BIO-MEDICAL WASTE MANAGEMENT IN GUWAHATI CITY

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

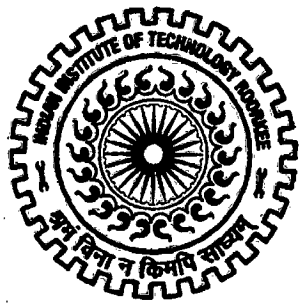
MASTER OF TECHNOLOGY

in

CONSERVATION OF RIVERS AND LAKES

By

MOUSUMI BARDALAI



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CANDIDATE'S DECLARATION

I hereby declare that the work which has been presented in the dissertation entitled **"BIO-MEDICAL WASTE MANAGEMENT IN GUWAHATI CITY"** in partial fulfillment of the requirements for the award of the degree of **Master of Technology in Conservation of Rivers and Lakes**, submitted in Alternate Hydro Energy Centre, Indian Institute of Technology, Roorkee, is an authentic record of my own work carried out during the period from July 2005 to June 2006 under the supervision of Dr. Renu Bhargava, Professor, Department of Civil Engineering, Indian Institute of Technology, Roorkee.

The matter embodied in the dissertation has not been submitted by me for the award of any other degree or diploma.

Place: Roorkee
Date: 29th JUNE, 2006

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CERTIFICATE

This is to certify that the above statement made by the candidate is correct to the best of my knowledge and belief.

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Mousumi Bardalai.

(MOUSUMI BARDALAI)

ABSTRACT

Bio-medical waste management refers to the management of waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals. The Ministry of Environment and Forests notified the BMW Rules in July, 1998. Since then, three amendments have been done in the Rules (March 2000, June 2000 and September 2003). Almost eight years have passed since the first notification, but still heaps of bio-medical wastes such as bandages, plaster casts, syringe, saline bottles, catheters, tubing, blood/urine bags etc. are sometimes observed in Municipal bins and low-lying areas in Guwahati city. This portrays that the situation of BMW management in Guwahati is grim and therefore needs serious attention.

To carry out the study, the hospitals were categorized based on bed capacity. From each category, one sample hospital was monitored to obtain the daily waste generation and the percentages of infectious, non-infectious and sharps waste. About 1290 kg of bio-medical wastes is generated everyday in the city. Out of which, infectious waste comprises between 15% to 45% and sharps comprises between 1% to 3%. The BMW management practice in all the hospitals of the city has been analyzed. Obvious gaps have been identified between the present management practice and the BMW Rules. To fill up the gap, a management plan is proposed which covers all aspects of segregation at the point of generation, collection and transportation to a common facility, treatment and disposal at the common facility. As a part of the plan, the capacity of transport vehicle, transport route, time of collection and the CBWTF have been designed. The initial investment for the CBWTF, its O&M cost, the pay back period has been calculated and the cess has been proposed.

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ABBREVIATIONS AND NOTATIONS

ABBREVIATIONS / NOTATIONS	DESCRIPTION
Avg.	Average
A.M.	Ante Meridiem
BOD	Biological Oxygen Demand
BMW	Bio-medical Waste
Cate.	Category
CBWTF	Common Bio-medical Waste Treatment Facility
CPCB	Central Pollution Control Board
COD	Chemical Oxygen Demand
CPHEEO	Central Public Health and Environmental Engineering Organization
DC	Double Chambered
etc.	et cetera
ETP	Effluent Treatment Plant
FF	First Floor
Fo F	Fourth Floor
Fig.	Figure
ft.	feet
ft^3	feet cube
GF	Ground Floor
GMCH	Guwahati Medical College Hospital
hr	hour
Inf.	Infectious
IIT	Indian Institute of Technology
i.e.	that is
Inc.	Incinerable
Kg	Kilogram

Kcal	Kilocalorie
km^2	Kilometer square
km	kilometer
L.D.O.	Light Diesel Oil
L/S	Lump Sum
L.S.H.S.	Low Sulphur High Speed
Ltd.	Limited
MT	Metric Tonne
min	minute
mm	milimeter
m	meter
m.s.l.	mean sea level
m^3	meter cube
mg	milligram
MOEF	Ministry of Environment and Forests
No.	Number
nos.	numbers
Non-inf.	Non-infectious
NS	Not measured separately
OPD	Out Patient Department
psi	pounds per square inch
P.M.	Post Meridiem
pt	patient
PVC	Poly Vinyl Chloride
Pvt.	Private
PWD	Public Works Department
Rs.	Rupees
RMW	Regulated Medical Waste
SC	Single Chambered
SF	Second Floor
Sl.	Serial

SR	Schedule of Rates
TERI	Tata Energy Research Institute
Th F	Third Floor
WHO	World Health Organization
^0C	degree centrigade
%	percentage
@	at the rate of

CHAPTER 1

INTRODUCTION

1.0 GENERAL

Hospital is one of the complex institutions which are frequented by people from every walk of life in the society without any distinction between age, sex, race and religion. This is over and above the normal inhabitants of hospital i.e. patients and staff. All of them produce waste which is increasing in its amount and type due to advances in scientific knowledge and is creating its impact. The mismanagement of bio-medical waste poses risks to people (caregivers, patients and individual members of the community) and the environment. Healthcare workers, patients, waste handlers, waste pickers and the general public are exposed to health risks from infectious wastes (particularly sharps), chemicals and other special bio-medical wastes. In India, the average number of healthcare injections per person is estimated to be 3.7 per year [Rao, 2004(a)]. Improper disposal of special bio-medical wastes, including open dumping and uncontrolled burning, increases the risk of spreading infections and of exposure to toxic emissions from incomplete combustion. Tembhurkar et al. had reported in the year 2002, that there are lot of deficiencies and problems in relation to the medical waste management, treatment and disposal within the institutions and in general. These problems and deficiencies in medical waste management are mainly due to the lack of awareness; inadequate services; limited utilization of existing facilities; lack of adequate institutional arrangement; operation inefficiencies; lack of research and development in this field; fragmented management; financial constraints; social and management apathy and use of inappropriate technologies.

In view of the above, the Ministry of Environment and Forests notified the "Bio-medical Waste (Management and Handling) Rules, 1998" in July, 1998. Since then, three amendments have been done in the Rules. The first amendment of March, 2000, extended the time schedule for setting up treatment facilities like incinerator/autoclave/microwave etc. The second amendment was notified in June, 2000 and the third amendment was notified in September, 2003. Even though almost eight years have passed since the first

notification, the concept of bio-medical waste management has come up only recently in the city of Guwahati.

1.1 DESCRIPTION OF THE AREA UNDER STUDY

1.1.1 General

Guwahati is a city in India, often considered to be the gateway to the north-east part of the country. A Guwahati suburb, Dispur is the capital of the Indian state of Assam. Guwahati city is an important commercial centre and is the node that connects six other north-eastern Indian states of Arunachal Pradesh, Nagaland, Manipur, Mizoram, Meghalaya and Tripura. Guwahati city has a population of over 10 lakhs (8, 14,575 as per 2001 census), covers an area of 216.79 km^2 and the literacy rate is 86.87%. The city is experiencing rapid urbanization as indicated by the population increase (as depicted in the Fig 1.1). (Source: Statistical Hand Book of Assam, 2005).

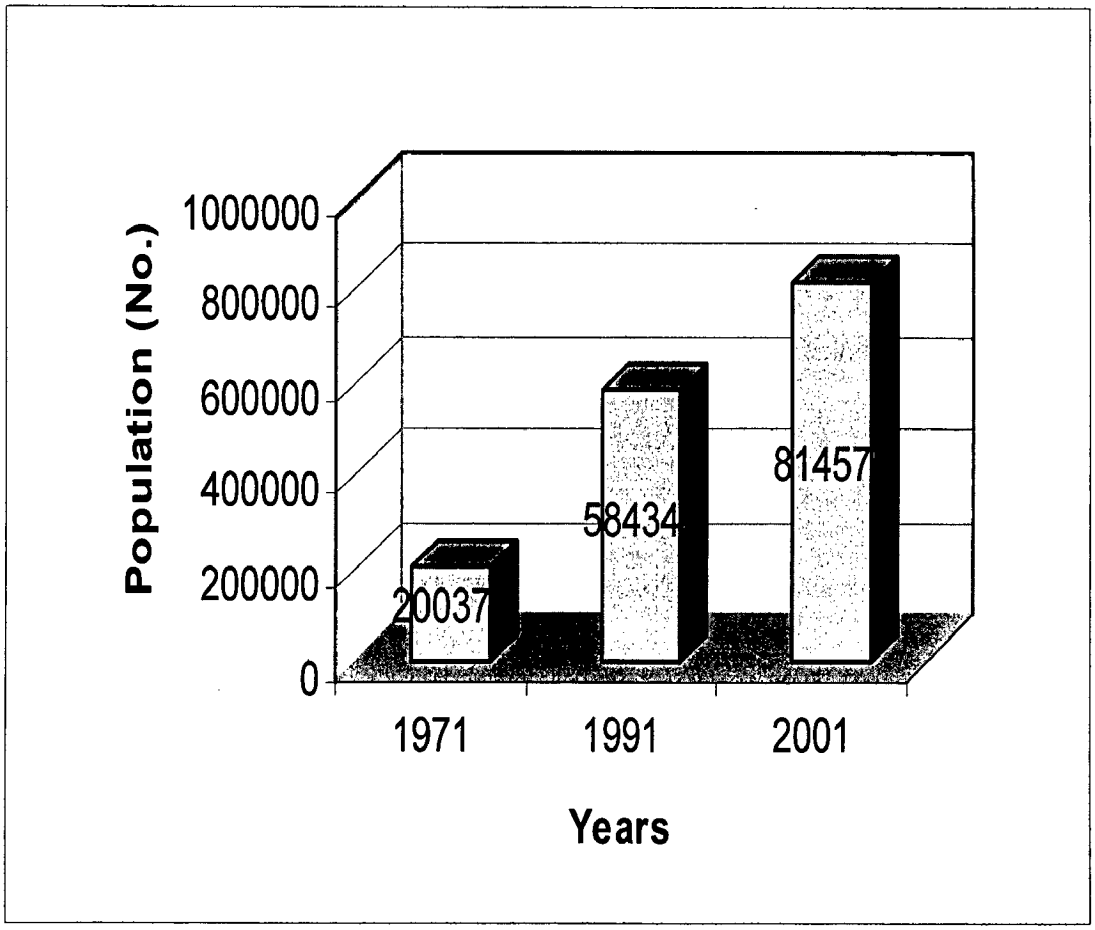


Fig. 1.1:- Population Growth of Guwahati

1.1.2 Location

Guwahati city is bounded by north latitudes $26^0 05'$ – $26^0 15'$ and east longitudes $91^0 35'$ – $91^0 55'$. It is sandwiched between the river Brahmaputra to the north and Meghalaya hills to the south. The location of Guwahati city is shown in fig. 1.2.

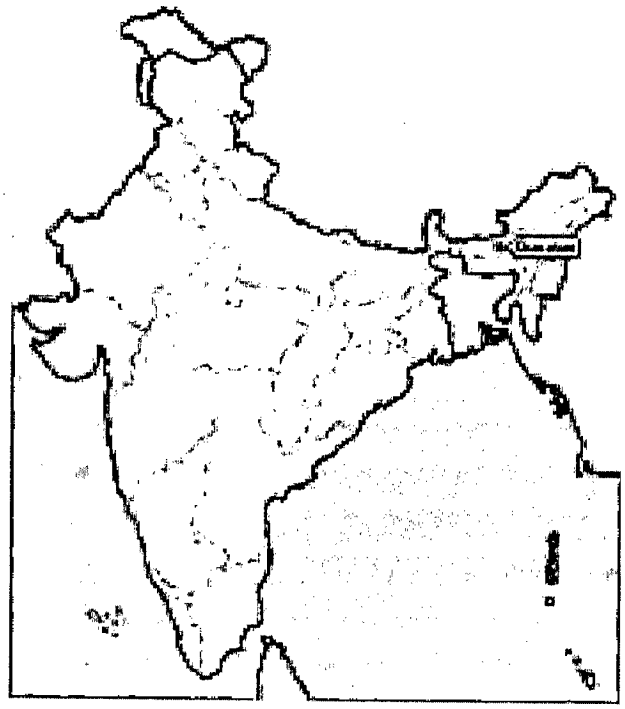


Fig. 1.2:- Location of Guwahati

1.1.3 Climate

Guwahati has a mesothermal climate characterized by high humidity and moderate temperature. The minimum and maximum temperatures range between 7^0C to 26^0C in January and 23^0C to 35^0C in July/August respectively. The average rainfall is recorded as 1725 mm and about 90% of the rain occurs between April and September, the maximum rainy months being July and August. Relative humidity is found to vary between 50% to 90%.

1.1.4 Topography

The topography of Guwahati city is undulating and lies between 45.82m to 316m above m.s.l. The major built-up area lies in the plains which are surrounded by hills on three sides (South, East and West).

1.1.5 Hospitals in Guwahati City

During the period of study, there were 41 numbers of hospitals in Guwahati city. Most of the hospitals are small, having bed capacity of less than or equal to 50 beds. These small hospitals are not financially strong to install all necessary treatment equipments to treat the bio-medical wastes. There is one government hospital having 1587 beds and it is the biggest hospital in the north-eastern region of India. Here too, bio-medical waste management is not proper.

1.2 NEED OF THE STUDY

Bio-medical waste management is a special case wherein the hazards and risks exist not just for the generators and operators but also for the general community. The persons handling the wastes are often cleaners, sweepers, ward boys, ayas and laboratory assistants. A study was conducted by Akter in 2002 for Bangladesh to determine whether such workers were suffering from any diseases. And the results are shown in table 1.1

Table 1.1:- Diseases: suffering from long time (% of positive case only)

Name of the disease	Nurse (No.=132)	Cleaners (No.=121)	Waste pickers (No.=88)
Diarrhea/dysentery	0.76	12.4	7.95
Hepatitis B/C	12.12	33.88	20.45
Sickness	6.82	26.45	18.18
Skin disease	15.91		7.95
Pox	3.79	0.83	0
TB			2.27
Malaria			1.14
Typhoid			12.5
Leg injury			1.14
Non-infectious	6.61	26.45	28.41

The above study indicates that there is a need for proper management of bio-medical waste. With rapid urbanization of Guwahati city, there is rapid increase in the number of hospitals and therefore in the generation of bio-medical waste. It is generally observed that only about 20% of the total bio-medical waste is infectious or hazardous [Patil et al., 2004(a)]. The present scenario necessitates the need to study the bio-medical waste management system in the city.

1.3 OBJECTIVES OF THE STUDY

- Study of the management of bio-medical waste in Guwahati city.
- To find out the shortcomings and gaps in the system.
- To chalk out an optimal transportation route for bio-medical waste collection.
- To design a common facility for treatment and disposal of bio-medical waste.

1.4 BMW MANAGEMENT PRACTICE

In this study, the BMW management practice in the different hospitals have been studied and analyzed to identify shortfalls in the system. Primary and secondary data were collected from sample hospitals in order to compute the waste generation per day and to calculate the percentages of infectious, non-infectious and sharps waste. To deal with the BMW problem, a management plan is proposed. The proposed management plan covers all aspects i.e. segregation, collection and transportation, treatment and disposal at a common facility.

The route for collection, timing of collection, transport vehicle capacity and CBWTF facilities has been designed.

The cost of the system and cess is also calculated.

1.5 ORGANIZATION OF THE DISSERTATION

The dissertation has been organized as follows:

- Chapter 1 gives the introduction to the subject matter. This chapter describes the area under study and focuses the need and objective of the study.
- Chapter 2 reviews the available literature related to the subject matter.
- Chapter 3 describes the methodology used in the study.
- Chapter 4 presents the observations and discusses the results with the aid of tables, figures, drawings, flowcharts and map. This chapter also deals with the design of vehicle, transportation route, time of collection and CBWTF. It also covers the cost estimation and cess for the CBWTF.
- Chapter 5 gives the conclusions, limitations and further scope of the work.

CHAPTER 2

LITERATURE REVIEW

2.0 GENERAL

"Bio-medical waste" means any waste, which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining thereto or in the production or testing of biologicals, and including categories mentioned in Schedule I of Bio-medical Waste Rules 1998.

2.1 CATEGORIES OF BIO-MEDICAL WASTE

As per Schedule I of Bio-medical Waste Rules 1998, the categories of bio-medical waste are listed below in table 2.1.

Table 2.1:- Categories of Wastes

Category	Waste type	Treatment and disposal
1.	Human anatomical waste (human tissues, organs, body parts)	Incineration/Deep burial
2.	Animal waste (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses)	Incineration/Deep burial
3.	Microbiological and biotechnology waste (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local autoclaving/microwaving/incineration

Contd.....

4.	Wastes sharp (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	Disinfection, autoclaving /microwaving and mutilation/incineration
5.	Discarded medicines and cytotoxic drugs (wastes comprising of outdated, contaminated and discarded medicines)	Incineration/secure landfill
6.	Soiled waste (Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	Incineration/autoclaving/microwaving
7.	Disposable solid waste like tubes, catheters, blood or urine bags, gloves etc.	Disinfection, mutilation/shredding
8.	Liquid waste (waste generated from laboratory and washing, cleaning, house- keeping and disinfecting activities)	Disinfection and discharge in sewer
9.	Incinerated ash (ash from incineration of any bio-medical waste)	Landfill
10.	Chemical solid wastes (chemicals used in production of biologicals, chemicals used in disinfection, as insecticides, etc.)	Disinfection and discharge in sewer for liquid and secured landfill for solids.

(Reproduced from MOEF Notification)

2.2 THE BIO-MEDICAL WASTE (MANAGEMENT AND HANDLING) RULES

The B.M.W. Rules, 1998 were framed in July, 1998. These rules stipulate the definition of bio-medical waste and its categories and also define the duty of bio-medical waste generator to take all steps to ensure that bio-medical waste is handled without any adverse effect to human health and environment.

Since the notification of the Rules in July, 1998, three amendments have been done in the Rules. The first amendment of March, 2000 extended the time schedule for setting up treatment facilities like incinerator/autoclave/microwave etc. The second amendment was notified in June, 2000 and following are the salient features:

(i) The State Pollution Control Board in respect of States and the Pollution Control Committees in respect of the Union Territories, have been notified as the prescribed authority for enforcement of the provisions of these rules.

(ii) The Municipal Corporations, Municipal Boards or Urban Local Bodies, as the case may be, shall be responsible for providing suitable common disposal/incineration sites for the bio-medical wastes generated in the area under their jurisdiction. And in areas outside the jurisdiction of any municipal body, it shall be the responsibility of the occupier generating bio-medical wastes/operator of a bio-medical waste treatment facility to arrange for suitable sites individually or in association, so as to comply with the provisions of these rules.

(iii) The Municipal body of the area shall continue to pick up and transport segregated non bio-medical solid waste as well as duly treated bio-medical wastes for disposal at municipal dumpsite.

(iv) Occupier/operator wishing to use other state-of-the-art technologies shall approach the Central Pollution Control Board to get the standards laid down to enable the prescribed authority to consider grant of authorization.

The third amendment notified in September, 2003, constituted Director General, Armed Forces Medical Services as the Prescribed Authority for healthcare facilities under the Ministry of Defense. An advisory committee for implementation of the Rules in healthcare facilities under the Ministry of Defense has also been notified. The C.P.C.B. has been made responsible to monitor the implementation of these rules in respect of such healthcare establishments [Sharma, 2004].

2.3 BIO-MEDICAL WASTES

Bio-medical waste can be classified into two types: general waste and special waste. Since general waste is not regulated or defined as hazardous or potentially dangerous wastes, it does not require special handling, treatment, and disposal. Therefore, it is sometimes called non-regulated medical waste (NRMW). Special waste includes materials considered to be potential health hazards, requiring special handling, treatment, and disposal according to B.M.W. Rules and guidelines, e.g. chemical waste, infectious waste, and radioactive waste. Therefore, most of special waste is handled and treated as

regulated medical waste (RMW) [Lee et al., 2004]. Also, wastes generated in the typical clinical veterinary medical practice are considered as regulated veterinary medical wastes [Brody, 1989].

In general health-care waste includes all the waste generated by health-care establishments, research facilities, and laboratories. In addition, it includes the waste originating from "minor" or "scattered" sources—such as that produced in the course of health care undertaken in the home (dialysis, insulin injections, etc.). Between 75% and 90% of the waste produced by health-care providers is non-risk or "general" health-care waste, comparable to domestic waste. It comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10–25% of health-care waste is regarded as hazardous and may create a variety of health risks [WHO website]. The total solid waste from the hospitals consists of bandages, linen and other infectious waste (30–35%), plastics (7–10%), disposable syringes (0·3–0·5%), glass (3–5%) and other general wastes including food (40–45%).[Patil et al., 2001(b)]

2.3.1 Average Composition of Hospital Waste in India

The data below (table 2.2) are average values obtained from 10 large hospitals in Bombay, Calcutta, Delhi, and Nagpur during the period 1993–1996 [WHO website].

Table 2.2:- Average composition of hospital waste in India

Material	Percentage (wet-weight basis)
Paper	15.0
Plastics	10.0
Rags	15.0
Metals (sharps, etc.)	1.0
Infectious waste	1.5
Glass	4.0
General waste (food waste, sweepings from hospital premises)	53.5

Source: National Environmental Engineering Research Institute (1997)

2.3.2 Approximate Physico Chemical Composition of General Bio-medical Waste

The approximate chemical composition of general bio-medical waste is usually 50% Carbon, 20% Oxygen, 6% Hydrogen and 24% other elements [WHO website].

The following data are derived from a survey performed in several Italian general hospitals of different size. They are based on daily waste production of 0.44kg per bed in use. [WHO website].

Density = 0.11kg/litre

Heating value:

dry waste = 5400kcal/kg

wet waste = 3900kcal/kg

Chlorine content = 0.4%

Mercury content = 2.5mg/kg

Cadmium content = 1.5mg/kg

Lead content = 28mg/kg

2.3.3 Bio-medical Waste Generation in India

In India, there are no national level studies on quantum of hospital waste generated per bed per day. But studies have been carried out at local or regional levels in various hospitals. From whatever data is available from these studies, it can safely be presumed that in most hospitals roughly about 1 to 2 kg of waste is generated per bed per day. Some of the notable studies carried out at Calcutta, New Delhi, Mumbai, Jaipur, Manipal and Amritsar are tabulated in table 2.3. [Anand et al., 2000].

Table 2.3:- Bio-medical Waste Generation in India

Sl. No.	City/Place	Type of Hospitals	Quantum of Waste Generated in kg/pt/day	Composition %
1.	Calcutta	Govt., Private Nursing Homes (large hospitals)	1.044 to 1.368	20-30% infectious, 50-75% general

Contd....

2.	New Delhi	Govt. and Pvt. hospital Govt. teaching hospital Research hospital	1.500 kg 1.4 to 1.6 kg 2.2 kg	45% infectious waste
3.	Mumbai	Cancer hospital	1.13 kg	46% infectious waste
4.	Jaipur	Large hospital Small hospital	1.5 kg 0.25 to 0.50 kg	
5.	Manipal	Large hospital	0.775 kg	16.26% infectious waste
6.	Amritsar	Large hospital	1.051 to 1.300 kg	

Singh et al. (2004) had reported that the rate of generation of BMW in Chandigarh varied from 0.06 kg/day/bed to 0.25 kg/day/bed. In the United States of America, infectious waste comprises 15% of the total hospital waste [Rutala et al., 1989 and Copeland et al., 1989]. This value is much lower than in India (shown in table 2.3).

2.4 HEALTH HAZARDS DUE TO BIO-MEDICAL WASTES

Health hazards due to bio-medical waste are not only confined within the premises of the hospital walls, but also spread to the public outside the boundary walls of the healthcare establishment. According to the WHO the global life expectancy is increasing year after year. However, deaths due to infectious diseases are increasing. A WHO study conducted in 1996 revealed that more than 50,000 people die everyday from infectious diseases. One of the causes for the increase in infectious diseases is improper waste management. Blood, body fluids and body secretions, which are constituents of bio-medical waste, harbour most of the viruses, bacteria and parasites that cause infection. This passes via a number of human contacts, all of whom are potential 'recipients' of the infection. Human Immunodeficiency Virus (HIV) and hepatitis viruses spearhead an extensive list of infections and diseases documented to have spread through bio-medical waste. Other common diseases which are spread due to improper waste management are tuberculosis, pneumonia, diarrhea, tetanus, whooping cough etc. [Nath et al., 2004]

2.5 ENVIRONMENTAL CONCERN

The following are the main environmental concerns with respect to improper disposal of bio-medical waste management: [CPHEEO, 2000)]

- Spread of infection and disease through vectors (fly, mosquito, insects etc.) which affect the in-house as well as surrounding population.
- Spread of infection through contact/injury among medical/non-medical personnel and sweeper/rag pickers, especially from the sharps (needles, blades etc.).
- Spread of infection through unauthorized recycling of disposable items such as hypodermic needles, tubes, blades, bottles etc.
- Reaction due to use of discarded medicines.
- Toxic emissions from defective/inefficient incinerators.
- Indiscriminate disposal of incinerator ash/residues.

2.6 CONTRIBUTION OF MERCURY FROM HEALTH-CARE SECTOR

Health-care facilities are one of the main sources of mercury release into the atmosphere because of emissions from the incineration of medical waste. These facilities are also responsible for mercury pollution taking place in water bodies from the release of untreated wastewater. According to a 1999 report, health-care facilities may also have been responsible for as much as 5% of all mercury releases in wastewater.

Dental amalgam, the most commonly used dental filling material, is a mixture of mercury and a metal alloy. The normal composition is 45-55% mercury, approximately 30% silver and other metals such as copper, tin and zinc. In 1991, the World Health Organization confirmed that mercury contained in dental amalgam is the greatest source of mercury vapour in non-industrialized settings and it exposes the concerned population to mercury levels significantly exceeding those set for food and for air.

Waste incineration and crematoria are also listed as major sources of mercury emissions. It is recognized that there is mercury contribution from hospital thermometers, dental amalgams, hospital waste and/or medical waste incinerators but there is no quantitative data. Despite the lack of data, there is good reason to believe that mercury releases from the health-care sector in general is substantial. [WHO, 2005]

2.7 TECHNOLOGIES FOR THE TREATMENT OF BIO-MEDICAL WASTES

There are many technologies in use for the treatment of medical wastes. According to the treatment studies of medical wastes, about 59–60% of RMWs are treated through incineration, 37–20% by steam sterilization, and 4–5% by other treatment methods. Currently, the proportion of off-site treatment and disposal has been increasing up to 84% due to severe regulations concerning on-site incineration. Historically, incineration has been used as an important treatment method for RMW. That is because incineration has many advantages including putrefaction prevention and sterilization of pathological or anatomic wastes, volume reduction, and waste heat recovery. Many hospitals are employing on-site incineration for treatment of their RMWs. However, RMW includes significant quantities of chlorine containing wastes, such as polyvinyl chloride (PVC) or disinfectants, and it might be incinerated with status lacking proper controls and emission reduction devices. Therefore, incineration of RMWs might produce dioxins and furans known as hazardous pollutants. Considerable amounts of heavy metals waste can also be emitted as forms of fumes or vapors, particles and ashes produced from incineration of RMW [Lee et al., 2004].

Consequently, many new techniques without incineration are now being developed. New technologies being considered by RMW disposal engineers include microwaving, autoclaving, radiowaving, and electrotechnologies, which incorporate electron-beam irradiation, pyrolysis and oxidation, steam sterilization, and steam detoxification. Currently, microwaving and autoclaving have been considered as positive alternative treatment methods to incineration. Microwaving might be economically competitive with incineration and applicable to continuous or batch operation [Lee et al., 2004].

2.8 RELATED STUDIES

A few of the studies related to bio-medical waste are listed below:

- Patil et al. (2000) conducted a study on health-care waste management in India. This study concluded that the waste generation rate ranges between 0.5 to 2.0 kg/bed/day and it has been estimated that annually about 0.33 million tones of waste are generated in India.

- Lee et al. (2003) investigated generation volume and sources, composition and treatment and disposal methods for regulated medical wastes obtained from three typical city hospitals in Massachusetts. The study compared the generation patterns and amounts of regulated medical wastes between hospital and medical school. This study indicated that careful exclusion of non-RMW from RMW can reduce the RMW volume that requires special treatment and thus reduce disposal costs.
- Patil et al. (2004) assessed the waste handling and treatment system of bio-medical solid waste in India and its mandatory compliance with BMW rules. The study estimated the amount of non-infectious and infectious waste generated in the different wards/sections of KLE Society's 1000 bed Hospital and Medical Research Centre at Belgaum in Karnataka. The study concluded that the management and treatment of BMW in the study centre conformed to the BMW Rules and the infectious waste generation is 16.4%.
- Rao et al. (2004) conducted a study to assess the infrastructural requirement for BMW management in five sample hospitals in Pune and concluded that there is an urgent need to standardize the infrastructural requirement so that hospitals following BMW rules strictly do not suffer additional costs.
- TERI, Bangalore (2002) conducted a study of BMW generation in four sample hospitals in Bangalore and found that the total BMW generation in the city amounts to 0.5 % of the total solid waste generation per day.
- CPCB (2000) carried out bio-medical waste management study in 9 hospitals in Kolkata, having bed capacity more than 500. The study indicated that there was barely any BMW segregation as per the BMW Rules.
- CPCB (2000) carried out bio-medical waste management study in Allahabad. The study concluded that the average waste generation/bed in the city is 250 gram/day and the total BMW generated is 1.3 MT/day.
- Anon (2001) conducted a study of hospitals in Mexico to establish a framework for pollution prevention and waste management in hospitals.

- Chitnis et al. (2003) has conducted a study on solar disinfection of infectious biomedical waste and concluded that solar heating can be an alternative technology for treatment of BMW.
- Research is being carried out at IIT, Roorkee for vermicomposting of bio-medical waste (Bhargava, 2004).
- WHO (2005) has conducted a study "Safe Management of Bio-medical Sharps Waste in India" and concluded that reprocessing of the sharps waste was a better solution to the present problem of sharps management, than disposal into sharps pit.
- Tembhurkar et al. (2002) conducted a study of the various activities required during planning and the development of medical waste management plan.

CHAPTER 3

METHODOLOGY

3.0 GENERAL

This chapter gives the description of the methodology followed in the present dissertation. Flow chart gives the steps involved in the study. Primary data were collected during the study while Secondary data were obtained from the record books.

3.1 PRELIMINARY SURVEY

A preliminary survey was conducted to find out the number and types of hospitals/nursing homes in the city of Guwahati. Information was collected from the Directorate of Health Services regarding the number of hospitals/nursing homes and the bed capacity of each.

3.2 CATEGORIZATION OF HOSPITALS

The hospitals were categorized into different types based on bed capacity, as follows:

Type A	Less than 30 beds
Type B	Between 30 to 50 beds
Type C	More than 50 beds and upto 100 beds
Type D	More than 100 beds and upto 150 beds
Type E	More than 200 beds and upto 250 beds
Type F	More than 250 beds and upto 300 beds
Type G	1587 bedded hospital

3.3 SELECTION OF HOSPITAL

For each category of hospital, one hospital was selected as the sample hospital. Care was taken to see that the sample hospital is a representative of its category having different wards (i.e. gynecology, pediatric, surgery, orthopedic etc.). In total, seven hospitals were selected.

3.4 DATA COLLECTION

Primary and secondary data were collected from each sample hospital. For the other hospitals, general survey was carried out to study the management of bio-medical waste.

3.4.1 Primary Data

Each sample hospital staff was instructed to put the different categories of waste into the different colour coded bags and to label the bags accordingly. To the small hospitals, bags were supplied. The bags with waste were weighed by a cylindrical weighing scale to determine the weights of the different waste categories. Questionnaires were prepared to collect the information from the hospital and general public. Questionnaires Q-1 and Q-2 are given in Appendix I and II.

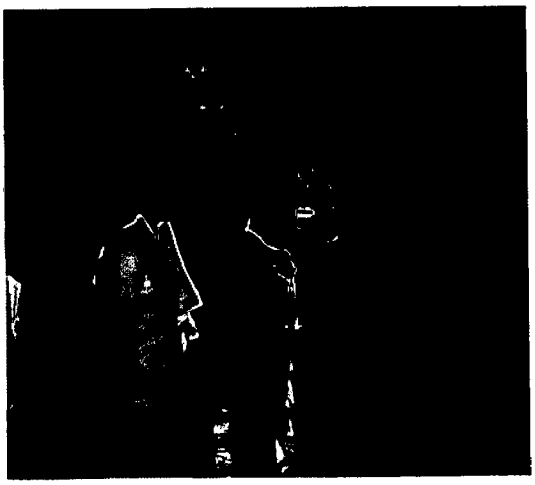


Fig. 3.1:- Primary Data Collection

3.4.1.1 *Preparation of Questionnaire*

Two questionnaires are prepared. The first questionnaire (Q-1) is based on the Bio-medical Waste Rules, 1998. Q-1 is prepared for hospitals/nursing homes/clinics/pathological laboratories/blood banks. The second questionnaire (Q-2) is prepared for public to know their views/opinions and awareness regarding bio-medical waste.

3.4.2 Secondary Data

For each sample hospital, secondary data of waste generation was taken from their record books.

3.5 INFECTIOUS WASTES

Infectious Waste may be defined as waste suspected to contain pathogens, e.g. laboratory cultures, waste from isolation wards, tissues (swabs), material/equipment that have been in contact with infected patients, excreta.[Nath et al., 2004]. In this study, waste categories 1, 3, 6 and 7 are considered as infectious wastes.

3.6 DATA ANALYSIS

The tabulated data are analyzed to find out the percentage of infectious waste, non-infectious waste and sharps. An effort is also made to design a Common Bio-medical Waste Treatment Facility (CBWTF) and to chalk out an optimal waste transportation route.

3.7 SELECTION OF OPTIMAL TRANSPORTATION ROUTE

The optimal route for BMW transportation was selected based on the following points:

- Distance
- Time
- Cost
- Road condition
- Weight of bio-medical waste
- Capacity of vehicle

CHAPTER 4

OBSERVATIONS, RESULTS AND DISCUSSION

4.0 GENERAL

Guwahati city is a major business hub and it is the gateway to the north-east of India. It has a population of over 10 lakhs presently (8,14,575 as per 2001 census). Guwahati city has 41 nos. of hospitals during the period of study (October, 2005 to April, 2006). Table 4.1 gives the list of hospitals with capacity. These hospitals are categorized into Type A, B, C, D, E, F and G based on bed capacity.

Table 4.1:- Hospitals in Guwahati City and their Capacity in terms of Number of Beds

Sl. No.	Name of Hospital and Location	Capacity (no. of beds)	Occupancy Factor
1	Advance Neuro Science Hospital, Hatigaon Road.	25	90%
2	Aruna Memorial Hospital Pvt. Ltd., Rajgarh	25	90%
3	Azile Hospital, Beltola.	35	90%
4	Army Base Hospital, Basistha.	100	90%
5	Borthakur Clinic Pvt. Ltd., Kharghuli.	30	90%
6	Brahmaputra Hospital Ltd., Six mile.	30	90%
7	Care Home Hospital, Bamunimaidan	21	90%
8	Central Clinic and Nursing Home, Opposite Jail.	15	90%
9	Central Railway Hospital, Maligaon.	300	90%
10	City Heart Hospital, Rajgarh	30	90%
11	City Nursing Home, Near Kumarpara.	15	90%
12	Dispur Polyclinic and Research Centre, Ganeshguri.	150	90%
13	Downtown Hospital, Dispur.	300	90%
14	ESI Hospital, Khanapara.	25	90%
15	ESI Model Hospital, Dhirenpara	30	90%
16	Global Hospital, Hatigaon.	30	90%
17	GNRC Hospital, Dispur Supermarket	250	90%

Contd.....

18	Green Land Hospital, Azara.	20	90%
19	Gurucharan Nursing Home and Polyclinic, Near Nepali Mandir.	30	90%
20	Guwahati Medical College Hospital, Bhangagarh.	1587	95%
21	H.M. Hospital, Hatigaon.	30	90%
22	Institute Of Human Reproduction, Near Bharalumukh.	15	90%
23	International Hospital, Near Ganeshguri.	114	90%
24	K.C. Das Nursing Home and Polyclinic, Near Arya College.	30	90%
25	Kumars Nursing Home, Kumarpara.	25	90%
26	M.M.C. Hospital, Panbazar.	300	95%
27	Marwari Hospital and Research Centre, Near Kumarpara.	45	90%
28	Marwari Maternity Hospital, Near Kumarpara.	65	90%
29	Midland Hospital, Zoo Road.	25	90%
30	Nemcare Hospital, Bhangagarh.	50	90%
31	Nightingale Hospital, Beltola.	14	90%
32	Refinery Hospital, Noonmati.	30	90%
33	Sanjevani Hospital, Near Maligaon.	40	90%
34	Sankardev Nethralaya, Beltola.	30	90%
35	Swagat Endocrinological Centre, Near Bharalumukh.	25	90%
36	Wintrobe Hospital, Ambari.	30	90%
37	East End Hospital, Bamunimaidan.	40	90%
38	Good Friend Hospital, Ulubari.	25	90%
39	Good Health Hospital, Dispur.	35	90%
40	CRPF Base Hospital, Nine Mile.	205	90%
41	Chatribari Hospital, Chatribari	100	90%

[Source: Directorate of Health Services, Assam]

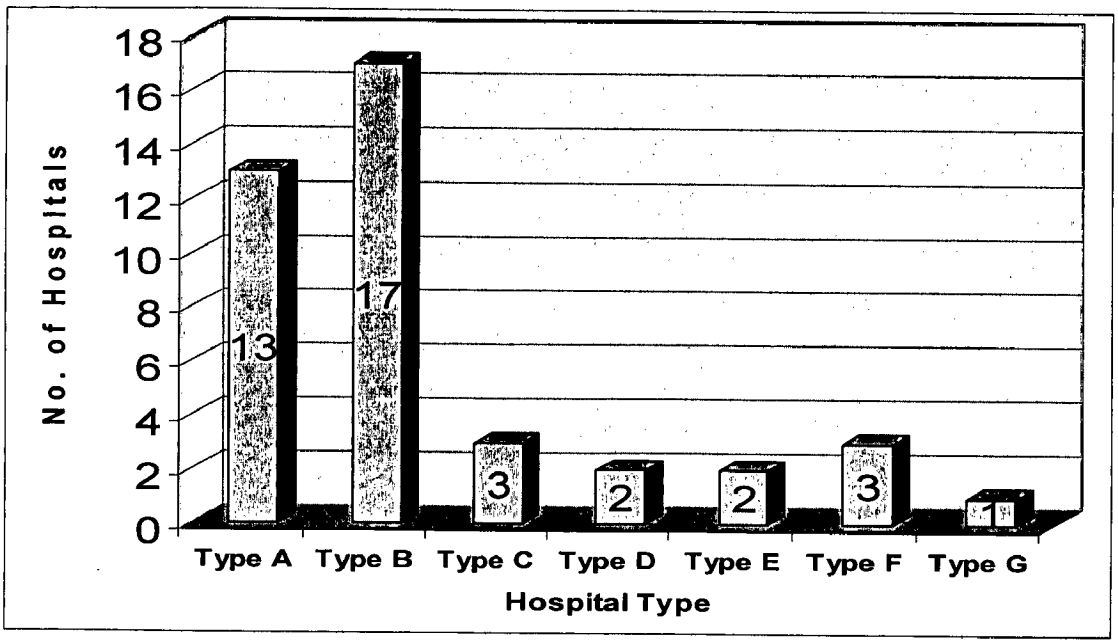


Fig. 4.1:- Nos. of Hospitals in each Hospital Type

For this study, one hospital from each type was selected as sample hospital. The numbers of hospitals in each category are presented in fig. 4.1 and the no. of beds in the sample hospitals is shown in table 4.2.

Table 4.2:- No. of Beds in Sample Hospitals

Hospital Type	No. of beds in sample hospital.
A	25
B	35
C	100
D	114
E	250
F	300
G	1587

All these sample hospital staff were instructed to put the different categories of wastes into different colour coded bags (as per the BMW Rules) and to label the bags accordingly. To the small hospitals, bags were supplied. During monitoring period, the primary data was obtained. Also, the questionnaires were filled up.

Bio-medical waste management includes storage, handling and treatment at hospital level as well as transport, treatment and disposal at the centralized place. All these aspects of management are studied for each of the hospitals.

4.1 TYPE A HOSPITALS

4.1.1 General

Type A comprises of hospitals having less than 30 beds. There are 13 nos. of Type A hospitals. Such hospitals are equipped with blood bank, dressing room, medicine ward, surgery ward, Operation Theatre and gynecological ward. Plan of sample hospital is shown in Drawing I. Secondary data for 15 days was collected from the record book. Secondary data is tabulated in table 4.3. Primary data was measured for 15 days from 8/1/2006 to 22/1/2006. The primary data is tabulated in table 4.4.

Table 4.3:- Type A Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.2 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Inf. Waste (Cate.1+3+6+7) (Kg)	Sharps(4) (Kg)	Non-inf. Waste Kg)
1/12/2005	2.5	Nil	0.5	1.2	5.5	5.0	13.5	1.2	45.3
2/12/2005	0.0	Nil	0.0	0.0	5.0	0.0	5.0	0.0	55.0
3/12/2005	2.1	Nil	1.0	1.2	3.5	6.0	12.6	1.2	46.2
4/12/2005	1.0	Nil	1.0	0.8	3.5	6.0	11.5	0.8	47.7
5/12/2005	0.5	Nil	1.0	1.2	5.5	5.0	12.0	1.2	46.8
6/12/2005	0.0	Nil	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7/12/2005	0.5	Nil	0.5	0.9	3.6	6.0	10.6	0.9	48.5
8/12/2005	1.0	Nil	1.0	1.2	1.5	6.0	9.5	1.2	49.3
9/12/2005	0.0	Nil	0.0	0.0	5.4	3.5	8.9	0.0	51.1
10/12/2005	2.5	Nil	1.0	2.1	0.0	0.0	3.5	2.1	54.4
11/12/2005	0.5	Nil	1.2	1.2	3.5	6.0	11.2	1.2	47.6
12/12/2005	0.5	Nil	0.0	1.5	5.5	5.0	11.0	1.5	47.5
13/12/2005	0.5	Nil	0.0	1.2	5.5	3.0	9.0	1.2	49.8
14/12/2005	0.5	Nil	0.5	1.5	0.0	0.0	1.0	1.5	57.6
15/12/2005	2.5	Nil	0.0	0.9	3.5	2.1	8.1	0.9	51.0
Avg. value	**1.0**	**Nil**	**0.5**	**1.0**	**3.4**	**3.6**	**8.5**	**1.0**	**48.3**

Table 4.4:- Type A Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Inf. Waste (Cate.1+3+6+7) (Kg)	Sharps(4) (Kg)	Non-inf. Waste (Kg)
8/1/2006	1.5	0.5	0.9	5.5	5.0	0.8	12.5	0.9	46.6
9/1/2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
10/1/2006	2.5	0.5	1.2	5.4	3.5	0.9	11.9	1.2	46.9
11/1/2006	0.5	1.0	0.8	5.3	5.0	0.7	11.8	0.8	47.4
12/1/2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
13/1/2006	3.0	1.2	1.4	5.5	5.0	1.0	14.7	1.4	43.9
14/1/2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
15/1/2006	0.5	1.0	0.9	5.5	5.0	0.6	12.0	0.9	47.1
16/1/2006	0.5	0.5	0.8	3.5	5.5	0.6	10.0	0.8	49.2
17/1/2006	0.0	0.0	0.0	5.5	3.5	0.0	9.0	0.0	51.0
18/1/2006	0.5	0.5	1.0	5.5	3.0	0.7	9.5	1.0	49.5
19/1/2006	0.5	0.5	0.7	3.5	7.0	0.7	11.5	0.7	47.8
20/1/2006	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0
21/1/2006	0.5	1.0	0.9	5.0	8.0	0.7	14.5	0.9	44.6
22/1/2006	3.0	0.5	1.3	5.0	5.0	1.0	13.5	1.3	45.3
Avg. value	**0.9**	**0.5**	**0.7**	**3.7**	**3.7**	**0.5**	**8.7**	**0.7**	**49.2**

On comparison of these two tables, it is observed that average values of category 1 and category 4 are higher while average values of category 6 and category 7 are lower in the secondary data table. The average value of category 3 is same in both tables. From the analysis of the data, it is found that infectious waste comprises 15%, non- infectious waste comprises 84% and sharps comprises 1%. The percentages of the different categories of waste and the percentages of infectious waste, non-infectious waste and sharps in Type A hospitals are depicted in the fig. 4.2 and fig. 4.3.

