HAZARDOUS MATERIALS & WASTE MANAGEMENT AT CFB SHILO

by

Frank Krumme

A Practicum Submitted
In Partial Fulfillment
Of The Requirements For The Degree
Master of Natural Resources Management

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A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF NATURAL RESOURCES MANAGEMENT

ABSTRACT

This research illustrates the effectiveness of hazardous materials and waste management at CFB Shilo, analyzes potential options in hazardous materials use and waste reduction and offers solutions for improving their management at the Base.

Inspection of CFB Shilo facilities through a waste audit revealed that the Base is complying with all existing governmental regulations and guidelines. At least 8 hazardous material and 12 hazardous waste categories were prevalent. Slightly more than one million litres of bulk hazardous materials come into the Base annually, with fuels and petroleum products representing most of these. Of that quantity, approximately half yield unavoidable losses (eg. as evaporants) during operations, and the other half contribute to a hazardous waste stream of about 57,500 litres per year. Emission of atmospheric contaminants is possible, and should be monitored.

Hazardous waste reduction and other waste minimization ventures could be further considered at the Base. However, existing plans for hazardous waste disposal by contract should be continued, with enhanced education and coordination to be considered as future alternatives.

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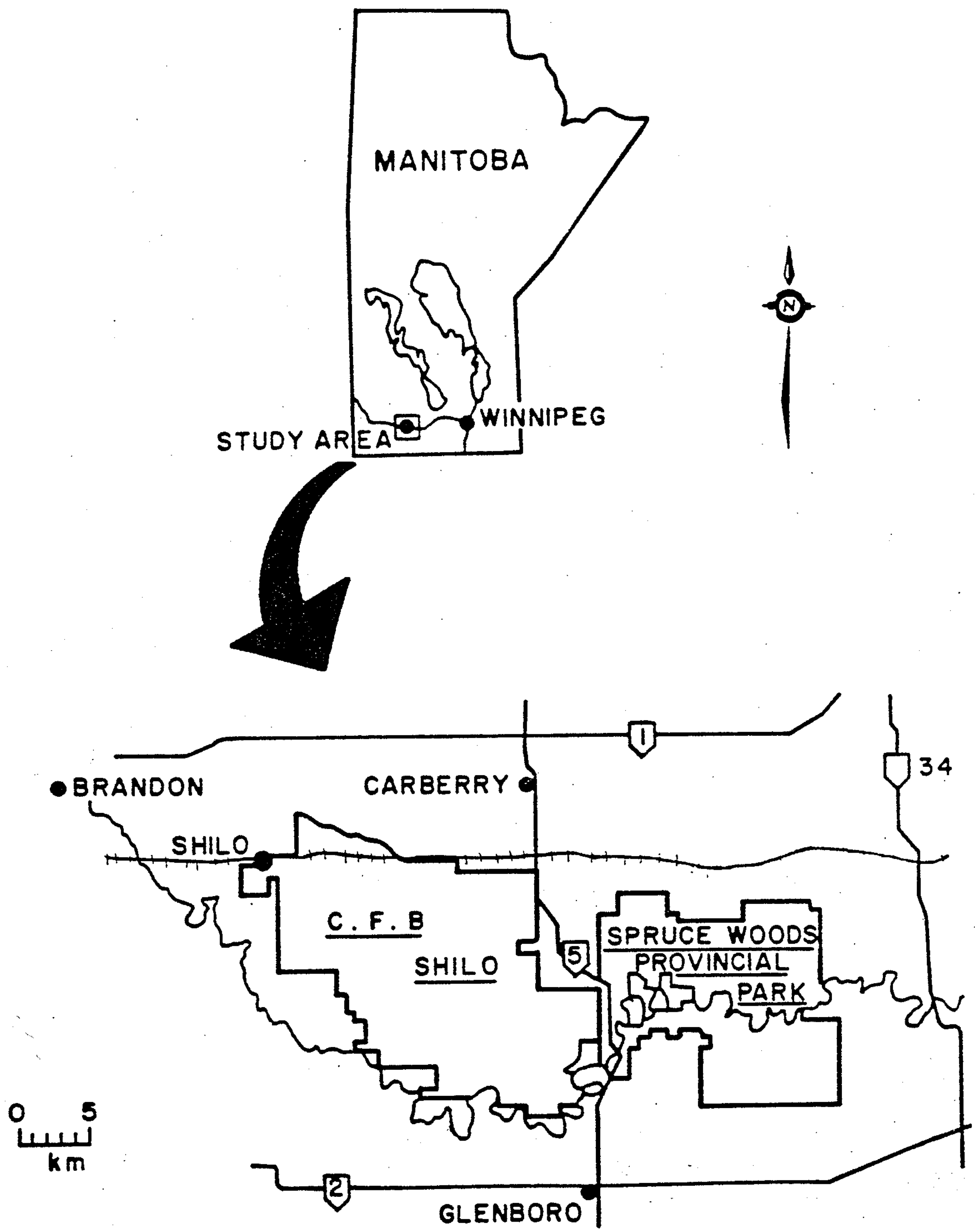
CHAPTER I - BACKGROUND

