facilities, to initiate enforcement of the revised air emission standards, from January 2002 onwards. Further enforcement action will be taken where necessary;
- A public awareness and education campaign, focusing on the hazards of HCW and the legal responsibilities of generators, will be developed by DEAT by December 2000 and implemented from 2001 onwards;
- Planning for a system of HCRW treatment plants will be completed by 2002. Additional treatment facilities will be established and operated thereafter, in accordance with this plan.

In order for Gauteng to meet its obligations and provide plans for hazardous waste management in the Province, including HCW, information is required on the waste generation and the treatment facilities available. This report gives the results of an investigation undertaken from March 2000 to May 2000, into the current treatment and disposal facilities for HCRW in Gauteng.

4.2 Investigation Methods

A questionnaire for capturing of data that is related to the operation and maintenance of incinerators to be investigated was drawn up on the basis of a survey document that was previously used by one of the consultants and the questionnaire presented in A Pruss et al., "Safe Management of Wastes from Health Care Activities", World Health Organisation, Geneva, 1999. The questionnaire was adapted during the initial stages of the survey in order to include issues of importance to South Africa. A copy of the questionnaire that was finally used is included as ***Annexure 4.1***.

The information required fell into three broad categories, i.e. Facility Information, Incinerator details and Information on HCRW Handling. Background information on each item in the questionnaire, the information obtained from the facilities and general comments are given below in Sections 4.3.1 to 4.3.3 below.

Initial information on the location or possible future location of incinerators was obtained from DACEL's database, from the Hospital and Nursing Yearbook of Southern Africa, 1999, from Mr C du Plooy of the Department of Environment Affairs and Tourism, and from Mr M Eksteen of the Gauteng Department of Transport and Public Works. (Because the list of private hospitals was very long, each hospital was telephonically interviewed to establish whether they had an incinerator on their premises. Only those that indicated that it was equipped with an incinerator were visited. During the study, information was received on the location of additional incinerators and these were added to the list.

4.3 Results of Survey

4.3.1 Facility information:

The facility information is summarised in ***Table 4.1*** and each column is discussed as follows: -

Table 4.1

Name and type of facility

The facilities were divided into Private Hospitals, Provincial Hospitals, Miscellaneous (Laboratories and Prisons) as well as Waste Service Companies. Details of the numbers in each category are included in ***Table 4.2***

Table 4.2: Categories of Health Care Facilities

Type of Institution	Number with Incinerators	Number of Incinerators	Number Operational	Registration Certificates
Private Hospitals	14	14	13	5
Provincial Hospitals	32	38	28	11
Miscellaneous*	8	11	10	2
Waste Service Companies*	4	7	7	7
TOTALS	58	70	58 (83%)	25 (37%)

*This category includes the waste management companies and the Johannesburg Metro.

Table 4.2 shows that there are 58 institutions that have incineration facilities in Gauteng, the majority of these, 55%, are Provincial Hospitals with the next largest category being the Private Hospitals at 24%. The total number of incinerators identified was 70, as some institutions have more than one incinerator on the same site. These include some of the larger Provincial Hospitals, including Johannesburg, Photosong, Tambo Memorial and Tembisa Hospital, all of which have two incinerators. The waste management companies also tend to operate more than one incinerator; Envirocin has two small Furntec Units at their premises in Zandspruit, Randburg, whereas EnviroServ operates 4 incinerators, two of the TOXIC type at their premises in Roodepoort and two of the Macroburn type at Rietfontein, Germiston.

One of the difficulties that arose during the survey was that many of the hospitals had or were in the process of changing its names. As far as possible, the current or, where the name change has been ratified, the new name is included in the list.

Addresses and contact details

The town, the physical and postal addresses as well as the telephone and fax numbers for all the facilities are included in columns 2 to 6 of ***Table 4.1***. These were confirmed during the respective interviews and were correct at that time.

Location – Latitude and longitude

The latitudes and longitudes of some of the facilities were available at commencement of the project. Only where the co-ordinates were not included in GDACEL's list or where there was some uncertainty regarding the values, were readings taken. A Garmin 12 hand held GPS instrument was used. The values were confirmed by plotting the locations on a map and by comparison with the available *Map Studio* maps. A map indicating the location of the existing incinerators is presented in ***Figure 5.4*** of Chapter 5.

Contact person and ownership of facility

The contact details and for some private hospitals, the holding company details, are presented in ***Table 4.1****;* Columns 9 and 10.

Type of facility and service required

The type of institution presented in ***Table 4.1***, Column 11 is indicated by:

- H Hospital
- C Clinic
- RC Rehabilitation Centre
- LAB Laboratory
- P Prison
- WMS Waste Management Service

In addition, the type of service offered is indicated by:

- Me Medical
- Ma Maternity
- WR Welfare Retirement Village
- I Incineration Service

Number of beds and occupancy rate

Most hospitals and clinics interviewed were well aware of the number of beds, which varied from as low as 43 at the Bronkhorstspruit Private Hospital to 1 804 at the Ga-Rankuwa Hospital in Pretoria. However, only three of the facilities interviewed had any idea of the occupancy rate, a figure that is important if the elected procedure of determining the mass of waste generated per patient per day is to be used.

Date of survey and interviewers

The date of the survey presented in ***Table 4.1***, Column 13, is that of the first visit by the interviewer. In some instances, the facility was visited more than once or contacted by phone in order to verify certain information.