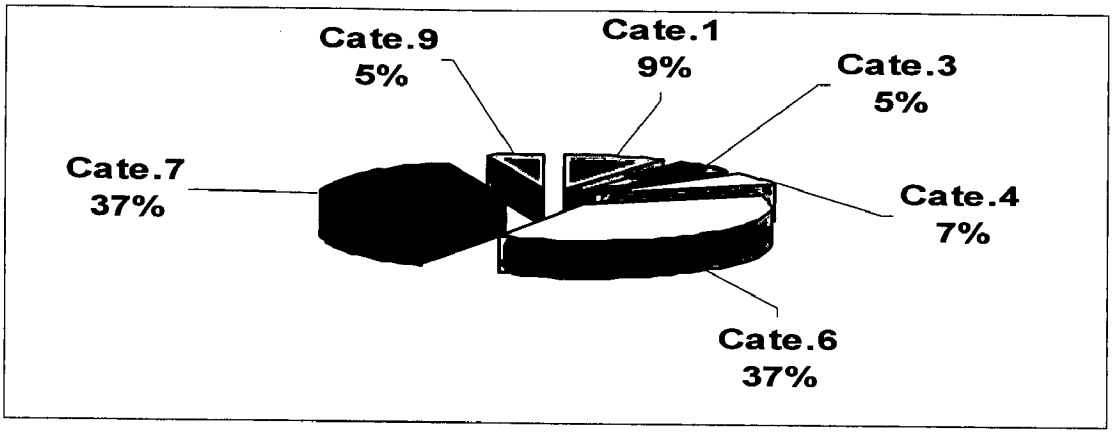


Fig. 4.2:- Waste Categories (Type A Hospital)

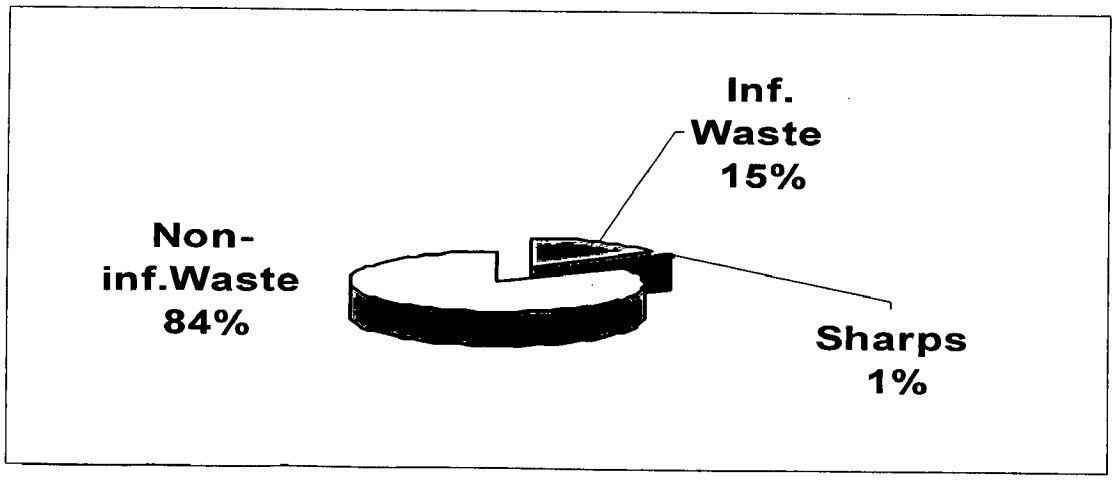


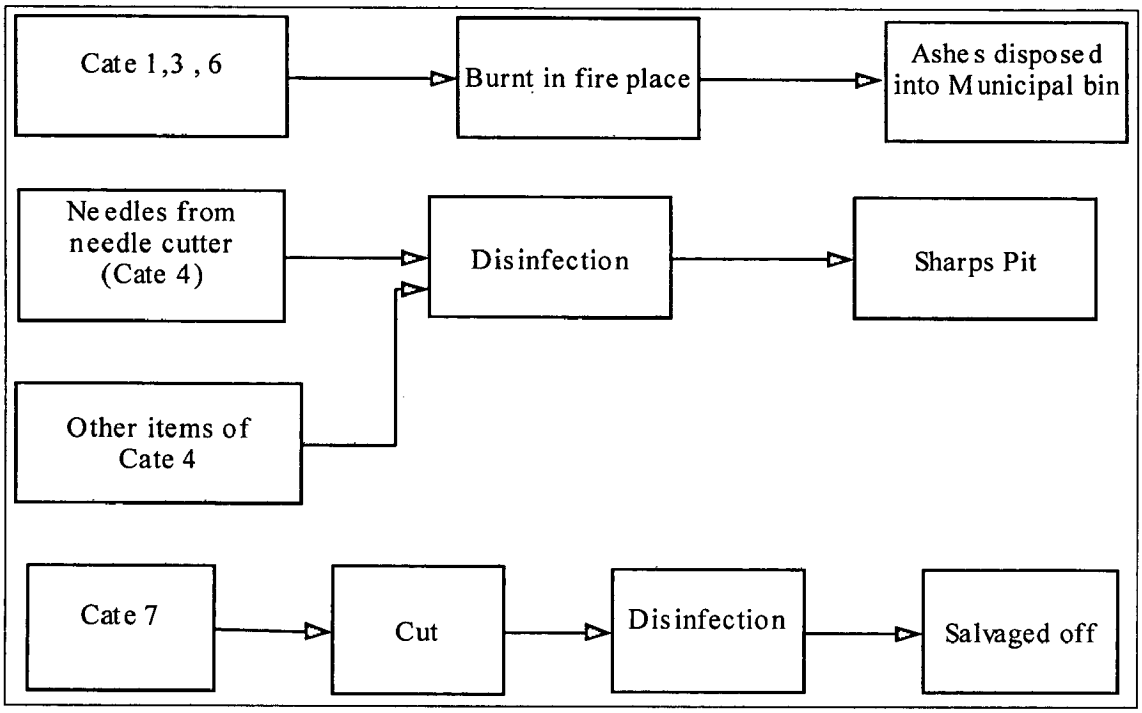
Fig. 4.3:- Inf., Non-inf. And Sharps Waste (Type A Hospital)

4.1.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management followed in various Type A hospitals is explained in the following paragraphs.

4.1.2.1 *Advance Neuro Science Hospital*

This hospital is located on Hatigaon Road. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.1.



Flow-chart 4.1:- Present BMW Management Practice Advance Neuro Science at Hospital

- **Management of incinerable waste:**

The incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags and then burnt in a fire-place. The ashes are disposed into the Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe by use of needle cutter. All items of category 4 are dipped into 1% hypochlorite solution in a covered bucket for 30 minutes and then sharps are disposed into a sharps pit.

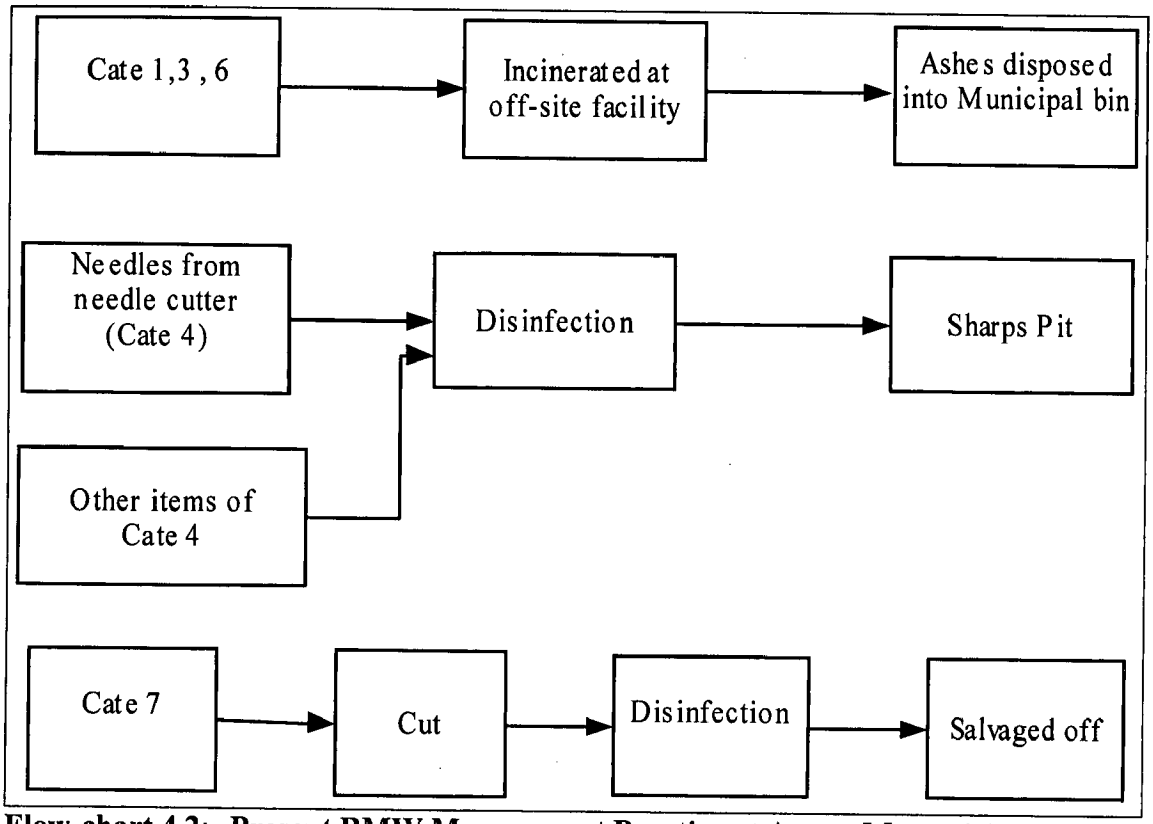
- **Management of infectious plastics:**

All items of category 7 are cut and then dis-infected using hypochlorite solution and then salvaged off.

The burning of incinerable waste causes air pollution in the atmosphere. As all sharps are disposed into the sharps pit, it will soon get filled up.

4.1.2.2 *Aruna Memorial Hospital Pvt. Ltd.*

This hospital is located on Rajgarh Road. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.2



Flow-chart 4.2:- Present BMW Management Practice at Aruna Memorial Hospital

- **Management of incinerable waste:**

The incinerable wastes i.e. categories 1, 3 and 6 are stored together in non-PVC bags. The bags are collected by the contractor for incineration in International Hospital.

- **Management of sharps:**

The needles are cut from the syringe by use of needle cutter. All items of category 4 are dis-infected in 1% hypochlorite solution in a covered bucket for half hour. After this dis-infection, sharps are disposed into a sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and then dis-infected in hypochlorite solution. After this, it is salvaged off.

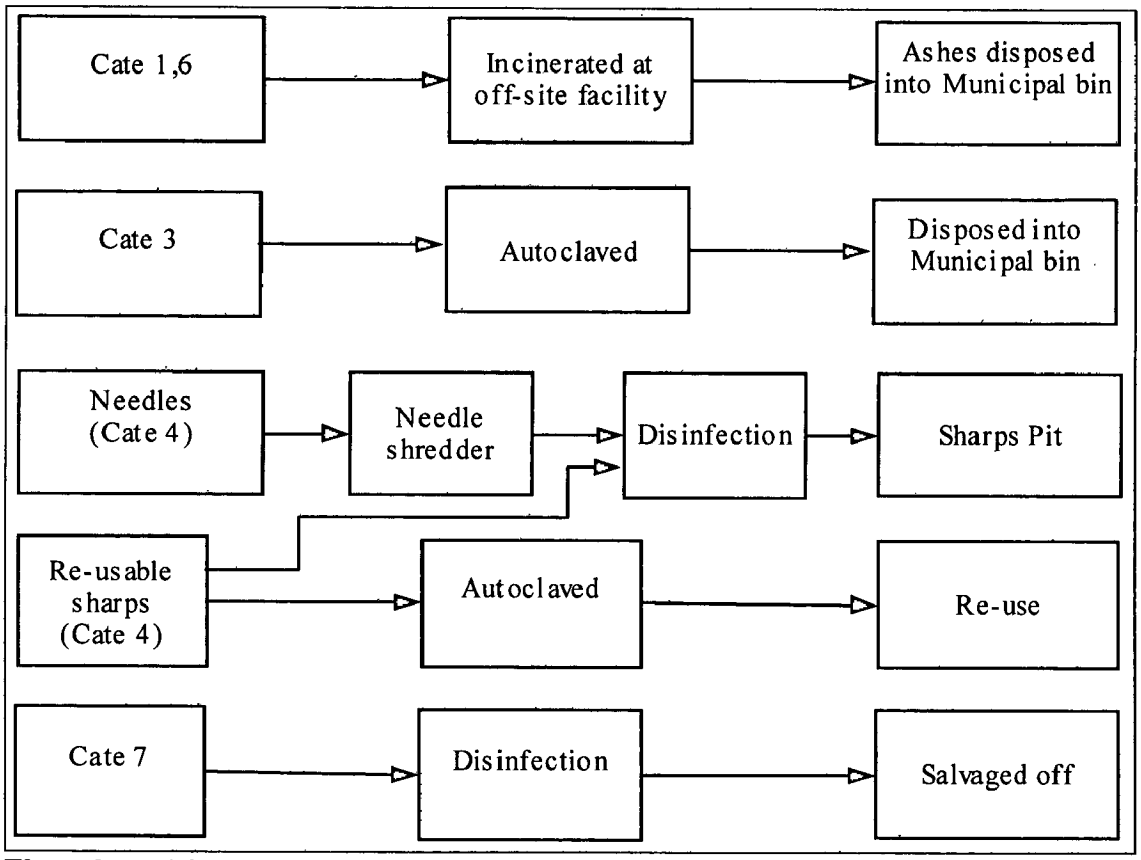
This hospital is also following the short-term solution of the sharps pit. The pit will soon get filled up and there is lack of space to build many pits.

4.1.2.3 *Care Home Hospital*

This hospital is located in Bamunimaidan area. It has bed capacity of 21 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Aruna Memorial Hospital Pvt. Ltd.

4.1.2.4 *Central Clinic and Nursing Home*

This hospital is located opposite to the Jail in Fancy Bazar. It has bed capacity of 15 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.3.



Flow-chart 4.3:- Present BMW Management Practice at Central Clinic and Nursing Home

- **Management of incinerable waste:**

Waste categories 1 and 6 are stored together in non-PVC bags. The bags are collected by the contractor for incineration in International Hospital. Category 3 is locally autoclaved, then disposed into Municipal bin.

- **Management of sharps:**

The needles are shredded in Needle Shredder. The shredded needles are dis-infected in 1% hypochlorite solution and then disposed into sharps pit. Re-useable sharps like surgical accessories are autoclaved and re-used. When surgical sharps become waste, it is dis-infected and disposed into the sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and then dis-infected in hypochlorite solution. After this, it is salvaged off.

While autoclaving re-useable surgical sharps, the correct temperature and pressure are maintained. But spore testing is not done. The needle shredders are not dis-infected regularly.

4.1.2.5 *City Nursing Home*

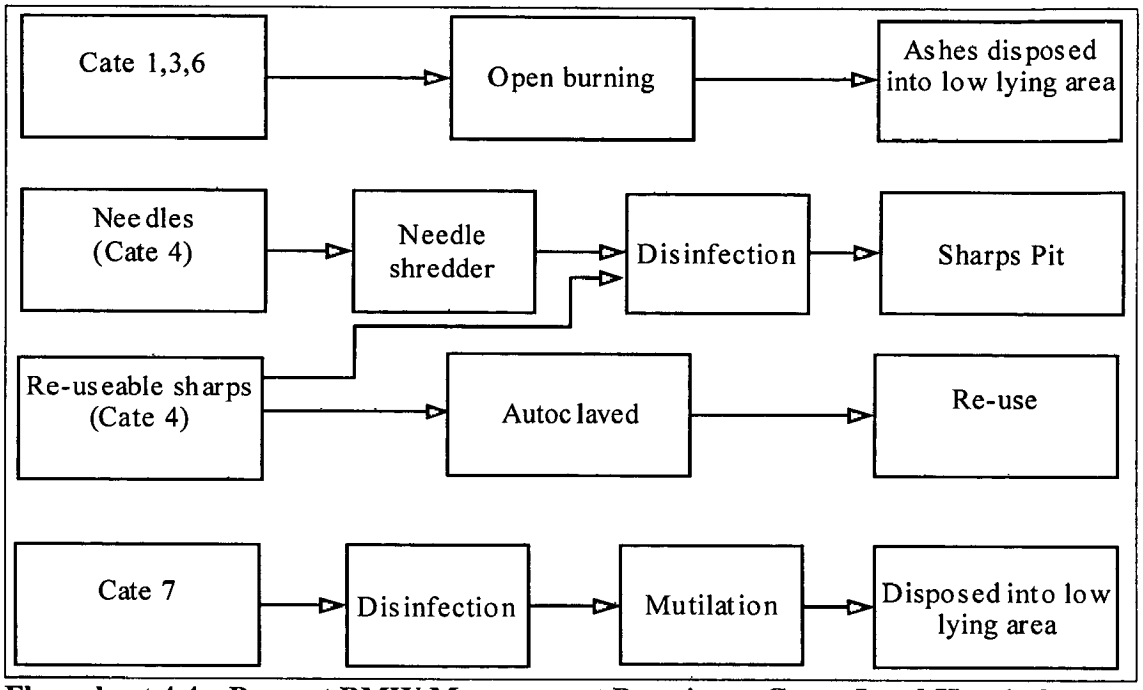
This hospital is located near Kumarpara. It has bed capacity of 15 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Advance Neuro Science Hospital.

4.1.2.6 *E.S.I. Hospital*

This hospital is located at Khanapara. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Advance Neuro Science Hospital.

4.1.2.7 *Green Land Hospital*

This hospital is located in Azara, away from the main city. It has bed capacity of 20 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.4.



Flow-chart 4.4:- Present BMW Management Practice at Green Land Hospital

- **Management of incinerable waste:**

The waste categories 1, 3 and 6 are incinerable wastes. These are stored together in non-PVC bags. The bags are openly burnt and the ashes are disposed into low-lying area.

- **Management of sharps:**

The needles are shredded in Needle Shredder. Post shredding, it is dis-infected in 1% hypochlorite solution, after which it is disposed into sharps pit. Re-useable sharps like surgical accessories are autoclaved and re-used. When it becomes waste, it is dis-infected and disposed into sharps pit.

- **Management of infectious plastics:**

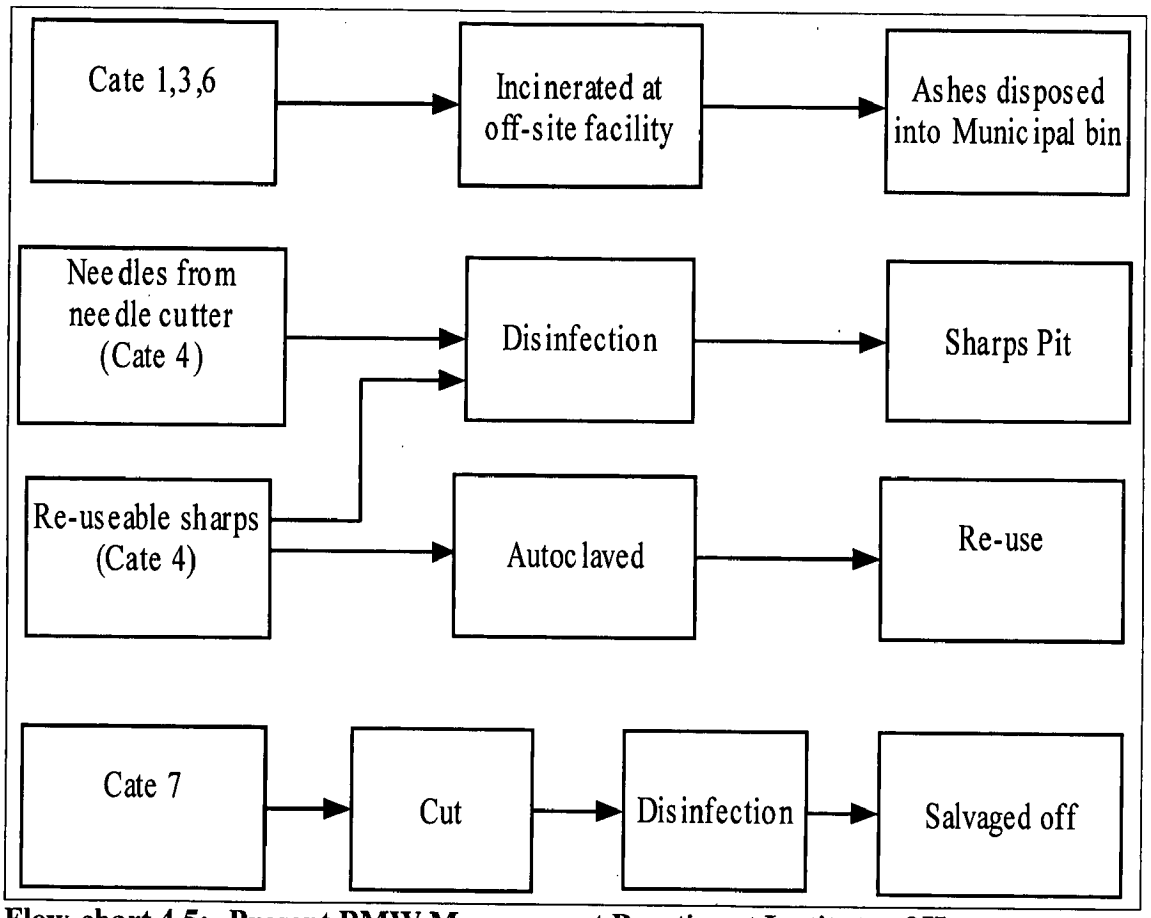
All items of category 7 are segregated into a drum filled with 1% hypochlorite solution. After retaining for at least 30 minutes, these are mutilated and disposed into nearby low-lying area.

The open burning of incinerable waste release air pollutants like dioxins and furans into the atmosphere. The dumping of plastic waste causes solid waste/land pollution and it also spoils the aesthetic of the surrounding area. The re-useable sharps

are autoclaved but post autoclaving, spore testing is not done to check for complete sterilization.

4.1.2.8 *Institute of Human Reproduction*

This hospital is located in Shantipur area. It has bed capacity of 15 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.5.



Flow-chart 4.5:- Present BMW Management Practice at Institute of Human Reproduction

- **Management of incinerable waste:**

Incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags. It is collected by the contractor for incineration in the incinerator of International Hospital.

- **Management of sharps:**

The needles are cut in needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. When it becomes waste, it is dis-infected and disposed into sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and dis-infected and then salvaged off.

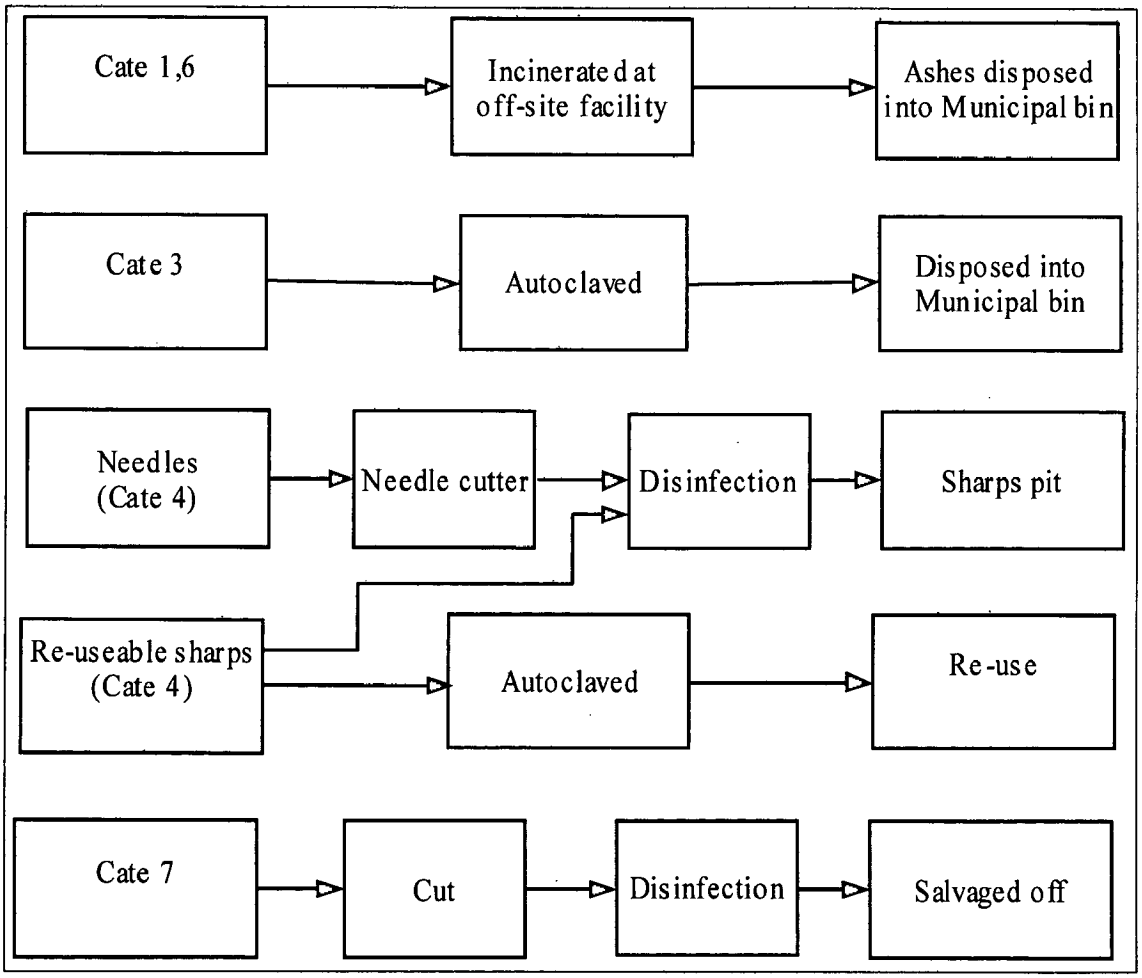
Here also, spore testing after autoclaving is not done. Sometimes, all items of category 7 are not cut properly. This may lead to illegal re-use.

4.1.2.9 *Kumar's Nursing Home*

This hospital is located at Kumarpara. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Institute of Human Reproduction.

4.1.2.10 *Midland Hospital*

This hospital is located close to Zoo Road. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.6.



Flow-chart 4.6:- Present BMW Management Practice at Midland Hospital

- **Management of incinerable waste:**

In this hospital, only categories 1 and 6 are incinerated. Categories 1 and 6 are stored together in non-PVC bags. It is collected by the contractor for incineration in the incinerator of International Hospital. The ashes are disposed into Municipal bin. Category 3 is autoclaved and disposed into Municipal bin.

- **Management of sharps:**

The needles are cut in needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. When it becomes waste, it is dis-infected and disposed into sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and put into a drum for dis-infection and then it is salvaged off.

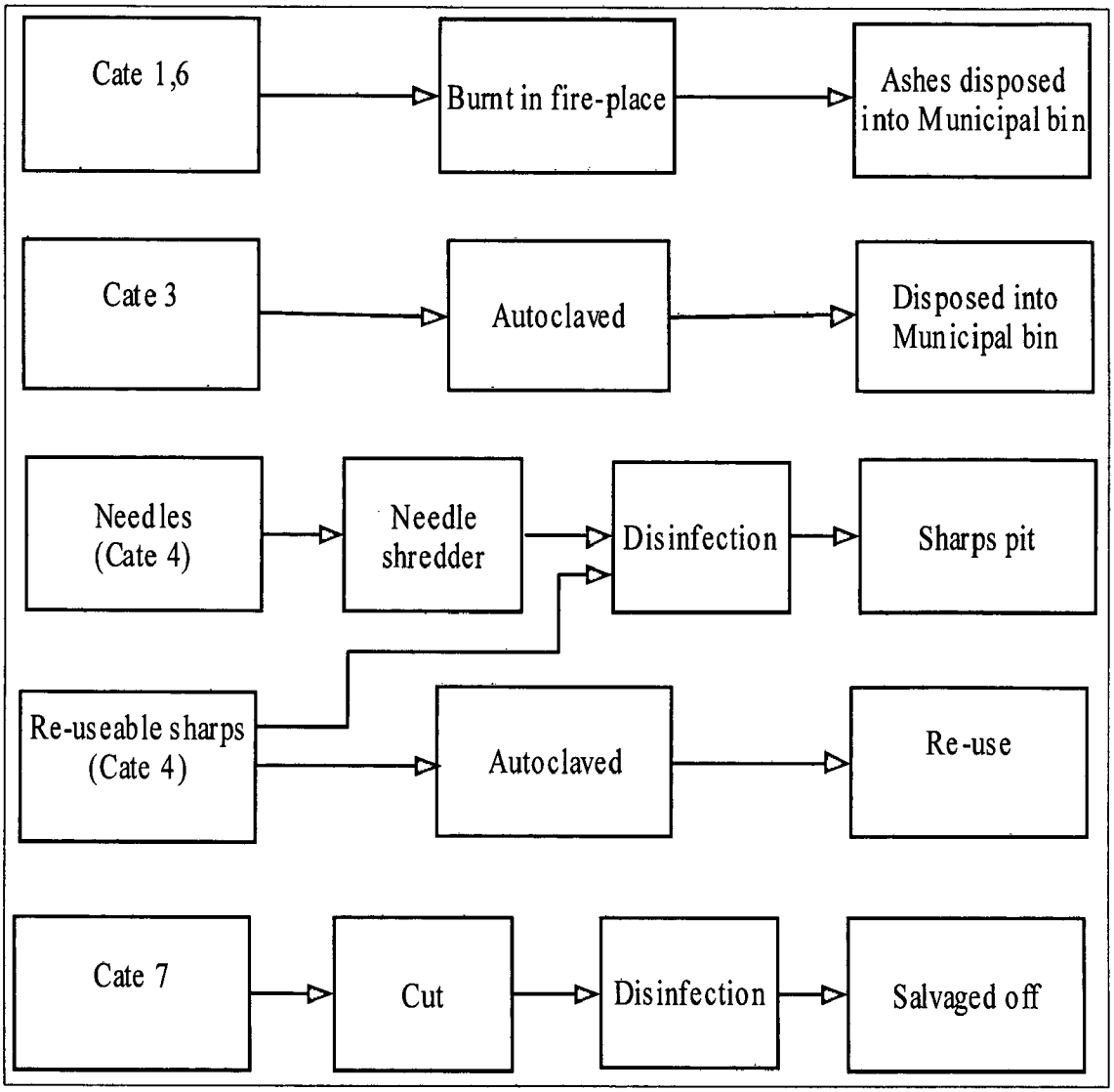
Both waste (category 3) and reusable sharps are autoclaved in the same autoclave. Post autoclaving spore testing is not done. As such, category 3 may be disposed without proper dis-infection. Also, re-useable sharps may not be properly sterilized.

4.1.2.11 *Nightingale Hospital*

This hospital is located in Beltola. It has bed capacity of 14 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Midland Hospital.

4.1.2.12 *Swagat Endocrinological Centre*

This hospital is located near Bharalumukh. It has bed capacity of 25 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.7.



Flow-chart 4.7:- Present BMW Management Practice at Swagat Endocrinological Centre

- **Management of incinerable waste:**

Incinerable waste categories 1 and 6 are stored together in non-PVC bags. These bags are burnt in a fire-place and the ashes are disposed into Municipal bin. Category 3 is autoclaved and disposed into Municipal bin.

- **Management of sharps:**

The needles are shredded in needle shredder, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. When it becomes waste, it is dis-infected and disposed into sharps pit.

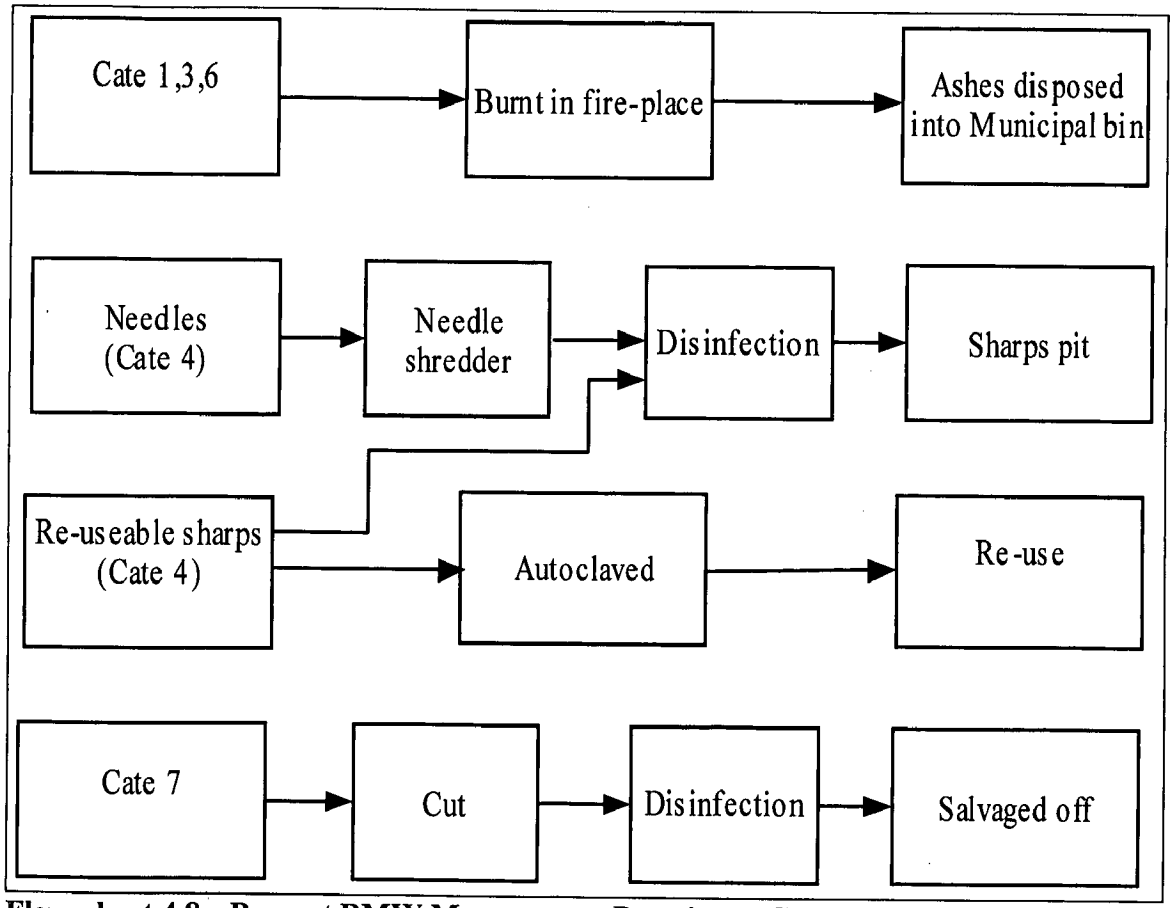
- **Management of infectious plastics:**

All items of category 7 are cut and put into a drum for disinfection and then it is salvaged off.

The chimney of the fire place is less than 10 m. As such, burning of waste causes air pollution. Post autoclaving, spore testing is not done. Hence the efficacy of disinfection is not ascertained.

4.1.2.13 *Good Friend Hospital*

This hospital is located in Ulubari area. It has bed capacity of 25 beds. The biomedical waste management followed in this hospital is depicted in flow-chart 4.8.



Flow-chart 4.8:- Present BMW Management Practice at Good Friend Hospital

- **Management of incinerable waste:**

Waste categories 1, 3 and 6 are stored together in non-PVC bags. These bags are burnt in a fire-place and the ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are shredded in needle shredder, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. Once it becomes waste, it is dis-infected and disposed into sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and dis-infected and than it is salvaged off.

4.1.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of category A, about 21 bags of 2 kg capacity are required daily.
- There is a sharps pit within every campus wherein the sharps are disposed off.
- Category 7 (plastic waste) is not shredded before salvaging, giving potential for re-use.
- In most of the Type A hospitals, category 1, 3 and 6 are burnt and not incinerated.
- All expired medicines are returned back to manufacturer.
- The primary data table shows that about 0.9 kg of category 1, 0.5 kg of category 3, 0.7 kg of category 4, 3.7 kg of category 6 and 3.7 kg of category 7 are generated every day in sample hospital having 25 no. of beds. Thus average daily waste generation per bed calculates to 0.036 kg of category 1, 0.020 kg of category 3, 0.028 kg of category 4, 0.148 kg of category 6 and 0.148 kg of category 7.

4.2 TYPE B HOSPITALS

4.2.1 General

Type B comprises of hospitals having 30 to 50 beds. There are 17 nos. of Type B hospitals. Such hospitals are equipped with blood bank, dressing room, laboratory, medicine ward, surgery ward, pediatric ward, operation theatre and gynecological ward. Plan of sample hospital is shown in Drawing II. Secondary data for 15 days was collected from the record book. Secondary data is tabulated in table 4.5. Primary data was measured for 15 days from 8/1/2006 to 22/1/2006. The primary data is tabulated in table 4.6.

Table 4.5:- Type B Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste(Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
20/12/2005	2.0	2.0	1.2	3.0	5.0	1.0	4.0	15.0	12.0	1.2	20.0
21/12/2005	1.0	2.5	1.3	3.0	6.5	1.0	3.5	14.0	13.0	1.3	18.5
22/12/2005	2.0	2.0	1.2	2.0	5.0	0.8	4.0	13.0	11.0	1.2	17.8
23/12/2005	2.5	2.5	1.6	3.0	7.0	1.0	4.0	16.0	15.0	1.6	21.0
24/12/2005	1.0	2.0	1.2	2.0	5.0	0.8	3.0	10.0	10.0	1.2	13.8
25/12/2005	1.5	2.0	1.4	2.0	6.0	0.8	3.0	12.0	11.5	1.4	15.8
26/12/2005	1.5	2.5	1.2	3.0	8.0	1.0	4.0	13.0	15.0	1.2	18.0
27/12/2005	2.0	2.5	1.6	3.5	7.0	1.0	3.0	14.0	15.0	1.6	18.0
28/12/2005	2.0	2.0	1.4	3.0	6.0	0.8	3.0	13.0	13.0	1.4	16.8
29/12/2005	1.0	2.0	1.2	3.0	5.0	0.8	4.0	14.0	11.0	1.2	18.8
30/12/2005	1.0	2.0	0.9	2.0	4.0	0.5	3.0	12.0	9.0	0.9	15.5
31/12/2005	1.5	2.0	0.7	2.0	4.0	0.5	3.5	13.0	9.5	0.7	17.0
1/1/2006	1.0	2.0	0.9	3.0	4.0	0.8	4.0	14.0	10.0	0.9	18.8
2/1/2006	1.5	2.0	1.2	2.0	5.0	0.8	3.0	13.0	10.5	1.2	16.8
3/1/2006	2.0	2.0	1.4	3.0	6.0	1.0	4.0	14.0	13.0	1.4	19.0
Avg. value	**1.6**	**2.1**	**1.2**	**2.6**	**5.6**	**0.8**	**3.5**	**13.3**	**11.9**	**1.2**	**17.7**

Table4.6:- Type B Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
8/1/2006	1.0	0.7	0.7	2.5	5.0	0.2	4.0	12.0	9.2	0.7	16.2
9/1/2006	2.0	1.4	1.6	2.0	6.0	0.6	3.0	14.0	11.4	1.6	17.6
10/1/2006	1.5	1.3	0.7	3.0	6.0	0.5	4.0	14.0	11.8	0.7	18.5
11/1/2006	1.0	1.0	0.5	2.5	4.5	0.3	4.5	12.0	9.0	0.5	16.8
12/1/2006	1.5	1.3	1.1	3.0	6.0	0.4	4.0	14.0	11.8	1.1	18.4
13/1/2006	1.0	1.2	0.5	1.5	5.0	0.3	3.0	13.0	8.7	0.5	16.3
14/1/2006	1.5	1.4	0.6	2.0	6.0	0.6	4.0	14.0	10.9	0.6	18.6
15/1/2006	2.0	1.8	1.5	3.0	7.0	0.6	3.0	15.0	13.8	1.5	18.6
16/1/2006	1.0	0.9	0.6	2.5	4.0	0.3	2.0	12.0	8.4	0.6	14.3
17/1/2006	2.0	1.3	1.0	2.0	6.0	0.6	3.0	13.0	11.3	1.0	16.6
18/1/2006	1.5	1.2	0.6	2.5	5.0	0.5	4.0	14.0	10.2	0.6	18.5
19/1/2006	1.5	1.2	0.7	2.5	7.0	0.6	5.0	15.0	12.2	0.7	20.6
20/1/2006	1.0	1.2	0.5	2.0	4.0	0.2	3.0	10.0	8.2	0.5	13.2
21/1/2006	1.0	0.8	0.6	2.5	5.0	0.3	3.0	12.0	9.3	0.6	15.3
22/1/2006	2.0	1.4	1.4	2.0	6.0	0.6	3.0	13.0	11.4	1.4	16.6
Avg. value	**1.4**	**1.1**	**0.8**	**2.4**	**5.5**	**0.4**	**3.5**	**13.1**	**10.5**	**0.8**	**17.1**

On comparison of the two tables, it is observed that average values of all the waste categories are higher in the secondary data table. From the analysis of the data, it is computed that infectious waste comprises 37%, non- infectious waste comprises 60% and sharps comprises 3%.The percentages of the different waste categories and the percentages of infectious waste, non-infectious waste and sharps in Type B hospitals are depicted in fig. 4.4 and fig. 4.5.