1.1 CFB SHILO

CFB Shilo, a federal military reserve, is located in southwestern Manitoba, 160 kilometres west of Winnipeg (Map 1.1). The Base, encompassing roughly 38,880 hectares (Shilo Base Operations, 1989), is bordered by the Canadian National Railway main line to the north, the Assiniboine River to the south and Provincial Highway 5 to the east (Map 1.1). CFB Shilo is situated on both federal and provincial land. Over 2/3 of the Base is leased from Manitoba.

Historically, the first permanent military quarters were developed in 1932 (Nilsson, 1983). Several Base features became evident during the Second World War: permanence as a year-round establishment, the opening of the Canadian Air Training Centre (CATC)[1], and major building construction. Since then, numerous militia and armament lodger units have resulted in enhanced military training, especially during the summer: the Royal Canadian Horse Artillery Third Regiment (3RCHA), the Royal Canadian Artillery (RCA) Battle School and the 731 Communication Squadron (CFB Shilo Base Information Directory, 1990). The German Army Training Establishment Shilo (GATES) has been in effect at CFB Shilo since May 1974, and a second bi-lateral ten-year agreement between the Federal Republic of Germany, the Canadian federal government and provincial officials was signed in 1983 (CFB Shilo Base Information Directory, 1990). A third term

[1] For a complete list of acronyms, please see Appendix 1



Map 1.1 The Location of CFB Shilo

(Baydack, 1986)

between the two countries has tentatively been discussed to account for future plans after 1993. These German troops utilize CFB Shilo as a training ground for tank and armoured infantry battalions.

CFB Shilo employs some 1000 Canadian military personnel and 450 Canadian Public Employees (Beatty, personal communication). To accommodate all these personnel along with their families, CFB Shilo includes a town with 744 housing units, schools, a shopping mall and all other available social and recreational facilities (CFB Shilo Base Information Directory, 1990).

1.2 ISSUE STATEMENT

CFB Shilo is a self-contained military establishment which includes all of the amenities of an urban centre, but on a much smaller scale. The Base should be examined to determine if hazardous materials and wastes are being properly handled[2]. Various facilities on the Base may be using hazardous materials and generating hazardous wastes without addressing the potential environmental dangers.

1.3 OBJECTIVES

The primary objective was to assist in developing strategies for CFB Shilo which would optimize hazardous

[2]For a definition of technical terms used in this document, please refer to Appendix 2.

materials management including waste reduction and recovery.

Specific objectives were:

1) To document hazardous materials and wastes and their handling on the Base by military facilities,
2) To analyze possible alternative options in hazardous materials use and waste reduction or recovery, and
3) To recommend strategies for optimizing the management of hazardous materials and wastes on the Base.

1.4 LIMITATIONS

The scope of this study was to determine the hazardous materials on CFB Shilo, especially in buildings used by the Canadian military forces, and to develop strategies for proper hazardous waste management procedures. One military site in Manitoba was selected due to time and budget constraints. The GATES was not audited because records to some of their hazardous materials were not available in Canada. Waste ammunition, even though recovered by the Base Range Control, was not included since it was decided to be beyond the scope of this study.

CHAPTER II - METHODS

2.1 INTRODUCTION

This study consisted of four sequential phases which correspond to the specific objectives. The phases were conducted in the following order: literature review, site inspection, option analysis and recommendations.