4.3.2 Incinerator details:

Treatment and disposal method

The approach to the treatment and disposal of the infectious waste stream is presented in ***Table 4.3***, Columns 2 and 3. Many health care facilities use their own incinerators together with an external contractor for the management of the infectious waste. Three scenarios were encountered:

- All infectious waste is removed by a contractor.
- Only human tissue and/or sharps are incinerated on site.
- All infectious waste is incinerated on site.

The type of waste incinerated is indicated in Column 3 as:

mw = medical waste (HCRW)
ht = human tissue
gw = general waste
lab waste = biologically contaminated laboratory waste

Envirocin is a specialised company that cremates animal carcasses. Hillbrow hospital on the other hand, reports that it uses its incinerator occasionally for incinerating drugs that are confiscated by the police. It should be noted that this practice is unacceptable from an environmental standpoint as most drugs, except dagga (which is a plant material), are chemical formulations that should only be destroyed in an incinerator designed for chemical hazardous waste.

Some health care institutions have closed down their incinerators, resulting in all HCRW being removed by an external contractor. Johannesburg General Hospital uses its incinerator for human tissue as well as for general waste. However, it became apparent from interviews that practices at many institutions vary considerably during the year. For example, at the end of the financial year, when funds are low, some facilities resort to using their own facilities, as they cannot afford to pay for the external service.

Make and size of incinerators

The make and size of each incinerator is presented in ***Table 4.3***. Note that some facilities have more than one incinerator on site, resulting in the 58 health care facilities having 70 incinerators. (See ***Table 4.2)***

There are seven makes of incinerators still in use in Gauteng, some of which are outdated and some that is no longer available, namely:

- **TOXIC** (Thermal Oxidation Incineration Company) is manufactured by Johnson Thermal Engineering, Randburg and is a modern "controlled air" type incinerator;
- **Lucifer, SA Incinerator Company** and **Mitchell Monk** incinerators are very similar and use the original Los Angeles design. They are "excess air" incinerators. Lucifer are very old units and are no longer available, but many are still in use;
- **Safex** has also been discontinued. The units were originally supplied as coal burning units but were later converted to diesel or gas;
- **Macroburn** also developed from the old Lucifer units of LA design, but has been modernised and many design improvements were made. Although the latest units have much better control over the combustion air, it is still the "excess air" type;
- **Furntec** is a recent entry into the market and is a "starved" or "controlled air" type incinerator.

The model identification numbers given in ***Table 4.3*****,** Column 3 give the capacity of the incinerator according to the manufacturer. The model number of the Lucifer, SA Incinerator, Mitchell Monk and Safex incinerators refer to the mass ***in pounds*** of General Waste that they can incinerate in one hour. Therefore, an LA 100 can incinerate 100 lb (pounds) of general waste. The older Macroburn incinerators also referred to pounds, but the numbers were later converted to kilograms so that a Macroburn 500 can incinerate 500 kg of general waste. The Furntech and TOXIC incinerators also refer to the mass of general waste that can be incinerated in kilograms per hour.

However, it should be noted that the actual mass of HCRW that can be incinerated usually differs considerably from the capacities claimed by the manufacturers as discussed in Section 3.3.

Permit/Registration Certificate status

Only 24 of the incinerators have registration certificates (of which some are temporary) and although many of the operators indicated that they were applying for registration, the actual status is uncertain.

Type of incinerator: excess air or controlled air

The incinerators are predominately of excess air type, with only 5 of the 70 incinerators being the more modern controlled air type. The latter are all operated by waste management companies.

Table 4.3

The types of incinerators were discussed in detail in a previous report prepared for GDACEL: "Background Study on Medical Waste Management", by Infotox, November 1998 as part of the Danced Capacity Building Project. The more modern excess air incinerators in use in South Africa are Multi-chamber Incinerators equipped with both primary and secondary combustion chambers. Many of the older excess air incinerators however cannot reach temperatures above 800^{o}C in the primary chamber and often work at temperatures considerably lower than that. The advantages and disadvantages of this type of incinerators are listed in ***Table 4.4***.

Table 4.4 Advantages and disadvantages of Multi-Chamber ("Excess Air") Incinerators*

Advantages	Disadvantages
a) Relatively inexpensive b) Physically compact	a) Require very high excess air levels, b) Unable to comply with regulations without pollution control equipment, especially particulate emission standards, c) High fuel use in order to maintain the required high temperatures in the primary and secondary chambers, d) Expensive to retrofit air pollution control equipment, e) Difficult to control combustion air levels and rate of combustion, f) Limited to batch operation unless some form of air control added, g) Regular incidents of poor combustion, smoke and release of hazardous substances, h) Ash removal manual, leading to potential exposure to dust.

*Adapted from GDACEL, "Background Study on Medical Waste Management", by Infotox, November 1998

Note that the emissions from the incinerators are dependant on the quality of the in-put waste. The presence of PVC in the HCRW streams results in the permitted levels of HCl in the gas almost always being exceeded. However, the excess air incinerators do emit considerably more particulates that the controlled air type, which means that they often cannot even meet South Africa's generous standard of 180 mg/Nm^3 for particulates.

The advantages and disadvantages of the controlled air type of incinerator are listed in ***Table 4.5.***

Table 4.5: Advantages and Disadvantages of "Controlled Air" Incinerators*

Advantages	Disadvantages
a) Reduction of waste volumes without excess quantities of supplementary fuel, b) High thermal efficiency due to relatively low air requirements, c) Lower fuel costs, d) Uncontrolled air emissions can be low, e) Converts carbonaceous solids to gases that are more easily combusted, f) Limited particulate emissions, g) Can burn waste with a minimum amount of processing, h) Capital costs modest compared to performance.	a) May have incomplete combustion of carbonaceous material in ash, b) Needs regular maintenance to remove clinker and scale build-up on refractory surfaces, c) Difficult to control operating parameters, if the waste type varies, d) If the primary chamber temperature is too high because of the waste characteristics or poor operating practices, metal emissions may be high.