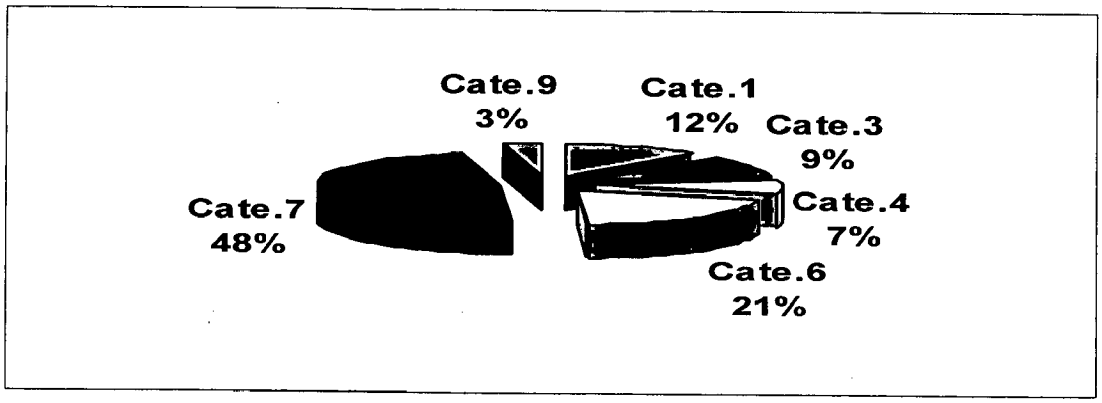


Fig. 4.4:- Waste Categories (Type B Hospital)

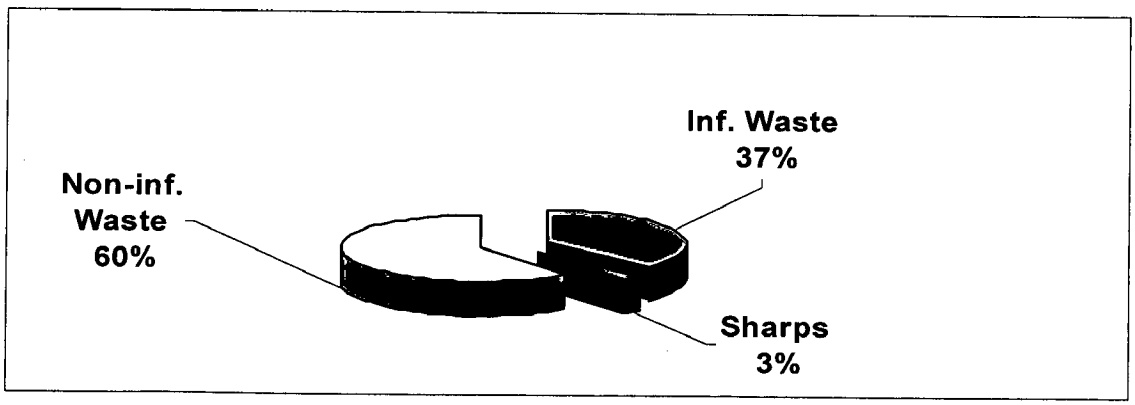


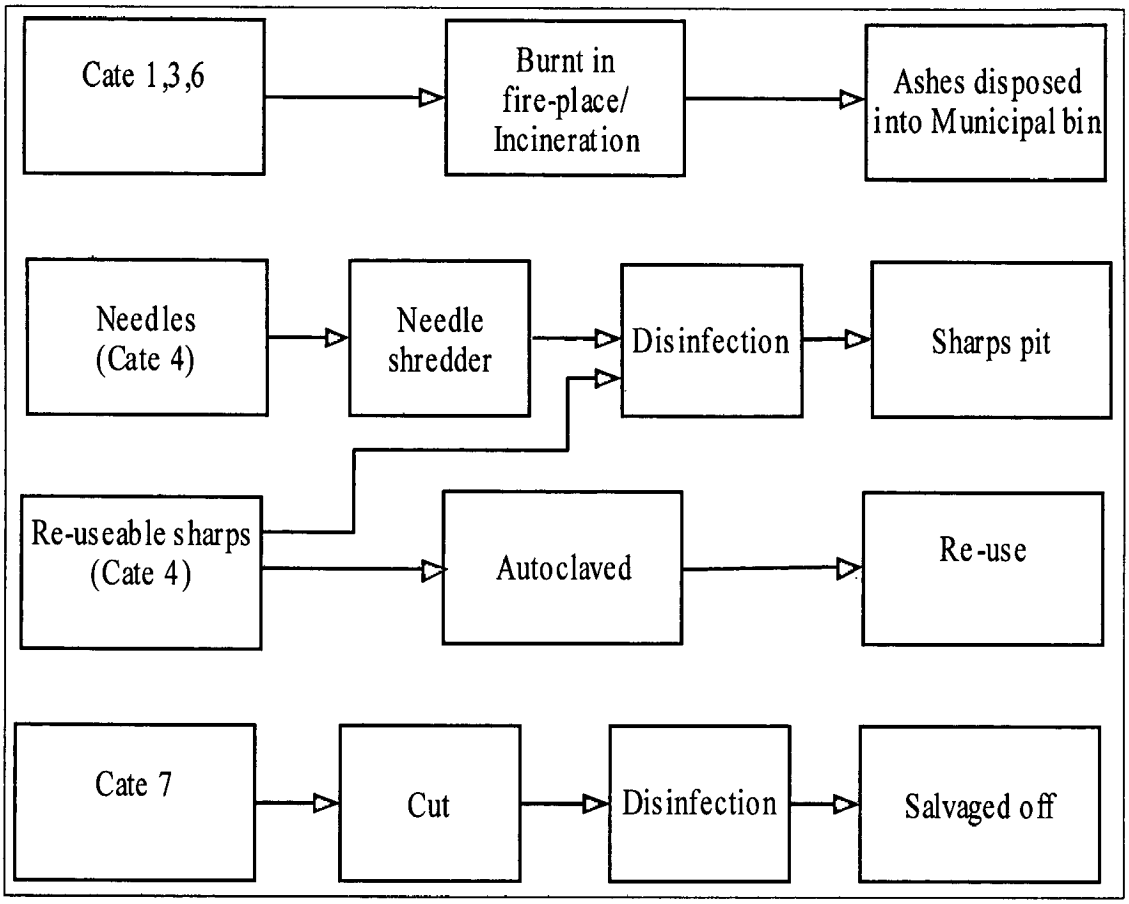
Fig. 4.5:- Inf., Non-inf. And Sharps Waste (Type B Hospital)

4.2.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management in Type B hospitals is explained in the following paragraphs.

4.2.2.1 *Azile Hospital*

This hospital is located in Beltola area. It has bed capacity of 35 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.9.



Flow-chart 4.9:- Present BMW Management Practice at Azile Hospital

- **Management of incinerable waste:**

Incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags. There is a double chambered incinerator of 5 kg/hour capacity and also a fire-place. The incinerable waste is burnt most of the time. The ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are shredded in needle shredder, dis-infected and then disposed into sharps pit. When re-useable surgical sharps become waste, these are disinfected and disposed into sharps pits.

- **Management of infectious plastics:**

All items of category 7 are cut and put into a drum containing 1% hypochlorite solution. After this dis-infection, it is salvaged off.

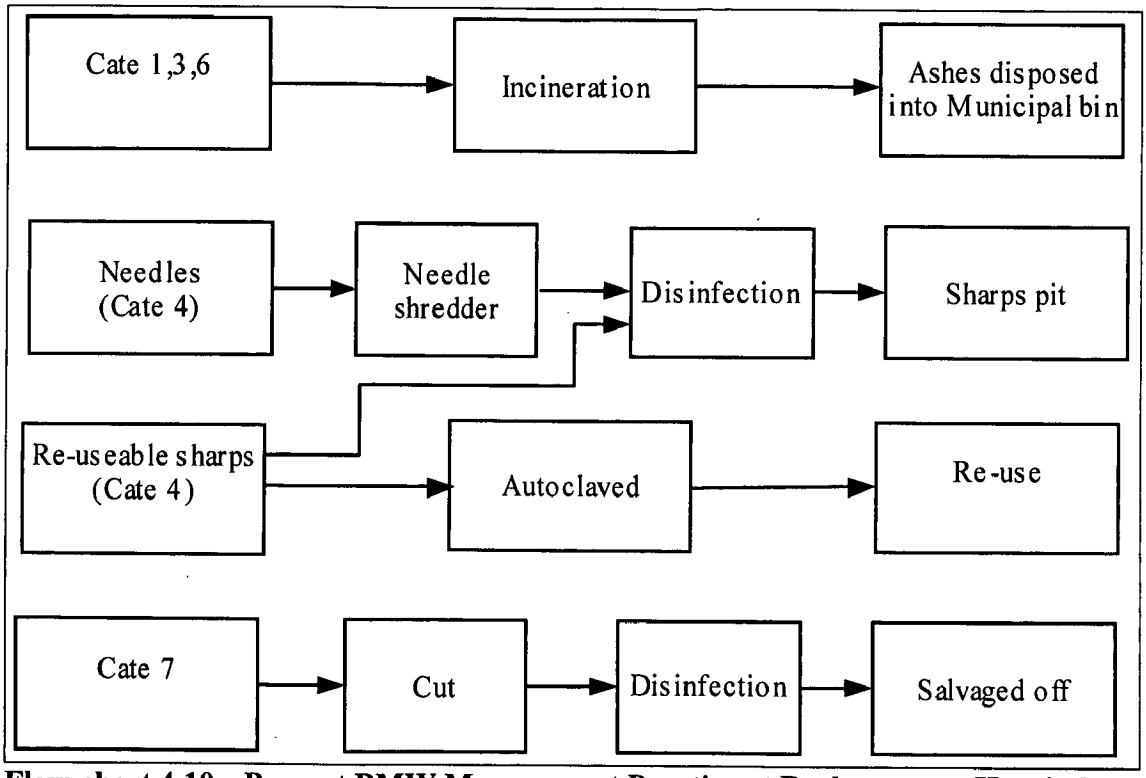
The incinerator is not used regularly. The burning of waste releases air pollutants into the atmosphere. Post autoclaving, spore testing is not done.

4.2.2.2 *Borthakur Clinic Pvt. Ltd.*

This hospital is located in Kharghuli. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Institute of Human Reproduction

4.2.2.3 *Brahmaputra Hospital Ltd.*

This hospital is located in Six-mile area. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.10.



Flow-chart 4.10:- Present BMW Management Practice at Brahmaputra Hospital

- **Management of incinerable waste:**

Incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags. There is a double chambered incinerator of 5 kg/hour capacity. These bags are incinerated and the ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. When re-useable surgical sharps become waste, these are disinfected and disposed into sharps pits.

- **Management of infectious plastics:**

  All items of category 7 are cut and dis-infected and then it is salvaged off.

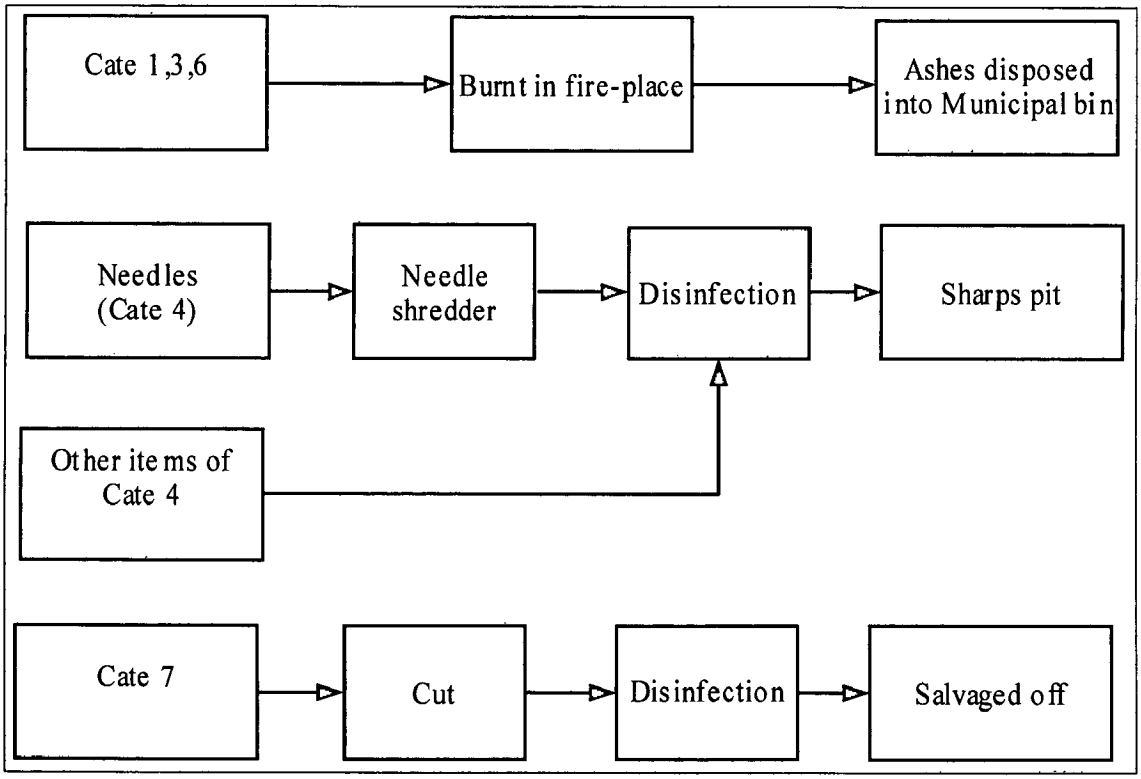
  Post autoclaving, spore testing is not done.

4.2.2.4 *City Heart Hospital*

This hospital is located on Rajgarh Road. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Good Friend Hospital.

4.2.2.5 *E.S.I. Model Hospital*

This hospital is located in Dhirenpara. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.11.



Flow-chart 4.11:- Present BMW Management Practice at E.S.I. Model Hospital

- **Management of incinerable waste:**

Categories 1, 3 and 6 are incinerable waste and these are stored together in non-PVC bags. These bags are burnt in a fire-place and the ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Other items of Category 4 are also dis-infected and disposed into the sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and dis-infected and than salvaged off.

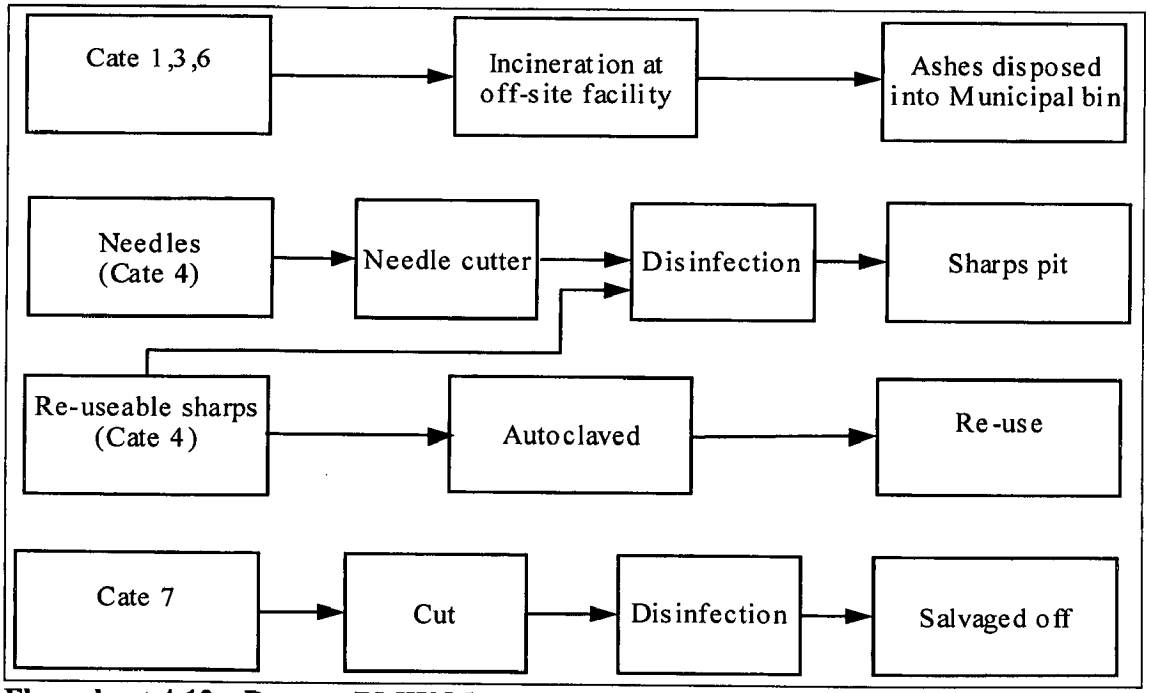
The burning of waste causes air pollution. As all sharps are disposed into sharps pit, the pit will soon get filled up.

4.2.2.6 *Global Hospital*

This hospital is located in Hatigaon. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Brahmaputra Hospital Ltd. There is a single chambered incinerator of capacity equal to 5 kg/hour.

4.2.2.7 *Gurucharan Nursing Home and Polyclinic*

This hospital is located near Nepali Mandir. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.12.



Flow-chart 4.12:- Present BMW Management Practice at Gurucharan Nursing Home and Polyclinic

- **Management of incinerable waste:**

The incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags. The bags are collected by the contractor for incineration in the incinerator of International Hospital. The ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. But when it becomes waste, it is also dis-infected and disposed into the sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and dis-infected in 1% hypochlorite solution. After this dis-infection, it is salvaged off.

Post autoclaving, spore testing is not done. As such, re-useable sharps may not be properly sterilized.

4.2.2.8 *H.M. Hospital*

This hospital is located in Hatigaon. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Good Friend Hospital.

4.2.2.9 *K.C.Das Nursing Home and Polyclinic*

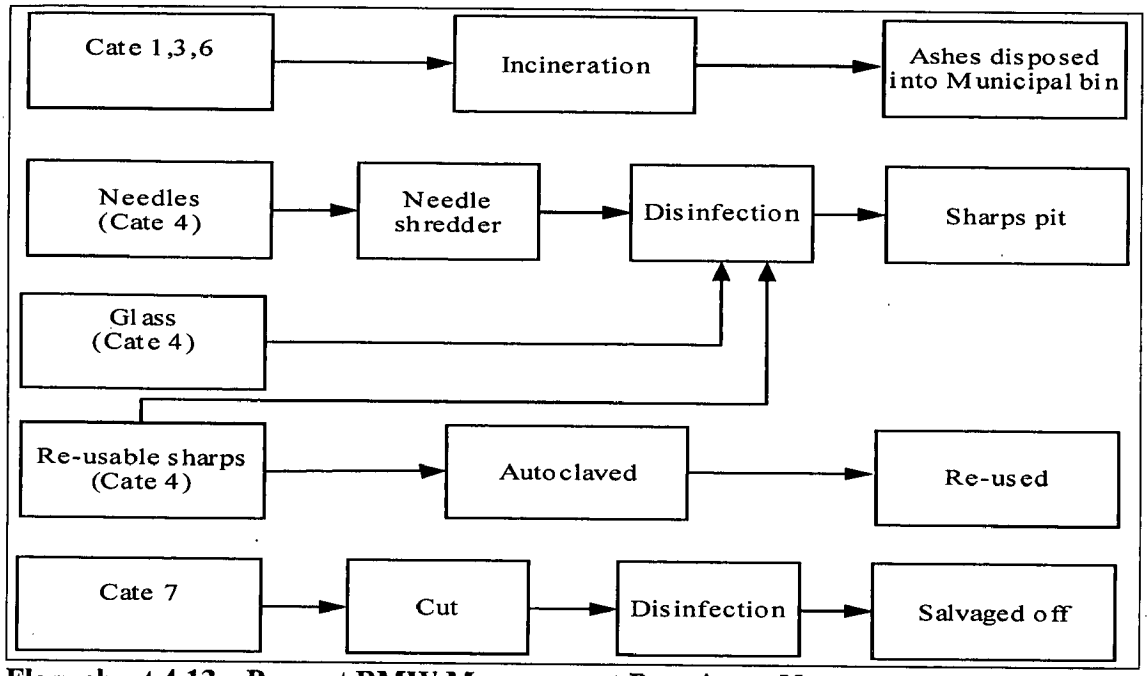
This hospital is located near Arya College. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Gurucharan Nursing Home and Polyclinic.

4.2.2.10 *Marwari Hospital and Research Centre*

This hospital is located near Kumarpara. It has bed capacity of 45 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Gurucharan Nursing Home and Polyclinic. The off-site facility is at the nearby Marwari Maternity Hospital.

4.2.2.11 *Nemcare Hospital*

This hospital is located in Bhangagarh. It has bed capacity of 50 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.13.



Flow-chart 4.13:- Present BMW Management Practice at Nemcare Hospital

- **Management of incinerable waste:**

Incinerable waste categories 1, 3 and 6 are stored together in non-PVC bags. There is a double chambered incinerator of 5 kg/hour capacity. The incinerable waste is incinerated and the ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are shredded in needle shredder, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Glass pieces are also dis-infected and disposed into the sharps pit. Re-useable surgical sharps are autoclaved and re-used. Once it becomes waste, it is disinfected and disposed into sharps pit.

- **Management of infectious plastics:**

All items of category 7 are cut and dis-infected and then salvaged off.

4.2.2.12 *Refinery Hospital*

This hospital is located in Noonmati, within the campus of Guwahati Refinery. It caters only to the employees and staff of Guwahati Refinery. The bio-medical waste

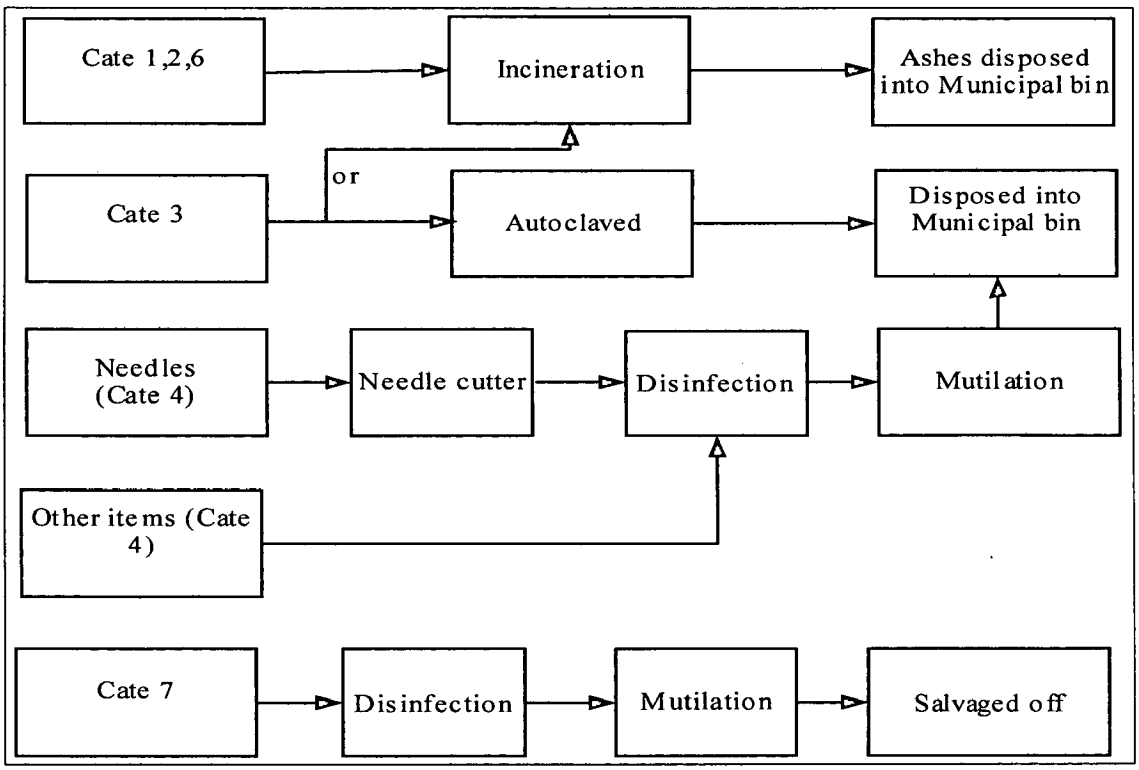
management followed in this hospital is similar to that practiced in Nemcare Hospital but the incinerator is single chambered.

4.2.2.13 *Sanjevani Hospital*

This hospital is located near Maligaon. It has bed capacity of 40 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Gurucharan Nursing Home and Polyclinic.

4.2.2.14 *Sankardev Nethralaya*

This hospital is located at Beltola. It has bed capacity of 30 beds. It is an eye specialty hospital where research is also carried out. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.14.



Flow-chart 4.14:- Present BMW Management Practice at Sankardev Nethralaya

- **Management of incinerable waste:**

In this hospital, category 2 (goat's eye) is generated sometimes when research/study work is done. In general, the incinerable waste generated is less compared to other hospitals. Category 1, 2 and 6 are stored together in non-PVC bags and

incinerated in an incinerator of capacity 5 kg/hour. Category 3 is either locally autoclaved or incinerated. After incineration/autoclaving, it is disposed into municipal bin.

- **Management of sharps:**

  All items of category 4 are first dis-infected, then mutilated and disposed into Municipal bin.

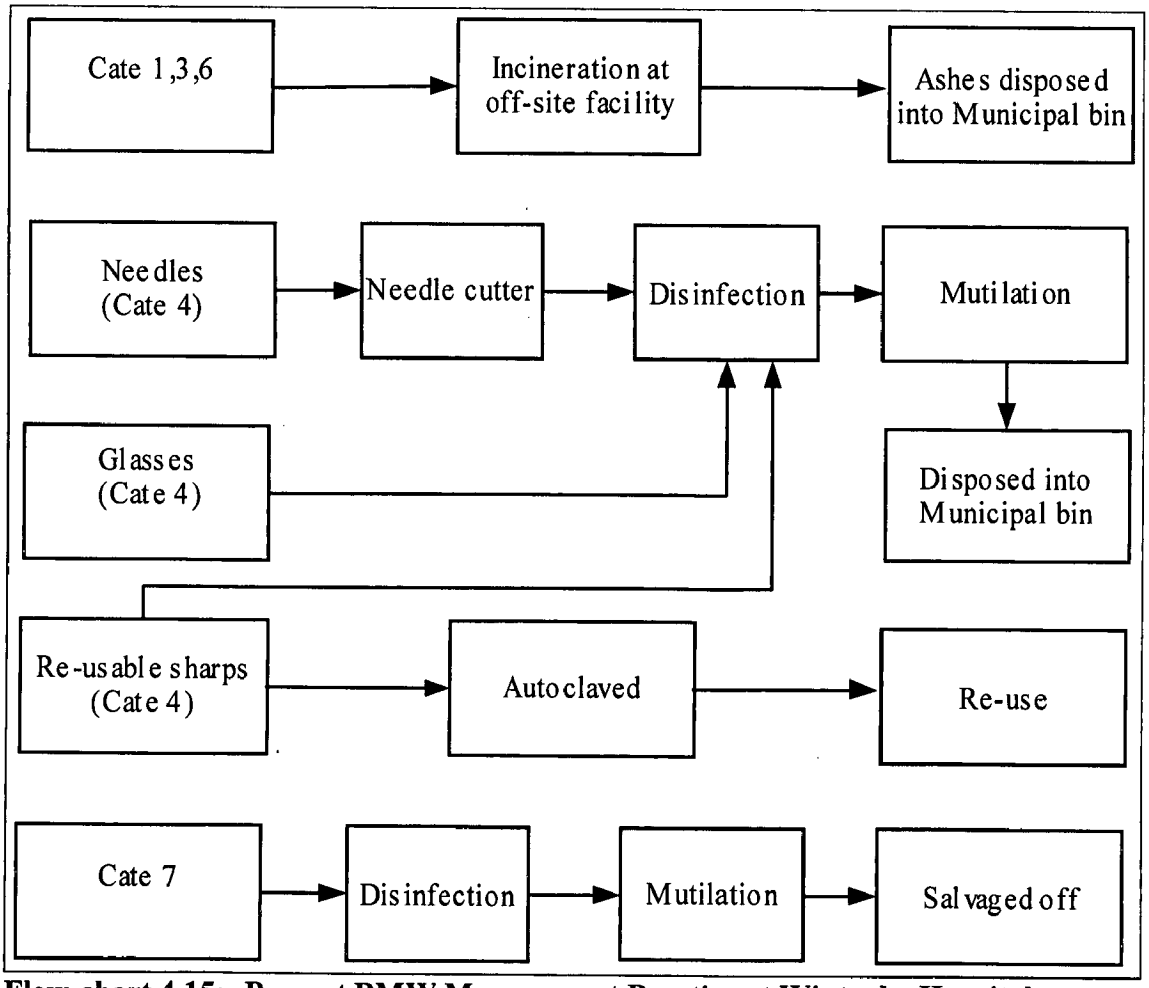
- **Management of infectious plastics:**

  All items of category 7 are first dis-infected, then mutilated and salvaged off.

  Post autoclaving, spore testing to check for complete disinfection is not done.

4.2.1.15 *Wintrobe Hospital*

This hospital is located at Ambari. It has bed capacity of 30 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.15.



Flow-chart 4.15:- Present BMW Management Practice at Wintrobe Hospital

- **Management of incinerable waste:**

Waste categories 1, 3 and 6 are stored together in non-PVC bags. It is collected by the contractor for incineration in the incinerator of International Hospital. The ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter and dis-infected in 1% hypochlorite solution. Then it is mutilated and disposed into Municipal bin. Glass pieces are dis-infected, mutilated and disposed into Municipal bin. Re-useable surgical sharps are autoclaved and re-used When it becomes waste, it is also treated and disposed in the same manner.

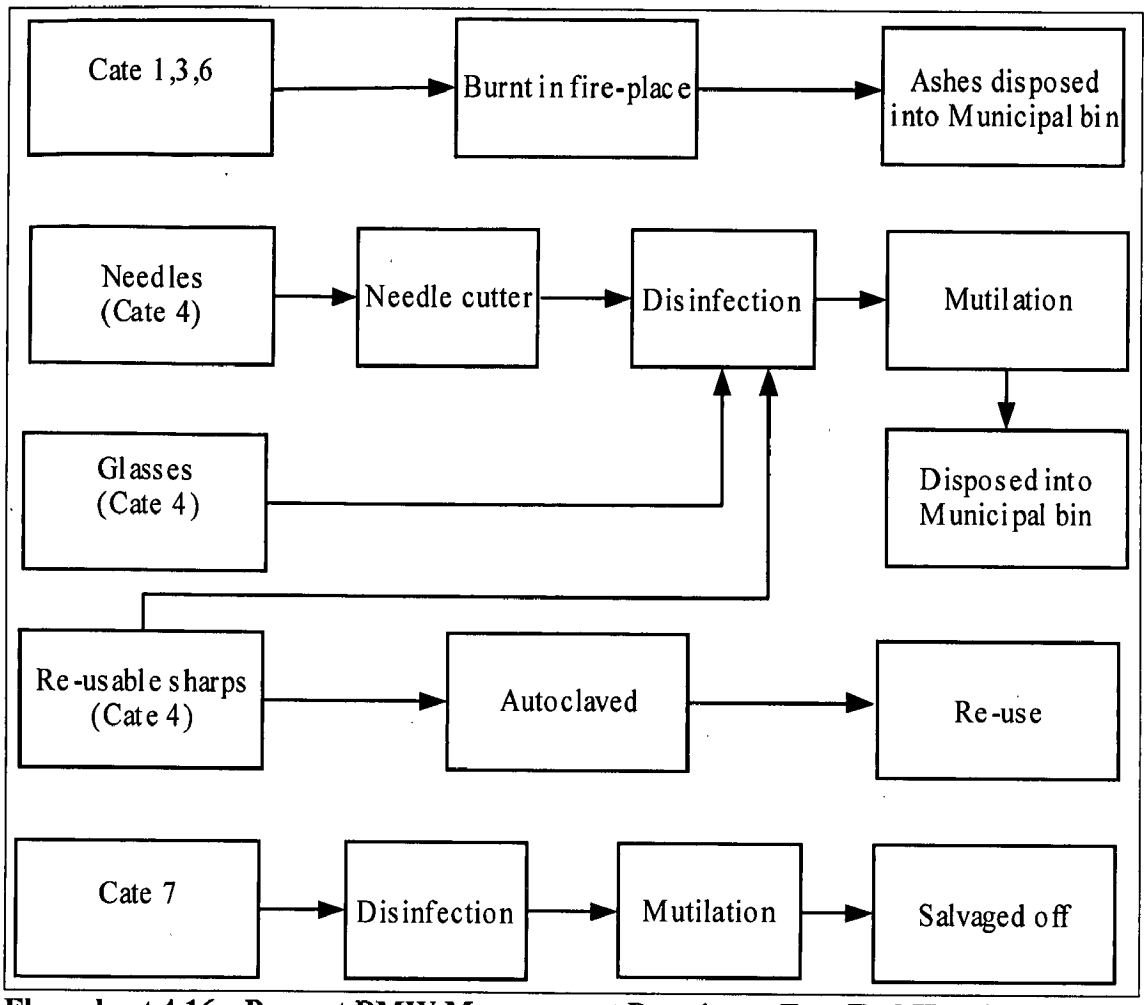
- **Management of infectious plastics:**

All items of category 7 are first dis-infected, then mutilated and salvaged off.

Needle cutter is not disinfected regularly. Also post autoclaving spore testing to check for complete disinfection is not done

4.2.1.16`*East End Hospital*

This hospital is located in Bamunimaidan area. It has bed capacity of 40 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.16.



Flow-chart 4.16:- Present BMW Management Practice at East End Hospital

- **Management of incinerable waste:**

The waste categories 1, 3 and 6 are stored together in non-PVC bags. These bags are burnt in a fire-place and the ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter and dis-infected in 1% hypochlorite solution. Then it is mutilated and disposed into Municipal bin. Glass pieces are dis-infected, mutilated and disposed into Municipal bin. Re-useable surgical sharps are autoclaved and re-used. But when it becomes waste, it is treated and disposed into municipal bin.

- **Management of infectious plastics:**

All items of category 7 are first dis-infected, then mutilated and salvaged off. As waste is burnt, and not incinerated, it causes air pollution.

4.2.1.17 *Good Health Hospital*

This hospital is located in Dispur. It has bed capacity of 35 beds. The bio-medical waste management followed in this hospital is similar to that practiced in Nemcare Hospital.

4.2.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of the category B, about 20 bags of 2 kg capacity and 10 bags of 5 kg capacity are required daily.
- All hospitals do not have sharps pit. Mutilated sharps are disposed into Municipal bin.
- In most hospitals, category 7 (plastic waste) is not shredded before salvaging. There could be possible re-use.
- In some hospitals, categories 1, 3 and 6 are burnt and not incinerated. In some hospitals, there is single chambered incinerator.
- All expired medicines are returned back to manufacturer.
- The primary data table shows that about 1.4 kg of category 1, 1.1 kg of category 3, 0.8 kg of category 4, 2.4 kg of category 6 and 5.5 kg of category 7 are generated every day in sample hospital having 35 no. of beds. Thus average daily waste generation per bed calculates to 0.040 kg of category 1, 0.031 kg of category 3, 0.023 kg of category 4, 0.069 kg of category 6 and 0.157 kg of category 7.

4.3 TYPE C HOSPITALS

4.3.1 General

Type C comprises of hospitals having more than 50 beds and upto 100 beds. There are 3 nos. of Type C hospital. Such hospitals are equipped with blood bank, dressing room, laboratory, medicine ward, isolation ward, psychiatric ward, surgery ward, pediatric ward, operation theatre and gynecological ward. Plan of sample hospital is shown in Drawing III. Secondary data for 15 days is collected from the record book. Secondary data is tabulated in table 4.7. Primary data of waste generation was measured for 15 days from 10/1/2006 to 24/1/2006. Primary data is tabulated in table 4.8.

Table 4.7:- Type C Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
1/12/2005	5.7	3.0	1.6	4.2	11.4	2.5	12.1	15.0	24.2	1.6	29.6
2/12/2005	3.8	3.0	1.3	4.2	8.5	2.0	15.1	16.0	19.5	1.3	33.1
3/12/2005	5.7	3.0	1.6	5.5	10.0	2.5	13.6	14.0	24.2	1.6	30.1
4/12/2005	3.8	2.0	1.3	4.2	8.5	2.0	10.6	12.0	18.5	1.3	24.6
5/12/2005	3.8	3.0	1.3	4.2	10.0	2.0	15.1	13.0	20.9	1.3	30.1
6/12/2005	5.7	3.0	1.6	4.2	10.0	2.5	12.1	15.5	22.8	1.6	30.1
7/12/2005	5.7	3.0	1.6	4.8	11.4	2.5	13.6	14.0	24.9	1.6	30.1
8/12/2005	3.8	3.0	1.3	4.2	8.5	2.0	15.1	12.0	19.5	1.3	29.1
9/12/2005	5.7	3.0	1.3	5.5	8.5	2.5	18.1	14.0	22.8	1.3	34.6
10/12/2005	3.8	2.0	1.3	4.2	10.0	2.0	15.1	13.0	19.9	1.3	30.1
11/12/2005	5.7	3.0	1.6	4.2	10.0	2.5	18.1	14.0	22.8	1.6	34.6
12/12/2005	3.8	3.0	1.1	4.2	7.1	2.0	16.6	12.0	18.1	1.1	30.6
13/12/2005	5.7	3.0	1.6	5.5	10.0	2.5	19.6	15.0	24.2	1.6	37.1
14/12/2005	3.8	2.0	1.3	4.2	8.5	2.0	15.1	12.0	18.5	1.3	29.1
15/12/2005	5.7	3.0	1.3	4.2	10.0	2.5	18.1	13.0	22.8	1.3	33.6
Avg. value.	**4.8**	**2.8**	**1.4**	**4.5**	**9.5**	**2.3**	**15.2**	**13.6**	**21.6**	**1.4**	**31.1**

Table 4.8:- Type C Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
10/1/2006	6.0	3.4	1.4	6.4	12.0	1.8	22.5	15.0	27.7	1.4	39.3
11/1/2006	4.0	1.9	0.9	4.7	14.0	0.9	18.0	12.0	24.5	0.9	30.9
12/1/2006	6.0	3.0	1.2	6.5	14.0	1.7	19.5	13.0	29.5	1.2	34.2
13/1/2006	5.0	2.7	1.1	6.2	12.0	1.6	21.0	14.0	25.8	1.1	36.6
14/1/2006	6.0	2.9	1.5	6.3	16.0	1.7	19.5	13.0	31.2	1.5	34.2
15/1/2006	4.0	2.2	0.8	5.3	12.0	0.9	18.0	12.0	23.5	0.8	30.9
16/1/2006	6.0	3.2	1.5	6.0	14.0	1.4	19.5	13.0	29.2	1.5	33.9
17/1/2006	4.0	2.2	1.0	4.5	12.0	0.9	20.3	13.5	22.7	1.0	34.6
18/1/2006	6.0	2.9	1.7	6.2	12.0	1.7	18.0	12.0	27.0	1.7	31.7
19/1/2006	6.0	2.7	1.6	5.9	14.0	1.5	22.5	15.0	28.6	1.6	39.0
20/1/2006	4.0	2.2	0.7	4.2	12.0	0.8	18.8	12.5	22.4	0.7	32.0
21/1/2006	4.0	2.2	0.7	4.3	13.0	0.7	19.5	13.0	23.5	0.7	33.2
22/1/2006	6.0	3.4	1.4	5.8	12.0	1.7	21.0	14.0	27.1	1.4	36.7
23/1/2006	6.0	3.4	1.7	5.9	15.0	1.9	22.5	15.0	30.3	1.7	39.4
24/1/2006	4.0	1.9	1.0	4.3	10.0	1.2	18.0	12.0	20.1	1.0	31.2
Avg. value	**5.1**	**2.7**	**1.2**	**5.5**	**12.9**	**1.4**	**19.9**	**13.3**	**26.2**	**1.9**	**34.5**

On comparison of the two tables, it is observed that average values of all the waste categories are higher in the secondary data table. From the analysis of the data, it is computed that infectious waste comprises 42%, non- infectious waste comprises 55% and sharps comprises 3%. The percentages of the different waste categories and the percentages of infectious waste, non- infectious waste and sharps in Type C hospital are depicted in fig.4.6 and fig.4.7.

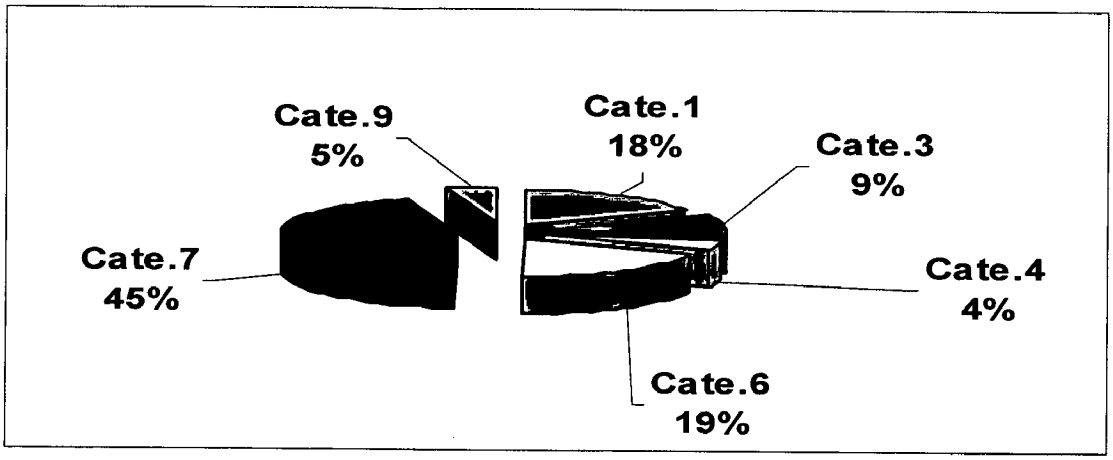


Fig. 4.6:- Waste Categories (Type C Hospital)

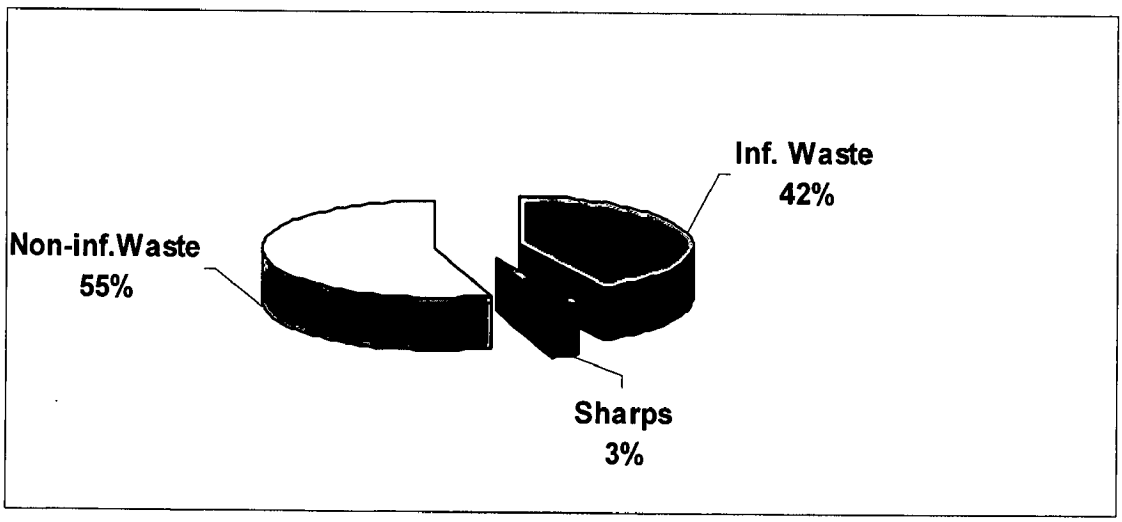


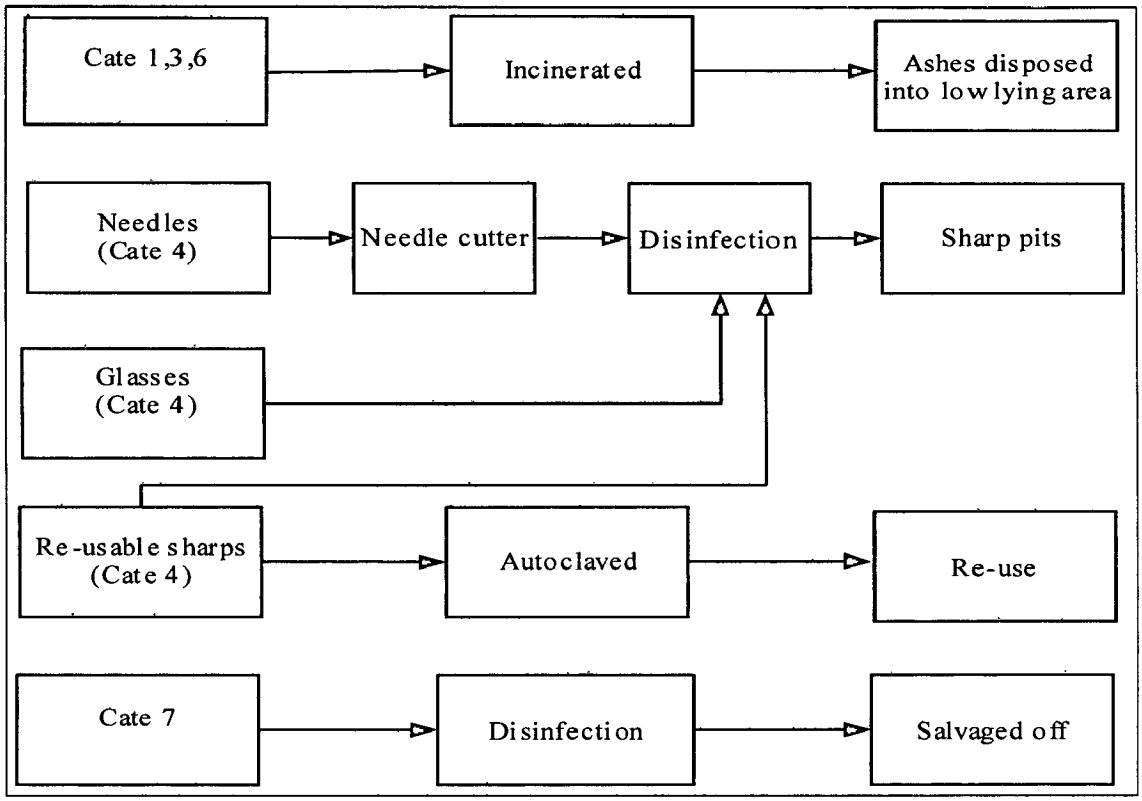
Fig. 4.7:- Inf., Non-inf. And Sharps Waste (Type C Hospital)

4.3.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management in various Type C hospitals is explained in the following paragraphs.