2.2 LITERATURE REVIEW (Phase I)

This first phase was an identification of alternative management options for hazardous materials and wastes. The review was done by searching through technical articles and by examining case examples (eg. Campbell et al.,1982). Literature on the American military's hazardous waste management efforts (eg. Dharmavaram et al., 1988) was also noted.

2.3 SITE INSPECTION (Phase II)

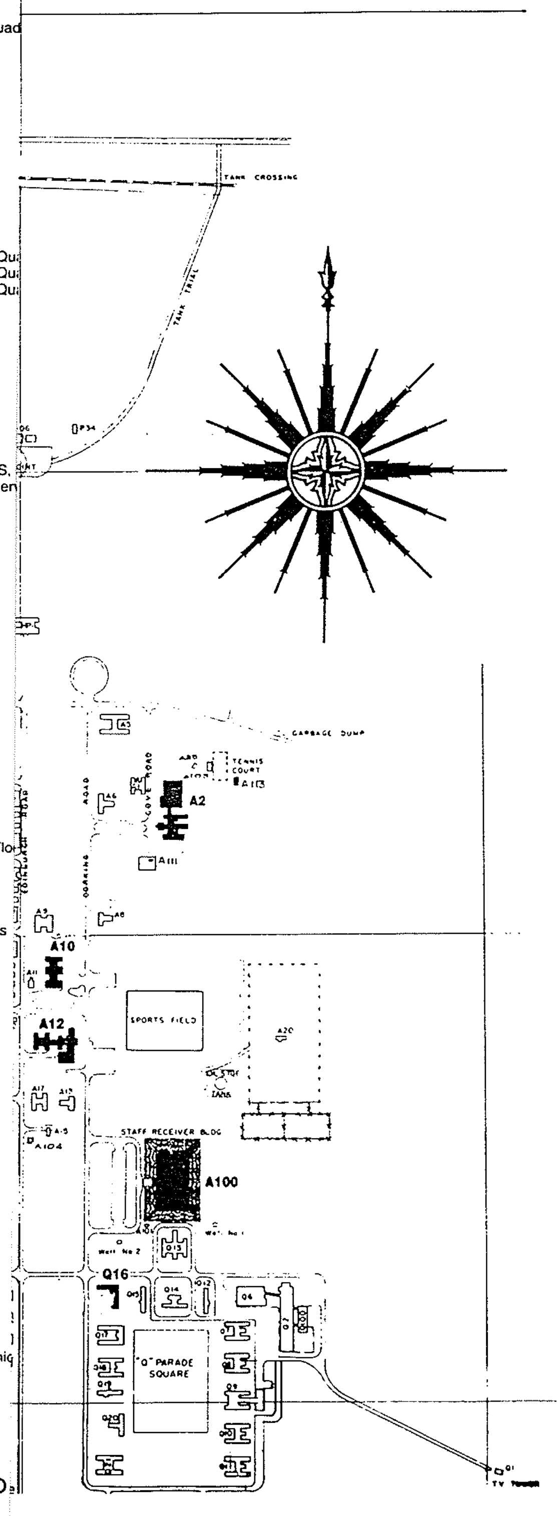
The second phase of the study was an inspection of CFB Shilo and an examination of what types of facilities, hazardous materials and wastes were on the Base.

Facilities were classified through observation of a base map, site visits and discussion with personnel. From a map of CFB Shilo (Map 2.1), those facilities having hazardous materials and also those generating potential hazardous wastes were identified (Table 2.1).