*Adapted from GDACEL, "Background Study on Medical Waste Management", by Infotox, November 1998

Generally, the controlled air type is more effective and efficient, particularly when a larger capacity is required. Note that the latest incinerators installed by both waste management companies are the controlled air type.

Operational status

The number of incinerators actually operational was estimated at 58, i.e. 83% of the total, (see ***Table 4.2***). The reasons for some not being operational ranged from old and inoperable (such as that at Cullinan Rehabilitation Hospital), to those at Tambo Memorial and Tembisa Hospitals that have only recently been installed, but did not comply with the EIA requirements. As described below and is evident from the comments by the investigator given in ***Table 4.3***, the actual status of many of the incinerators is extremely poor.

Installation date

The date installed was in most instances difficult to obtain, as there has been a turnover of staff and often nobody was able to provide the information. Therefore, some dates in ***Table 4.3*** are no more than educated guesses. Note that the installation dates vary from about 1967 to 1999, with the controlled air incinerators being installed from 1996 onwards.

Condition

Condition of the incinerators is given as:

- **G = good:** Indicating that the steel shell, burners, chimney and refractory appear from a limited inspection to be in a reasonable condition. If classed as good, however, it does not necessarily indicate that the unit can be upgraded to meet the Department of Environmental Affairs and Tourism's emission guidelines.
- **NR = needs repair:** One or more of the above-mentioned items needs repair.
- **N/O = not operating:** For the reason given in the comments section, ***Table 4.3.***
- **B = bad:** the incinerator is in bad state of repair and probably not repairable.

The incinerators at 32 of the 58 facilities identified were described as being in a good state of repair.

Fuel used and fuel usage

The type of fuel used is indicated in Column 12 and the amount used, if known, in Column 13. The most common fuel used is diesel, although there are four that are gas fired and three that are still using coal. The new Toxic 350, operated by the Johannesburg Metropolitan Council is gas fired. The figures vary widely for fuel used and this is a reflection of: -

- Uncertainty in the figures – many operators do not have accurate records of the volume of fuel used;
- The considerable variation in the utilisation of burners. For example, at Ga-Rankuwa Hospital, the burners were not even running during the visit;

- The type and quality of the waste being burnt;
- The type of incinerator. For example, the Macroburn's are excess air incinerators and utilise ~0.25 litres/kg of waste, whereas the controlled air Toxic incinerators utilise ~0.1 litres/kg of waste. Note that at the current price of diesel the controlled air incinerators are therefore considerably more cost effective in this regard. Assuming the price of diesel to be R3.00 a litre, the fuel cost for the excess air incinerator works out to be R750 per ton whereas for the controlled air incinerators the cost is R300 per ton.

Operating hours/month

The estimated operating hours per month for the incinerators are given in Column 13 of ***Table 4.3***. In many instances, it was very difficult to establish these times, as some units are only used when human tissue or other health care waste was available for treatment. Note that the times vary considerably with the Carletonville and Kutsong Hospitals recording only operating 8 hrs per month whereas one of the waste management companies operate their incinerators for 400 hours per month.

Scrubber fitted

Of the 70 incinerators, only the Johannesburg Metropolitan Council's incinerator is fitted with a scrubber. However, the scrubber is not operational for most of the time. At the time of the visit by the investigating team for instance, the scrubber had been disconnected because of corrosion problems in the connection pipe from the incinerator.

The gas emissions from all health care waste incinerators in South Africa cannot meet the Department of Environmental Affairs and Tourism's requirements in terms of the Atmospheric Pollution Control Act. The HCRW stream in South Africa includes significant amounts of PVC and other chlorine containing compounds and therefore the emissions of HCl are generally well above the limit of 30 ppm, currently set by the Department of Environmental Affairs and Tourism. In addition, the current limit for particulates of 180mg/Nm^3 is high compared to international limits, which fall in the range 10 to ~30mg/Nm^3. The addition of scrubbers could reduce the acid gases and particulates to more acceptable levels and this may have to be introduced in the future. However, it is estimated that the costs for incineration would increase by a minimum of 50%. It is argued by many that South Africa cannot afford this cost, although many others believe that the environment cannot and should not be required to accept the pollution load. The argument is, however, more complex since various factors such as location of the incinerator, the stack height and the potential low volumes of waste incinerated mean that incinerators not meeting the emission standards may still have a low impact on human health and the environment. It is further recognised that if one operator is required to install a scrubber and not the other, then the former would clearly be at a considerable commercial disadvantage. An application to operate an incinerator without a scrubber requires a full multi-pathway health risk assessment to prove that the impact is acceptable before the Department of Environmental Affairs and Tourism will grant a permit. The burden of proof is therefore on the operator/owner of the incinerator.

Feed mechanism

Only five of the existing incinerators, those of Sanumed (EnviroServ) and the Johannesburg Metropolitan Council, have mechanical feeding systems. In these incinerators, the feed rate is determined by the temperature in the primary chamber as well as the maximum feed rate set by the operator. These parameters are generally specified by the incinerator manufacturer but have also been determined by the CSIR during studies carried out for one of the waste management companies.

The guidelines for Class 2B incinerators set in Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965) state that:

"Controlled hygienic (preferably mechanical or automatic) feeding methods should be used which will not affect the air supply and temperatures in the primary and secondary chambers of the incinerator."