4.3.2.1 *Army Base Hospital*

This hospital is located in Basistha area. It has bed capacity of 100 beds. This hospital caters to defense personnel only. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.17.



Flow-chart 4.17:- Present BMW Management Practice at Army Base Hospital

- **Management of incinerable waste:**

Waste categories 1, 3 and 6 are stored together in non-PVC bags. There is a double chambered incinerator of 15 kg/hour capacity. The incinerable waste is incinerated and the ashes are disposed into low-lying area.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter, dis-infected in 1% hypochlorite solution, and then disposed into sharps pit. Glass pieces are dis-infected and disposed into sharps pit. Re-useable surgical sharps are autoclaved and re-used. After it becomes waste, it is disinfected and disposed into sharps pit.

- **Management of infectious plastics:**

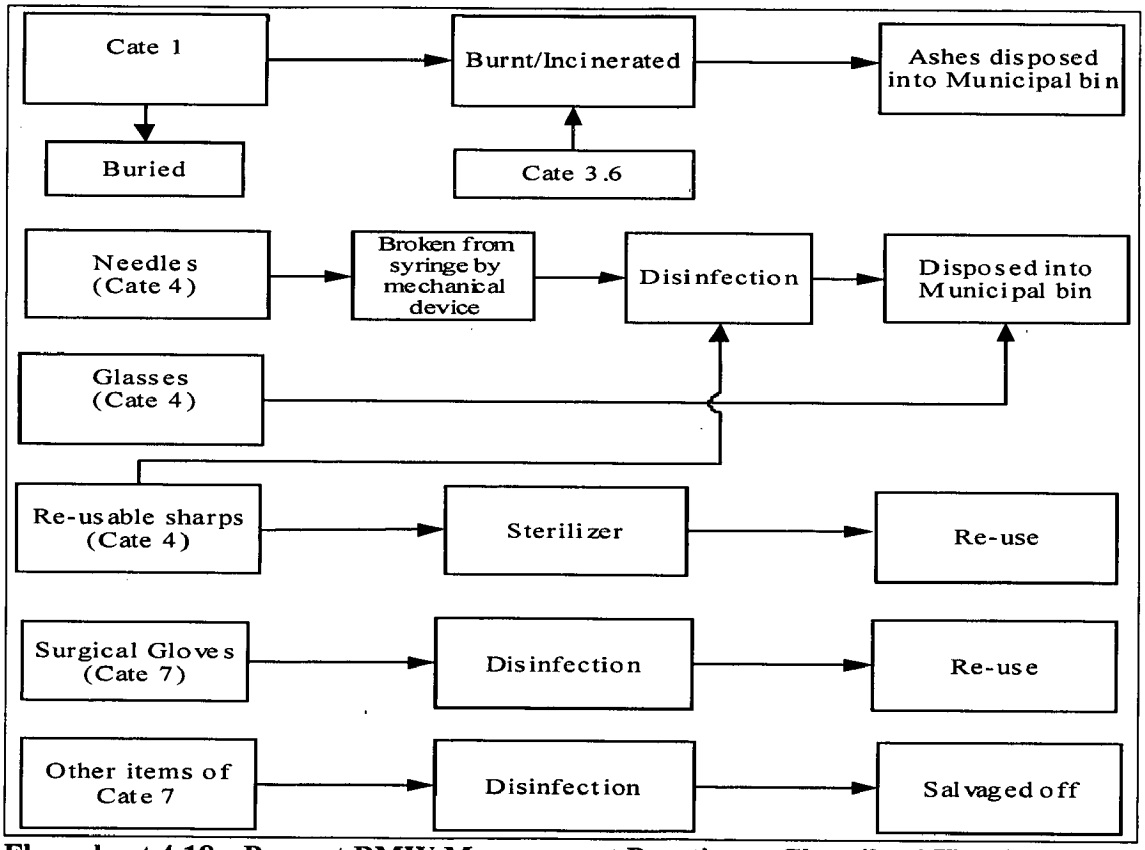
All items of category 7 are dis-infected and salvaged off.

4.3.2.2 *Marwari Maternity Hospital*

This hospital is located near Kumarpara. It has bed capacity of 65 beds. There is a double chambered incinerator of 5 kg/hour capacity. The bio-medical waste management followed in this hospital is similar to that practiced in Nemcare Hospital.

4.3.2.3 *Chatribari Hospital*

This hospital is located in Chatribari area. It has bed capacity of 100 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.18



Flow-chart 4.18:- Present BMW Management Practice at Chatribari Hospital

- **Management of incinerable waste:**

There is a double chambered incinerator of 20 kg/hour capacity. But the incinerable waste (category 1, 3 and 6) is burnt most of the time. The ashes are disposed into Municipal bin. At times, category 1 is buried.

- **Management of sharps:**

There is no needle cutter/shredder in this hospital. Needles are broken from the syringe by a mechanical device, dis-infected in 1% hypochlorite solution, and then

disposed into Municipal bin. Re-useable surgical sharps are sterilized and re-used. When it becomes waste, it is disinfected and disposed into Municipal bin.

- **Management of infectious plastics:**

It was observed that surgical gloves were dis-infected and re-used. Other items of category 7 are dis-infected and salvaged off.

Infectious glass is disposed without disinfection. For the surgical gloves, no test is done to check for sterilization.

4.3.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of the category C, about 20 nos. of 2 kg capacity bags and 15 nos. of 5 kg capacity bags are required every day.
- All hospitals do not utilize their incinerator, even if present.
- Every hospital do not have sharps pit.
- Category 7 (plastic waste) is not shredded before disposal. Surgical gloves are being re-used, which may cause grave infection.
- The primary data table shows that about 5.1kg of category 1, 2.7 kg of category 3, 1.2 kg of category 4, 5.5 kg of category 6 and 12.9 kg of category 7 are generated every day in sample hospital having 100 no. of beds. Thus average daily waste generation per bed calculates to 0.051 kg of category 1, 0.027 kg of category 3, 0.012 kg of category 4, 0.055 kg of category 6 and 0.129 kg of category 7.

4.4 TYPE D HOSPITALS

4.4.1 General

Type D comprises of hospitals having more than 100 beds and upto 150 beds. There are 2 nos. of Type D hospital. Such hospitals are equipped with intensive care unit, blood bank, laboratory, medicine ward, surgical ward, gynecological ward, pediatric ward, eye ward, E.N.T. ward, operation theatre and nephrology ward. Plan of sample hospital is shown in Drawing IV. Secondary data for 15 days was collected from the record book. Secondary data is tabulated in table 4.9. Primary data was measured for 15 days from 15/1/2006 to 29/1/2006. Primary data is tabulated in table 4.10.

Table 4.9:- Type D Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
15/12/2005	3.0	3.0	1.2	7.9	0.0	0.7	28.0	6.0	13.8	1.2	34.7
16/12/2005	14.8	3.0	1.2	7.9	41.3	2.5	31.5	30.0	66.9	1.2	64.0
17/12/2005	14.8	4.5	2.0	0.0	0.0	2.5	31.5	9.0	19.2	2.0	43.0
18/12/2005	0.0	0.0	2.0	9.2	0.0	0.0	7.0	3.0	9.2	2.0	10.0
19/12/2005	3.0	1.5	0.0	0.0	59.0	0.7	17.5	39.0	63.4	0.0	57.2
20/12/2005	3.0	4.5	0.0	9.2	0.0	0.7	17.5	6.0	16.6	0.0	24.2
21/12/2005	3.0	1.5	2.0	9.2	0.0	0.7	28.0	6.0	13.7	2.0	34.7
22/12/2005	0.0	0.0	1.2	5.5	53.1	0.0	14.0	42.0	58.6	1.2	56.0
23/12/2005	12.4	3.0	0.0	0.0	0.0	1.4	10.5	6.0	15.4	0.0	17.9
24/12/2005	14.8	3.0	0.0	5.5	41.3	2.5	17.5	30.0	64.6	0.0	50.0
25/12/2005	17.7	3.0	2.2	9.2	0.0	2.1	28.0	9.0	29.9	2.2	39.1
26/12/2005	0.0	1.8	0.5	0.0	0.0	0.0	7.0	6.0	1.8	0.5	13.0
27/12/2005	3.0	0.9	2.4	9.2	41.3	0.7	24.5	36.0	54.4	2.4	61.2
28/12/2005	3.0	3.0	2.0	7.9	0.0	0.7	17.5	9.0	13.8	2.0	27.2
29/12/2005	0.0	0.6	2.0	5.5	35.4	0.0	14.0	27.0	41.5	2.0	41.0
Avg. value	**6.1**	**2.2**	**1.3**	**5.8**	**18.1**	**1.0**	**19.6**	**17.6**	**41.5**	**1.3**	**38.2**

Table 4.10:- Type D Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
15/1/2006	4.9	1.2	0.8	5.2	0.0	1.4	18.8	15.2	11.2	0.8	35.4
16/1/2006	6.1	1.8	1.4	6.7	41.3	2.0	20.0	19.5	55.8	1.4	41.4
17/1/2006	6.3	5.9	1.7	6.5	0.0	2.3	23.5	16.7	18.7	1.7	42.4
18/1/2006	5.2	3.5	1.1	5.3	59.0	1.3	25.2	15.4	73.1	1.1	41.8
19/1/2006	5.5	0.0	0.9	5.9	0.0	1.3	18.5	18.2	11.3	0.9	38.0
20/1/2006	6.2	5.9	1.3	6.8	0.0	1.9	18.2	15.9	18.9	1.3	36.0
21/1/2006	4.9	3.5	0.7	5.3	59.0	1.2	19.6	12.9	72.7	0.7	33.7
22/1/2006	5.5	3.5	0.9	5.2	0.0	1.3	22.6	16.2	14.3	0.9	40.1
23/1/2006	5.2	5.9	0.9	5.5	41.3	1.3	23.2	16.5	57.9	0.9	41.0
24/1/2006	6.2	1.8	1.4	7.2	0.0	1.6	27.6	18.8	15.1	1.4	48.0
25/1/2006	5.5	0.0	1.2	5.9	41.3	1.5	18.0	17.2	52.7	1.2	36.6
26/1/2006	5.5	1.8	1.0	5.7	0.0	1.7	25.7	17.3	13.0	1.0	44.6
27/1/2006	6.2	3.5	1.4	7.2	35.4	1.9	26.3	19.7	52.3	1.4	47.9
28/1/2006	6.2	1.8	1.7	6.8	0.0	1.9	29.7	16.4	14.7	1.7	47.9
29/1/2006	4.4	3.0	0.7	5.3	0.0	1.2	19.8	15.7	12.6	0.7	36.7
Avg. value	**5.6**	**2.9**	**1.2**	**6.0**	**18.5**	**1.6**	**22.4**	**16.8**	**33.0**	**1.1**	**40.8**

On comparison of the two tables, it is observed that average values of category1 and category 4 are higher while average values of category 3, category 6, category 7 and category 9 are lower in the secondary data table. From the analysis of data, it is computed that infectious waste comprises 44%, non- infectious waste comprises 55% and sharps comprises 1%. The percentages of different categories of waste and the percentages of infectious waste, non- infectious waste and sharps in Type D hospitals are depicted in fig.4.8 and fig.4.9.

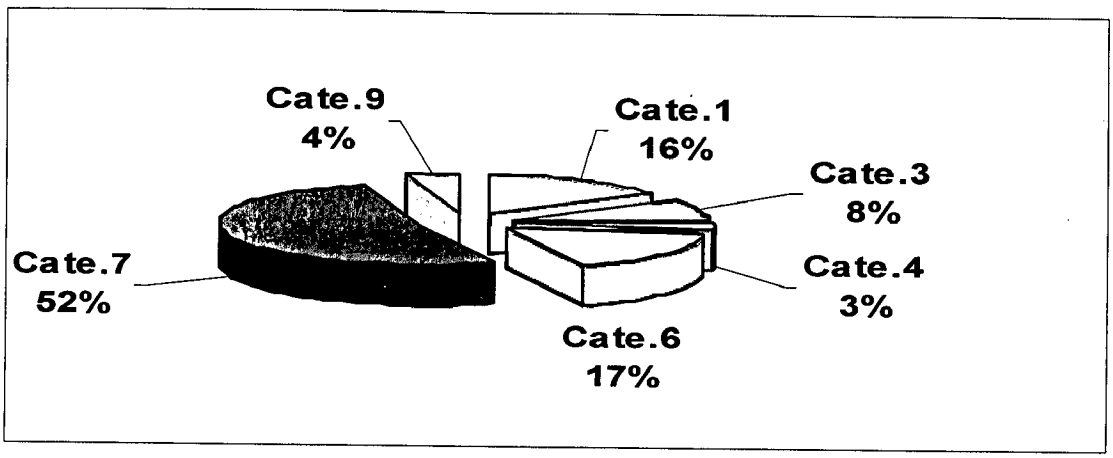


Fig. 4.8:- Waste Categories (Type D Hospital)

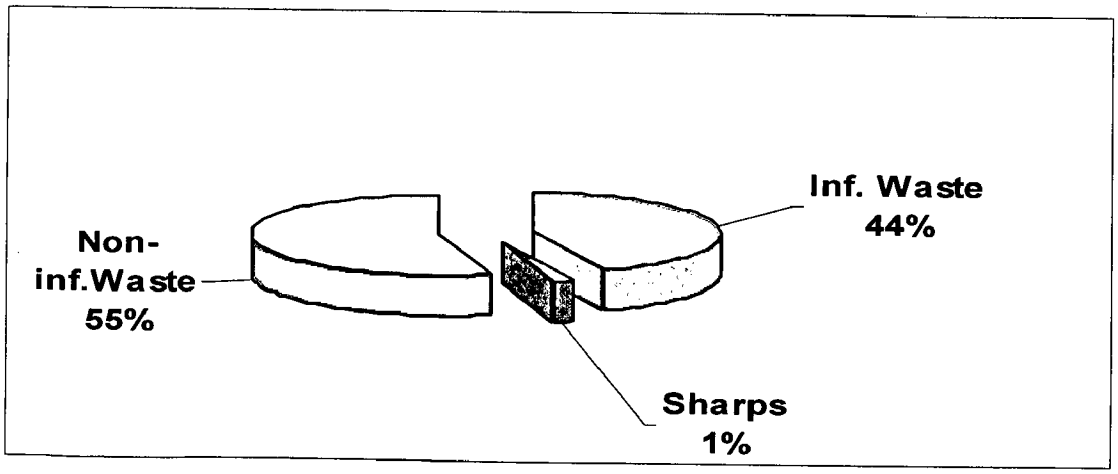


Fig. 4.9:- Inf., Non-inf. And Sharps Waste (Type D Hospital)

4.4.2 Present Bio-medical Waste Management Practice at Hospital

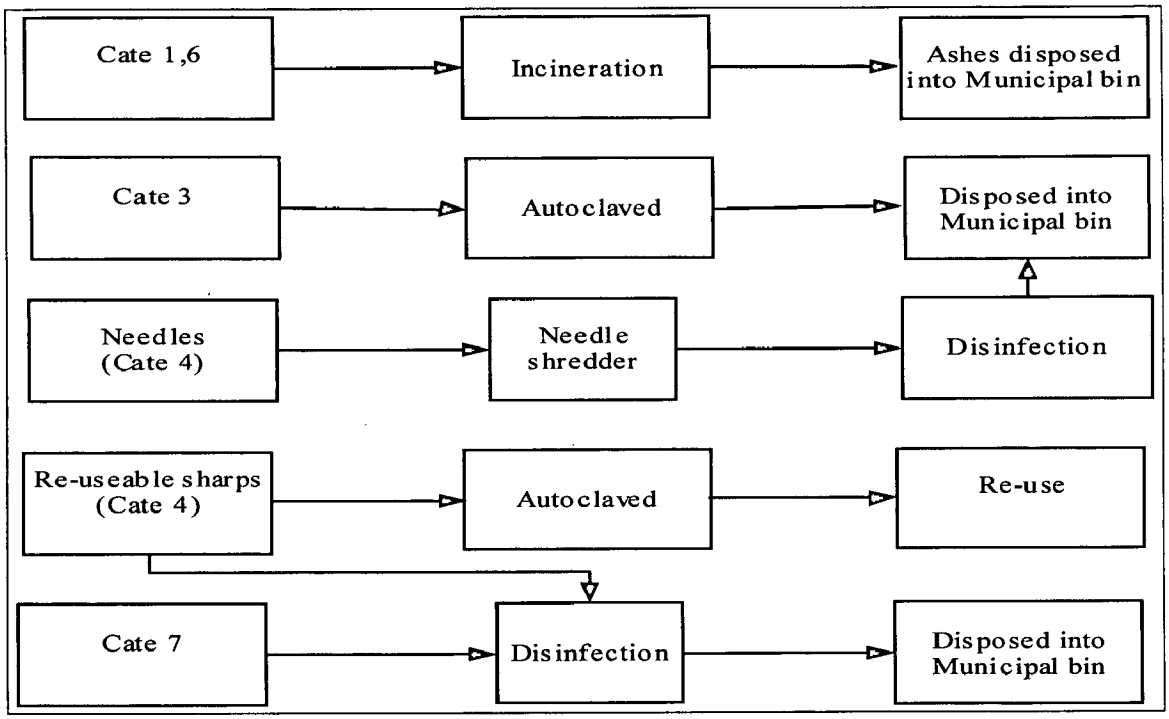
The existing bio-medical waste management in Type D hospitals is explained in the following paragraphs.

4.4.2.1 *Dispur Polyclinic and Research Centre*

This hospital is located at Ganeshguri. It has bed capacity of 150 beds. There is a single chambered incinerator of 15 kg/hour capacity. The bio-medical waste management followed in this hospital is similar to that practiced in Nemcare Hospital.

4.4.2.2 *International Hospital*

This hospital is located near Ganeshguri. It has bed capacity of 114 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.19



Flow-chart 4.19:- Present BMW Management Practice at International Hospital

- **Management of incinerable waste:**

The waste categories1and 6 are stored together in non-PVC bags. It is incinerated in the incinerator and the ashes are disposed into Municipal bin. The incinerator is double chambered having capacity of 15 kg/hour. This incinerator is used for incinerating waste from several small hospitals. Category 3 is autoclaved and disposed into Municipal bin.

- **Management of sharps:**

Needles are shredded in needle shredder, dis-infected and disposed into Municipal bin. Re-useable surgical sharps are autoclaved and re-used. Once it becomes waste, it is disinfected and disposed into Municipal bin.

- **Management of infectious plastics:**

All items of category 7 are dis-infected and disposed into Municipal bin.

Post autoclaving, spore testing to check for complete disinfection is not done. The plastic waste are not cut / shredded before disposal.

4.4.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of the category D, about 30 nos. of 2 kg capacity bags and 20 nos. of 5 kg capacity bags are required every day.
- Hospitals are incinerating the incinerable wastes.
- Sharps are being disposed into Municipal bin.
- Category 7 (plastic waste) is not shredded before disposal, giving potential for re-use.
- The primary data table shows that about 5.6 kg of category 1, 2.9 kg of category 3, 1.2 kg of category 4, 6.0 kg of category 6 and 18.5 kg of category 7 are generated every day in sample hospital having 114 no. of beds. Thus average daily waste generation per bed calculates to 0.049 kg of category 1, 0.025 kg of category 3, 0.009 kg of category 4, 0.053 kg of category 6 and 0.162 kg of category 7.

4.5 TYPE E HOSPITALS

4.5.1 General

Type E comprises of hospitals having more than 200 beds and upto 250 beds. There are no hospitals in the range of 150 to 200 beds. There are 2 nos. of Type E hospital. Such hospitals are equipped with blood bank, laboratory, medicine ward, surgical ward, gynecological ward, pediatric ward, eye ward, E.N.T. ward, operation theatre and orthopedic ward. Plan of sample hospital is shown in Drawing V. Secondary data is collected for 15 days from the record book. Secondary data is tabulated in table 4.11. Primary data is measured for 15 days from 18/1/2006 to 1/2/2006. The primary data is tabulated in table 4.12.

Table 4.11:- Type E Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
15/12/2005	14.7	4.9	3.3	12.8	31.5	3.0	20.0	33.0	64.0	3.3	56.0
16/12/2005	12.6	4.6	2.7	12.0	27.3	2.7	25.0	30.0	56.5	2.7	57.7
17/12/2005	16.8	5.3	3.8	15.4	37.8	3.1	25.0	35.0	75.3	3.8	63.1
18/12/2005	14.7	5.3	3.3	13.7	33.6	3.0	24.0	34.0	67.2	3.3	61.0
19/12/2005	16.8	5.3	3.3	13.7	31.5	3.1	23.0	29.0	67.2	3.3	55.1
20/12/2005	8.4	3.3	3.5	8.6	33.6	2.7	20.0	35.0	53.8	3.5	57.7
21/12/2005	10.5	3.9	2.2	10.3	21.0	2.4	25.0	30.0	45.7	2.2	57.4
22/12/2005	14.7	5.3	3.5	13.7	35.7	3.1	22.0	31.0	69.3	3.5	56.1
23/12/2005	12.6	4.6	3.3	12.0	31.5	2.4	25.0	30.0	60.7	3.3	57.4
24/12/2005	14.7	4.6	2.7	12.0	27.3	3.1	26.0	33.0	58.6	2.7	62.1
25/12/2005	12.6	5.3	3.3	13.7	33.6	3.0	25.0	30.0	65.1	3.3	58.0
26/12/2005	14.7	4.6	3.3	13.7	31.5	3.1	24.0	29.0	64.5	3.3	56.1
27/12/2005	12.6	4.6	3.8	12.0	37.8	3.0	30.0	35.0	67.0	3.8	68.0
28/12/2005	16.8	5.9	4.0	15.4	37.8	3.3	35.0	39.0	75.9	4.0	77.3
29/12/2005	10.5	3.3	2.2	8.6	21.0	2.4	25.0	30.0	43.3	2.2	57.4
Avg. value	**13.6**	**4.7**	**3.2**	**12.5**	**31.5**	**2.9**	**24.9**	**32.2**	**62.3**	**3.2**	**66.8**

Table 4.12:- Type E Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
18/1/2006	12.6	3.7	2.4	8.3	21.5	2.6	26.3	37.0	46.1	2.4	65.9
19/1/2006	12.6	4.3	3.2	9.7	29.4	2.3	25.4	33.6	55.9	3.2	61.3
20/1/2006	14.7	4.3	3.2	11.0	29.4	2.9	20.7	35.7	59.4	3.2	59.3
21/1/2006	14.7	4.9	3.2	11.0	31.3	2.9	24.9	37.1	62.0	3.2	64.9
22/1/2006	12.6	4.3	2.6	9.7	25.5	2.6	25.4	33.6	52.0	2.6	61.6
23/1/2006	10.5	3.1	2.1	6.9	19.6	2.3	25.6	33.8	40.0	2.1	61.7
24/1/2006	12.6	4.3	3.2	12.4	31.3	2.9	25.2	33.6	60.7	3.2	61.7
25/1/2006	14.7	4.9	3.4	11.0	33.3	3.1	22.3	34.7	63.9	3.4	60.1
26/1/2006	16.8	4.9	3.2	11.0	29.4	3.1	23.4	32.5	62.1	3.2	59.0
27/1/2006	10.5	3.7	2.1	8.3	19.6	2.3	25.2	33.6	42.0	2.1	61.1
28/1/2006	12.6	4.3	3.2	9.7	29.4	2.3	25.4	33.9	55.9	3.2	61.6
29/1/2006	14.7	3.7	3.9	9.7	33.3	2.9	30.7	39.3	61.3	3.9	72.9
30/1/2006	14.7	4.9	3.2	9.6	29.4	3.1	24.3	32.5	58.6	3.2	59.9
31/1/2006	12.6	3.7	2.4	8.3	21.5	2.6	26.1	36.9	46.1	2.4	65.6
1/2/2006	8.4	3.1	3.4	6.9	31.3	2.6	20.7	39.3	49.7	3.4	62.6
Avg. value	**13.0**	**4.1**	**3.0**	**9.6**	**27.7**	**2.7**	**24.8**	**35.3**	**54.4**	**3.0**	**62.6**

On comparison of the two tables, it is observed that average values of all the waste categories are higher in the secondary data table. From the analysis of the data, it is computed that infectious waste comprises 45%, non- infectious waste comprises 53% and sharps comprises 2%. The percentages of different waste categories and the percentage of infectious waste, non- infectious waste and sharps in Type E hospitals are depicted in fig.4.10 and fig.4.11.

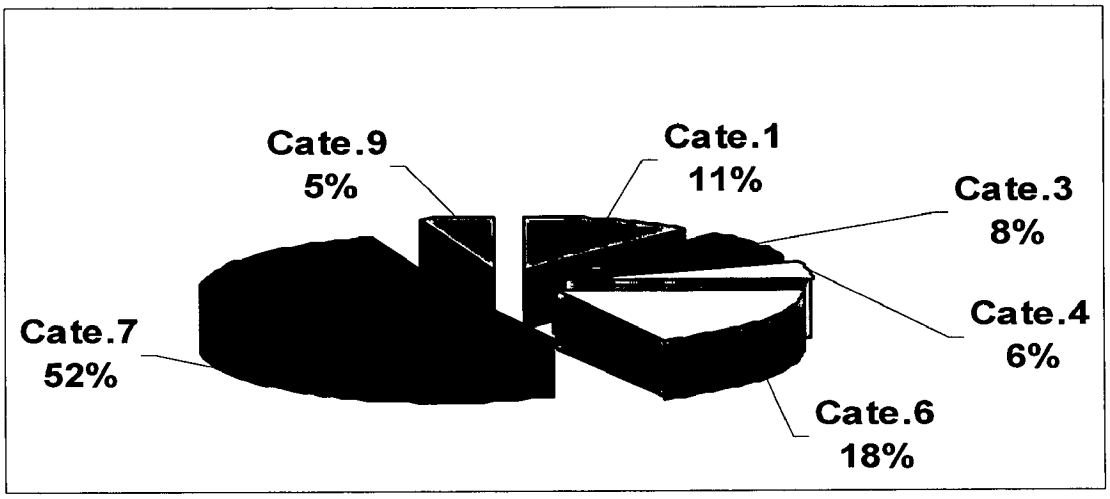


Fig. 4.10:- Waste Categories (Type E Hospital)

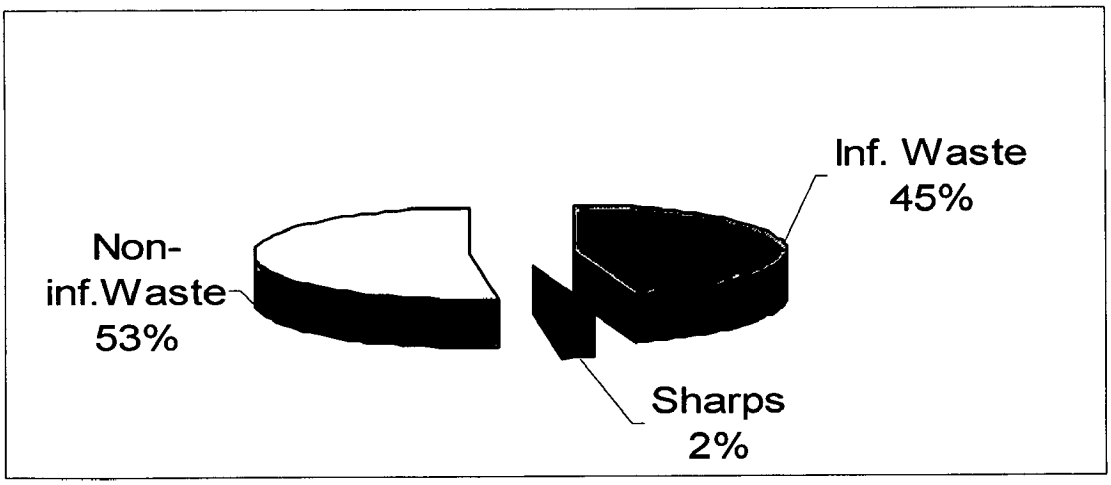


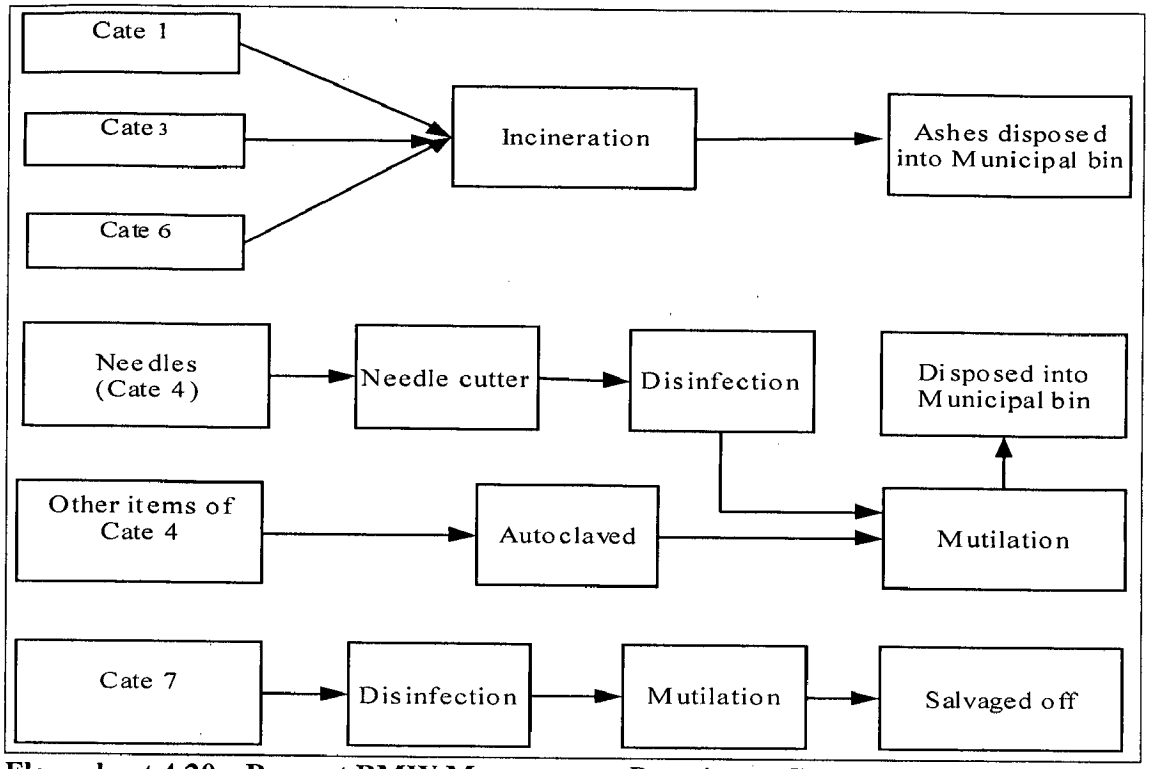
Fig. 4.11:- Inf., Non-inf. And Sharps Waste (Type E Hospital)

4.5.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management in Type E hospitals is explained in the following paragraphs.

4.5.2.1 *Guwahati Neurological Research Centre (G.N.R.C.)*

This hospital is located at Dispur. It has bed capacity of 250 beds. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.20.



Flow-chart 4.20:- Present BMW Management Practice at Guwahati Neurological Research Centre

- **Management of incinerable waste:**

Very small amount of category 1 and category 3 are generated in this hospital. Category 6 is generated in large amounts. Each category of waste is segregated separately in colour coded non-PVC bags (as per BMW Rules). Category 1, 3 and 6 are incinerated in the double chambered incinerator (capacity is 30 kg/hour). The ashes are disposed into Municipal bin.

- **Management of sharps:**

The needles are cut from the syringe in a needle cutter, dis-infected in 1% hypochlorite solution, then mutilated and disposed into Municipal bin. Other items of category 4 are autoclaved, then mutilated and disposed into Municipal bin.

- **Management of infectious plastics:**

All items of category 7 are first dis-infected, then mutilated and salvaged off.

Post autoclaving, spore testing to check for complete disinfection is not done.

4.5.2.2 *C.R.P.F. Base Hospital*

This hospital is located at Nine-mile. It has bed capacity of 205 beds. This hospital caters to C.R.P.F. personnel. There is a double chambered incinerator of capacity equal to 30 kg/hour. The bio-medical waste management followed in this hospital is similar to that practiced in Army Base Hospital.

4.5.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of the category E, about 30 nos. of 2 kg capacity bags and 30 nos. of 5 kg capacity bags are required every day.
- Incinerable wastes are being incinerated.
- Sharps are not disposed into sharps pit.
- Re-useable surgical sharps are autoclaved and re-used.
- The primary data table shows that about 13.0 kg of category 1, 4.1 kg of category 3, 3.0 kg of category 4, 9.6 kg of category 6 and 27.7 kg of category 7 are generated every day in sample hospital having 250 no. of beds.Thus average daily waste generation per bed calculates to 0.052 kg of category 1, 0.016 kg of category 3, 0.012 kg of category 4, 0.038 kg of category 6 and 0.111 kg of category 7.

4.6 TYPE F HOSPITALS

4.6.1 General

Type F comprises of hospitals having more than 250 beds and upto 300 beds. There are 3 nos. of Type F hospital. Such hospitals are equipped with blood bank, laboratory, medicine ward, surgical ward, gynecological ward, pediatric ward, orthopedic ward and Operation Theatre. Plan of sample hospital is shown in Drawing VI. Secondary data for 15 days was collected from record book. Secondary data is tabulated in table 4.13. Primary data of waste generation is measured for 15 days from 5/4/2006 to 19/4/2006. Primary data is tabulated in table 4.14.

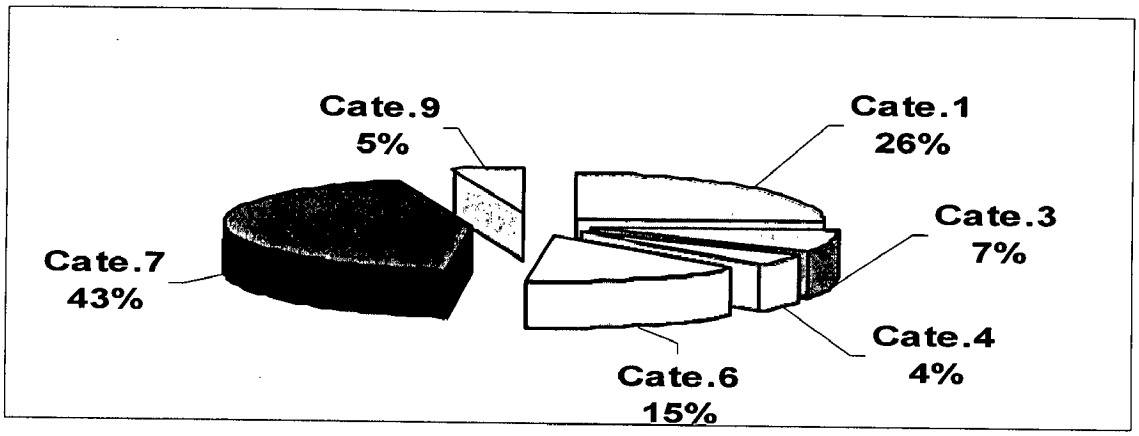
Table 4.13:- Type F Hospital (Secondary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
20/12/2005	16.9	5.1	2.1	14.0	41.3	3.2	29.6	45.5	77.3	2.1	78.3
21/12/2005	18.6	4.7	2.4	17.5	38.5	3.4	31.5	40.9	79.3	2.4	75.8
22/12/2005	17.8	5.1	2.6	14.0	35.0	3.0	25.9	43.2	71.9	2.6	72.2
23/12/2005	12.7	4.1	2.6	14.0	42.0	2.6	28.5	45.0	72.8	2.6	76.2
24/12/2005	13.5	3.9	2.5	17.5	38.5	3.2	30.8	54.5	73.4	2.5	88.5
25/12/2005	16.9	4.1	2.6	17.5	35.0	3.2	30.4	47.3	73.5	2.6	80.9
26/12/2005	16.9	4.1	2.6	21.0	49.0	3.4	37.1	54.5	91.0	2.6	95.0
27/12/2005	14.4	3.5	2.4	14.7	44.8	2.6	34.8	45.5	77.4	2.4	82.9
28/12/2005	18.6	5.1	3.4	21.0	52.5	3.4	41.5	59.1	97.2	3.4	104.0
29/12/2005	16.9	4.1	2.1	14.0	38.5	3.2	44.5	58.6	73.5	2.1	106.3
30/12/2005	17.8	4.7	2.6	16.1	35.0	3.0	33.3	50.0	73.6	2.6	86.4
31/12/2005	19.5	4.3	2.1	17.5	35.0	3.2	35.2	50.9	76.3	2.1	89.3
38718.0	17.8	5.3	2.6	14.7	38.5	3.4	37.1	59.1	76.3	2.6	99.6
38749.0	16.9	4.1	2.1	19.6	40.6	3.2	36.7	46.8	81.2	2.1	86.7
38777.0	12.7	5.1	2.6	21.0	35.0	3.4	40.8	54.5	73.8	2.6	98.7
Avg. value	**16.5**	**4.5**	**2.5**	**16.9**	**39.9**	**3.2**	**34.5**	**50.4**	78.0	**2.5**	88.1

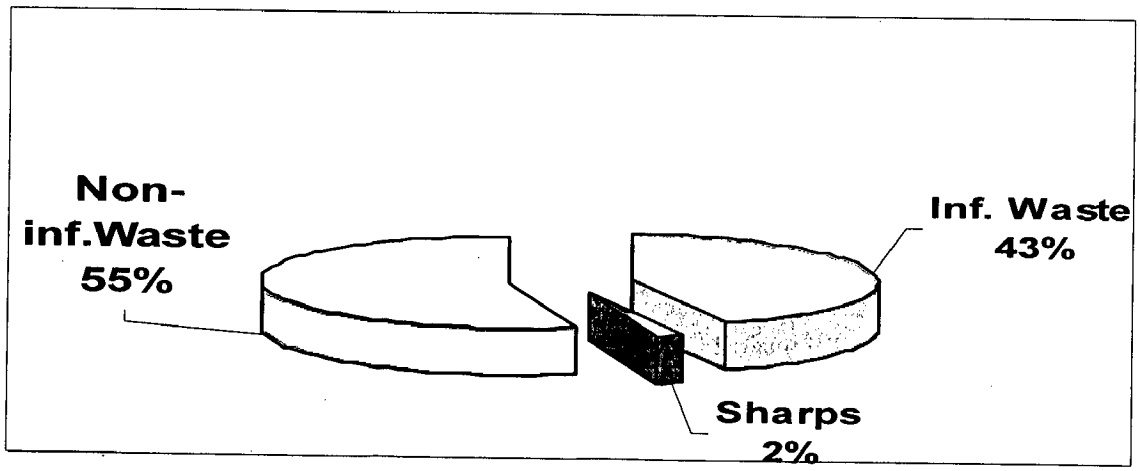
Table 4.14:- Type F Hospital (Primary Data)

Date	Cate.1 (Kg)	Cate.3 (Kg)	Cate.4 (Kg)	Cate.6 (Kg)	Cate.7 (Kg)	Cate.9 (Kg)	Kitchen Waste (Kg)	Non-infec. glass bottle(Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
5/4/2006	15.7	5.5	3.2	11.9	34.3	3.4	33.5	49.2	67.4	3.2	86.1
6/4/2006	17.3	4.8	2.9	9.1	30.9	3.3	29.4	45.1	62.1	2.9	77.8
7/4/2006	18.1	5.1	3.2	9.5	28.6	3.2	29.8	43.3	61.2	3.2	76.3
8/4/2006	17.4	5.3	3.2	12.0	29.7	3.4	30.1	47.1	64.4	3.2	80.6
9/4/2006	19.6	5.5	3.5	11.8	34.3	3.6	33.6	51.2	71.2	3.5	88.4
10/4/2006	23.6	4.9	2.6	11.9	33.1	3.2	30.2	46.3	73.5	2.6	79.7
11/4/2006	18.1	5.3	3.5	9.9	31.4	3.5	33.4	51.2	64.7	3.5	88.1
12/4/2006	18.2	5.1	3.3	9.5	28.6	3.4	28.4	35.4	61.3	3.3	67.3
13/4/2006	18.3	5.0	2.6	9.1	32.6	3.2	37.3	49.2	65.0	2.6	89.7
14/4/2006	15.6	4.4	2.7	7.9	26.9	3.0	30.1	39.0	54.8	2.7	72.1
15/4/2006	19.6	4.6	3.2	11.9	30.9	3.5	31.8	49.8	67.0	3.2	85.1
16/4/2006	19.4	5.6	3.5	11.5	31.4	3.6	26.8	39.4	67.9	3.5	69.8
17/4/2006	18.0	4.8	3.3	13.1	31.0	3.4	37.4	49.8	66.8	3.3	90.6
18/4/2006	17.3	4.9	3.2	8.6	28.5	3.2	26.0	48.0	59.2	3.2	77.2
19/4/2006	18.9	5.1	3.5	8.8	34.3	3.2	37.5	49.0	67.0	3.5	89.8
Avg. value	**18.3**	**5.1**	**3.2**	**10.4**	**31.1**	**3.3**	**31.7**	**46.2**	**64.9**	**3.2**	**81.2**

On comparison of the two tables, it is observed that average values of waste category 6 and category 7 are higher, while average values of category 1, category 3, category 4 and category 9 are lower in the secondary data table. From the analysis of the data, it is computed that infectious waste comprises 43 %, non- infectious waste comprises 55 % and sharps comprises 2%. The percentages of different waste categories and the percentages of infectious waste, non- infectious waste and sharps in Type F hospitals are depicted in the fig.4.12 and fig.4.13.



. **Fig. 4.12:- Waste Categories (Type F Hospital)**



. **Fig. 4.13:- Inf., Non-inf. And Sharps Waste (Type F Hospital)**

4.6.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management in Type F hospitals is explained in the following paragraphs.