Three site visits allowed for detailed observations of

BUILDING DIRECTORY C

A-2	Golf/Curling Country Club
A-5	Transient Quarters
A-9	Offices, 3 RCHA and "H" and "J" Batt
A-10	HQs 3 RCHA AND "G" Battery
A-11	3 RCHA Admin.
A-12	RCA Museum
A-13	Senior NCO Quarters (GATES)
A-16	RCA Museum
A-17	Officer's Quarters
A-100	PWC and 731 Communications Squad
A-102	Curling Club
C-4	Vacant
C-12	3 RCHA Men's Quarters
C-13	3 RCHA Men's Quarters
C-103	B Sup MSA
D-1	3 RCHA Storage
D-3	Vacant
D-5	Lecture Rooms (3 RCHA)
D-6	Offices, 3 RCHA "G" Bty
E-1	Cleaner Foreman/B Accn
E-2	Woodworking Shop and Club Hall
E-6	Lecture Rooms RCA Btl Sch
E-8	RCA Battle School Headquarters
E-11	RCA Battle School Lecture Rooms/Qu
E-12	RCA Battle School Lecture Rooms/Qu
E-13	RCA Battle School Lecture Rooms/Qu
G-4	Gunner Arena
HP1	Transient Quarters
HP3	Hospital and Dental Clinic
L-25	Drill Hall, Rifle Range and Clubs
L-33	Canex Warehouse
L-44	731 Comm Sqn Line Section
L-50	Base Ops
L-60	3 RCHA Sigs Tp
L-63	3 RCHA RQM Stores
L-101	3 RCHA Men's Quarter Cpl/Ptes
L-102	HQ CFB Shilo, B Compt, CO GATES, Townsite Officer, Civ Pers Officer, Sen Language Coordinator
L-103	Base-3 RCHA Men's Quarters
L-104	GATES Men's Quarters
L-105	Kitchen (500 man) (Base)
L-106	Kitchen (500 man) (GATES)
L-110	WOs & Sgt's Mess
L-111	WOs & Sgt's Quarters
L-117	Junior Ranks Club
L-125	BX Complex
L-126	BX Service Station
L-128	Fire Hall
L-132	OR Quarters
L-134	Security Bldg (MP)
M-1	Commissary
M-2	Base Supply Clothing Stores
M-24	Base Maintenance Control Office
M-101	RCHA LMT
M-102	B Tn Section Garage
M-103	General Strange Hall
N-114	Officer's Mess
N-115	Officer's Quarters
N-116	Officer's Quarters (Female Second Flo
N-118	3 RCHA Gun Park
P-2	Weigh Scales
P-106	POL Point
P-34	Gas Chamber
P-101	Base Engineers — Offices and Shops
P-103	Main Gate House
Q-6	3 RCHA Offices and Storage
Q-7	Quarters (GATES)
Q-8	Quarters (GATES)
Q-9	500 Man Kitchen (GATES)
Q-10	Quarters (GATES)
Q-11	Quarters (GATES)
Q-12	Lecture Training Building (GATES)
Q-13	Officer Quarters and Mess (GATES)
Q-14	Administration Building (GATES)
Q-15	GATES Storage and Supply
Q-16	Administration (GATES)
Q-17	GATES WOs & Sgt's Quarters
Q-18	GATES WOs & Sgt's Quarters
Q-20	Sr NCO Mess (GATES)
Q-21	Canteen — Cpl/Ptes
Q-101	GATES Veh Workshop
Q-102	GATES Veh Storage
Q-103	GATES Storage
Q-104	GATES POL
R2-1	Hangar AOP
T-98	RC Chapel
T-99	Protestant Chapel
T-100	Princess Elizabeth School
T-101	O'Kelly School
T-102	Crerar Bldg, Technical Library, Graphic
T-103	Community Centre



Map 2.1 CFB Shilo

Table 2.1 Facility Categories For CFB Shilo

Category	Description	Approx. # Facilities on Site	Examples
1	Warehouses & Storage Rooms	90	POL Point (4JH)
2	Admistration Bldgs. & Offices	30	Range Control HQ (L-50)
3	Vehicle Garages Maintenance	10	3RCHA LMT (M-101)
4	Workshops	15	CE Paint Shop (P-101)
5	Utility Bldgs.	5	Heating Plant (L-107)
6	Greenhouse Complex	4	Bldg. HP-101
7	Construction Engineering	8	Field Engineers (P-111)
8	Industrial Arts	1	Base Photo Lab (T-102)
9	Base Hospital	1	Bldg. HP-3
10	Incinerator Bldg.	1	Bldg. A-15
11	Range Bldgs.	15	Bldg. RH-24
12	Gas Chamber	1	Bldg. P-34
13	Metereolog-ical Site	1	Bldg. R2-101
14	Ammo Dump	N/A	Bldg. R1-107
15	Kitchens & Messes	4	Base Kitchen (L-105)
16	Sleeping Quarters	17	Officer's Quarters (N-115)
17	Other Locations	10	Base Landfill Sewage Lagoon

additional Base features. Through a waste auditing procedure, facility operations and handling or storage practices were recorded.