Waste should not be fed into the incinerator under the following circumstances:

- At start-up or until the minimum combustion temperatures have been reached;
- Whenever the minimum combustion temperatures are not maintained;
- In the case of a batch loader, whenever the previous charge has not been combusted completely; and
- If addition of waste would exceed the design specifications of the incinerator.

Note that the feeding of the waste without allowing a large intake of air through an open door is extremely important, since opening of the door can lead to generation of excess smoke and presumably the emission of other pollutants. With a mechanical feeder an airlock or other control system is used to minimise ingress of air.

Chimney height and position

Schedule 39 of the aforesaid Act requires that "the incinerator chimney should have a minimum height of 9 m above ground level and clear the highest point of the building by not less than 6 m for flat roofs, and 3 m for pitch roofs. The topography and height of adjacent buildings within a distance of approximately five times the chimney height should be taken into account."

An assessment of these factors was made by the investigator and in 8 cases (see ***Table 4.3***, Column 16), the chimney height was adjudged as being too low, although in general all incinerators were considered to be located adequately with regard to adjacent buildings, Column 17. In two instances, the emissions are lead into an existing boiler stack, one of which is 82 metres high.

In order to obtain good dispersion, the gas exit velocity should be at least 10 m per second, according to the guidelines. The investigators were however unable to judge whether the incinerators comply with this requirement.

Primary burner temperatures

Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965), gives the following guidelines for the primary chamber:

"The primary chamber should be equipped with a burner(s) burning gas or low sulphur liquid fuel. The primary air supply is to be controlled efficiently."

The guidelines do not specify the primary combustion zone temperature but for efficient combustion, temperatures above ~850^{o}C are recommended. Temperatures recorded in the primary chambers at most institution were well below this, with temperatures as low as 200^{o}C being recorded. However, the investigator noted that the measured temperature probably had no relationship to the actual temperature in either the waste body or gas because of the poor location and/or maintenance of the thermocouple. It should be noted that temperatures in excess of 600^{o}C are required if the sterilisation of the waste is to be guaranteed.

Secondary burner temperatures

Schedule 39 of the Atmospheric Pollution Prevention Act (Act 45 of 1965), gives the following the guidelines for the secondary chamber: -

- "The secondary chamber should be fitted with a secondary burner, burning gas or low sulphur liquid fuel, or other suitable fuel.

- The secondary air supply is to be controlled efficiently.

- A residence time of two seconds is specified to allow sufficient flame contact of the gases in the combustion zone.

- The gas temperature as measured against the inside wall in the secondary chamber should not be lower than 1100 degrees centigrade, if materials containing 1 percent or more of halogens are incinerated. In cases where halogens are present at concentrations from below 1 percent, the temperature may be reduced to 850 degrees centigrade. Those cytotoxic materials should be combusted at an after burner temperature of lower than 1000 degrees centigrade. The oxygen level of emitted gas should be not less than 11 percent."

Note that the requirements are set in order to minimise the emission of organic compounds and in particular the extremely toxic dioxins. The percentage of halogen in the South African HCRW stream is unknown, but from emission tests that have been done and the concentrations of HCl detected, it is likely that the percentage halogens reaches and exceeds 1%, at least in some instances.

Column 19 of ***Table 4.3*** gives, where known, the temperature of the secondary chamber and information on the status of the secondary burner. This data is also summarised in ***Table 4.6.***

Table 4.6: Summary of the status of the secondary burners

Requirement	Number of Incinerators meeting requirement
Temperature ≥ 1100^{o}C	5
Temperature ≥ 850^{o}C but < 1100^{o}C	12
Temperature < 850^{o}C	10
Not Measuring	5
Not Operating/in use	10
Not Fitted	15

Only five incinerators, i.e. those operated by Sanumed (EnviroServ) and the Johannesburg Metropolitan Council had temperatures ≥ 1100^{o}C in the secondary chambers and another 12 were possibly adequate in terms of the guidelines in that they were recording temperatures of between 850 and 1100^{o}C. However, ten facilities were recording secondary chamber temperatures below the required minimum of 850^{o}C. Five operators were not measuring the secondary temperature and fifteen of the incinerators were not even fitted with secondary chambers.

4.3.3 Operations and Waste Handling

Information on the quantity of HCRW treated, the number of operators and the HCRW handling and storage procedures at the incinerator facilities is presented in ***Table 4.7.***

Table 4.7

Operators: Number, qualifications and number of shifts

Columns 2,3 and 4 of ***Table 4.7*** provide information on the number of operators per shift, the number of shifts per week and the minimum qualifications of operators.

The number of operators per shift varies from one at most facilities with up to eight at the Johannesburg Metropolitan Council's Incinerator. Comparison of the number of operators with the operating hours and tonnage of waste handled (Columns 7 and 8 of Table 4.7) shows some correlation. However, for the smaller units, some of which only operate for eight hours per week or month, the operator presumably has other duties. Some institutions seem to be grossly overstaffed; for example the Johan Heyns Hospital that has four operators on a single shift and yet only treats 0,7 tons of waste per month, whereas one waste management company operates with two operators on each shift and handles 165 and 295 tons of HCRW per month at their facilities in Rietfontein and Roodepoort respectively.