4.6.2.1 *Central Railway Hospital*

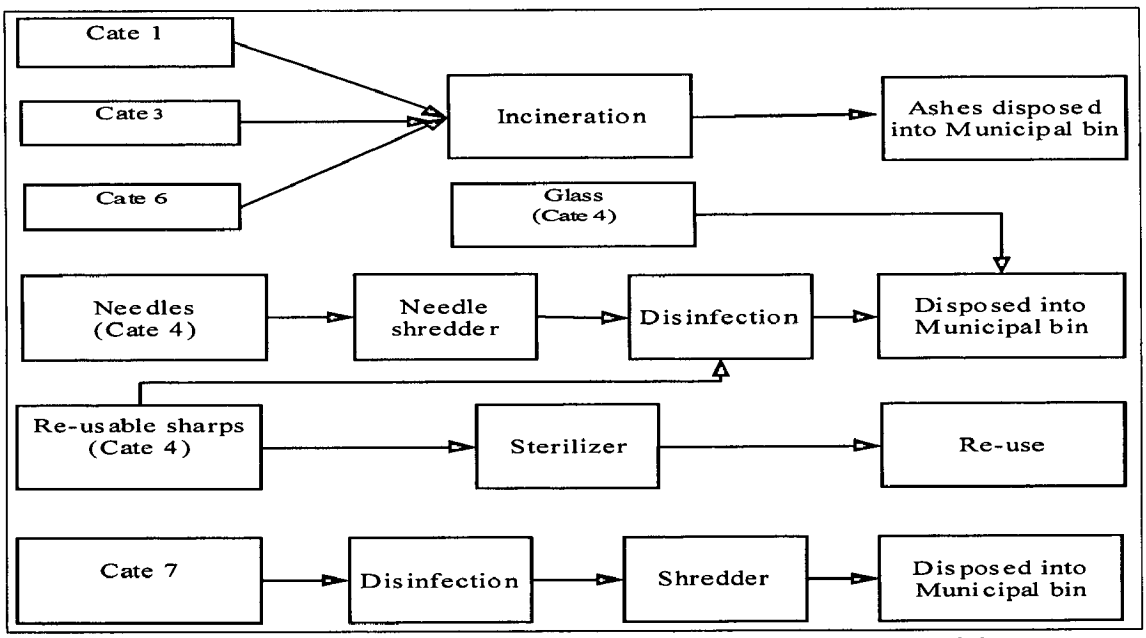
This hospital is located at Maligaon. It has bed capacity of 300 beds. There is a double chambered incinerator of 15 kg/hour capacity. The bio-medical waste management followed in this hospital is similar to that practiced in Nemcare Hospital.

4.6.2.2 *Downtown Hospital*

This hospital is located at Dispur. It has bed capacity of 300 beds. There is a double chambered incinerator of 15 kg/hour capacity. The bio-medical waste management followed in this hospital is similar to that practiced in International Hospital.

4.6.2.3 *Mahendra Mohan Choudhury Hospital*

This hospital is located at Panbazar. It has bed capacity of 300 beds. It is a Government hospital. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.21.



Flow-chart 4.21:- Present BMW Management Practice at Mahendra Mohan Choudhury Hospital

- **Management of incinerable waste:**

The waste categories 1, 3 and 6 are segregated separately in non-PVC bags. These bags are incinerated in the double chambered incinerator (capacity of 30 kg/hour). The ashes are disposed into Municipal bin.

- **Management of sharps:**

Needles are shredded in needle shredder, dis-infected and disposed into Municipal bin. Glass pieces are also disposed into Municipal bin. Re-useable surgical sharps are sterilized and re-used. When re-useable surgical sharps become waste, these are disinfected and disposed into Municipal bin.

- **Management of infectious plastics:**

All items of category 7 are first dis-infected, then shredded in an electrical shredder and disposed into Municipal bin.

Infectious glass is not disinfected before disposal.

4.6.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- In each hospital of the category F, about 30 nos. of 2 kg capacity bags, 30 nos. of 5 kg capacity bags and 10 nos. of 10 kg capacity bags are required every day.
- Incinerable wastes are being incinerated.
- Sharps are disposed into Municipal bin.
- The primary data table shows that about 18.3 kg of category 1, 5.1 kg of category 3, 3.2 kg of category 4, 10.4 kg of category 6 and 31.1 kg of category 7 are generated every day in sample hospital having 300 no. of beds. Thus average daily waste generation per bed calculates to 0.061 kg of category 1, 0.017 kg of category 3, 0.011 kg of category 4, 0.035 kg of category 6 and 0.104 kg of category 7.

4.7 TYPE G HOSPITAL

4.7.1 General

Type G comprises of a single hospital having 1587 beds. It is the biggest hospital in the entire north-east India. This hospital is equipped with dressing room, blood bank, laboratory, medicine ward, surgical ward, gynecological ward, pediatric ward, orthopedic ward, dermatology ward, nephrology ward, urology ward, cardiology ward, radiology ward, eye ward, E.N.T. ward, many Operation Theatres etc. Plan of the hospital is shown in Drawing VII. In this hospital, the waste amounts are not recorded. Hence, secondary

data is not available. Primary data was measured for one day. The primary data is tabulated in table 4.15.

Table 4.15:- Type G Hospital (Primary Data)

Incinerable Waste (1+3+6) (Kg)	Cate.4 (Kg)	Cate.7 (Kg)	Inf. Waste (1+3+6+7) (Kg)	Sharps (4) (Kg)	Non-inf. Waste (Kg)
403.9	16.6	122.9	526.8	16.6	1229.2

From analysis of the above data, it is computed that infectious waste comprises 30%, non- infectious waste comprises 69% and sharps comprises 1%.The percentages of infectious waste, non-infectious waste and sharps in this Type G hospital is depicted in the fig.4.14.

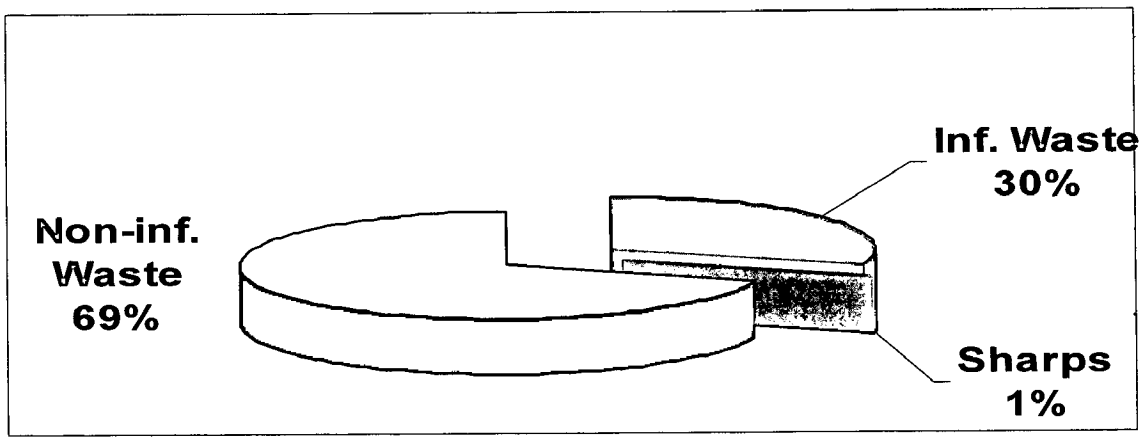


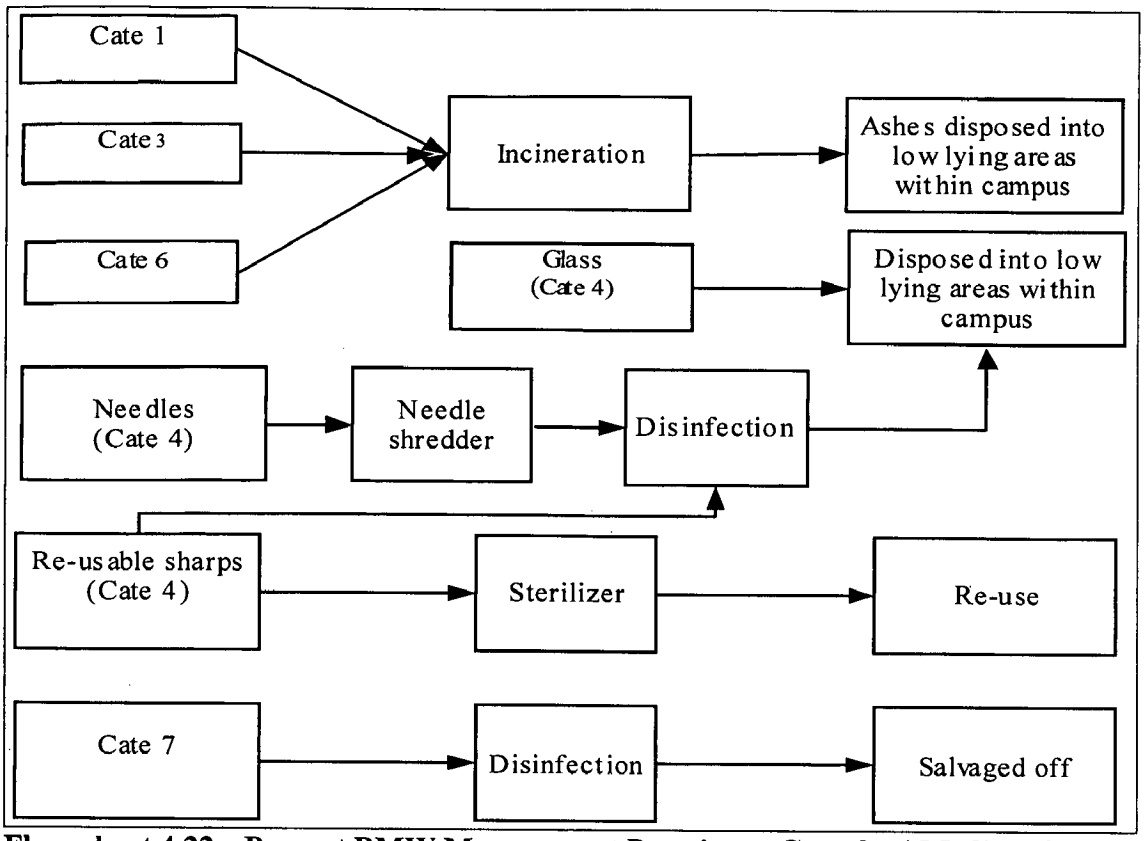
Fig. 4.14:- Inf., Non-inf. And Sharps Waste (Type G Hospital)

4.7.2 Present Bio-medical Waste Management Practice at Hospital

The existing bio-medical waste management in Type G hospital is explained in the following paragraphs.

4.7.2.1 *Guwahati Medical College Hospital*

This hospital is located in Bhangagarh. It has bed capacity of 1587 beds. It is a multispecialty hospital and there is a medical college attached to it. The bio-medical waste management followed in this hospital is depicted in flow-chart 4.22.



Flow-chart 4.22:- Present BMW Management Practice at Guwahati Medical College Hospital

- **Management of incinerable waste:**

Categories 1, 3 and 6 are segregated separately in non-PVC bags. These bags are incinerated in the double chambered incinerator (capacity of 50 kg/hour). The ashes are disposed into low lying area within campus.

- **Management of sharps:**

Needles are shredded in needle shredder, dis-infected in 1% hypochlorite solution and then disposed into low lying area within campus. Glass pieces are also disposed into low lying area within campus. Re-useable surgical sharps are sterilized and re-used. When it becomes waste, it is also disinfected and disposed.

- **Management of infectious plastics:**

All items of category 7 are first dis-infected, and then salvaged off.

4.7.3 General Observations

From data presented above, some general observations regarding this category can be made as follows:

- Infectious glass is not dis-infected before disposal.
- Re-useable surgical sharps are sterilized for re-use, not autoclaved.
- Category 7 (plastic waste) is not shredded before it is salvaged off. There could be re-use.
- Colour coded bags were introduced recently.
- The primary data table shows that about 16.6 kg of category 4, 122.9 kg of category 7 and 526.8 kg of infectious waste are generated every day in the sample hospital having 1587 no. of beds. Thus average daily waste generation per bed calculates to 0.010 kg of category 4, 0.077 kg of category 7 and 0.332 kg of infectious waste.

4.8 GENERAL OBSERVATIONS ABOUT MANAGEMENT OF BMW AT HOSPITALS IN GUWAHATI CITY

There were obvious gaps in the present management and the BMW guidelines in all the hospitals. It was observed that in many hospitals, infectious glass was not disinfected before disposal. Re-useable surgical sharps were sterilized by a sterilizer for re-use and not autoclaved. In some hospitals, category 3 (microbiology and biotechnology waste) were treated by autoclaving. But spore testing by standard methods to check whether it is completely disinfected is not done. And so the treatment is not ensured. Category 7 (disposable plastic solid waste like tubes, catheters, blood or urine bags, gloves etc.) are not shredded/mutilated before salvaging off, which generates a potential for illegal re-use. Some of the practices nonconforming to the BMW rules are depicted in fig. 4.15 – 4.26.

Fig. No. 4.15:- Salvaging without Mutilation

Fig. No. 4.16:- Improper Colour Coding

Fig. No. 4.17:- Overfilled Bin

Fig. No. 4.18:- Improper Storage

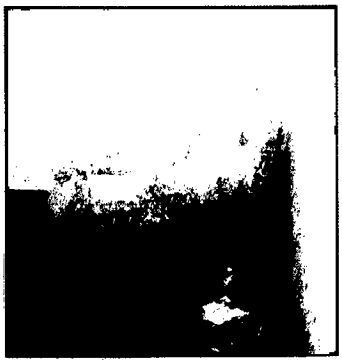


Fig. No. 4.19:- Unhygienic Environment

Fig. No. 4.20:- Broken Bin

Fig. No. 4.21:- Surgical Gloves for Reuse

Fig. No. 4.22:- Improper Segregation

Fig. No. 4.23:-Waste & Sterilized Cotton side by side

Fig. No. 4.24:- Clean & Unused Segregation Area

Fig. No. 4.25:- Insufficient Stack Height

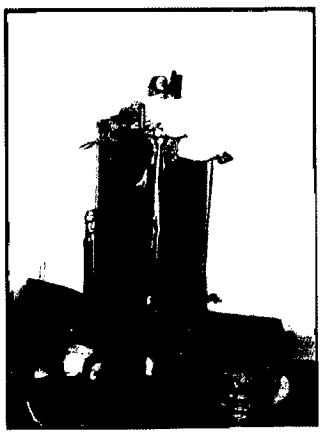


Fig. No. 4.26:- Autoclave Used as Cloth Shelf

4.9 BIO-MEDICAL WASTE MANAGEMENT AT CITY LEVEL

From the above observations, it is felt that city level management of BMW also needs modification as:

- Category 1 can be transported to a common facility to impart incineration.
- Categories 3 and 6 can be transported to the common facility for autoclaving.
- Category 7 can be dis-infected at site, and then transported to the common facility for shredding and salvaging.
- For those hospitals, which do not have space to construct a sharps pit, the sharps can be transported to the common facility for disposal.

4.10 PROPOSED MANAGEMENT PLAN

A management plan has been proposed to deal with the situation as discussed in the following paragraphs.

4.10.1 Segregation

Segregation of waste as per the B.M.W. Rules has to be done at the hospital level i.e. at the point of generation. When the bags are $3/4^{th}$ full, these have to be taken out from the re-useable sturdy containers and transferred by a wheel barrow to the segregation area. Each of the wards' waste will be labeled. At the segregation area, the waste bags which will be treated at the hospital level should be separated from those which need to be transported to the common facility. The respective coloured bags to be sent to CBWTF will be put into bigger bags of similar colour. The bigger bags should be labeled showing name of hospital, date and time of collection. This should be done to save time spent on handling too many small bags.

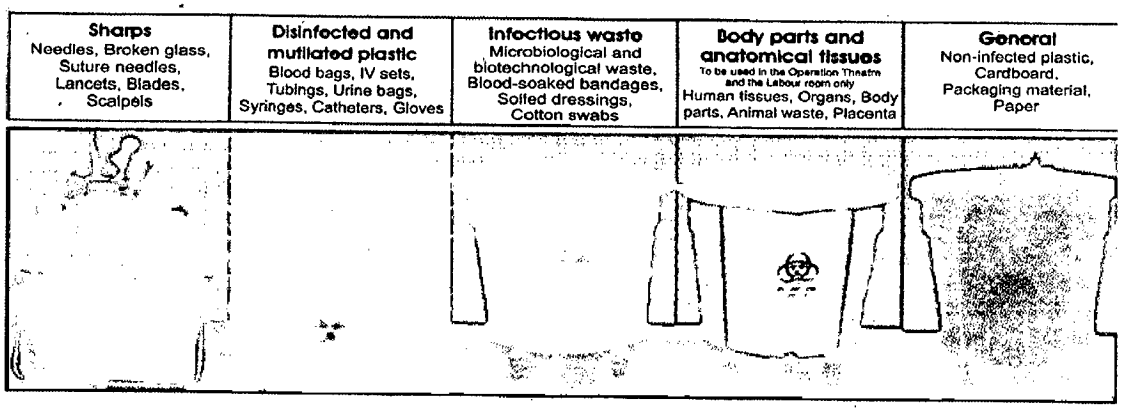


Fig. No. 4.27:- Segregation as per BMW Rules, 1998

4.10.2 Collection and Transportation

The vehicle will arrive at the hospital and wait. The bags to be transported to CBWTF will be weighed in the segregation area. Weights will be recorded in the register copy of vehicle crew and countersigned by both parties. There are coloured collection bins (2.5 feet high, 1.5 feet top diameter) inside the vehicle. The respective coloured bags will be put into the similar coloured bins. Sharps will be collected in puncture resistant containers (Agarwal, 2003 and CPCB, 2003).

4.10.2.1 *Transport Vehicle*

An old ambulance (or the special vehicle) can be the dedicated vehicle for the collection of bio-medical waste (Nath et al., 2004). It should fulfill the requirements as per the guidelines for CBWTF, i.e.

- It should have separate cabins for driver/staff and bio-medical waste containers.
- The base of the waste cabin should be leak proof to avoid pilferage of liquid.
- Shelves could be fitted to store waste containers in tiers.
- The waste cabin should be easy to wash and dis-infect.
- The inner surface of waste cabin should be smooth, so that there is minimum water retention.
- There should be provision of sufficient opening in the rear so that waste containers can be easily loaded and unloaded.

The vehicle shall be labeled with bio-medical waste symbol (as per the Schedule III of the B.M.W. Rules) and should display the name, address and telephone no. of the CBWTF (CPCB, 2003). The collection bins will be loaded onto the vehicle, for transportation to CBWTF. The design of the vehicle is discussed under Design (paragraph 4.11.1).

4.10.2.2 *Transport Route*

It is proposed to set up the CBWTF at / near the Guwahati Medical College (GMC) Hospital campus. Hence, a route is chalked out to transport bio-medical waste from the hospitals to the GMC Hospital campus. The analysis for the optimal route is discussed under Design (paragraph 4.11.2).

4.10.2.3 *Time of Collection*

It is proposed that collection of bio-medical waste will start at 10 P.M. and end before 6 A.M. so as to avoid traffic congestion.

4.10.3 Treatment

At the CBWTF, treatment shall be imparted to the different categories of waste as per the provisions of the BMW Rules, which is tabulated in table 4.16.

Table 4.16:- Treatment and Disposal of BMW

Waste Category	Treatment and disposal
1	Incineration
2	Incineration
3	Autoclaving
4	Disinfection, autoclaving and mutilation/shredding
5	Incineration/secure landfill
6	Autoclaving
7	Disinfection, mutilation/shredding
8	Disinfection and discharge in sewer
9	Landfill
10	Disinfection and discharge in sewer for liquid and secured landfill for solids.

(Source: MOEF Notification, 1998)

Only waste categories 1 and 2 and cytotoxic wastes will be incinerated (Agarwal, 2003 and CPCB, 2003).

4.10.4 Disposal

The final disposal of treated waste shall be done at CBWTF as follows (CPCB, 2003).

- Incineration ashes and expired medicines (if any) shall be disposed into secured landfill within CBWTF campus.
- Treated soiled waste shall be disposed into municipal landfill.

- Those items which can be salvaged off shall be done so after shredding / mutilation.
- Sharps shall be disposed into sharps pit.
- Treated waste water shall be discharged into sewer or drain.

The design of the CBWTF is discussed under Design (paragraph 4.11.3).

4.11 DESIGN

4.11.1 Design of Vehicle

The existing ambulance (not in use) shall be converted into waste carrying van. The dimensions of the ambulance are width 1.83m, length 3.50m and height 1.83m. The height is divided by a shelf (0.46m wide and 3.50m long) on both sides of the vehicle. The aisle is 0.91m wide. Standard bins are available, having height of 0.76m, top diameter 0.46m and bottom diameter 0.30m. The capacity of each bin is calculated to be 0.092 m^3. The calculation is shown in Appendix III. 42 nos. of such bins can be accommodated inside the vehicle, as shown in fig. 4.28. The density of BMW is 110 Kg/m^3.

Considering container utilization factor as 85%, each bin can carry 8.6 kg of BMW. Therefore, the vehicle can carry 361.0 kg of BMW in one trip.

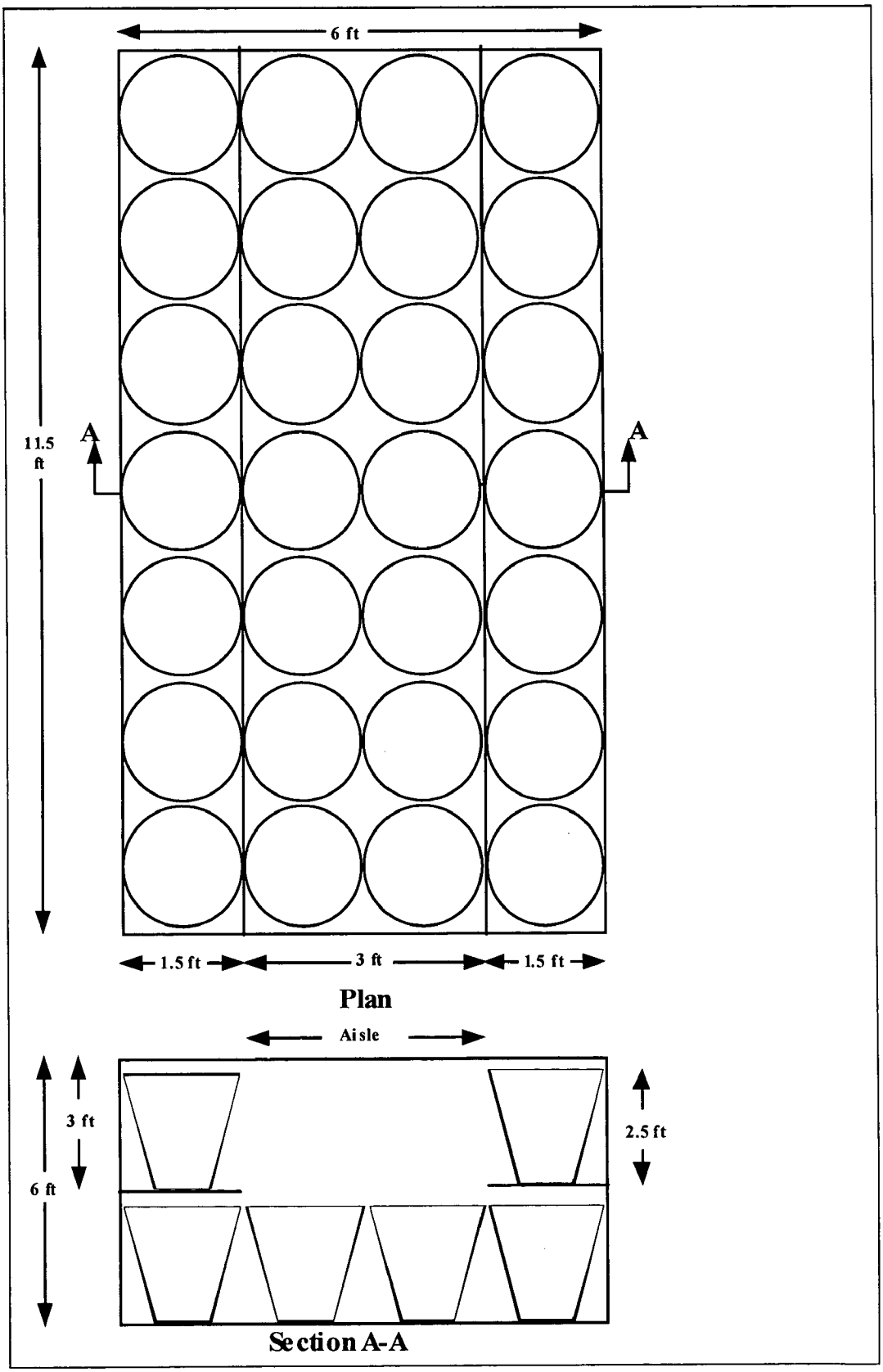


Fig. 4.28:-Lay out of Bins inside Vehicle

An auto van will be employed for transporting BMW from the hospital no. 18 which is located far away from the main city and also from those hospitals which are in interior places (hospital no. 25, 22, 11, 24 and 15). The dimensions of the auto van are width 1.22m, length 1.52m and height 1.22m.

Six numbers of standard bins can be accommodated inside the auto van, as shown in fig. 4.29. Each bin can carry 8.6 kg of BMW. Therefore, the auto van can carry 51.6 kg of BMW.

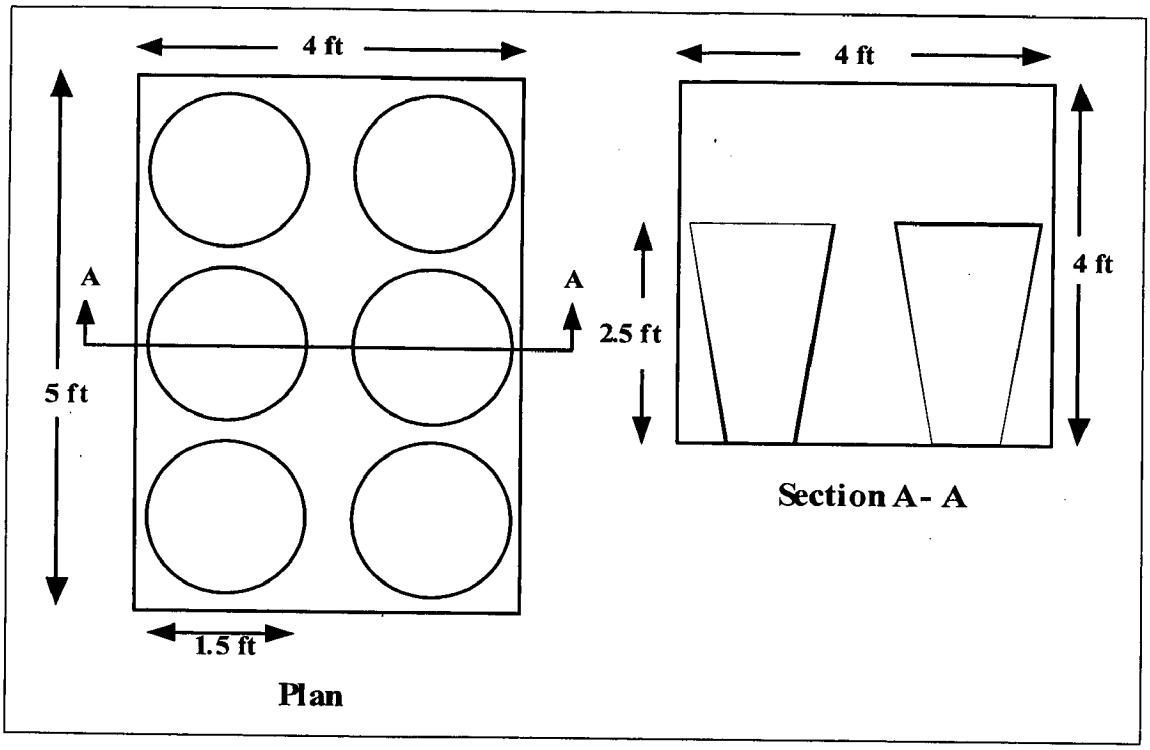


Fig. 4.29:-Lay out of Bins inside Auto van

4.11.2 Route Design

The route has been designed by taking the following factors into consideration:

- Distance
- Time
- Cost
- Road condition
- Weight of bio-medical waste
- Capacity of vehicle

4.11.2.1 *Weight of BMW to be Transported*

The weight of BMW to be transported to the CBWTF depends upon the facilities available at the hospital. But all incinerable wastes are to be transported to CBWTF because CPCB has laid stress that incinerator should be allowed only in the CBWTF. The waste generation in each hospital and the treatment facilities available at hospitals is presented in table 4.17.

From table 4.17, the BMW amount to be transported to CBWTF is computed and presented in table 4.18.

Table 4.17:- Waste Generation

Sl. No.	Hospital Type	Total Daily Waste (kg)						No. of beds	Average Daily Waste of each Category (Kg/bed)						Treatment Facilities Present		
		1	3	4	6	7	9		1	3	4	6	7	9	Incinerator	Sharps Pit	Shredder
1	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
2	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
3	B	1.4	1.1	0.8	2.4	5.5	0.4	35	0.040	0.031	0.023	0.069	0.157	0.011	Yes (DC)	Yes	No
4	C	5.1	2.7	1.2	5.5	12.9	1.4	100	0.051	0.027	0.012	0.055	0.129	0.014	Yes (DC)	Yes	No
5	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.04	0.031	0.023	0.069	0.157	0.011	No	Yes	No
6	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	Yes (DC)	Yes	No
7	A	0.8	0.4	0.6	3.1	3.1	0.4	21	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
8	A	0.5	0.3	0.4	2.2	2.2	0.3	15	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
9	F	18.3	5.1	3.2	10.4	31.1	3.3	300	0.061	0.017	0.011	0.035	0.104	0.011	Yes (DC)	Yes	No
10	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
11	A	0.5	0.3	0.4	2.2	2.2	0.3	15	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
12	D	7.4	3.8	1.4	8.0	24.3	2.1	150	0.049	0.025	0.009	0.053	0.162	0.014	Yes (SC)	Yes	No
13	F	18.3	5.1	3.2	10.4	31.1	3.3	300	0.061	0.017	0.011	0.035	0.104	0.011	Yes (DC)	No	No
14	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
15	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No

Contd....

Sl. No	Hospital Type	Total Daily Waste (kg)						No. of beds	Average Daily Waste of each Category (kg/bed)						Treatment Facilities Present		
		1	3	4	6	7	9		1	3	4	6	7	9	Incinerator	Sharps Pit	Shredder
16	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	Yes (SC)	Yes	No
17	E	13.0	4.1	3.0	9.6	27.7	2.7	250	0.052	0.016	0.012	0.038	0.111	0.011	Yes (DC)	No	No
18	A	0.7	0.4	0.6	3.0	3.0	0.4	20	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
19	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
20	G	NS	NS	16.6	NS	122.9	-	1587	NS	NS	0.010	NS	0.077	-	Yes (DC)	No	No
21	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
22	A	0.5	0.3	0.4	2.2	2.2	0.3	15	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
23	D	5.6	2.9	1.2	6.0	18.5	1.6	114	0.049	0.025	0.009	0.053	0.162	0.014	Yes (DC)	No	No
24	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
25	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
26	F	18.3	5.1	3.2	10.4	31.1	3.3	300	0.061	0.017	0.011	0.035	0.104	0.011	Yes (DC)	No	Yes
27	B	1.8	1.4	1.0	3.1	7.1	0.5	45	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
28	C	3.3	1.8	0.8	3.6	8.4	0.9	65	0.051	0.027	0.012	0.055	0.129	0.014	Yes (DC)	Yes	No
29	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
30	B	2.0	1.6	1.2	3.5	7.9	0.6	50	0.040	0.031	0.023	0.069	0.157	0.011	Yes (DC)	Yes	No
31	A	0.5	0.3	0.4	2.1	2.1	0.3	14	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No

Contd....

Sl. No.	Hospital Type	Total Daily Waste (kg)						No. of beds	Average Daily Waste of each Category (kg/bed)						Treatment Facilities Present		
		1	3	4	6	7	9		1	3	4	6	7	9	Incinerator	Sharps Pit	Shredder
32	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	Yes (SC)	Yes	No
33	B	1.6	1.2	0.9	2.8	6.3	0.4	40	0.040	0.031	0.023	0.069	0.157	0.011	No	Yes	No
34	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	Yes (DC)	No	No
35	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.02	0.028	0.148	0.148	0.02	No	Yes	No
36	B	1.2	0.9	0.7	2.1	4.7	0.3	30	0.040	0.031	0.023	0.069	0.157	0.011	No	No	No
37	B	1.6	1.2	0.9	2.8	6.3	0.4	40	0.040	0.031	0.023	0.069	0.157	0.011	No	No	No
38	A	0.9	0.5	0.7	3.7	3.7	0.5	25	0.036	0.020	0.028	0.148	0.148	0.020	No	Yes	No
39	B	1.4	1.1	0.8	2.4	5.5	0.4	35	0.040	0.031	0.023	0.069	0.157	0.011	Yes (DC)	Yes	No
40	E	10.7	3.3	2.5	7.8	22.8	2.3	205	0.052	0.016	0.012	0.038	0.111	0.011	Yes (DC)	No	No
41	C	5.1	2.7	1.2	5.5	12.9	1.4	100	0.051	0.027	0.012	0.055	0.129	0.014	Yes (DC)	No	No

[Note: NS - not measured separately
SC – single chamber incinerator
DC – double chamber incinerator]

Table 4.18:- Quantity of Waste for Treatment in CBWTF

Sl. No.	Hospital Type	Waste for Treatment in CBWTF (Kg)									
		Cate. 1	Cate. 3	Cate. 4	Cate. 6	Cate. 7	Inc. Waste (1)	Autoclaving (3+6)	Sharps Pit (4)	Shredder (7)	Total BMW
1	A	0.9	0.5	-	3.7	3.7	0.9	4.2	-	3.7	8.8
2	A	0.9	0.5	-	3.7	3.7	0.9	4.2	-	3.7	8.8
3	B	1.4	1.1	-	2.4	5.5	1.4	3.5	-	5.5	10.4
4	C	5.1	2.7	-	5.5	12.9	5.1	8.2	-	12.9	26.2
5	B	1.2	0.9	-	2.1	4.7	1.2	3	-	4.7	8.9
6	B	1.2	0.9	-	2.1	4.7	1.2	3	-	4.7	8.9
7	A	0.8	0.4	-	3.1	3.1	0.8	3.5	-	3.1	7.4
8	A	0.5	0.3	-	2.2	2.2	0.5	2.5	-	2.2	5.3
9	F	18.3	5.1	-	10.4	31.1	18.3	15.5	-	31.1	65
10	B	1.2	0.9	-	2.1	4.7	1.2	3	-	4.7	8.9
11	A	0.5	0.3	-	2.2	2.2	0.5	2.5	-	2.2	5.3
12	D	7.4	3.8	-	8.0	24.3	7.4	11.8	-	24.3	43.4
13	F	18.3	5.1	3.2	10.4	31.1	18.3	15.5	3.2	31.1	68.2
14	A	0.9	0.5	-	3.7	3.7	0.9	4.2	-	3.7	8.8
15	B	1.2	0.9	-	2.1	4.7	1.2	3	-	4.7	8.9
16	B	1.2	0.9	-	2.1	4.7	1.2	3	-	4.7	8.9
17	E	13.0	4.1	3.0	9.6	27.7	13.0	13.7	3.0	27.7	57.4

Contd....

Sl. No	Hospital Type	Waste for Treatment in CBWTF (Kg)									
		Cate. 1	Cate. 3	Cate. 4	Cate. 6	Cate. 7	Inc. Waste (1)	Autoclaving (3+6)	Sharps Pit (4)	Shredder (7)	Total BMW
18	A	0.7	0.4	-	3.0	3.0	0.7	3.7	-	3.0	7.1
19	B	1.2	0.9	-	2.1	4.7	1.2	3.3	-	4.7	8.9
20	G	NS	NS	16.6	NS	122.9	NS	NS	16.6	122.9	543.4
21	B	1.2	0.9	-	2.1	4.7	1.2	3.3	-	4.7	8.9
22	A	0.5	0.3	-	2.2	2.2	0.5	2.7	-	2.2	5.3
23	D	5.6	2.9	1.1	6.0	18.5	5.6	11.6	1.1	18.5	34.1
24	B	1.2	0.9	-	2.1	4.7	1.2	3.3	-	4.7	8.9
25	A	0.9	0.5	-	3.7	3.7	0.9	4.6	-	3.7	8.8
26	F	18.3	5.1	3.2	10.4	-	18.3	28.7	3.2	-	37.1
27	B	1.8	1.4	-	3.1	7.1	1.8	4.9	-	7.1	13.4
28	C	3.3	1.8	-	3.6	8.4	3.3	6.9	-	8.4	17.1
29	A	0.9	0.5	-	3.7	3.7	0.9	4.6	-	3.7	8.8
30	B	2.0	1.6	-	3.5	7.9	2.0	5.5	-	7.9	14.9
31	A	0.5	0.3	-	2.1	2.1	0.5	2.6	-	2.1	5
32	B	1.2	0.9	-	2.1	4.7	1.2	3.3	-	4.7	8.9
33	B	1.6	1.2	-	2.8	6.3	1.6	4.4	-	6.3	11.9
34	B	1.2	0.9	0.7	2.1	4.7	1.2	3.3	0.7	4.7	9.6

Contd....

Sl. No	Hospital Type	Waste for Treatment in CBWTF (Kg)									
		Cate. 1	Cate. 3	Cate. 4	Cate. 6	Cate. 7	Inc. Waste (1)	Autoclaving (3+6)	Sharps Pit (4)	Shredder (7)	Total BMW
35	A	0.9	0.5	-	3.7	3.7	0.9	4.6	-	3.7	8.8
36	B	1.2	0.9	0.7	2.1	4.7	1.2	3.3	0.7	4.7	9.6
37	B	1.6	1.2	-	2.8	6.3	1.6	4.4	-	6.3	12.8
38	A	0.9	0.5	-	3.7	3.7	0.9	4.6	-	3.7	8.8
39	B	1.4	1.1	-	2.4	5.5	1.4	3.8	-	5.5	10.4
40	E	10.7	3.3	2.5	7.8	22.8	10.7	18.5	2.5	22.8	47
41	C	5.1	2.7	1.2	5.5	12.9	5.1	10.6	1.2	12.9	27.4

[Note: NS - not measured separately
Inc. Waste – Incinerable Waste]

4.11.2.2 *Time*

The total time for a route is defined as follows:

Total time = [(Pick-up time + Traveling time) × Off-route factor] for each trip +
[Check in time + Unloading time + Check out time] for each trip +
Time taken to travel back to halting station.

The **pick-up time** for each hospital will start from the moment the vehicle stops inside the campus of the hospital, the big bags are weighed, weights recorded and signed, bags put inside the bins and the bins are loaded into the vehicle. Thus pick-up time will be different for the different hospital type and it is estimated as shown in table 4.19.

Table 4.19:- Pick-up Time of each Hospital Type

Hospital Type	Pick-up Time (minutes)
A	5
B	5
C	7
D	10
E	15
F	18
G	nil

The **traveling time** is the time taken to travel to the different hospitals and to transport the waste to the CBWTF.

The **off-route time** includes all time spent on activities that are nonproductive from the point of view of the overall collection operation. Many of the activities associated with off-route times are sometimes necessary or inherent in the operation. Therefore the time spent on off-route activities may be sub-divided into two categories: necessary and unnecessary. In practice, however, both necessary and unnecessary off-route times are considered together because it must be distributed equally over the entire operation. In this study, necessary off-route time includes time lost due to unavoidable congestion, and time spent on equipment repairs, maintenance, and so on. Unnecessary off-route time includes time spent for lunch in excess of the stated lunch period and time

spent on taking unauthorized coffee breaks, talking to friends, and the like. Here, off-route time is taken as 10% of the total of pick-up time and traveling time involved in the route [Tchobanoglous et al., 1993].

The **actual time** is the total of traveling time and pick-up time multiplied by the off-route factor. Actual time is calculated for each trip. Tchobanoglous et al. (1993) has defined t_1 as the time taken to drive from dispatch station to first pick up location to be serviced for the day and t_2 as the time taken to drive from the last pick up location to be serviced for the day to the dispatch station. In this study $t_1=0$ for all the routes as the first pick-up point is located at the halting station. And t_2 is considered as the time taken to travel from the proposed CBWTF to the halting station.

4.11.2.3 *Alternative Routes*

The number of trips to be made by the vehicle is determined by the capacity of the vehicle. Five different routes are identified and depicted on **Map 1.** A comparative statement of these five routes are prepared and shown in table 4.20.

Table 4.20:- Comparative Statement of Alternative Routes

Route No.	Distance Traveled (km)	Fuel Cost (Rs. 31.96/litre of diesel) 1.@ 5 km/liter 2.@ 8 km/litre	Time Taken	No. of Pick up Points	BMW Picked Up (kg)	Road Condition
I						
1.By big	74.18	Rs. 474	8hr	39	685.9	Good
vehicle	46.86	Rs. 187	27min	1	7.1	Good
2.By auto van			1hr			
			39min			
II						
1.By big	76.31	Rs. 488	8hr	39	685.9	Good
vehicle	46.86	Rs. 187	31min	1	7.1	Good
2.By auto van			1hr			
			39min			
III						
1.By big	69.47	Rs. 444	8hr	39	685.9	Good
vehicle	46.86	Rs. 187	22min	1	7.1	Good
2.By auto van			1hr			
			39min			

Contd.....

IV 1.By big vehicle 2.By auto van	74.35 46.86	Rs. 475 Rs. 187	8hr 29min 1hr 39min	39 1	685.9 7.1	Good Good
V 1.By big vehicle 2.By auto van	64.37 51.96	Rs. 411 Rs. 207	7hr 46min 2hr 25min	34 6	648.7 44.3	Good Good

The Routes are described below and calculations for Route I is shown as sample calculation. In the following descriptions of the different routes, the hospitals are numbered as given in table 4.1.

Sample Calculation (Route I):

The vehicle will be stationed in the campus of hospital no. **4**.The first trip will start from hospital no. **4**. Vehicle will pick up BMW from hospitals no. **4, 40, 6, 3, 14, 34, 16, 21, 1, 17, 39, 13, 12, 31, 23** and travel to CBWTF at hospital no. **20**.

The total distance traveled = 24.58 km

Average speed = 40 km/hour

Therefore, time taken to travel = 0.61 hours.

Pick-up time for first trip is calculated as below:

Table 4.21:- Pick-up Time for First Trip (Big Vehicle)

Hospital Type	Pick-up time per hospital (minutes)	No. of hospitals	Pick-up time (minutes)	Total pick-up time	Total BMW picked up.
A	5	3	15	2 hours	356 kg (<361 kg)
B	5	6	30		
C	7	1	7		
D	10	2	20		
E	15	2	30		
F	18	1	18		
G	-	-			

Therefore, traveling time + pick-up time = 0.61 hours + 2 hours = 2.61 hours

An off-route time of 10% is considered.

Therefore, actual time for first trip = 2.87 hours = 2 hours 52 minutes.

At the CBWTF, the time taken for check-in, unloading and check-out is estimated to be equal to 45 minutes. The vehicle then starts the second trip. The vehicle will pick up BMW from hospitals no. **38, 19, 41, 27, 28, 25, 22, 11, 24, 15, 9, 33, 35, 8, 26, 36, 5, 37, 7, 32, 29, 10, 2, 30** and return back to CBWTF

The total distance traveled = 39.6 km

Average speed = 40 km/hour

Therefore, time taken to travel = 0.99 hours.