Where qualifications are required for employment, the private hospitals and waste management companies require at least a formal grade 10 education. However, the Provincial Hospitals do not set a minimum entrance qualification but only rely on in-service training. In South Africa, there are many people with low formal qualifications that will, through in-service training and experience, work at a much higher level. However, successful operation of a modern incinerator requires a good understanding of the operating parameters in order to minimise the pollution potential and it appears that the quality of the staff used as operators and the training they receive may not be adequate in many hospitals. Larger incinerators, in particular, are sophisticated pieces of equipment that work at extreme high temperatures to attain good combustion efficiency. The low temperatures recorded in the secondary chambers and the general neglect of the equipment at some facilities is indicative of poor management control and a lack of understanding of the correct operating requirements amongst staff.

Tonnage of waste treated per month

The tonnage of waste that the facilities claimed to treat per month is included in Column 5 of ***Table 4.7.*** Many facilities did not have any records on the amount of HCRW treated and some staff members guessed the amount. In order to properly manage the waste generated, the waste should be weighed prior to incineration. Most facilities did not have scales and only the waste management companies routinely weighed the waste received at their incinerators. Once the theoretical maximum amounts were estimated from the incinerator capacities (see Maximum Theoretical Capacity), a follow up call was made to the various facilities in order to verify the amounts claimed since, for many, the amounts did not correlate well. See Section 4.3.4, below for further discussion of this issue.

Maximum theoretical capacity of incinerators

The actual maximum capacity of an incinerator depends not only on its design but also on the calorific value of the waste. Macroburn have used as a standard the concept of General Refuse Equivalent (GRE) to determine the capacity of its incinerators. The burning rate of waste in an incinerator varies according to the characteristics of the waste. The variation is taken into account by comparing the waste with "general waste" which is defined as follows:

- Calorific value 4600k Cal/kg.
- Moisture 15% max.
- Density 160kg/m^3
- Ash 5% approx.

Dry loose office waste that does not have excessive quantities of food, plastics or densely packed paper is typical of "general waste". The ratio between the weight of general waste and the weight of a particular waste that an incinerator can burn in a given period of time is called the General Refuse Equivalent

Table 4.8: Proposed GRE factors for Health Care Risk Waste.

Type of Waste	GRE
Sorted boxed HCRW	2.0
Hospitals : General	1,30
Hospitals : Maternity	1,40
Hospitals : Teaching	1,50
Nurses homes	1,20
Old age homes	1,25
Out Patients	1,25

Actual capacity = GRE capacity / GRE factor

For example, if an incinerator can incinerate 100 kg GRE waste/hour, it will only be able to incinerate
100/2 = 50 kg/h sorted boxed health care risk waste (GRE=2),
100/1,3 = 77 kg/h general hospital waste (GRE+1,3) or,
100/1,4 = 71 kg/h maternity hospital waste (GRE=1,4).

Note that EnviroServ have had both the Macroburn and Toxic incinerators evaluated by the CSIR in order to get maximum burning capacity with the best environmental performance, i.e. lowest emissions. This does not mean that the incinerators can meet the emission standards since these require < 30ppm HCl and with the input waste containing PVC, it is not possible to achieve without scrubbers. The following data was obtained:

Macroburn Incinerators: A Macroburn 500 has a theoretical capacity for sorted and boxed infectious waste of 250 kg per hour, i.e. a GRE factor of 2 according to the manufacturer. In practice, the maximum capacity when operating efficiently is closer to 200 kg per hour, i.e. a GRE of 2.5. This is probably due to the practice of burning sharps together with the sorted infectious waste as this will result in a GRE of more than 2. The rated value in kilograms quoted by the manufacturer has thus been divided by 2.5 to get the estimated capacity per hour.

Toxic Incinerators: The TOXIC 350 has been found to burn approximately 350 kg of waste per hour, which is identical to the manufacturers contention that the model number reflects the amount of waste that can be incinerated per hour.

Other Incinerators: Since the other types of incinerators installed in South Africa, i.e. Lucifer, South Africa Incinerator Co, Mitchell Monk, etc, are excess air incinerators that are similar to the Macroburns, it was decided to apply the same GRE factor of 2.5 to determine the theoretical maximum capacity for the infectious waste stream. However, the model numbers of these incinerators reflect the capacity in pounds; a model 100 burns 100 pounds or 45.45 kg of general refuse an hour. The capacity for mixed HCRW, i.e. sorted waste and sharps, is therefore given as 45.45/2.5 = 18.2kg/hr.

All incinerators in use in Gauteng are of the intermittent operations type; a period is regularly required during the operation for de-ashing of the incinerator. For example, one commercial operation feeds the incinerators for 16 hours a day and uses the remaining eight hours for complete combustion of the remaining waste and for thorough cleaning out of any accumulated ash. Thus, a Macroburn 500 burns 16 x 200 = 3200kg/day and the Toxic 350 burns 16 x 350 = 5600kg/day. The incinerator is used only six days a week with the seventh day being used for maintenance. With 365 days per annum or an average 4.35 weeks per month, the amount of HCRW that can be incinerated in an average month is:

- Macroburn 500: 3200 x 6 x 4.35 = 83520kg = 83.5 ton per month
- Toxic 350: 4960 x 6 x 4.35 = 129500kg = 129.5 tons per month

Using the same assumptions for the other incinerators, the amount of HCRW that can be incinerated is:

- Lucifer 100: 290 x 6 x 4.35 = 7570kg = 7.57 tons per month

Note : The above calculations assume no downtime other than the weekly day for maintenance.