Pick-up time for second trip is calculated as below:

Table 4.22:- Pick-up time for Second Trip (Big Vehicle)

Hospital Type	Pick-up time per hospital (minutes)	No. of hospitals	Pick-up time (minutes)	Total pick-up time	Total BMW picked up.
A	5	9	45	150 min =2.5 hrs	329.90 kg (< 361 kg)
B	5	11	55		
C	7	2	14		
D	10	-	-		
E	15	-	-		
F	18	2	36		
G	-	-	-		

Therefore, traveling time + pick-up time = 0.99 hours + 2.5 hours = 3.49 hours

An off-route time of 10% is considered.

Therefore, actual time for second trip = 3.84 hours = 3hours 50 minutes.

At the CBWTF, the time taken for check-in, unloading and check-out is estimated to be equal to 45 minutes.

Then the vehicle travels to hospital no. **4** for halt.

The total distance traveled = 10.00 km

Average speed = 40 km/hour

Therefore, time taken to travel back to halting station =15 min

Total time taken by vehicle to complete two trips = 8hrs 27 min

Hospital no. **18** is located far away from the city. The BMW will be transported from this hospital to CBWTF by a small vehicle (auto van). The auto van will be stationed in the campus of hospital no. **18.** It will pick up BMW from hospital no. **18** and travel to CBWTF.

The total distance traveled = 23.43 km

Average speed = 40 km/hour

Therefore, time taken to travel = 0.59 hrs

= 35 min

Pick up time = 5 min.

Therefore, traveling time + pick-up time = 35 min + 5 min

= 40 min

An off-route time of 10% is considered.

Therefore, actual time taken by the auto van = 44 minutes.

At the CBWTF, the time taken for check-in, unloading and check-out is estimated to be equal to 20 minutes.

Then the auto van travels to hospital no. **18** for halt.

Time taken to travel back to hospital no. **18** = 35 min

Therefore, total time taken by auto van = 1 hr 39 min.

Route II: The vehicle will be stationed in the campus of hospital no. **9**. The first trip will start from hospital no. **9**. Vehicle will pick up BMW from hospitals no. **9, 33, 35, 25, 22, 11, 24, 15, 27, 28, 41, 8, 26, 36, 5, 38, 19, 37, 7, 32, 29, 10, 2, 30** and travel to CBWTF at hospital no. **20**.

It will check-in, unload and check-out to start the second trip. Second trip will start from C. B.W.T.F. and pick up BMW from hospitals no. **23, 12, 17, 39, 13, 6, 40, 14, 3, 34, 4, 16, 21, 1, 31** and return back to C. B.W.T.F. Again, it will check-in, unload and check-out to return to hospital no. **9** for halt.

The auto van will be stationed in the campus of hospital no. **18.** It will pick up BMW from hospital no. **18** and travel to CBWTF It will check-in, unload and check-out to return to hospital no. **18** for halt.

Route III: The vehicle will be stationed in the campus of hospital no. **1**.The first trip will start from hospital no. **1**. Vehicle will pick up BMW from hospitals no. **1, 21, 16, 4, 34, 3, 14, 40, 6, 13, 39, 17, 12, 31, 23** and travel to CBWTF at hospital no. **20**.

It will check-in, unload and check-out to start the second trip. Second trip will start from C. B.W.T.F. and pick up BMW from hospitals no. **38, 19, 41, 27, 28, 25, 22, 11, 24, 15, 9, 33, 35, 8, 26, 36, 5, 37, 7, 32, 29, 10, 2, 30** and return back to CBWTF Again, it will check-in, unload and check-out to return to hospital no. **1** for halt.

The auto van will be stationed in the campus of hospital no. **18.** It will pick up BMW from hospital no. **18** and travel to CBWTF. It will check-in, unload and check-out to return to hospital no. **18** for halt.

Route IV: The vehicle will be stationed in the campus of hospital no. **40**.The first trip will start from hospital no. **40**. Vehicle will pick up BMW from hospitals no. **40, 6, 3, 14, 34, 4, 16, 21, 1, 17, 39, 13, 12, 31, 23** and travel to CBWTF at hospital no. **20**.

It will check-in, unload and check-out to start the second trip. Second trip will start from C BWTF and pick up BMW from hospitals no. **38, 19, 41, 27, 28, 25, 22, 11, 24, 15, 9, 33, 35, 8, 26, 36, 5, 37, 7, 32, 29, 10, 2, 30** and return back to C BWTF. Again, it will check-in, unload and check-out to return to hospital no. **40** for halt.

The auto van will be stationed in the campus of hospital no. **18.** It will pick up BMW from hospital no. **18** and travel to CBWTF It will check-in, unload and check-out to return to hospital no. **18** for halt.

Route V: The vehicle will be stationed in the campus of hospital no. **1**.The first trip will start from hospital no. **1**. Vehicle will pick up BMW from hospitals no. **1, 21, 16, 4, 34, 3, 14, 40, 6, 13, 39, 17, 12, 31, 23** and travel to CBWTF at hospital no. **20**.

It will check-in, unload and check-out to start the second trip. Second trip will start from C BWTF and pick up BMW from hospitals no. **38, 19, 41, 27, 28, 35, 9, 33, 8, 26, 36, 5, 37, 7, 32, 29, 10, 2, 30** and return back to C BWTF. Again, it will check-in, unload and check-out to return to hospital no. **1** for halt.

The auto van will be stationed in the campus of CBWTF. The trip will start from CBWTF. The auto van will travel to hospital no. **18** and pick up BMW from hospitals no. **18, 25, 22, 11, 24, 15** and travel to CBWTF. It will check-in, unload and park in the Parking Shed for halt.

From the comparative statement (table 4.20), it is inferred that **Route V** is the optimal route.

4.11.3 Design of Common Bio-medical Waste Treatment Facility

A Common Bio-medical Waste Treatment Facility (CBWTF) is a set up where bio-medical waste, generated from a number of healthcare units, is imparted necessary treatment to reduce adverse effects that this waste may pose. Installation of individual treatment facilities by small healthcare units requires comparatively high capital investment. In addition, it requires separate manpower and infrastructure development for proper operation and maintenance of treatment systems. The concept of CBWTF not only addresses such problems but also prevents proliferation of treatment equipment in a city. In turn it reduces the monitoring pressure on regulatory agencies. By running the treatment equipment at CBWTF to its full capacity, the cost of treatment of per kilogram gets significantly reduced [CPCB, 2003]. A CBWTF is designed taking the following factors into consideration and the CPCB guidelines (Appendix V).

4.11.3.1 *Location*

The CBWTF will be located in the campus of the GMC Hospital. The proposed area is marked on the plan (fig. 4.15).

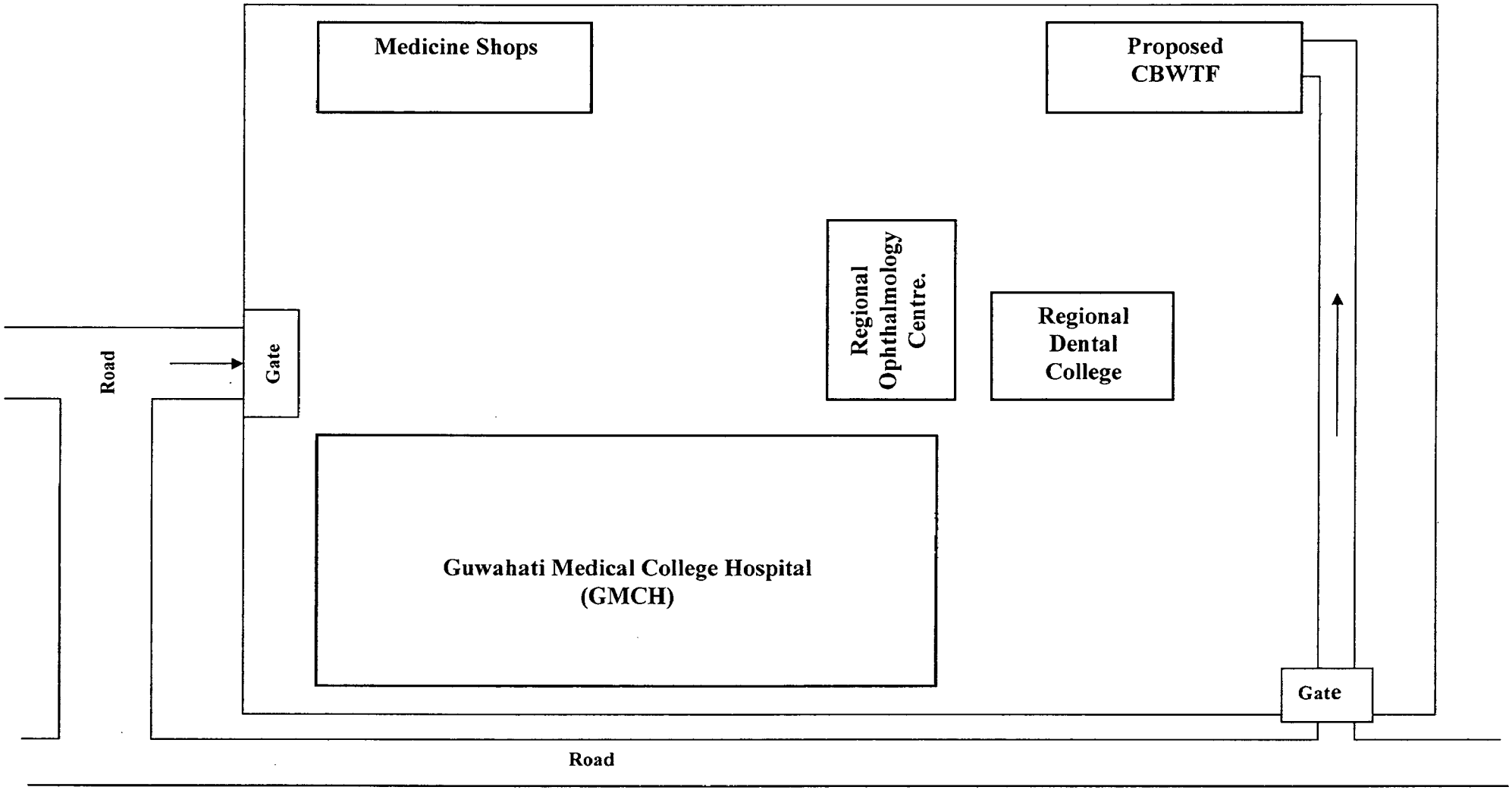


Fig. 4.30:- Location of Proposed CBWTF at GMCH Campus

4.11.3.2 *Land Requirement*

An area of one acre of land has been identified for the CBWTF.

4.11.3.3 *Coverage Area of CBWTF*

This CBWTF will cater to all the hospitals in Guwahati city.

4.11.3.4 *Treatment Equipment*

Following treatment equipments should be installed in the CBWTF:

- **Incinerator:** An incinerator of capacity equal to 50 kg/hour already exists at the site of the CBWTF. A standby incinerator of 30 kg/hour capacity should also be installed in the incinerator room. Both incinerators should be fitted with air pollution control device so that these are compatible with the emission norms laid down in the Standards for incinerators (Appended in Appendix IV).
- **Autoclave:** Capacity of the autoclave should be 35 kg/hour. It should be compatible with the norms laid down in Standards for Waste Autoclaving (Appended in Appendix IV)
- **Shredder:** The plastic shredder should have capacity of 40 kg/hour and the metal shredder should have capacity of 5 kg/hour.
- **Sharps Pit:** A sharps pit shall be provided for treated sharps. Dimensions of sharps pit should be 7m × 5m.
- **Vehicle/Container Washing Facility:** Every time a vehicle is unloaded, the vehicle and empty waste containers should be washed properly and dis-infected before it checks out of the CBWTF. Dimensions of this facility should be 10m×5m.
- **Effluent Treatment Plant:** An ETP should be installed to treat the liquid effluent which is generated during the process of washing containers, vehicles and floors. The treated effluent shall comply with the stipulated regulatory requirements. (Appended in Appendix IV)

4.11.3.5 *Infrastructure Set Up*

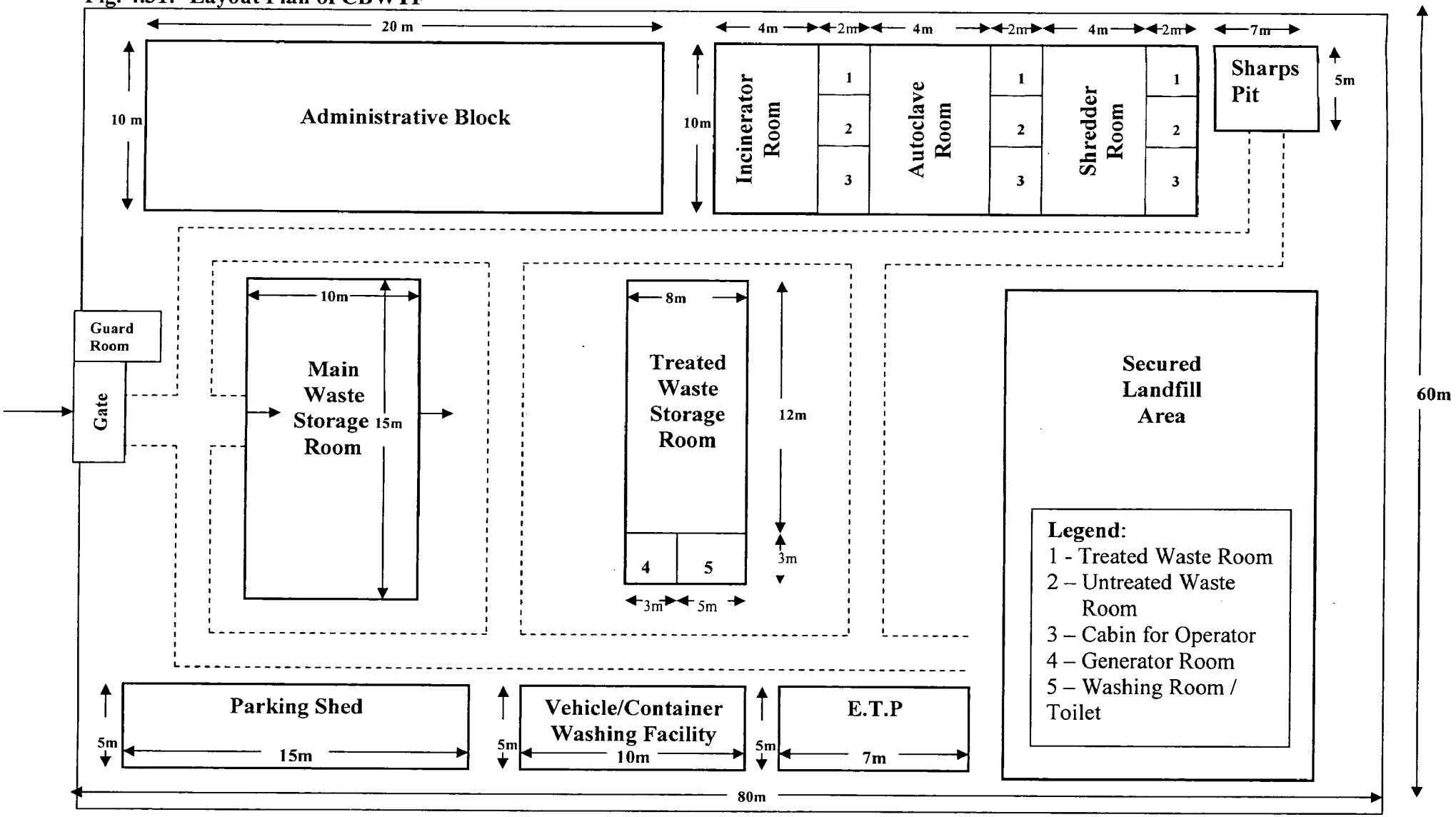
- **Treatment Equipment Room:** Each treatment equipment shall be housed in a separate room. Attached to each equipment room, there should be three small rooms –

one room for storage of untreated waste, one room for storage of treated waste and one room as a cabin for the operator.

- **Main Waste Storage Room:** This room should be provided near the entry point of the CBWTF to unload and store all BMW that has been transported to the facility by vehicle. The front portion of the room shall be utilized for unloading the waste from the vehicle and back portion shall be utilized for shifting the wastes to the respective treatment equipment.
- **Treated Waste Storage Room:** The wastes treated in the different treatment units should be stored in this room.
- **Administrative Block:** This block shall be utilized for general administration, record keeping, billing etc.
- **Generator Set:** A generator set, as standby arrangement for power, shall be housed in the generator room (attached to Treated Waste Storage Room).
- **Site Security:** High walls, fencing and guarded gates shall be provided at the facility to prevent unauthorized access to the site by humans and livestock.
- **Parking:** A parking shed (15m×5m) shall be provided.
- **Sign Board:** An identification board of durable material and finish shall be displayed at the entrance to the CBWTF. This should clearly display the name of the CBWTF, the name, address and telephone number of the operator and the prescribed authority, the hours of operation and the telephone numbers of the personnel to be contacted in the event of an emergency.
- **Green Belt:** Open area shall be developed into green belt. There shall be two rows of trees all around the CBWTF.
- **Washing Room:** Washing room and toilets shall be provided (attached to Treated Waste Storage Room).

All the above features are shown in the layout plan of the CBWTF (fig.4.16).

Fig. 4.31:- Layout Plan of CBWTF



4.11.4 Cost Estimate and Cess Calculation

The cost estimate for the proposed CBWTF is prepared based on Assam PWD Schedule of Rates 2004 – 05, local market rates and information provided by manufacturers.

For the construction items viz. building and boundary wall, the rates are taken from the Assam PWD SR 2004 – 05. For land and other construction items viz. parking sheds, vehicle washing sheds, guard room, sanitary and plumbing etc., lump sum amount based on prevailing local market is considered. The price and the operating cost of the equipments are obtained from the information as provided by manufacturers through email (www.alfathermltd.com).

A Debt-Equity Ratio of 3:1 is considered in the calculation i.e. 75% of the total initial investment shall be debt capital (Rs.89,09,250.00). Detailed calculations are shown in paragraph 4.11.4.1. The prevailing State Bank of India interest rate of 12% is used in the calculation. The Income Tax payable is considered as 30% of Net Profit. Presently, there is no Service Tax in this sector, but it will be levied from the year 2007 onwards, @ 10% of Gross Profit. Hence, this is also considered in the calculation.

4.11.4.1 *Estimation of the Initial Investment for the Proposed CBWTF*

The initial investment calculated for the proposed CBWTF is shown in table 4.23.

Table 4.23:- Estimation of the Initial Investment for the Proposed CBWTF

Item No.	Item in short	Rs (in Lakhs)
1	Land Rent (@ Rs 30,000.00 /acre/month)	3.60
2	Construction	
	(a) Building	
	(i) Administrative Block (Double Storied) GF : 200m^2 @ Rs.6,960/m^2 FF : 200m^2 @ Rs.5,675/m^2	25.27
	(ii) Other Buildings (Singled Storied) GF : 450m^2 @ Rs.6,860/m^2	30.87
	(iii) Parking Sheds, Vehicle Washing Sheds, etc. (L/S)	1.25

Contd....

	(iv) Boundary Wall (5'' Brick Work)	2.60
	(v) Sanitary and Plumbing Works (L/S)	0.60
	(b) Campus Roads (L/S)	1.50
	(c) Sharps Pit (L/S)	1.00
	(d) Sanitary Land Fill (L/S)	5.00
	(e) ETP (L/S)	6.00
3	Equipments	
	(a) Incinerators (i) 50 kg/hr oil fired (Rs.20,00,000.00 @ 10% depreciation/year, to purchase the existing one of GMC)	10.00
	(ii) 35 kg/hr oil fired	15.00
	(b) Autoclave	6.00
	(c) Shredder	
	(i) 40 kg/hr Plastic Shredder	3.50
	(ii) 5 kg/hr Metal Shredder	0.75
4	Vehicle	
	(a) Old Ambulance	4.00
	(b) Auto Van	1.50
5	Plantation for Green Belt Development	0.15
6	Miscellaneous (Trolley, Wheel Barrows, etc.)	0.20
	Total	118.79

4.11.4.2 *Estimation of the Annual O&M Cost for the Proposed CBWTF*

The annual operating and maintenance cost for the proposed CBWTF is calculated as shown in table 4.24.

Table 4.24:- Estimation of Annual O&M Cost for the Proposed CBWTF

Item No.	Item in short	Rs (in Lakhs)
1	Operating Cost	
	(a) Incinerator 50 kg/hr oil fired @Rs.350/hr	3.57
	(b) Autoclave 35 kg/hr @ Rs.20/hr	0.53
	(c) Shredder	
	(i) 40 kg/hr Plastic Shredder @ Rs.30/hr	1.22
	(ii) 5 kg/hr Metal Shredder @ Rs.10/hr	0.24
	(d) Vehicle	
	(i) Old Ambulance @ Rs.411/day	1.50
	(ii) Auto Van @ Rs.207/day	0.76
2	Protective Gears	0.02
3	Maintenance Cost of Building, Equipments, Vehicles (@ 5 % of the estimated capital cost)	5.76
4	Salaries	
	(a) Operators 3 Nos. (@ Rs.3,000.00pm)	1.08
	(b) Supervisor 1 No. (@ Rs.5,000.00pm)	0.60
	(c) Sweepers 2 Nos. (@ Rs.1,500.00pm)	0.36
	(d) Helper 1 No. (@ Rs.1,800.00pm)	0.22
	(e) Drivers 2 Nos. (@ Rs.3,000.00pm)	0.72
	(f) Handymen 2 Nos. (@ Rs.1,800.00pm)	0.43
	(g) Security Guards 3 Nos. (@ Rs.2,000.00pm)	0.72
	(h) Gardener 1 No. (@ Rs.1,800.00pm)	0.22
	Total	17.95

4.11.4.3 *Calculation of Pay Back Period*

Pay Back Period is the time required to recover the original investment through Incomes from the project. Assuming that the Annual Income from the project before depreciation but after taxes is uniform, then Pay Back Period is given as (Choudhury, 1998 and Chandra, 1996)

$$\text{Pay Back Period} = \frac{Original\ Investment\ (Rs.)}{Annual\ Income\ (Rs.)}$$

$$= \text{No. of years}$$

The Annual Income is computed as Gross Earnings less Total Operating Cost excluding depreciation (Choudhury, 1998).

Dayananda (2004) had reported that Image India operates a CBWTF in Pune and it charges Rs.2.00/bed/day from the health care institutes. Aggarwal (2003) had reported that the charge of Rs.2.00-2.50/bed/day should be raised to enable the service provider to "enhance their service quality as well leave margins for profit. In this study, as the number of beds is only 4321 beds, so a raised charge of Rs.2.75/bed/day is considered.

Therefore, Gross Profit = Rs.43,37,204.00

Net Profit = Gross Profit - Annual O&M cost

= Rs.25,42,204.00

The calculation of Annual Interest on Debt Finance and Taxes are shown below:

Bank Interest (@12% of Debt Capital)	Rs.10,69,110.00
Income Tax (@ 30% of Net Profit)	Rs.7,62,661.00
Service Tax (@ 10% of Gross Profit)	Rs.4,33,720.00

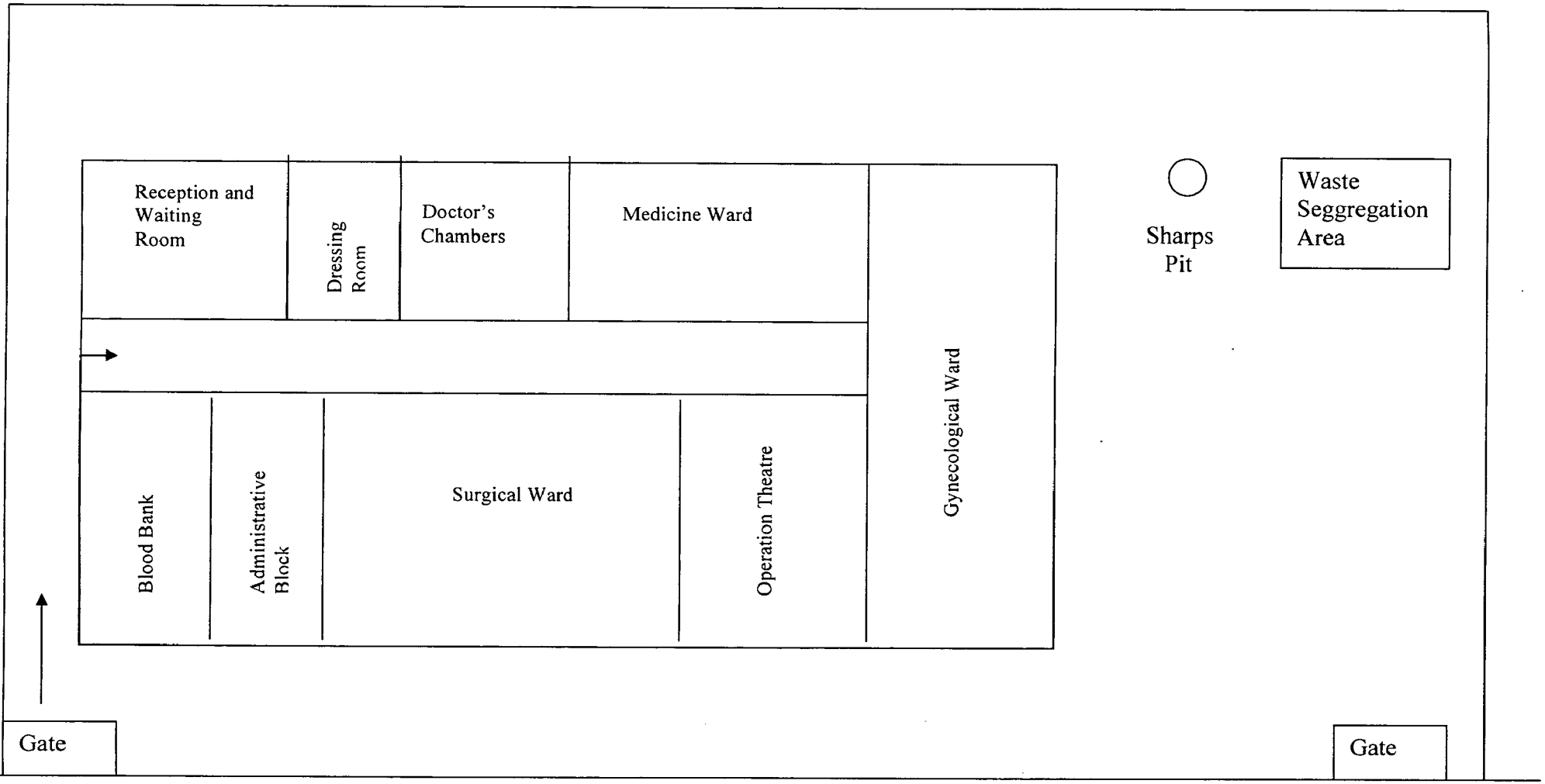
Hence, Annual Income = Gross Profit – (O&M Cost + Taxes)

= Rs.13,45,823.00

Therefore, Pay Back Period = 9.6 years.

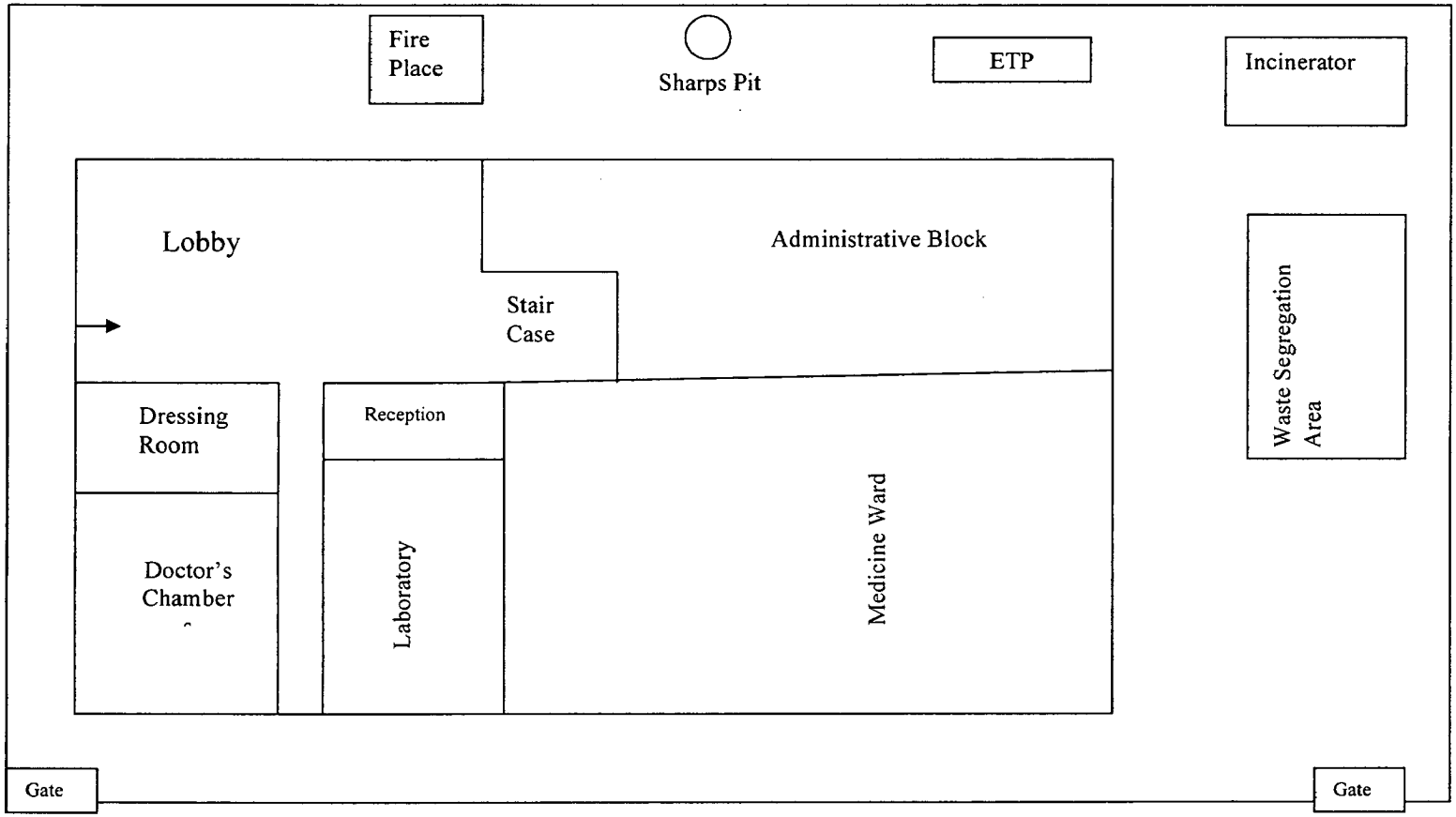
DRAWING I

Plan of Type A Sample Hospital (GF)

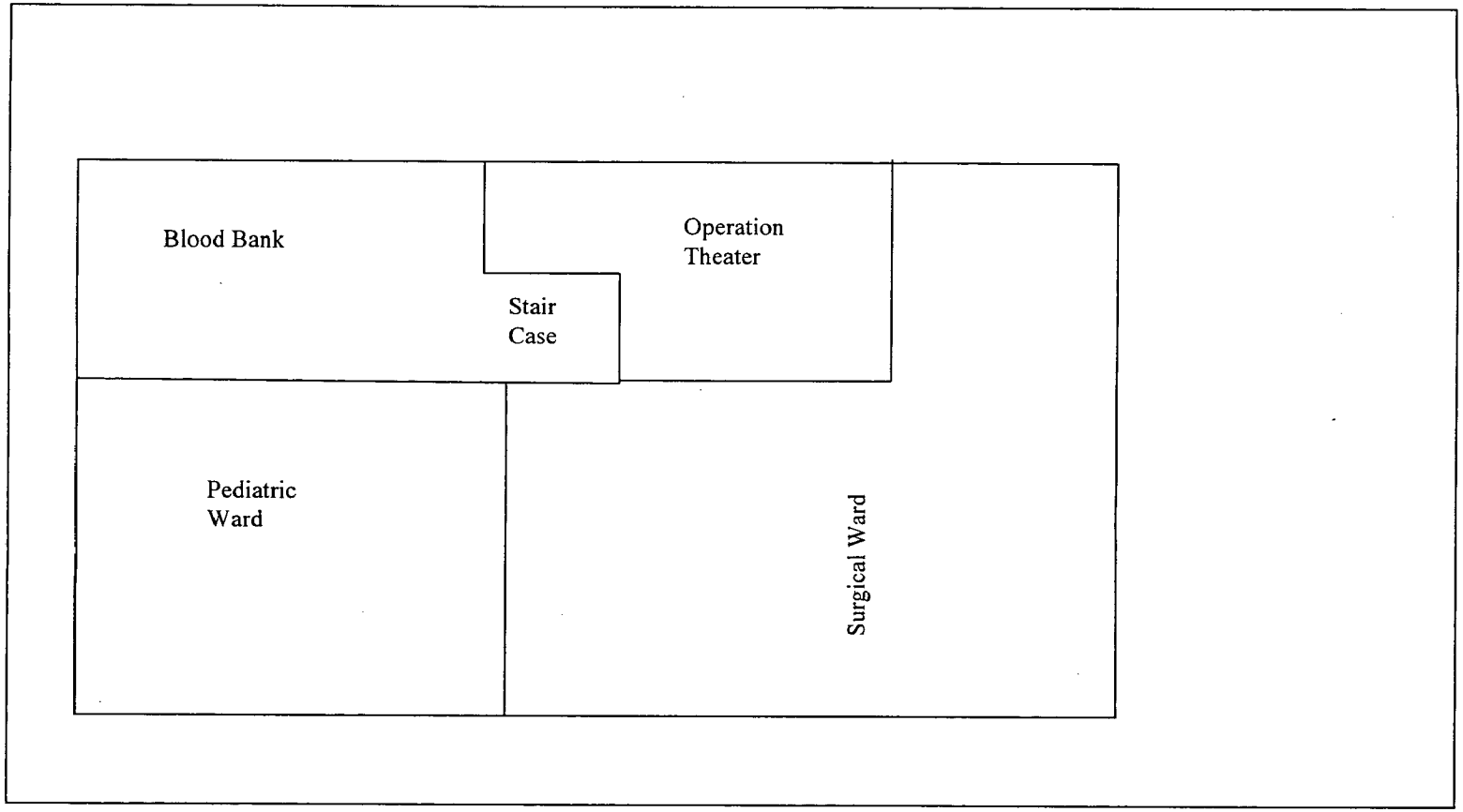


DRAWING II

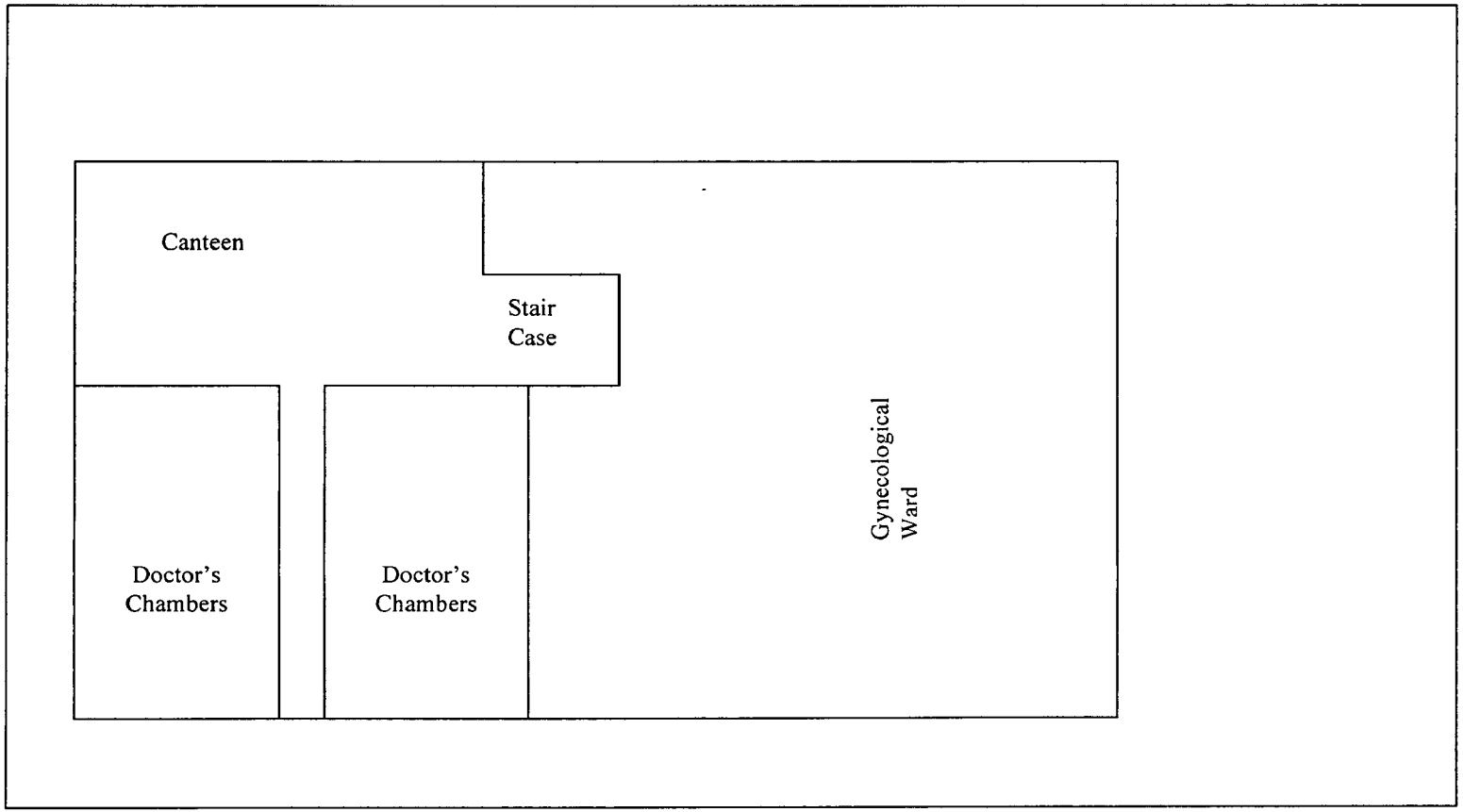
Plan of Type B Sample Hospital (GF)



Plan of Type B Sample Hospital (FF)

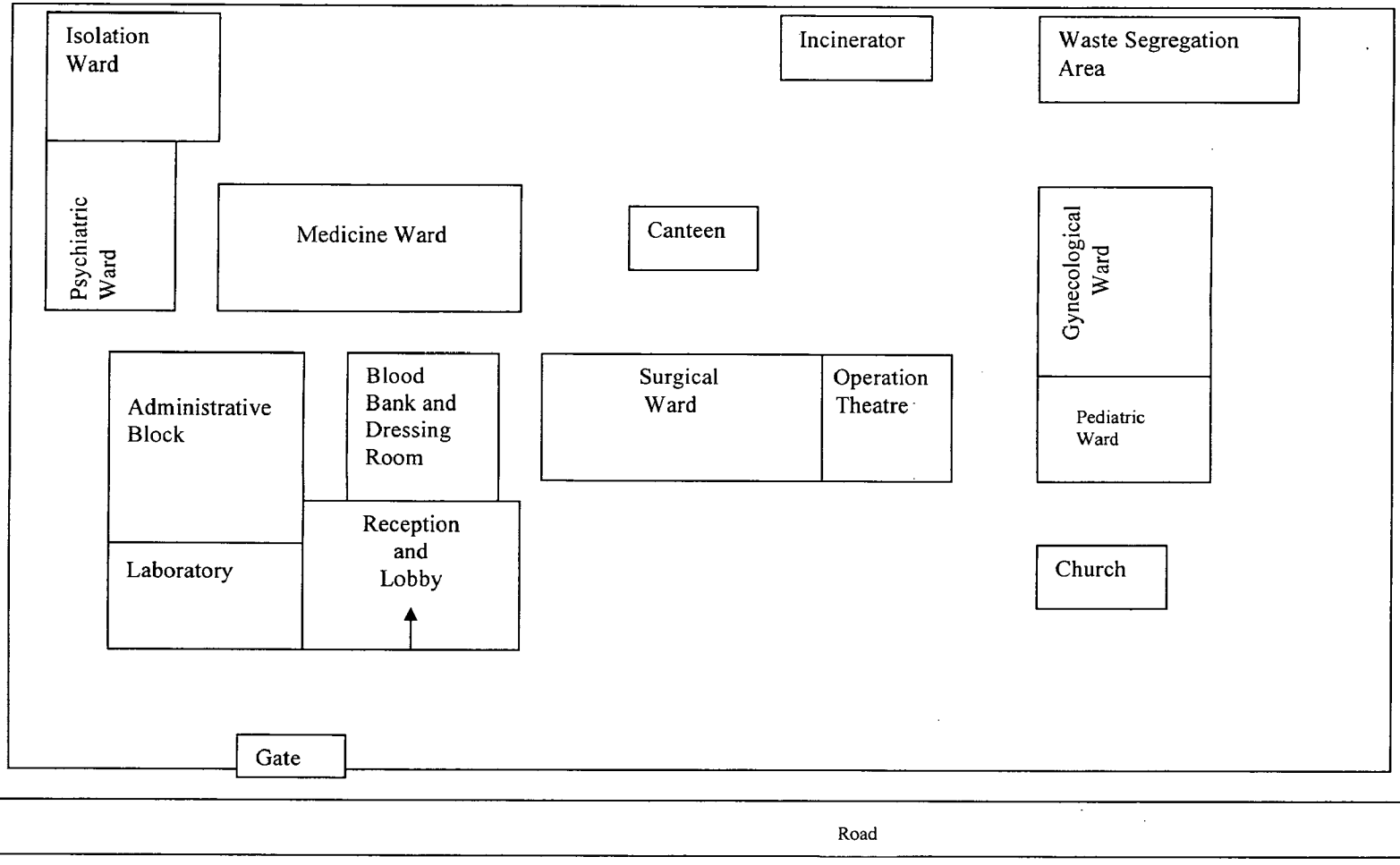


Plan of Type B Sample Hospital (SF)



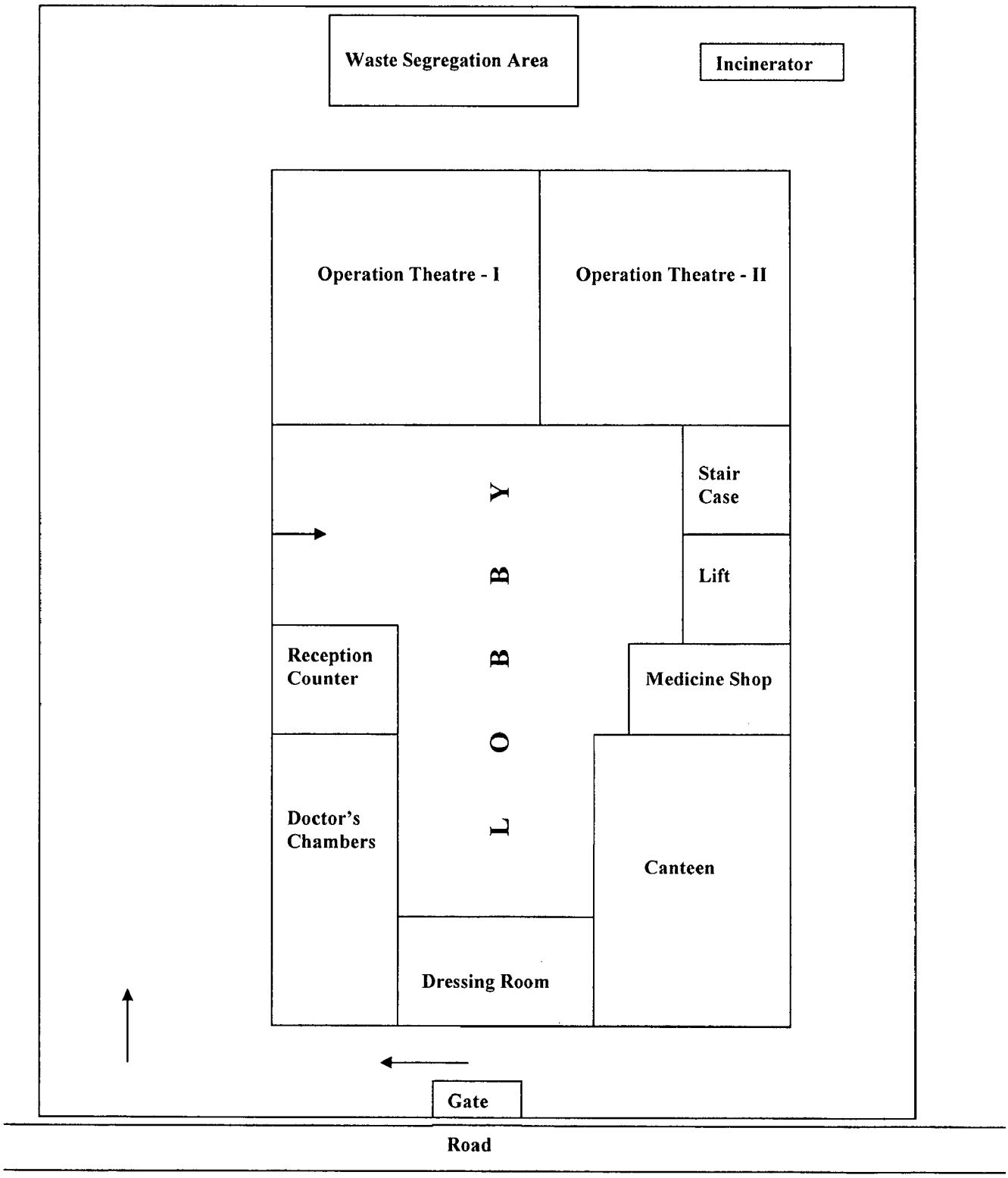
DRAWING III

Plan of Type C Sample Hospital (GF)

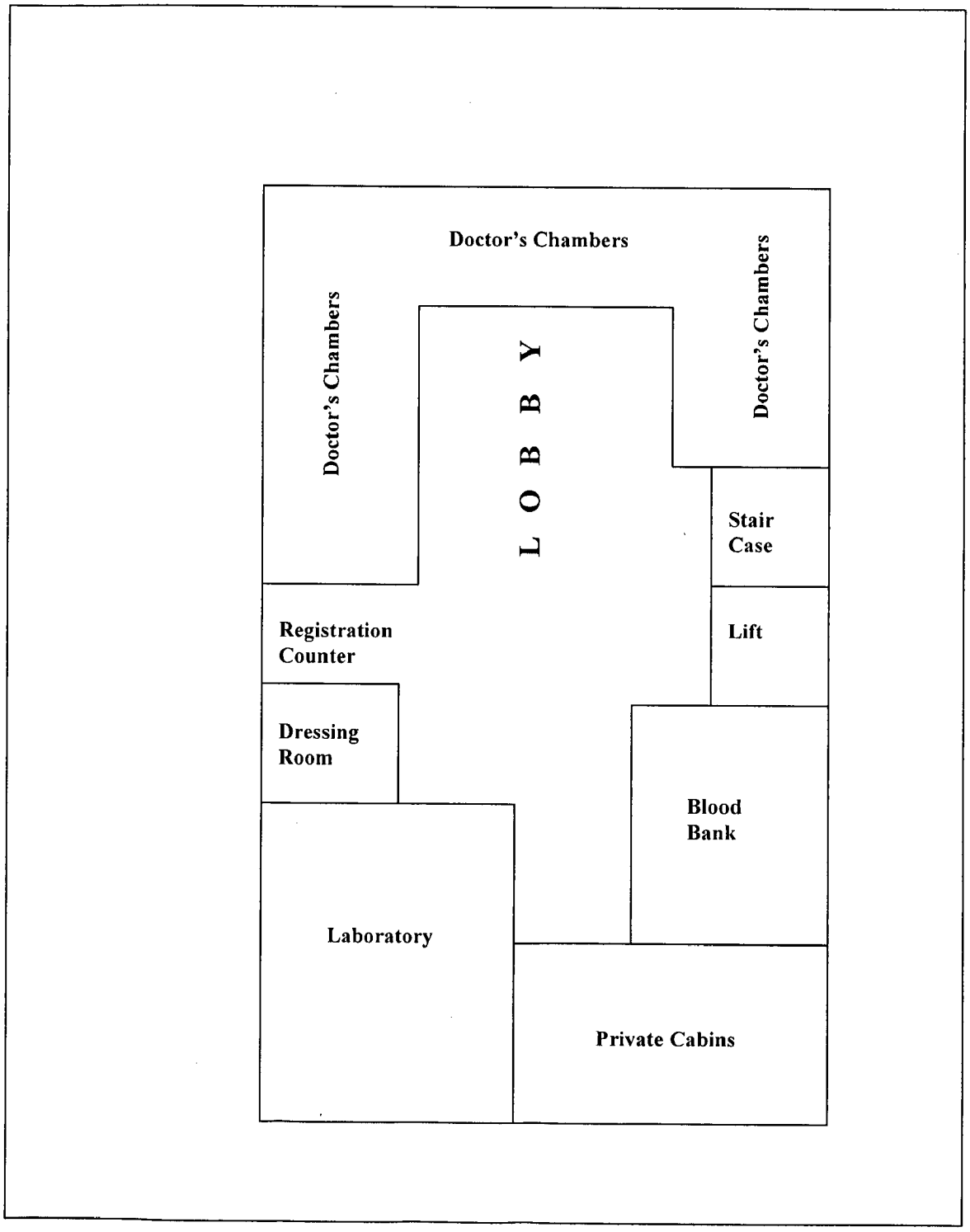


DRAWING IV

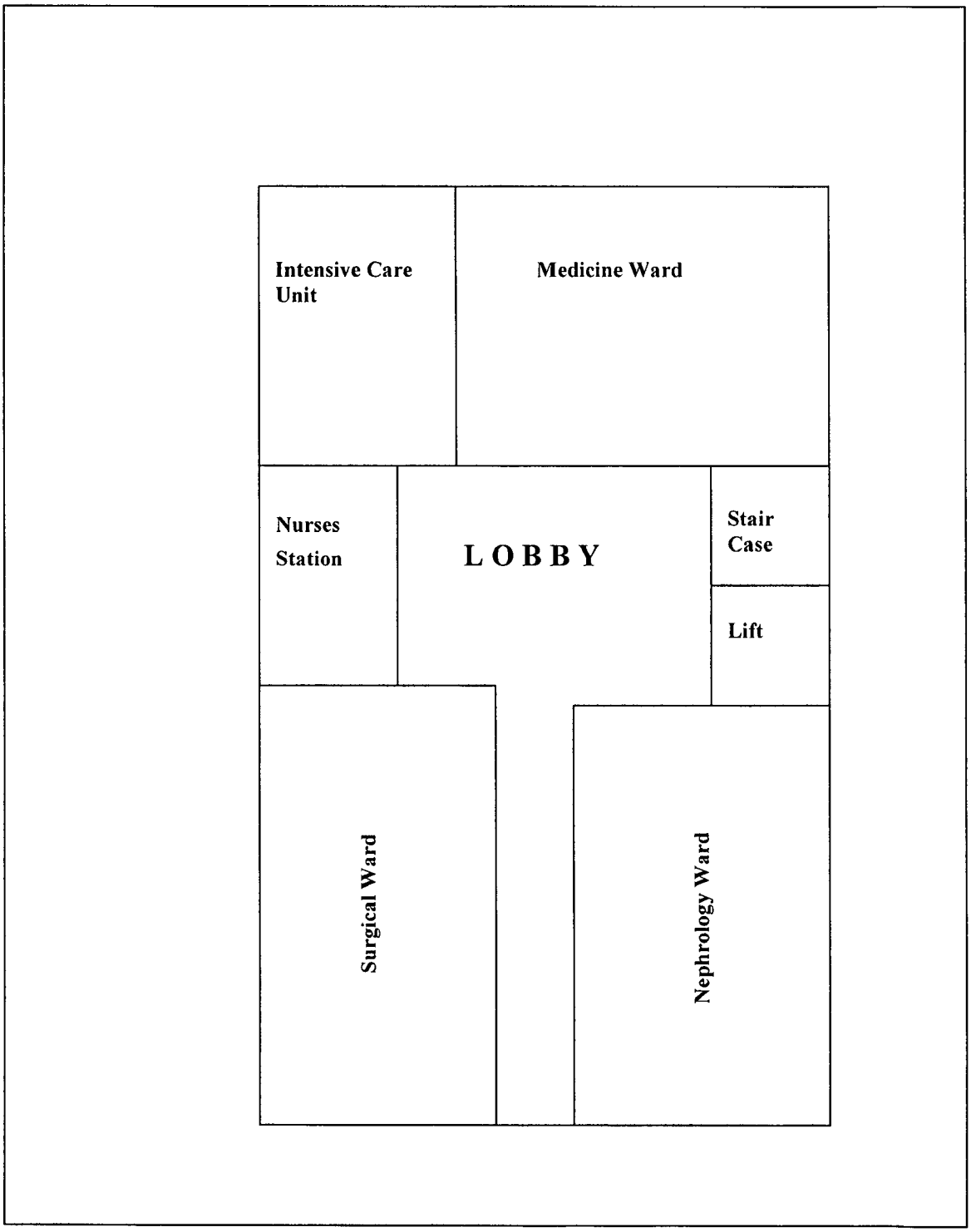
Plan of Type D Sample Hospital (GF)



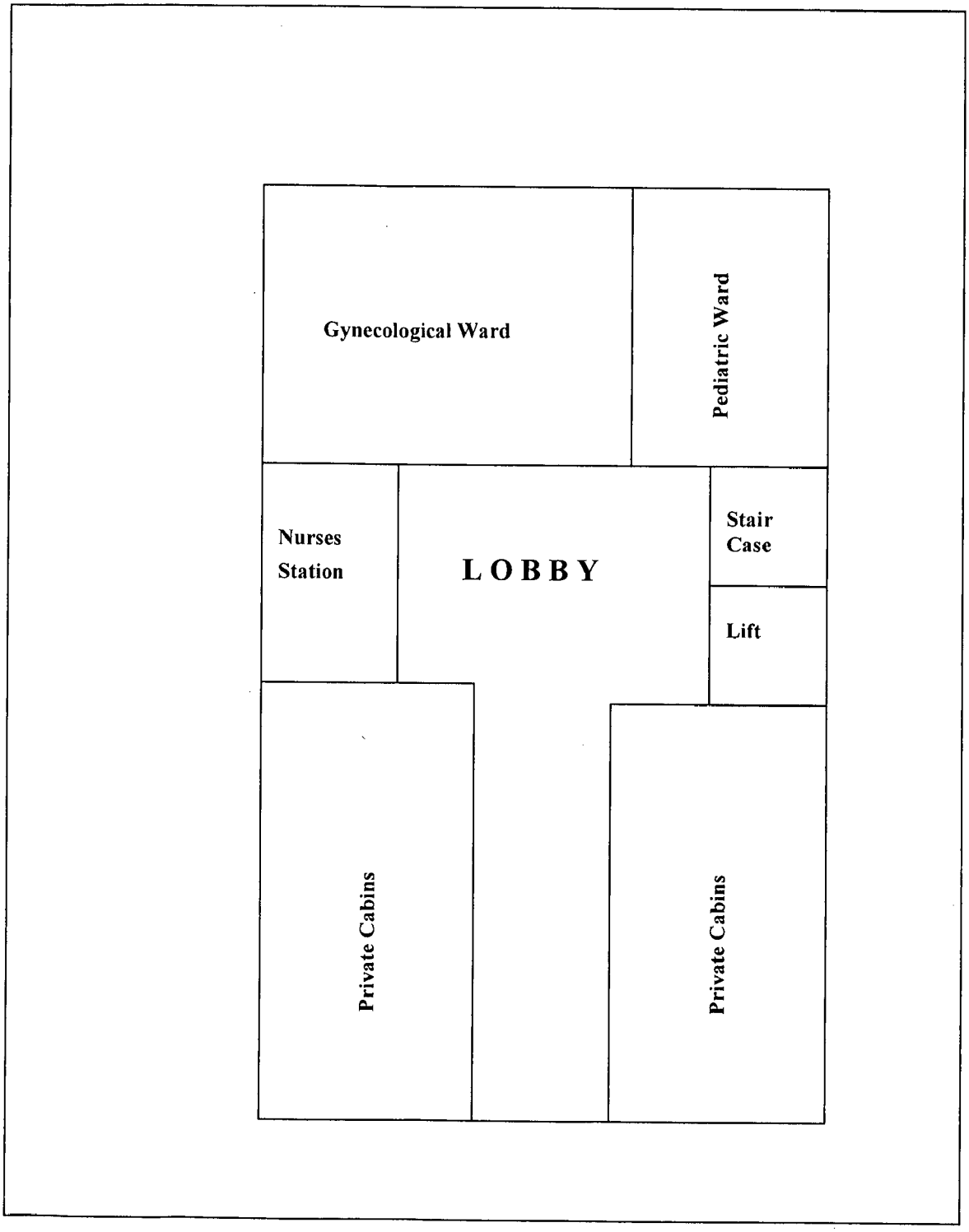
Plan of Type D Sample Hospital (FF)



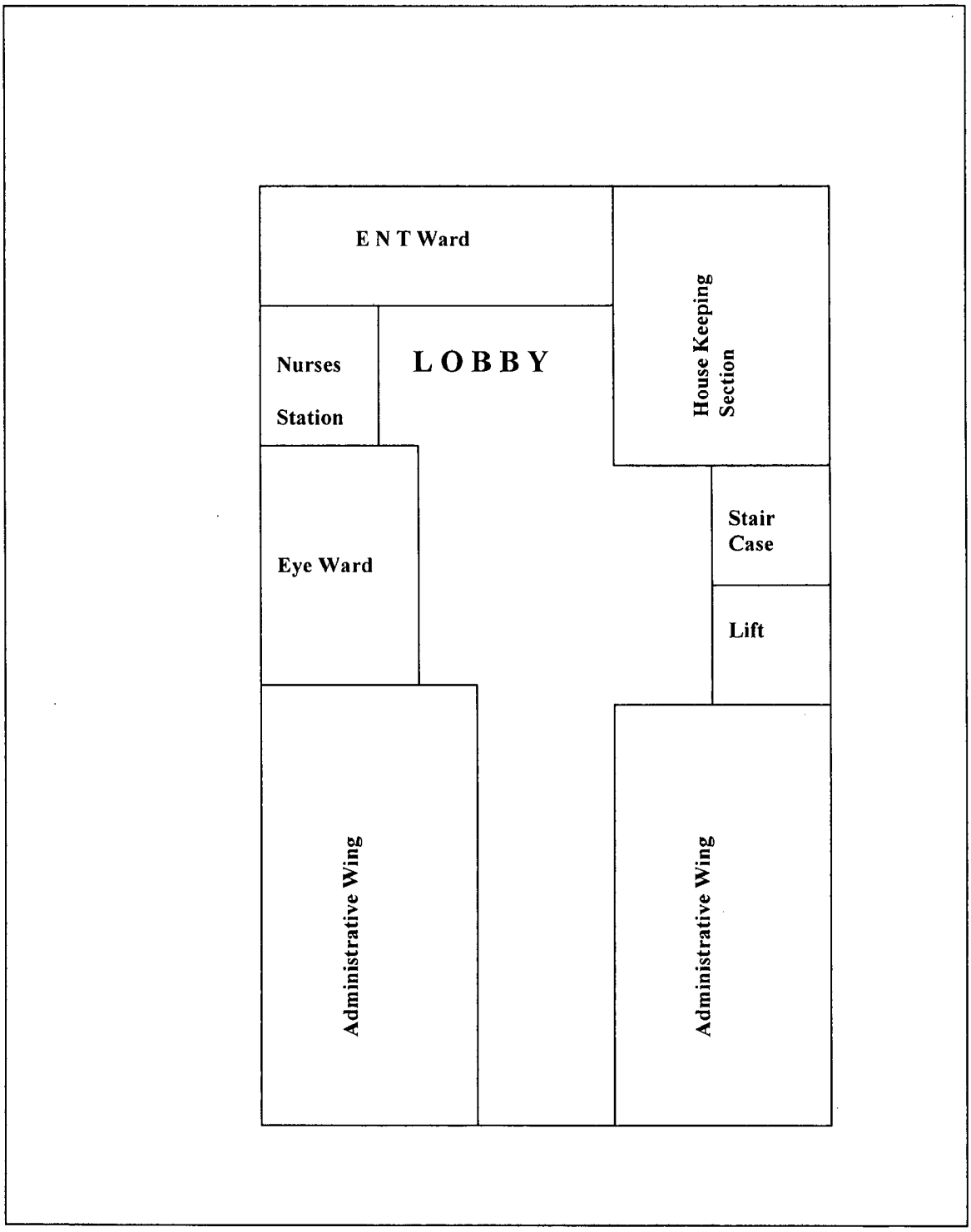
Plan of Type D Sample Hospital (SF)



Plan of Type D Sample Hospital (Th F)

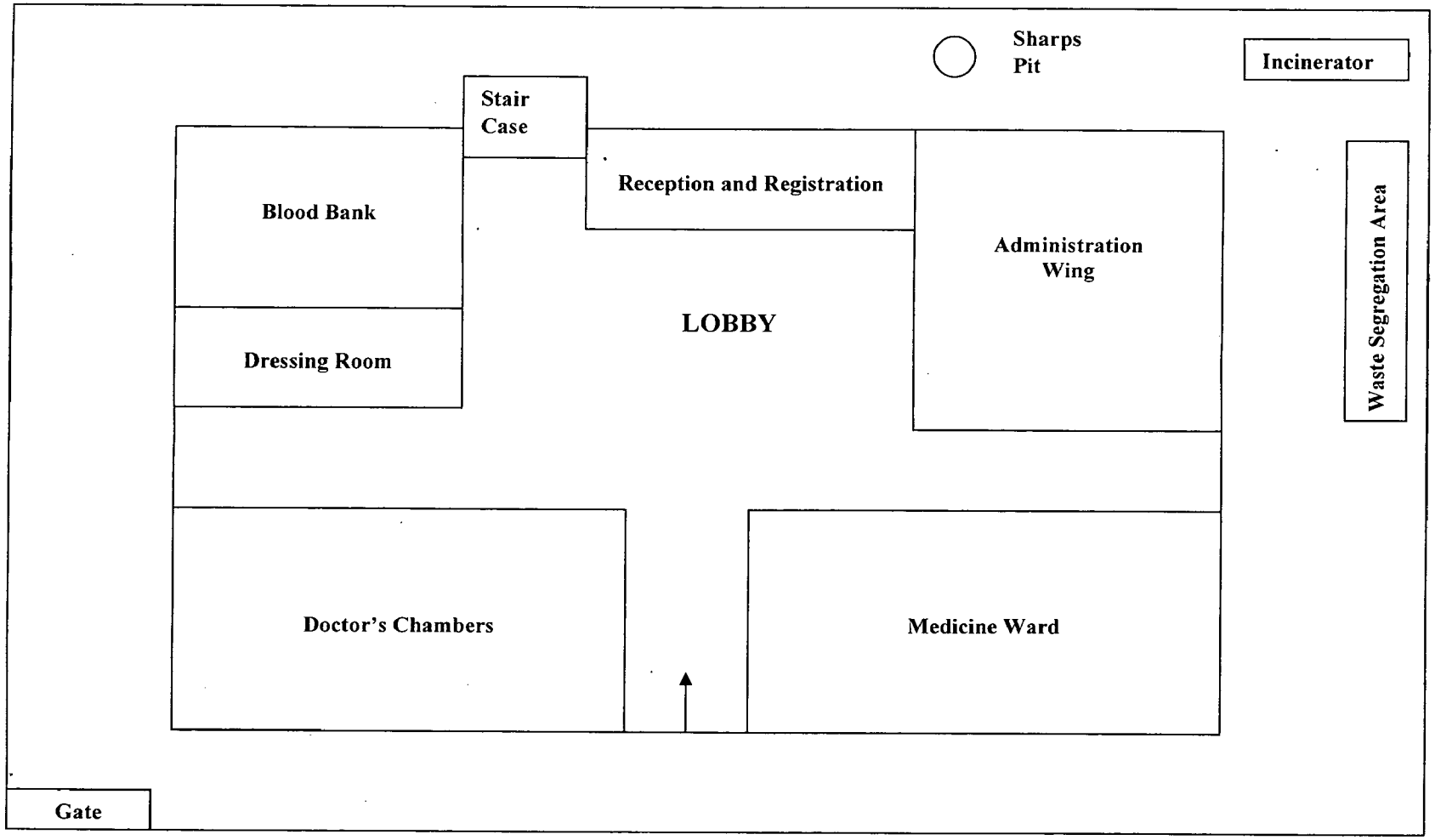


Plan of Type D Sample Hospital (Fo F)

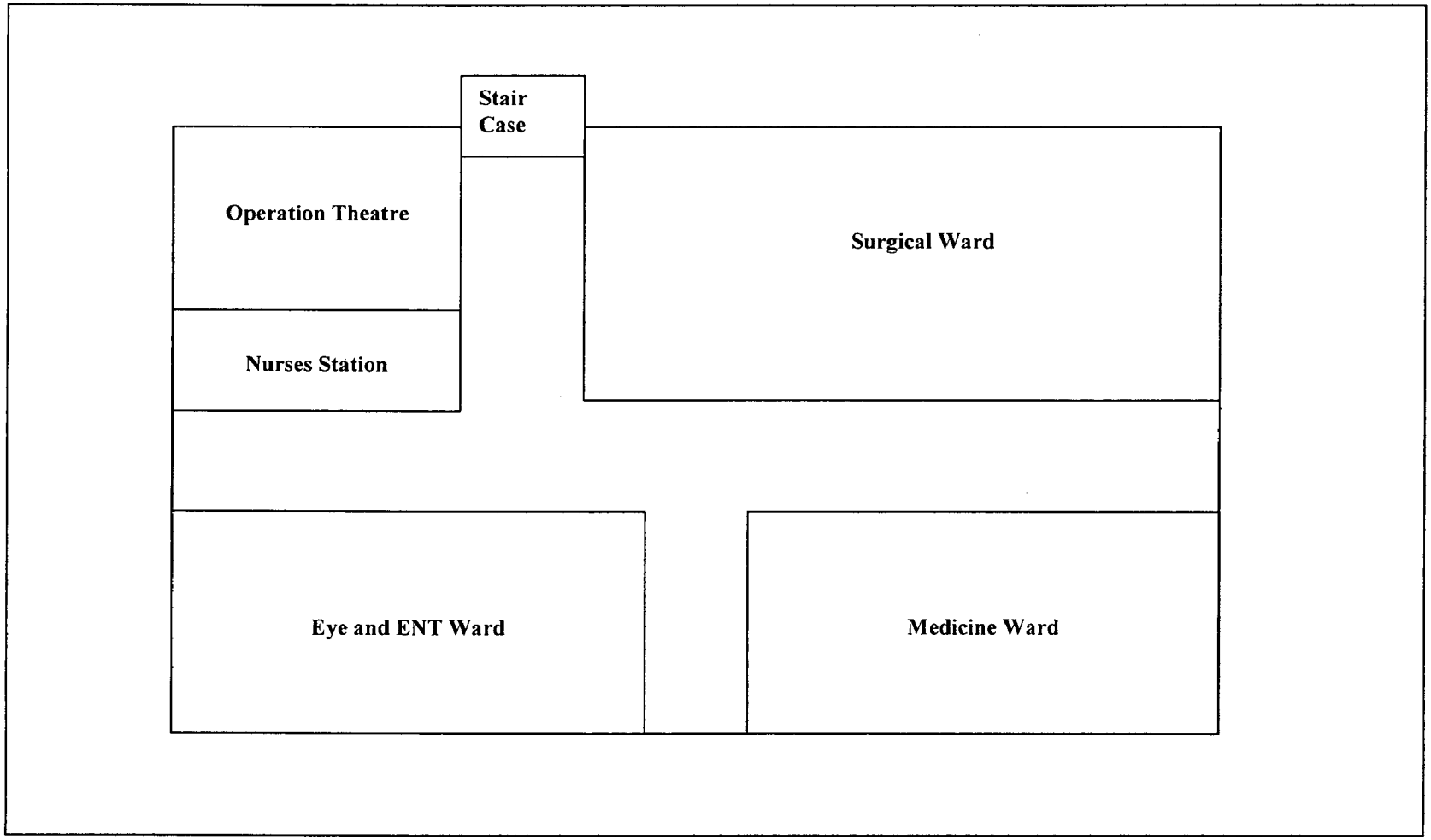


DRAWING V

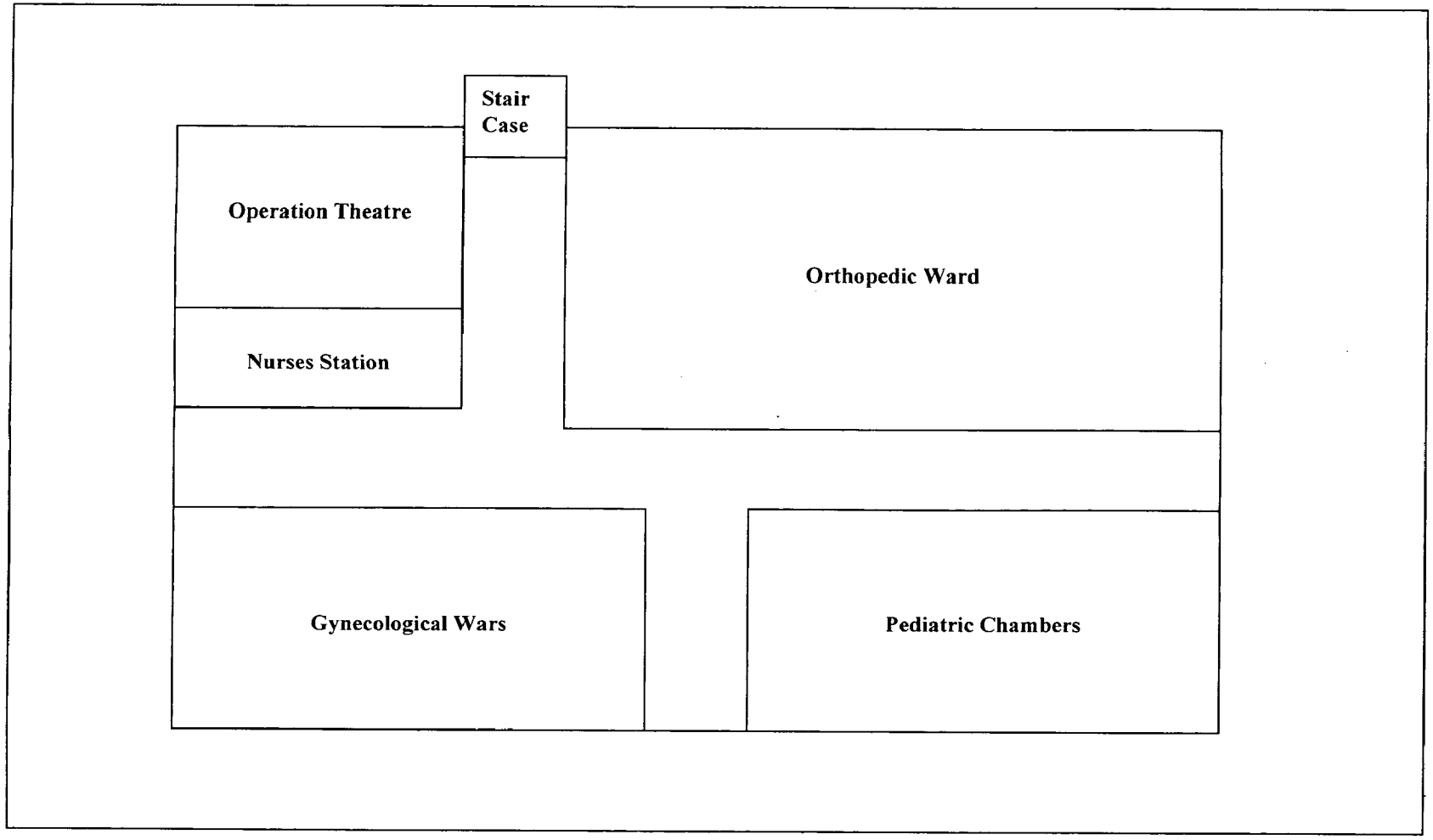
Plan of Type E Sample Hospital (GF)



Plan of Type E Sample Hospital (FF)

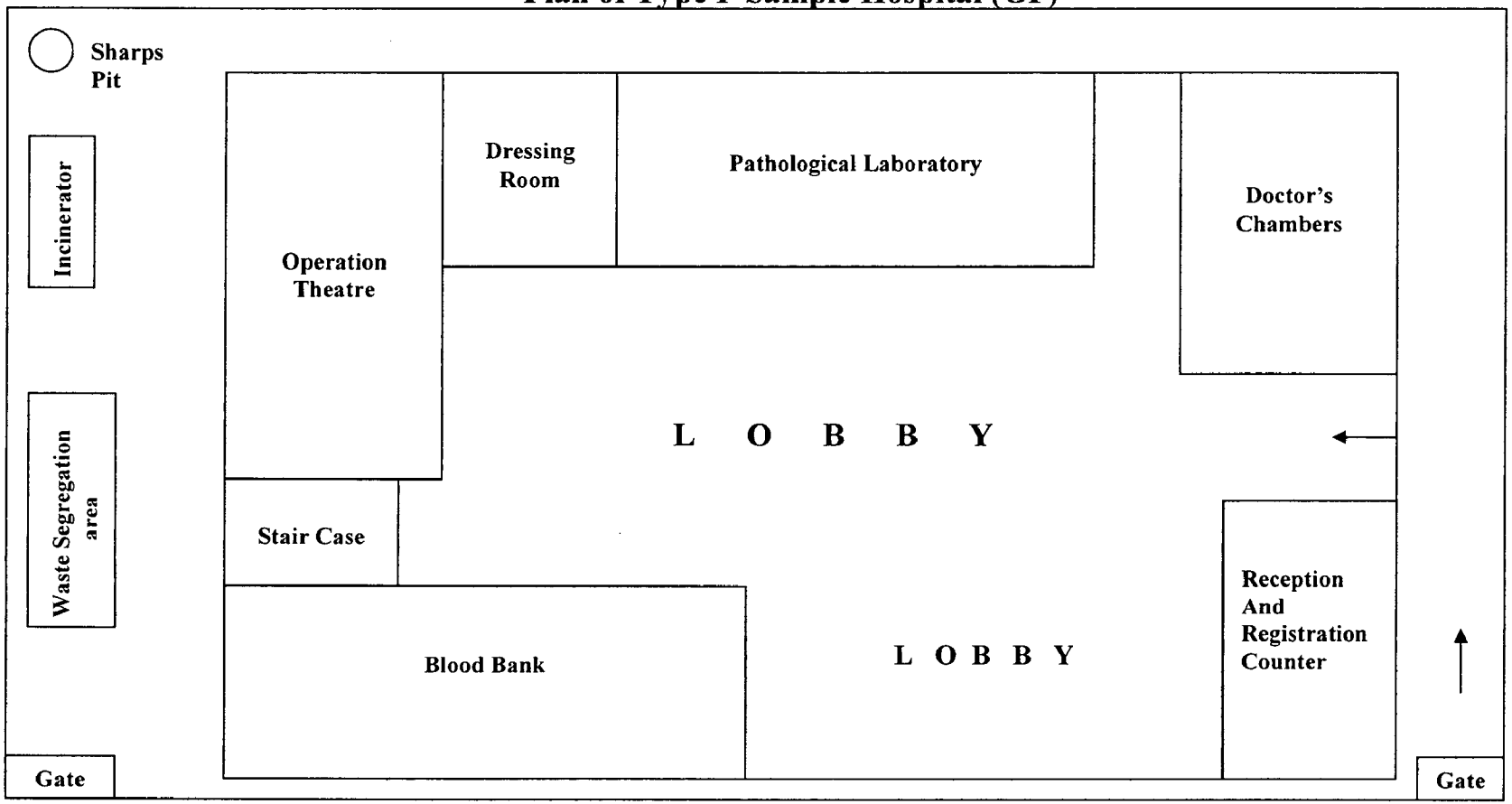


Plan of Type E Sample Hospital (SF)

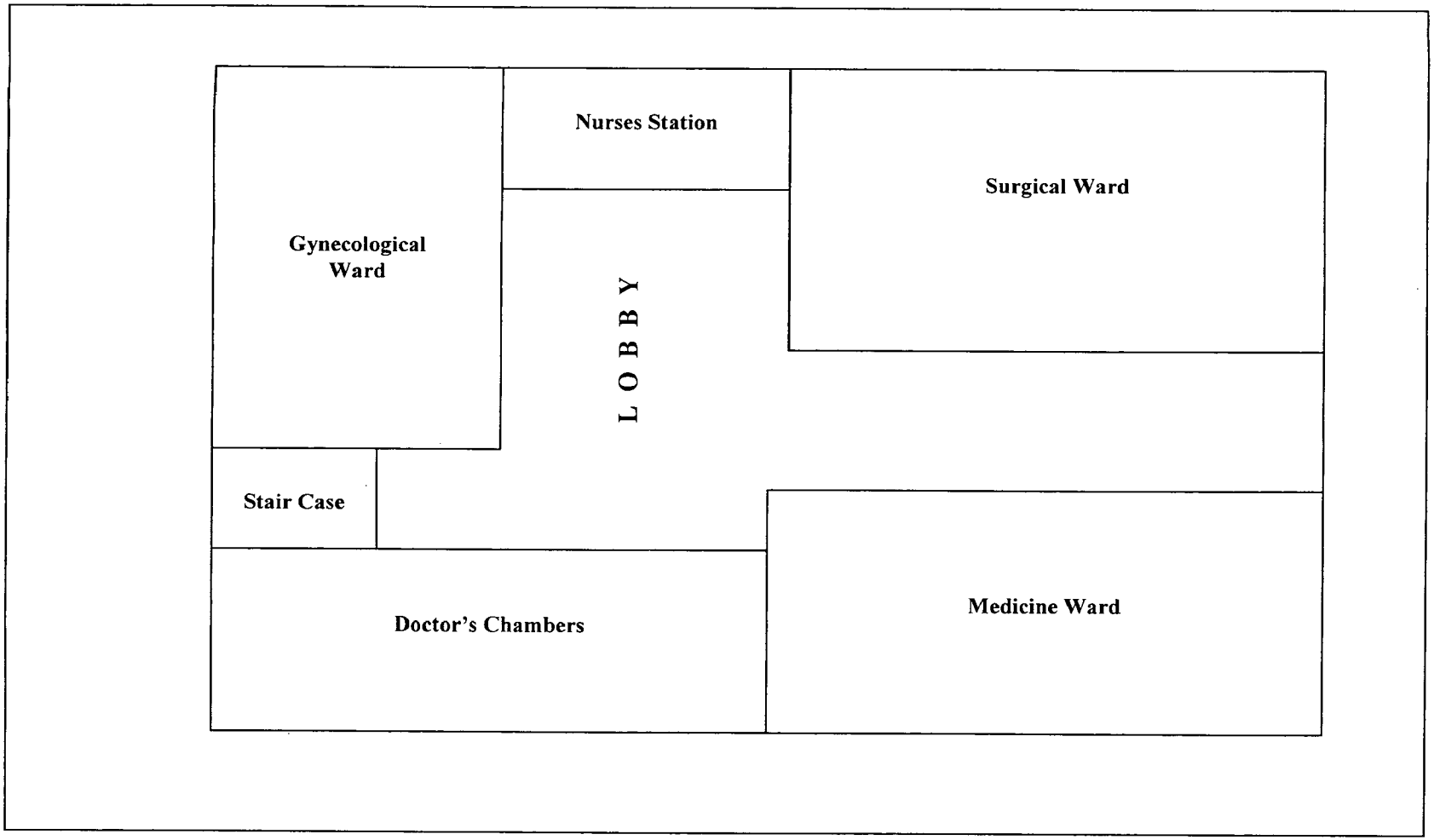


DRAWING VI

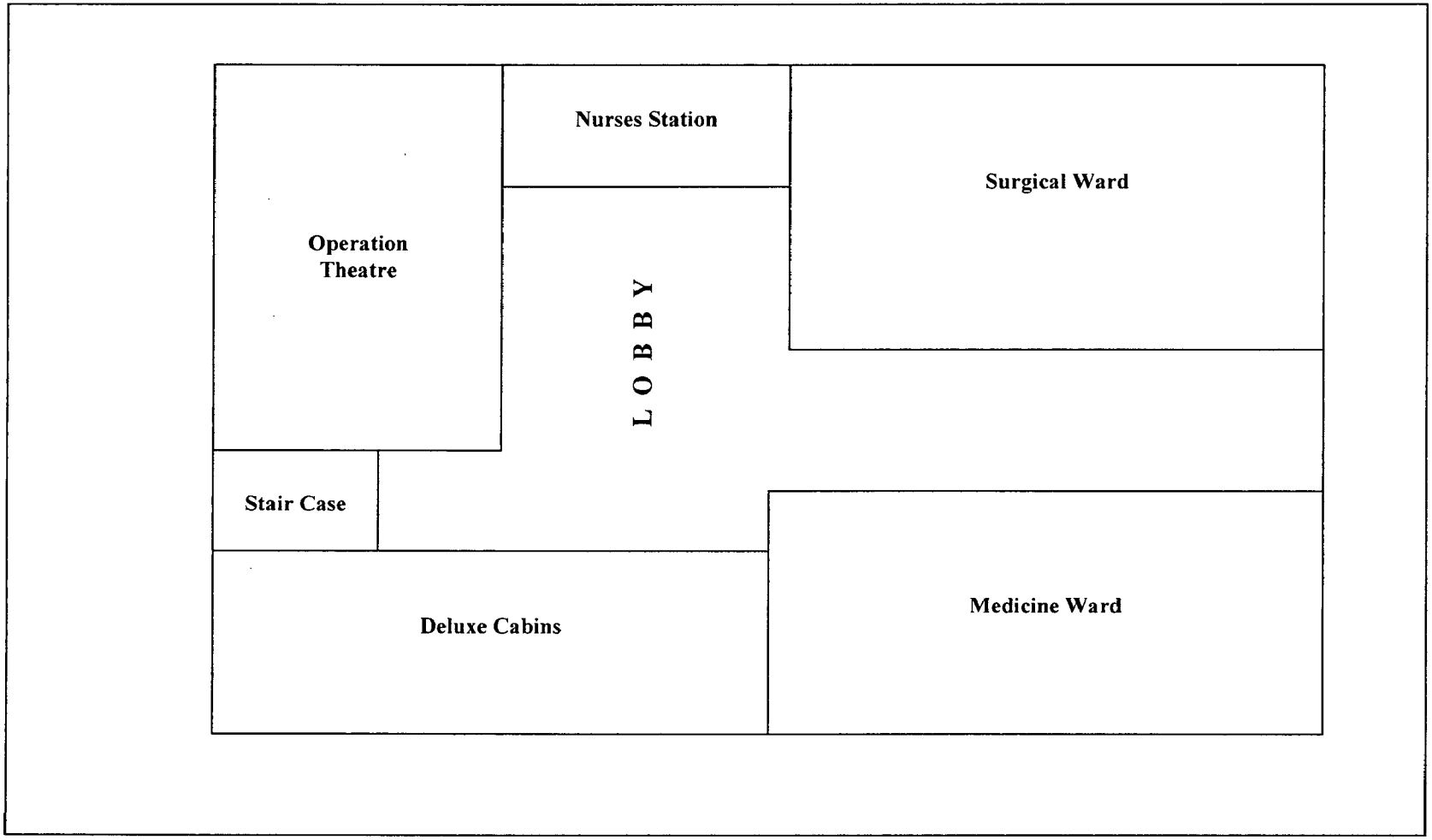
Plan of Type F Sample Hospital (GF)



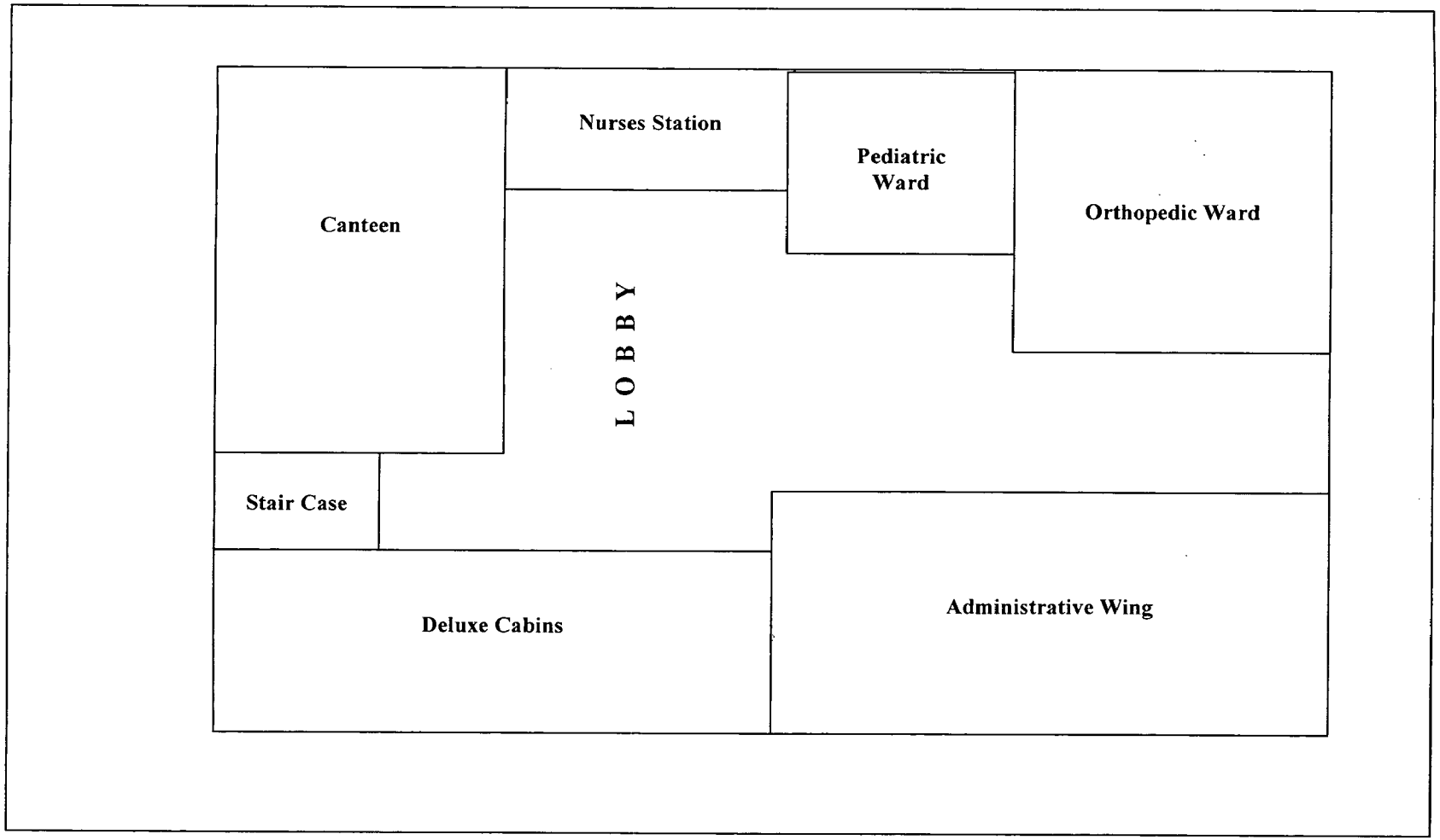
Plan of Type F Sample Hospital (FF)