Ash

In Column 8 of ***Table 4.7***, the method of disposal of the ash generated at the incinerator is indicated. ***Table 4.9*** gives the breakdown of the ash disposal methods used for the various incinerators:

Table 4.9: Disposal method for ash

Method	Number	Percentage of Total
With the General Waste (GW)	21	38.9
To General Waste Landfill (GWL)	2	3.6
With the Boiler Ash (BA)	28	51.9
To a Hazardous Waste Landfill (HazW)	3	5.6
TOTAL	54	100

Of the 54 facilities that provided information on the disposal methods used for the incinerator ash, 21 or 38.9% simply mixed the ash with the general waste; 2 disposed of it as a separate waste stream to a general waste landfill and 28 or 51.9% mixed it with the boiler ash, which presumably is also disposed to general waste landfills. Note that many of the incinerators at hospitals are operated by the maintenance staff also responsible for the boilers. This probably accounts for the

frequent mixing of the two ash streams. Only one facility, the Rietfontein Incinerator operated by EnviroServ, disposed of the ash at a hazardous waste landfill. Incinerator ash, including that from an infectious waste incinerator, is internationally considered to be a hazardous waste. In South Africa, the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, published by the Department of Water Affairs and Forestry, requires that (because of the presence of heavy metals) incinerator ash be considered as a hazardous waste. There are, however, procedures in the Minimum Requirements that can be used to demonstrate that such ash can delist as a hazardous waste or that, because of the small quantity generated and the low load it presents to a landfill, it can be accepted onto a permitted GLB^+ waste disposal site. Recent tests have indicated that incinerator ash generated in the excess air and controlled air incinerators leaches considerable amounts of lead, manganese and other heavy metals and is therefore classified as a hazardous waste. Incinerator ash accepted at the Holfontein H:H landfill is normally treated with lime or soda ash to reduce the leachability of the heavy metals before being co-disposed. From the above it is evident that incinerator ash disposal, particularly without treatment, as part of the general waste stream or with boiler ash, is not acceptable, unless proven through the procedures outlined in the Minimum Requirements, that it can be safely disposed of at a permitted general waste disposal facility.

Disposal of the incinerator ash with boiler ash is of particular concern, since the relatively small amounts of incinerator ash effectively renders the total boiler ash waste stream potentially hazardous. In addition to this, boiler ash is often used at landfills as daily cover material and there is a possibility that needles may not have been properly destroyed and that landfill staff could get needle stick injuries.

The quality of the incinerator ash at many facilities was poor with cool drink cans, bottles and other items that should be disposed of as general waste, being present. Unburnt carbon and even charred paper in some ash loads, was strong evidence of poor operating practices.

It should be noted that the ash from incinerators that burn radioactive waste either deliberately or inadvertently, must be checked periodically to ensure that it does not classify as radioactive waste that have to be disposed of at a dedicated radioactive waste disposal site. Only one facility surveyed was aware of the requirements by the Department of Health, Cape Town and forwarded samples of ash for analysis every three months, as required. Note that the permit holder of the treatment facility has a "duty of care" to ensure that any waste such as the ash, is disposed of correctly. This also includes ash that is derived from multiple HCRW generators.

Separation at source and handling

All the incinerator facilities indicated as "int = internal", Column 9 of ***Table 4.7***,handle the HCRW within the hospitals themselves and no external waste management contractor is used to collect the waste – a practice that is common in the USA and Europe. All operators insisted that sound separation at source was practiced at their health care facilities. However, it was clear from observations of HCRW being collected and incinerated as well as from interviews with waste management companies, that separation at source was not carried out well. The presence of general waste such as cool drink cans, hazardous waste such as bottles of solvents, aerosols that can explode in the incinerator and sharps in the boxed infectious waste stream is common. Separation at source is essential to ensure that only the required infectious waste is incinerated at

high cost and that compounds or products are not present that can damage the incinerator or potentially impact on the health and safety of the waste management staff.

Occupational health and safety programme

The handling and treatment of infectious waste by incineration represents a fairly high-risk occupation with the opportunity for needle stick injuries and contamination by the infectious waste handled being high. A strictly controlled and well-managed occupational health and safety programme is therefore essential. This should include entry and exit medical examinations as well as medical examinations for the staff.

It is a requirement of the Occupational Health and Safety Act that approved programmes for the management of the risks posed by hazardous waste to staff and the general population are in place. This should include well-documented procedures and a regular health-monitoring programme. Emergency procedures should *inter alia* be in place, for instance when staff obtained a needle stick injury or accidentally become contaminated with blood from the HCRW. At one waste management company, the procedure requires an immediate visit to the physician for an examination and an AZT injection against AIDS. All staff are further vaccinated against Hepatitis B and C.

From ***Table 4.7***, it can be seen that only 23 percent of the facilities stated that they had an Occupational Health and Safety programme. All the provincial hospitals and the incinerators at "other institutions" such as the prisons indicated that they had no occupational health and safety programme in place. Presumably, some form of infection control programme is in place in the hospitals in terms of the requirements of the Health Act.

It is however clear that the apparent situation observed during this limited study cannot be allowed to continue. The facilities that do not have an Occupational Health and Safety programme in place are probably placing their workers at risk and, therefore, could be liable to prosecution in terms of the Occupational Health and Safety Act.

Needle stick injuries

Needle stick injuries are an important occupational hazard when operating an infectious waste incinerator. Column 12 of ***Table 4.7*** indicates that only 5 of the facilities stated that they experienced needle stick injuries; some indicated that they had no injuries, whereas 26 facilities didn't know. Poor HCW separation at source often leads to needles being disposed in the ordinary plastic bags or the cardboard boxes and one facility indicated that, because of this practice, needle stick injuries occurred once or even twice a month. The literature (Pruss et al, Safe management of Wastes from Health Care Activities", WHO, 1999) indicates that up to 8 percent of needle stick injuries result in the worker being infected by hepatitis B or C, unless precautions have been taken such as a regular vaccination programme for the staff.

Containers used – General infectious waste and sharps

Most of the general infectious waste is collected in plastic bags or in plastic lined cardboard boxes. According to the investigators, both red and black plastic bags were used. In the previous

investigation (Department of Environment Affairs and Tourism "Background Document of the Management of Health Care Waste", March 2000) hospital staff were even observed transferring the waste from the normal red plastic bags into black plastic bags, which are used for general waste.

For sharps, almost all facilities used puncture proof polypropylene plastic containers. However, some of the containers used were observed to be inadequate, since they were over full, lids were not fitted properly, etc.

Storage and access control

The storage facilities for the infectious waste were generally found to be adequate at most of the medical facilities. The HCW was stored in the plastic bags or in the boxes. In the private hospitals, access was generally restricted to the operator. However, in the provincial hospitals, access was not restricted and during the study the investigators found that they could gain access to the storage areas and the incinerators without any restriction. Clearly, only authorised personnel should have access to the waste storage and treatment areas.

Costs for treatment

Only the private waste management companies that provide an incineration service knew the costs of incineration of the HCRW. EnviroServ and Envirocin both indicated incineration cost to be in the region of R1.00 per kg. The Johannesburg Metro facility stated that they charged 0.55c per kg to incinerate the HCRW, but it is understood that this figure does not include the recovery of the capital cost of the incinerator, which is written off at the time of purchase.

Support for regionalized facilities

There was general support for the concept of regional HCRW treatment facilities, although most respondents qualified their support and indicated that it must be cost effective.

4.3.4 Quantities of waste incinerated

Table 4.10, which is reproduced from ***Table 4.1*** of the report "The Development of a Medical Waste Incinerator Information System (IIMS), Developed for the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs", August 2000, calculates some data based on the theoretical total incinerator capacities that were calculated under Maximum Theoretical Capacity of Incinerators referred to in Section 4.3.3 above. The theoretical mass of infectious waste that could be incinerated at the facility has been calculated from the total hours reported by the operators multiplied by the theoretical maximum capacity per hour. This figure is then compared with the actual reported mass of infectious waste incinerated and the discrepancy between the theoretical and actual figures is presented in the last column. Note that most incinerators are being used at much lower capacities than its theoretical capacity as shown by the negative figures in the last column. Possible reasons for this phenomenon include:

- Low loading rates, which probably arise simply because of the small amounts of HCRW that need to be treated at some incinerators;

- Low combustion temperatures, which combined with low fuel usage, will result in slow combustion;
- Poor segregation resulting in some HCRW entering the general waste stream;
- Excess capacity due to the trend to make use of private waste management companies, at least for a portion of the HCRW stream;
- Poor condition of some incinerators including poor maintenance;
- Poorly trained operators.

Two facilities indicate that they are accepting much more waste than what can theoretically be incinerated. The EnviroServ facilities at Rietfontein, Germiston and in Roodepoort reported a combined excess of 52 tons per month. Note that the date of the survey was early April 2000, when the company was still appointed for the Gauteng Provincial Hospital Tender. The excess HCRW was taken up in a number of ways; which included transporting thereof to incinerators in other Provinces, using the Johannesburg Metropolitan Council's incinerator when available and by obtaining special permission from the Department of Water Affairs and Forestry to landfill HCRW at the Holfontein H:H Landfill. The Johan Heynes Hospital, Sebokeng and Sizwe Rietfontein, apparently also incinerate more HCRW than the theoretical capacity. This could be due to a number of reasons:

- Poor estimates of the HCRW mass incinerated;
- The operational hours are underestimated; or
- The waste is not completely combusted.

Many operators did not know the mass of waste being incinerated and the presence of carbon and other unburnt material was observed in the ash from certain incinerators.

The data suggests that there may be sufficient capacity for the apparent excess of infectious waste that needs treatment, although it is to be noted that many of the incinerators are in poor condition and would require considerable capital investment for upgrading. Such an investment may not be warranted in the short term, if more centralised facilities are envisaged in the longer term. A few incinerators could, however, take up some of the shortfall. For example, the four new Monk LA350 incinerators at Tambo Memorial and Tembisa Hospital could accept a total of 105.6 tons per month, if operated at full capacity. (See Maximum Theoretical Capacity of Incinerators in Section 4.3.3.)

Table 4.10. Theoretical incinerator capacities and masses incinerated against recorded weights incinerated per month.