Plan of Type F Sample Hospital (SF)

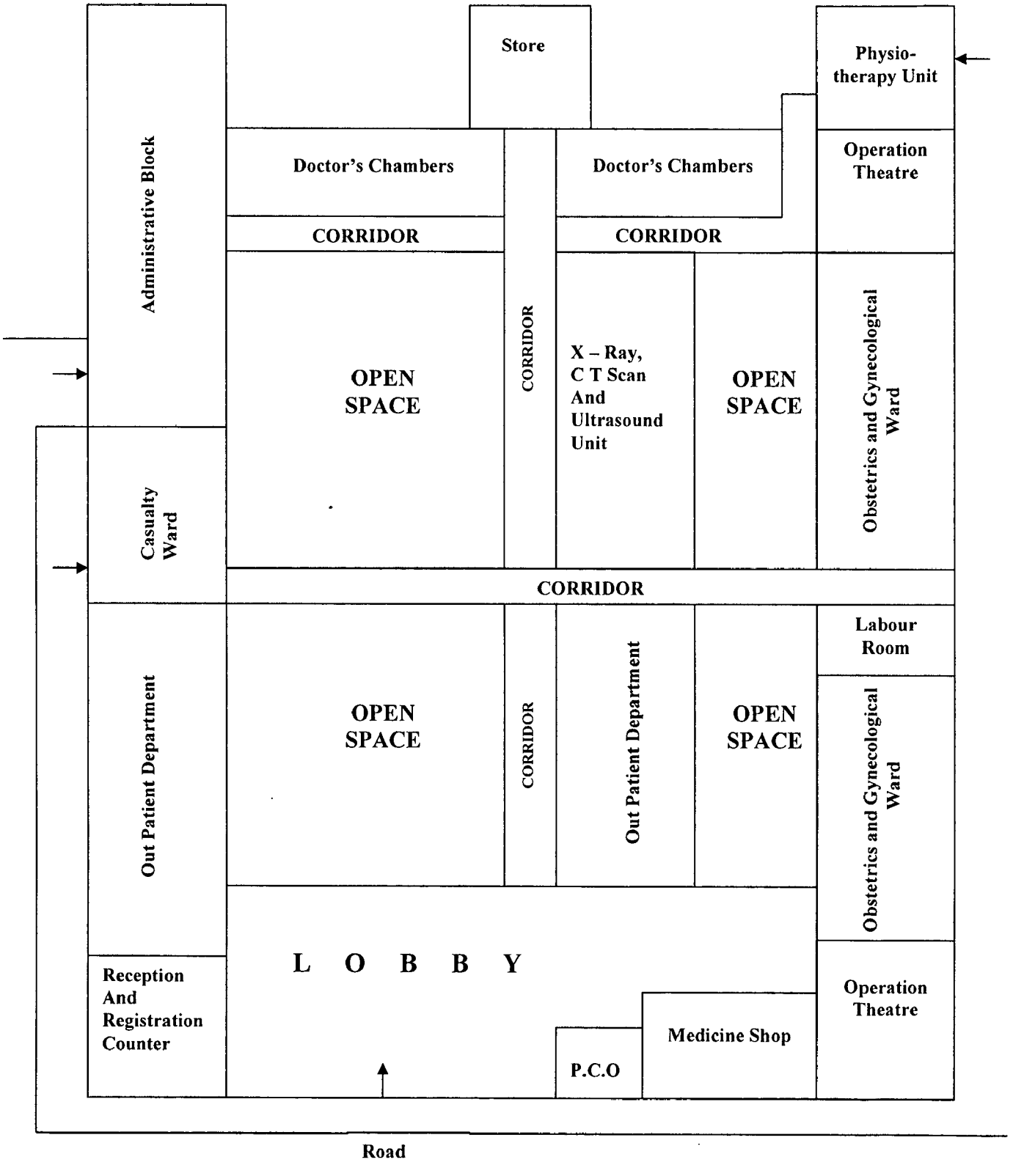


Plan of Type F Sample Hospital (TF)

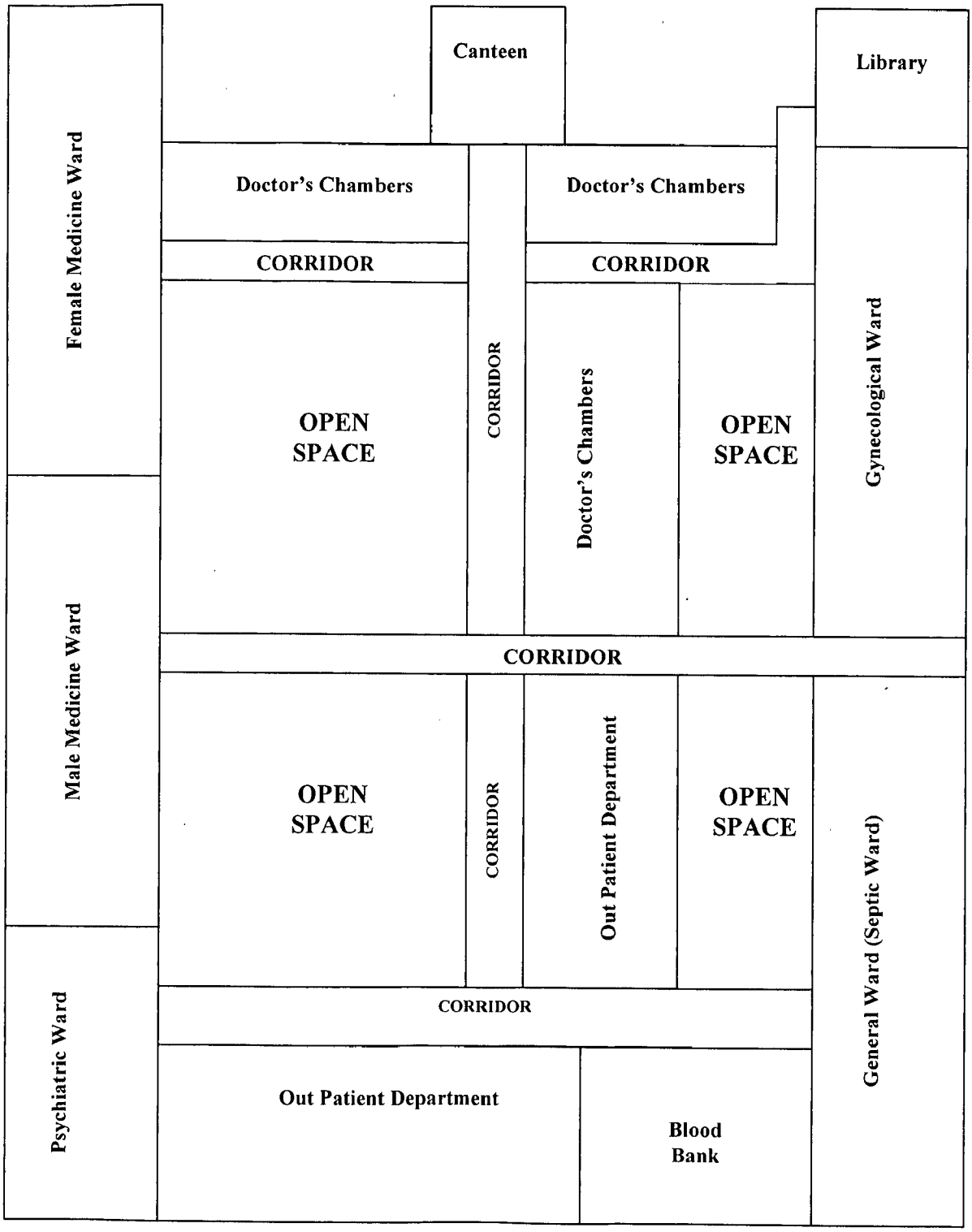


DRAWING VII

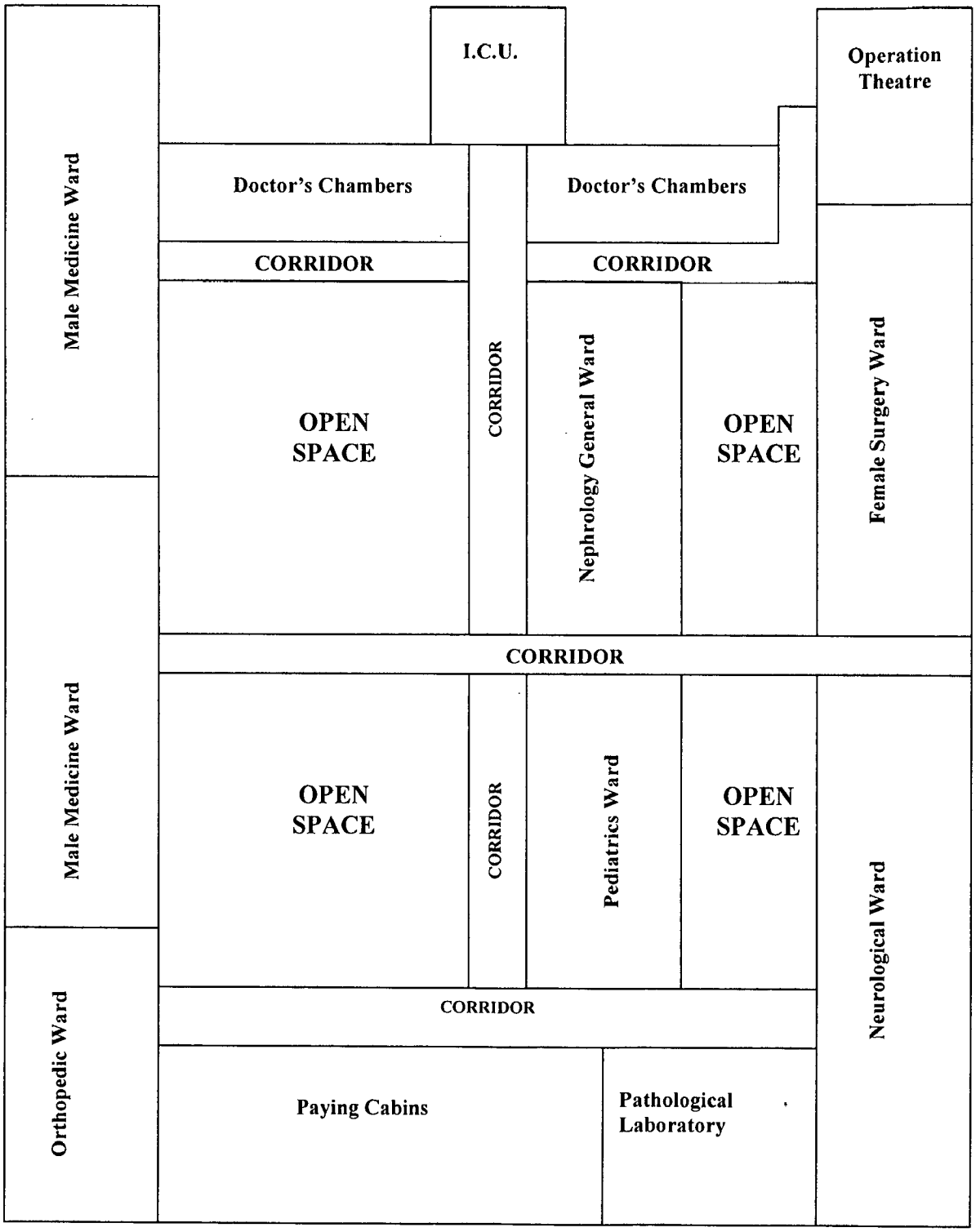
Plan of Type G Sample Hospital (GF)



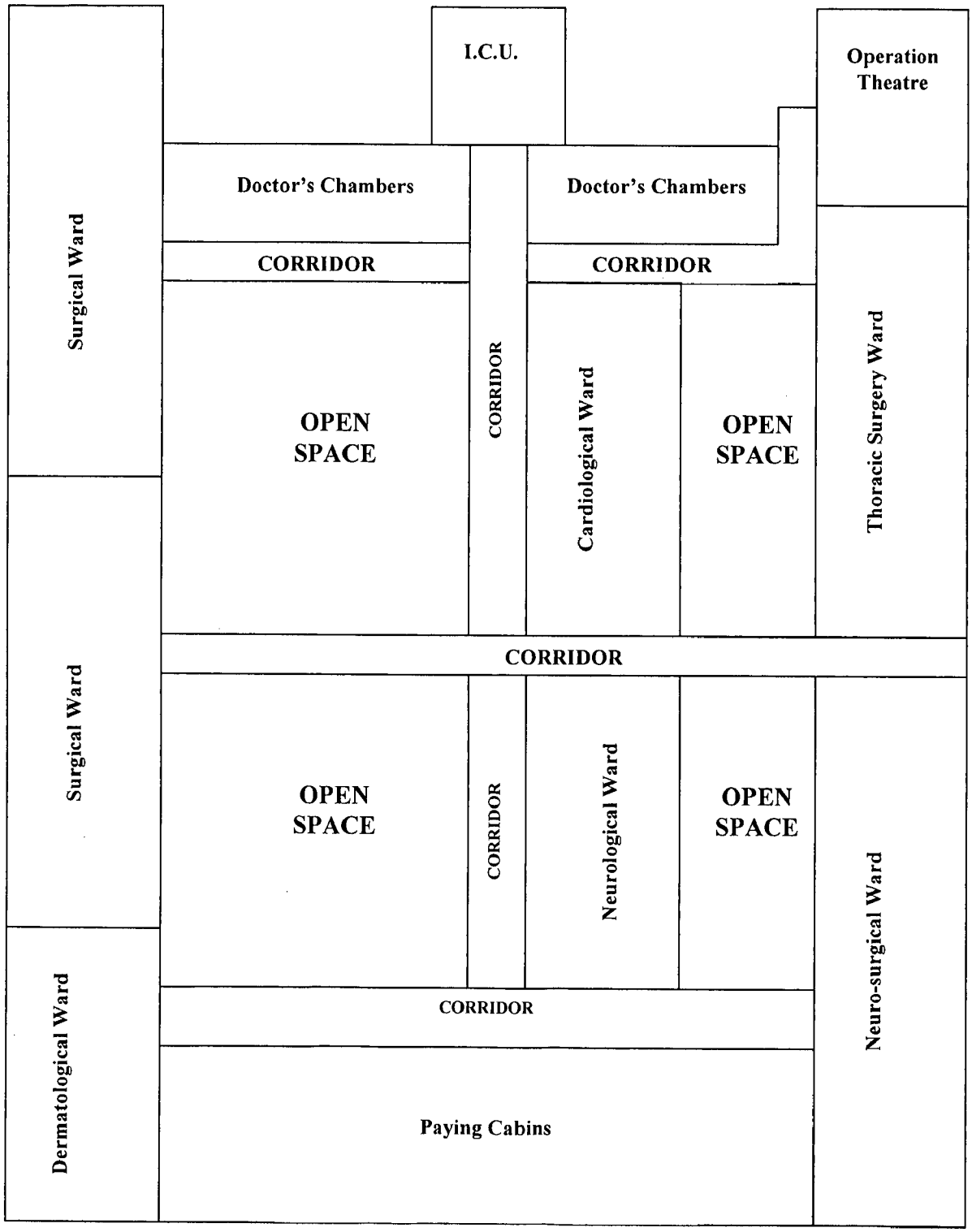
Plan of Type G Sample Hospital (FF)



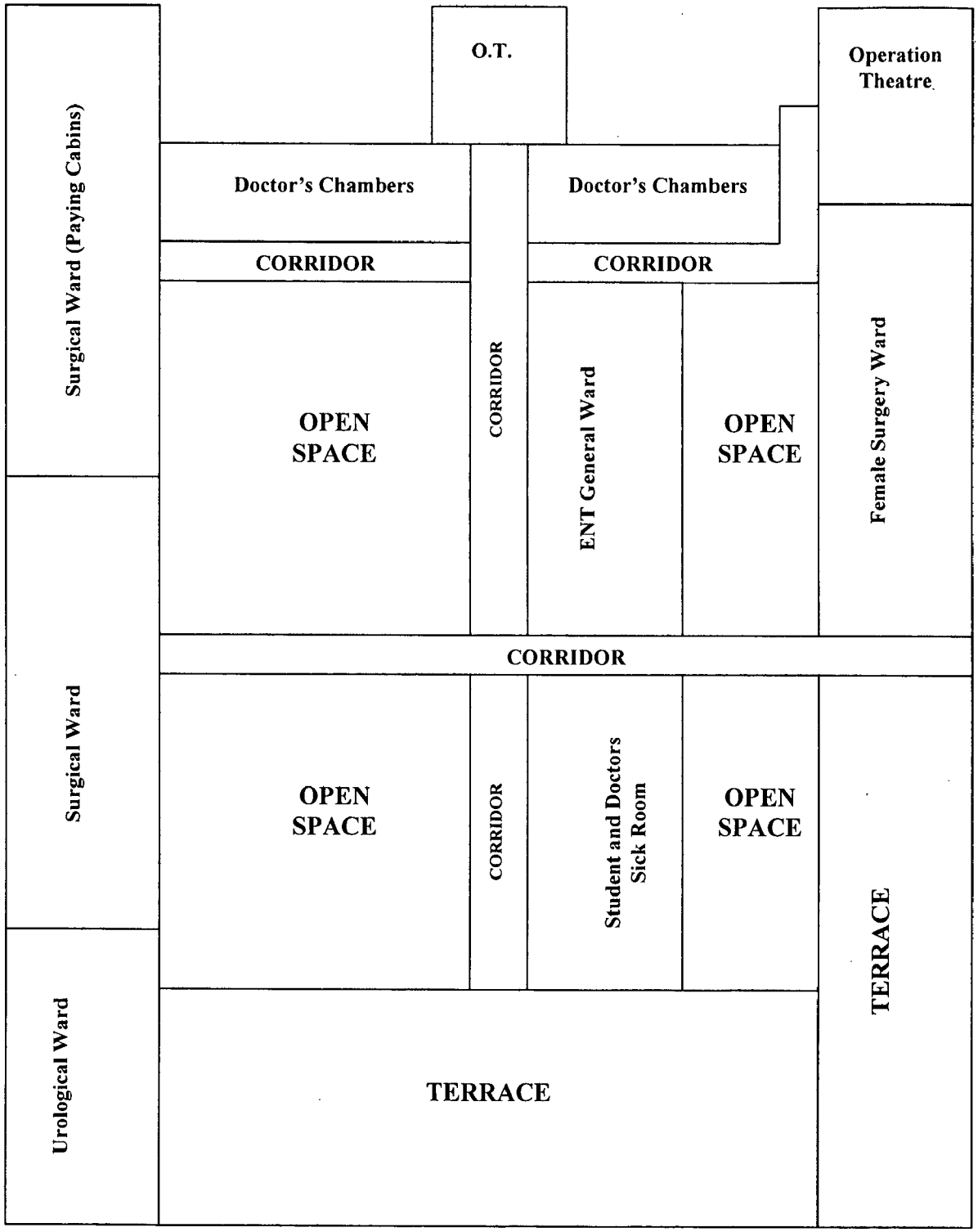
Plan of Type G Sample Hospital (SF)



Plan of Type G Sample Hospital (Th F)



Plan of Type G Sample Hospital (Fo F)



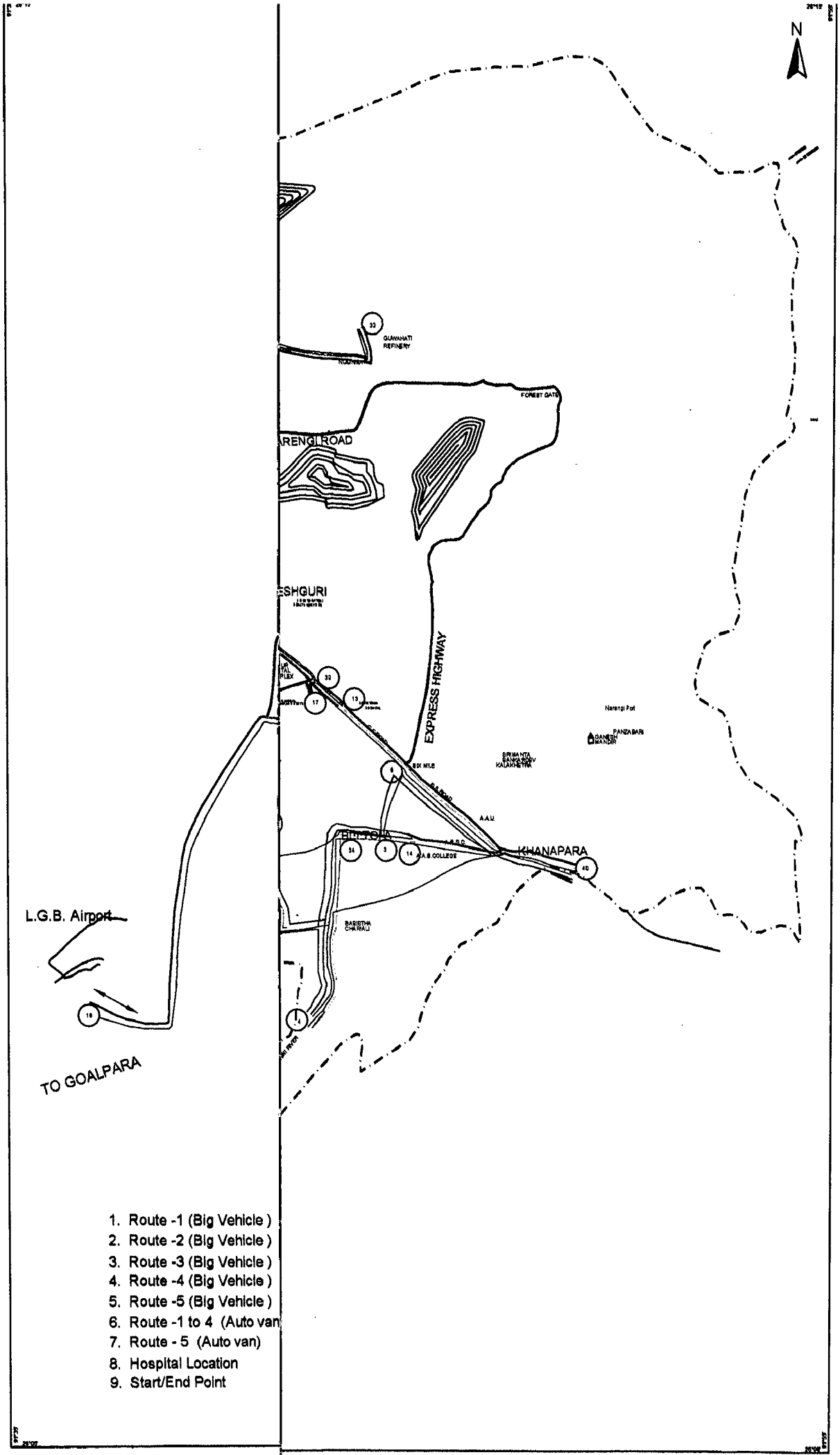


Fig. 4.32 : - Map Sho

CHAPTER 5

CONCLUSIONS

From the study, the following conclusions are drawn:

1. In most of the hospitals, occupancy rate is about 90% throughout the year.
2. Most hospitals are small with bed capacity less than or equal to 50 beds.
3. About 1290 kg of BMW is generated every day in the city. Out of which, infectious waste comprises between 15% to 45% and sharps comprises between 1% to 3%.
4. Presently waste is not handled and disposed off as per the BMW rules.
5. A Management Plan is proposed with regard to segregation at the point of generation, collection and transportation to a common facility, treatment and final disposal at the common facility.
6. Two nos. of dedicated vehicles have been designed for the transportation of BMW to the proposed CBWTF. An old and unused ambulance has been designed and converted to accommodate 42 nos. of standard bins inside it. Also an auto van has been designed to carry 6 nos. of such bins. In one trip the converted ambulance (big vehicle) can transport maximum amount of about 360 kg of BMW and the auto van can transport about 52 kg of BMW.
7. Five alternate routes for transportation of BMW have been considered and the Route V has been identified as the optimal route. In this route, the big vehicle is suggested to be stationed in the campus of hospital no. 1 and the auto van is proposed to be stationed in the campus of the proposed CBWTF.
8. The proposed CBWTF has been planned and designed. It will be located at/near the campus of GMC Hospital.
9. The costs for the establishment, operation and maintenance of the CBWTF have been calculated.
10. The Cess is proposed as Rs.2.75/bed/day, which calculates a pay back period of 9.6 yrs.

- **LIMITATIONS AND FURTHER SCOPE OF WORK**

1. For each sample hospital, primary data was collected for fifteen days only. More data collection will improve the study.
2. Pathological laboratories have not been taken into consideration in this study, due to limitation of resources.
3. Further Scope: An in-depth study of the disposal of mercury waste from health care establishments may be undertaken.

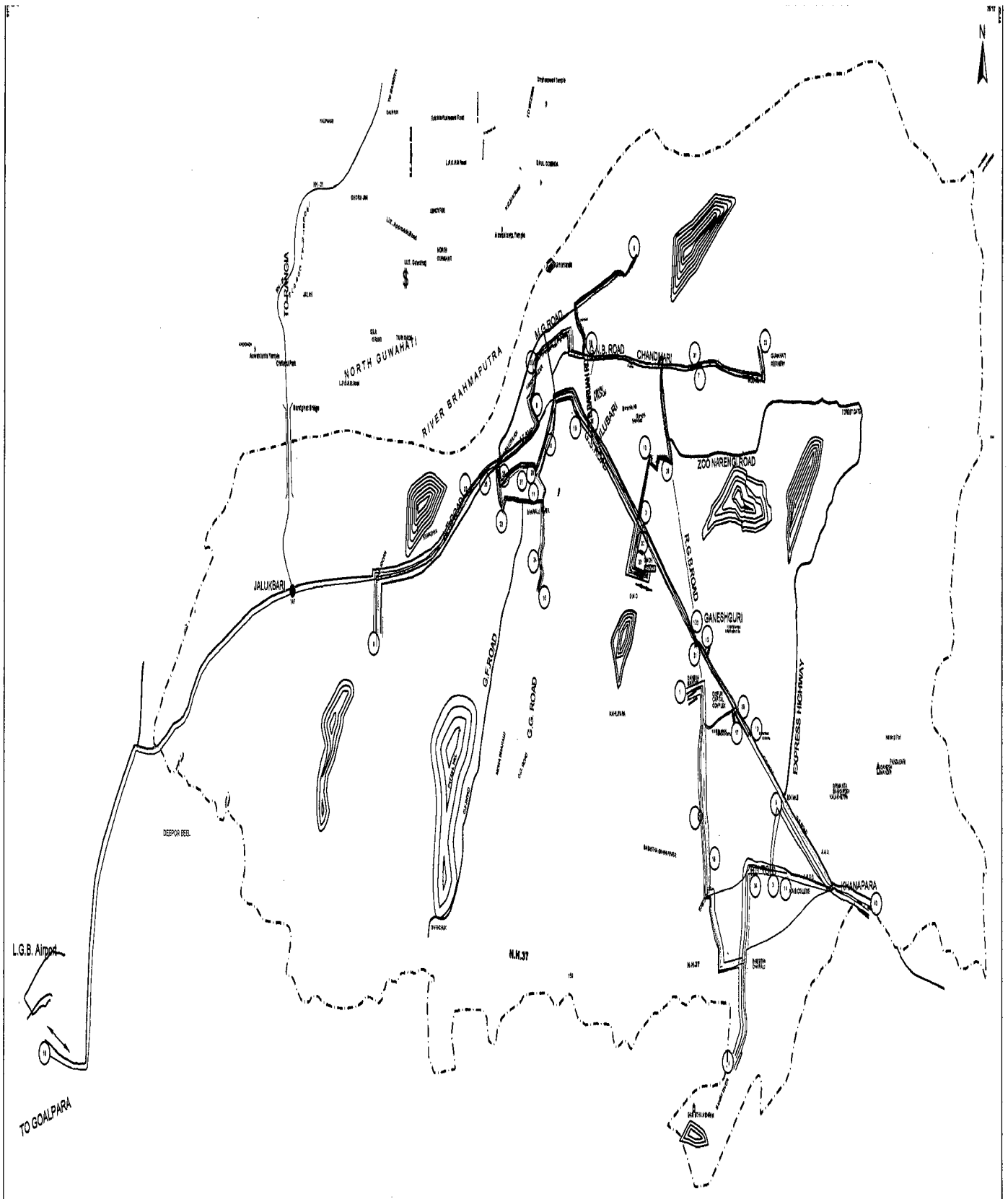


Fig. 4.32 : - Map Showing Proposed Optimal Route (Map 1)

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APPENDIX I

QUESTIONNAIRE FOR HOSPITAL / CLINIC / PATHOLOGICAL LABORATORY/ BLOOD BANK (Q-1)

1. What is the capacity in terms of number of beds?
2. Types of wards and numbers of beds in each ward.
   a)
   b)
   c)
   d)
   e)
3. Is the bio- medical waste (B.M.W.) mixed with other wastes?
4. What is the average amount of B.M.W. generated per bed per day?
5. Are you segregating B.M.W. into containers / bags at the point of generation?
   (a) If yes, is it done as per Schedule II of B.M.W. Rules? (Schedule II is enclosed).
   (b) Are the containers labeled according to Schedule III? (Schedule III is enclosed).
6. What is the average amount (in Kg) of each category of wastes generated per day?
   Category 1:
   Category 2:
   Category 3:
   Category 4:
   Category 5:
   Category 6:
   Category 7:
   Category 8:
   Category 9:
   Category 10:

7. Are you treating the B.M.W.?
   (a) If so, what treatment facilities are available in your hospital?
   (b) Do you have an incinerator?
   (i) If yes, what type (single chambered/ multiple chambered)?
   (ii) What are the operating temperatures?
   (iii) Are you incinerating chlorinated plastics?
   (iv) Prior to incineration, is any waste treated with chlorinated disinfectants?
   (v) What is the minimum stack height above ground?
   (vi) Is there any pollution control device installed/ retrofitted with the incinerator?
   (vii) Which fuel is used?
   (viii) What is the capacity of the incinerator?
   (c) What treatment is given to the different categories of wastes?

   Category 1:

   Category 2:

   Category 3:

   Category 4:

   Category 5:

   Category 6:

   Category 7:

   Category 8:

   Category 9:

   Category 10:

8. Are you storing untreated B.M.W. beyond a period of 48 hours?
9. What is the average quantity of liquid waste produced per day?
10. How are the following waste categories ultimately disposed after treatment?

    Category 1. (Human anatomical wastes).

    Category 3. (Microbiology and Biotechnological waste).

    Category 4. (Waste sharps).

    Category 5. (Discarded medicines and cytotoxic drugs).

    Category 6. (Items contaminated with blood and body fluids including

cotton, dressings, soiled plaster casts, beddings, other material contaminated with blood).

Category 7. (Wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc)

Category 8. (Liquid waste generated from laboratory and washing, cleaning, house- keeping and disinfecting activities).

Category 9. (Incineration ash).

Category10. (Chemical waste i.e. chemicals used in production of biological, chemicals used in disinfections, as insecticides etc.)

11. Please provide a LAYOUT PLAN of your hospital.
12. What is the amount of each category of waste generated in the OPD?

Category 1:

Category 2:

Category 3:

Category 4:

Category 5:

Category 6:

Category 7:

Category 8:

Category 9:

Category 10

APPENDIX II

QUESTIONNAIRE FOR PUBLIC (Q-2)

1. Name:
2. Occupation:
3. Are you aware that bio-medical wastes (hospital wastes) are different from normal solid wastes (garbage)?

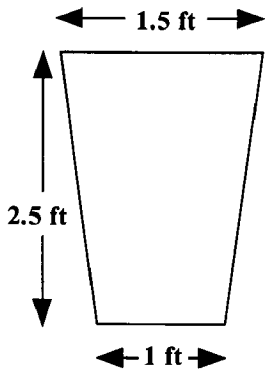
   (a) If yes, how is it different?
4. Are you aware of the Bio- medical waste Rules?
5. The last time you visited a hospital.

   (a)Did you notice hospital waste thrown in the nearby garbage dump. (Yes/no)?

   (b)Did you notice different coloured bins for collecting wastes segregated at source? (Yes/no)

APPENDIX III

CAPACITY OF BIN



Height of bin = 2.5 feet

Top diameter = 1.5 feet

Bottom diameter = 1 feet

Volume of bin = $\pi \times (\text{average radius})^2 \times \text{height}$

$$= \pi \times \left(\frac{1.25}{2}\right)^2 \times 2.5 \text{ ft}^3$$

$$= 3.07 \text{ ft}^3$$

$$= 0.092 \text{ m}^3$$

$$\approx 90 \text{ liters}$$

APPENDIX IV

STANDARDS FOR TREATMENT AND DISPOSAL OF BIO-MEDICAL WASTES

STANDARDS FOR INCINERATORS:

All incinerators shall meet the following operating and emission standards

A. Operating Standards

1. Combustion efficiency (CE) shall be at least 99.00%.

2. The Combustion efficiency is computed as follows:

$$C.E. = \frac{\%CO_2}{\%CO_2 + \%\ CO} \times 100$$

3. The temperature of the primary chamber shall be $800 \pm 50\ ^0C$

4. The secondary chamber gas residence time shall be at least 1 (one) second at $1050 \pm 50\ ^0C$, with minimum 3% Oxygen in the stack gas.

B. Emission Standards

Parameters	**Concentration mg/Nm^3 at (12% CO_2 correction)**
(1) Particulate matter	150
(2) Nitrogen Oxides	450
(3) HCI	50

(4) Minimum stack height shall be 30 meters above ground

(5) Volatile organic compounds in ash shall not be more than 0.01%

Note :

• Suitably designed pollution control devices should be installed/retrofitted with the incinerator to achieve the above emission limits, if necessary.

• Wastes to be incinerated shall not be chemically treated with any chlorinated disinfectants.

• Chlorinated plastics shall not be incinerated.

• Toxic metals in incineration ash shall be limited within the regulatory quantities as defined under the Hazardous Waste (Management and Handling Rules,) 1989.

• Only low sulphur fuel like L.D.O., L.S.H.S. Diesel shall be used as fuel in the incinerator.

STANDARDS FOR WASTE AUTOCLAVING:

The autoclave should be dedicated for the purposes of disinfecting and treating bio-medical waste,

(I) When operating a gravity flow autoclave, medical waste shall be subjected to :

(i) a temperature of not less than 121 ^{0}C and pressure of 15 pounds per square inch (psi) for an autoclave residence time of not less than 60 minutes; or

(ii) a temperature of not less than 135 ^{0}C and a pressure of 31 psi for an autoclave residence time of not less than 45 minutes; or

(iii) a temperature of not less than 149 ^{0}C and a pressure of 52 psi for an autoclave residence time of not less than 30 minutes.

(II) When operating a vacuum autoclave, medical waste shall be subjected to a minimum of one pre-vacuum pulse to purge the autoclave of all air. The waste shall be subjected to the following:

(i) a temperature of not less than 121 ^{0}C and pressure of 15 psi per an autoclave residence time of not less than 45 minutes; or

(ii) a temperature of not less than 135 ^{0}C and a pressure of 31 psi for an autoclave residence time of not less than 30 minutes;

(III) Medical waste shall not be considered properly treated unless the time, temperature and pressure indicators indicate that the required time, temperature and pressure were reached during the autoclave process. If for any reasons, time, temperature or pressure indicator indicates that the required temperature, pressure or residence time was not reached, the entire load of medical waste must be autoclaved again until the proper temperature, pressure and residence time were achieved.

(IV) Recording of operational parameters

Each autoclave shall have graphic or computer recording devices which will automatically and continuously monitor and record dates, time of day, load identification number and operating parameters throughout the entire length of the autoclave cycle.

(V) Validation test

Spore testing :

The autoclave should completely and consistently kill the approved biological indicator at the maximum design capacity of each autoclave unit. Biological indicator for autoclave shall be Bacillus stearothermophilus spores using vials or spore strips; with at least $1X10^4$ spores per milliliter. Under no circumstances will an autoclave have minimum operating parameters less than a residence time of 30 minutes, regardless of temperature and pressure, a temperature less than 121 ^{0}C or a pressure less than 15 psi.

(VI) Routine Test

A chemical indicator strip/tape the changes colour when a certain temperature is reached can be used to verify that a specific temperature has been achieved. It may be necessary to use more than one strip over the waste package at different location to ensure that the inner content of the package has been adequately autoclaved

STANDARD FOR LIQUID WASTE:

The effluent generated from the hospital should conform to the following limits

Parameters	**Permissible Limits**
pH	6.3-9.0
Suspended solids	100 mg/l
Oil and grease	10 mg/l
BOD	30 mg/l
COD	250 mg/l
Bio-assay test	90% survival of fish after 96 hours in 100% effluent.

These limits are applicable to those hospitals which are either connected with sewers without terminal sewage treatment plant or not connected to public sewers. For discharge

into public sewers with terminal facilities, the general standards as notified under the Environment (Protection) Act, 1986 shall be applicable.

STANDARDS OF MICROWAVING:

1 Microwave treatment shall not be used for cytotoxic, hazardous or radioactive wastes, contaminated animal carcasses, body parts and large metal items.

2. The microwave system shall comply with the efficacy test/routine tests and a performance guarantee may be provided by the supplier before operation of the unit.

3. The microwave should completely and consistently kill the bacteria and other pathogenic organisms that are ensured by approved biological indicator at the maximum design capacity of each microwave unit. Biological indicators for microwave shall be Bacillus Subtilis spores using vials or spore strips with at least 1 x 10^4 spores per milliliter.

STANDARDS FOR DEEP BURIAL:

1. A pit or trench should be dug about 2 meters deep. It should be half filled with waste, and then covered with lime within 50 cm of the surface, before filling the rest of the pit with soil.

2. It must be ensured that animals do not have any access to burial sites. Covers of galvanized iron/wire meshes may be used.

3. On each occasion, when wastes are added to the pit, a layer of 10 cm of soil shall be added to cover the wastes.

4. Burial must be performed under close and dedicated supervision.

5. The deep burial site should be relatively impermeable and no shallow well should be close to the site.

6. The pits should be distant from habitation, and sited so as to ensure that no contamination occurs to any surface water or ground water. The area should not be prone to flooding or erosion.

7. The location of the deep burial site will be authorized by the prescribed authority.

8. The institution shall maintain a record of all pits for deep burial.

APPENDIX V

CPCB GUIDELINES FOR THE ESTABLISHMENT OF CBWTF

1. LOCATION

A CBWTF shall be located at a place reasonably far away from residential and sensitive area so that it has minimal impact on these areas. The CBWTF shall be located as near to its area of operation as possible in order to minimize the travel distance in waste collection, thus enhancing its operational flexibility. The location shall be decided in consultation with the State Pollution Control Board (SPCB)/Pollution Control Committee (PCC).

2. LAND REQUIREMENT

Sufficient land shall be allocated for CBWTF to provide all requisite systems. It is felt that a CBWTF will require minimum of 1 acre land area. So, preferably, a CBWTF be set up on a plot size of not less than one acre.

3. COVERAGE AREA OF CBWTF

In any area, only one CBWTF may be allowed to cater up to 10,000 beds at the approved rate by the Prescribed Authority. A CBWTF shall not be allowed to cater healthcare units situated beyond a radius of 150 km. However, in an area where 10,000 beds are not available within a radius of 150 km, another CBWTF may be allowed to cater the healthcare units situated outside the said 150 km.

4. TREATMENT EQUIPMENT

A CBWTF shall have following treatment facilities:

- **Incineration:**

The guidelines for "Design & Construction of Bio-medical Waste Incinerators" prepared by CPCB shall be followed for selecting/installing a better bio-medical waste incinerator.

• **Autoclaving/ Microwaving/ Hydroclaving:**

The Autoclave/ Microwave/ Hydroclave should conform to the CPCB Standards (Appendix IV).

Though chemical disinfection is also an option for the treatment of certain categories of bio-medical waste but looking at the volume of waste to be disinfected at the CBWTF and the pollution load associated with the use of disinfectants, the use of chemical disinfection for the treatment of bio-medical waste at CBWTF is not recommended.

• **Shredder:**

A shredder to be used for shredding bio-medical waste shall confirm to the following minimum requirements:

(a) The shredder for bio-medical waste shall be of robust design with minimum maintenance requirement.

(b) The shredder should be properly designed and covered to avoid spillage and dust generation. It should be designed such that it has minimum manual handling.

(c) The hopper and cutting chamber of the shredder should be so designed to accommodate the waste bag full of bio-medical waste.

(d) The shredder blade should be highly resistant and should be able to shred waste sharps, syringes, scalpels, glass vials, blades, plastics, catheters, broken ampoules, intravenous sets/ bottles, blood bags, gloves, bandages etc. It should be able to handle/ shred wet waste, specially after microwave/ autoclave/hydroclave.

(e) The shredder blade shall be of non-corrosive and hardened steel.

(f) The shredder should be so designed and mounted so as not to generate high noise & vibration.

(g) If hopper lid or door of collection box is opened, the shredder should stop automatically for safety of operator.

(h) In case of shock-loading (non-shreddable material in the hopper), there should be a mechanism to automatically stop the shredder to avoid any emergency/accident.

(i) In case of overload or jamming, the shredder should have mechanism of reverse motion of shaft to avoid any emergency/accident.

(j) The motor shall be connected to the shredder shaft through a gear mechanism, to ensure low rpm and safety.

(k) The unit shall be suitably designed for operator safety, mechanical as well as electrical.

(l) The shredder should have low rotational speed (maximum 50 rpm). This will ensure better gripping and cutting of the bio-medical waste.

(m) The discharge height (from discharge point to ground level) shall be sufficient (minimum 3 feet) to accommodate the containers for collection of shredded material. This would avoid spillage of shredded material.

(n) The minimum capacity of the motor attached with the shredder shall be 3 kW for 50 kg/hr, 5 kW for 100 kg/hr & 7.5 kW for 200 kg/hr and shall be three phase induction motor. This will ensure efficient cutting of the bio-medical wastes as prescribed in the Bio-medical Waste (Management & Handling) Rules.

• Sharp pit / Encapsulation:

A sharp pit or a facility for sharp encapsulation shall be provided for treated sharps. An option may also be worked out for recovery of metal from sharps in a factory.

• Vehicle / Container Washing Facility:

Every time a vehicle is unloaded, the vehicle and empty waste containers shall be washed properly and disinfected. It can be carried out in an open area but on an impermeable surface and liquid effluent so generated shall be collected and treated in an effluent treatment plant. The impermeable area shall be of appropriate size so as to avoid spillage of liquid during washing.

• Effluent Treatment Plant:

A suitable Effluent Treatment Plant shall be installed to ensure that liquid effluent generated during the process of washing containers, vehicles, floors etc. is disposed after treatment. The treated effluent shall comply with the stipulated regulatory requirements. All the treatment equipment installed at the CBWTF shall comply with the standards stipulated in the Bio-medical Waste (Management & Handling) Rules, 1998.

5. INFRASTRUCTURE SETUP

A CBWTF shall have the following infrastructure:

- Treatment Equipment Room
- Main Waste Storage Room
- Treated Waste Storage Room
- Administrative Room
- Generator Set
- Site Security
- Parking
- Sign Board
- Green Belt
- Washing Room