Name of Hospital/Clinic	Unit	Make of Incinerator	Size	Total Capacity (kg/hr)	Unit Capacity (kg/hr)	Operational hours (hrs/month)	Theoretical Mass (kg/month)	Recorded Mass (kg/month)	Discre-pancy (kg/month)
Actonville Hospital		SA Incin LA150	150	27		75	2 025	400	-1 625
Anglogold Health Western Deep Levels		Lucifer LA150	150	27		170	4 590	750	-3 840
Arwyp Medical Centre		SA Incin LA50	50	9		150	1 350		
Boksburg Prison		M Monk LA50	50	9		44	396	150	-246
Bronkhorstspruit Hospital		SA Incin LA50	50	9		75	675	500	-175
Carletonville		Lucifer LA150	150	27		8	216	235	19
Carstenhof		SA Incin LA100	100	18		200	3 600	1 500	-2 100
Coronation Hospital		Sinderator 120	120	22		180	3 960		-3 960
Cullinan Rehabilitation		SA Incin LA50	50	9					
Discovery		M Monk LA150	150	27		120	3 240	1 500	-1 740
Dr.Yusaf Dadoo Hospital		SA Incin LA150	150	27					
Edenvale General		SA Incin LA150	150	27		180	4 860	540	-4 320
EnviroServ Rietfontein	Unit 1	Macroburn 500	500	400	200	400	160 000	165 000	5 000
	Unit 2	Macroburn 500	500		200				
EnviroServ Roodepoort	Unit 1	Toxic 350	350	620	350	400	248 000	295 000	**47 000**
	Unit 2	Toxic 350	350		350				
ERPM Hospital		Lucifer LA150	150						
Far East Rand		M Monk LA150	150	27		120	3 240	5 000	**1 760**
Forensic Science Labs		SA Incin LA150	150	27		25	675		-675
Ga-Rankuwa	Unit 1	SA Incin 450LA	450	164	82			9 000	
	Unit 2	SA Incin 450LA	450		82				
Germiston		Lucifer LA150	150	27		120	3 240	1 000	-2 240
Glynnwood Hospital		Lucifer LA150	150	27		120	3 240	3 000	-240
H.A. Grove		Lucifer LA450	450	82		32	2 624		-2 624
Heidelberg		Lucifer LA150	150	27		120	3 240	250	-2 990
Helen Joseph		M Monk 200	200	36		180	6 480	5 550	-930
Hillbrow		Macroburn 200	200	36					

Name of Hospital/Clinic	Unit	Make of Incinerator	Size	Total Capacity (kg/hr)	Unit Capacity (kg/hr)	Operational hours (hrs/month)	Theoretical Mass (kg/month)	Recorded Mass (kg/month)	Discre-pancy (kg/month)
JHB City Incinerator		Toxic 350	350	350		240	84 000	80 000	-4 000
Johannesburg Hospital	Unit 1	Sinderator 120	120	44	22	200			
	Unit 2	Sinderator 120	120		22				
Jonan Heyns		Lucifer LA100	100	18		180	3 240	700	-2 540
Kalafong		Safex Burnall 100	100	18		60	1 080	2 400	**1 320**
Khutsong Public Hospital		M Monk LA350	350	64		8	512	132	-380
Kopanong		Lucifer LA150	150	27		360	9 720	1 800	-7 920
Laudium Hospital		Lucifer LA100	100	18				1 800	
Leeuwkop Prison	Unit 1	M Monk 250	250	109	45	140	15 260		
	Unit 2	M Monk LA350	350		64				
Lenmed Clinic		SA Incin LA100	100	18		150	2 700	3 000	300
Leratong		M Monk LA350	350	64		180	11 520	2 300	-9 220
Leslie Williams Memorial Hospital		SA Incin LA250	250	45		100	4 500	3 000	-1 500
Little Company of Mary		SA Incin LA100	100	18		300	5 400		
Mamelodi		M Monk LA100	100	18		120	2 160	1 800	-360
Naledi Nkanyezi Hospital		SA Incin LA150	150	27		120	3 240		-3 240
Natalspruit Hospital		Lucifer LA100	100	18		120	2 160	990	-1 170
National Institute Virology	Unit 1	M Monk LA350	350	204	102	100	20 400		-20 400
	Unit 2	Macro	350		102				
Nigel Hospital		Safex Burnall 100	100	18		120	2 160	50	-2 110
Onderstepoort Biol Prod	Unit 1	Macroburn LA450	450	360	180	120	43 200		-43 200
	Unit 2	Macroburn LA450	450		180				
Pholosong Hospital	Unit 1	SA Incin 450LA	450	164	82	180	29 520	200	-29 320
	Unit 2	SA Incin 450LA	450		82				
Pretoria Academic	Unit 1	Lucifer LA450	450	164	82	30	4 920	4 500	-420

Name of Hospital/Clinic	Unit	Make of Incinerator	Size	Total Capacity (kg/hr)	Unit Capacity (kg/hr)	Operational hours (hrs/month)	Theoretical Mass (kg/month)	Recorded Mass (kg/month)	Discre-pancy (kg/month)
	Unit 2	Lucifer LA450	450		82				
Pretoria East Hospital		SA Incin LA250	250	45		90	4 050	1 600	-2 450
Pretoria West		Safex Burnall 100	100	18		240	4 320	200	-4 120
Protechnic Lab		SA Incin 450LA	450	82				20 000	
Rand Aid Association		Macroburn 100B	100	18		42	756		-756
Sebokeng		Lucifer LA150	150	27		300	8 100	10 000	1 900
Sizwe Rietfontein		Lucifer LA150	150	27		300	8 100	10 000	1 900
Soshanguwe Clinic 3		M Monk LA100	100	18		600	10 800	1 260	-9 540
South Rand Hospital		SA Incin LA200	200	36		300	10 800	540	-10 260
Sterkfontein Hospital		SA Incin LA150	150	27		24	648		-648
Tambo Memorial	Unit 1	M Monk LA350	350	128	64			400	
	Unit 2	M Monk LA350	350		64				
Tembisa Hospital	Unit 1	M Monk LA350	350	128	64			500	
	Unit 2	M Monk LA350	350		64				
Univ Pretoria Pathology		Macroburn LA450	450	180		150	27 000		
Vaal Med		SA Incin LA150	150	27		210	5 670	3 000	-2 670
TOTALS				3 265		6 992	813 587	637 747	150844
Envirocin	Unit 1	FURNTEC	100	80	40	200	16 000	10 000	-6 000
	Unit 2	FURNTEC	100		40				