During the first two Base visits (Dec.10-14, 1990 and March 4-8, 1991), examples of all facility categories were inspected (Table 2.1). With the cooperation of CFB Shilo facility supervisors through interviews and inquiries, a waste audit was performed. The audit identified operational functions of buildings and characteristics of hazardous materials and wastes (eg. chemical nature). Questions were posed to each facility supervisor with respect to the handling and storage procedures for hazardous materials and wastes, the hazardous material quantities used, the hazardous waste quantities generated, the operations which generate them and the final Base destinations for hazardous wastes. To supplement questions asked at each facility, NATO Stock and Manufacturers' Numbers were recorded for hazardous products in the warehouse and user areas.

During the April 21-24, 1992 visit to CFB Shilo, previously obtained NATO Stock and Manufacturers' Numbers were used to derive quantities of hazardous waste-contributing materials. Purchasing records from the Base Supply sections (eg.POL Point-4JH) served as the sources for estimating annual quantities of incoming hazardous materials. WHMIS Material Safety Data Sheets (MSDS) and DND Hazardous Material Guide Sheets (HMGS), corresponding to the NATO

Stock Numbers, were obtained from Base Supply personnel so that the range of hazardous components in a product could be further identified.

Members of Repair & Disposal in the Base Supply section were contacted to determine what hazardous wastes were presently stored on-site or disposed of by contract. From discussion, specific quantities of these were noted as well. Manifest records and disposal contracts were examined to further identify disposal features.

2.4 OPTION ANALYSIS (Phase III)

The third phase of the study examined which hazardous materials and waste management alternatives mentioned in the literature review (Phase I) were feasible for CFB Shilo. Factors such as applicability, costs and effectiveness were considered in the feasibility analysis. The visits to each facility further supplemented the determination of what additional facility requirements were necessary.

2.5 DEVELOPMENT OF RECOMMENDATIONS (Phase IV)

This final phase of the study, based upon waste stream quantities and costs, emphasized the most logical and viable approach(es) for hazardous material and waste management at CFB Shilo. Results of the findings provided the best options or strategies to pursue. Staged development was considered in order to better assess overall cost-effectiveness. Legal requirements were also included as factors in recommending appropriate strategies. Consultation with knowledgeable experts, including industrial representatives, provided supplementary guidance regarding hazardous material and waste management recommendations for the Base.

CHAPTER III - HAZARDOUS MATERIALS & WASTE MANAGEMENT

3.1 FEATURES OF A HAZARDOUS MATERIAL

Hazardous materials are those materials that are flammable, explosive, corrosive, toxic or otherwise potentially hazardous to people or the environment (Andres, 1988).

Most hazardous materials are classified under eight distinct categories of the Workplace Hazardous Material Information System (WHMIS) since these dangerous goods are either found or utilized at the worksite (Appendix 3). The Canadian Transportation of Dangerous Goods Act (TDGA)(1980) also applies to all hazardous materials when these are shipped to and from the worksite (Milko, 1986). The TDGA classification is based partly on the United Nations designation for dangerous goods (Milko, 1986). There are nine primary classes on this inclusive list (Appendix 4).

Other categories of hazardous materials exist as well: pest control products, explosives, radioactives (eg. substances which yield energy from the break up of their atoms), polychlorinated biphenyls (PCB's) and ozone-depleting substances. The first three categories are, respectively, defined in the federal Pesticide, Explosive and Atomic Energy Control Acts. The latter two are considered as restricted hazardous materials and have their own guidelines.

3.2 FEATURES OF A HAZARDOUS WASTE

Waste materials are discarded substances for which the owner or generator has no further use (Milko, 1986). Some of these wastes have been deemed as hazardous since they are distinct from other categories (Cope, 1983).

In Canada, a Federal Task Force on Hazardous Waste Definition was organized and agreed upon the following definition (Quinn, 1985):

Hazardous waste - any waste which, due to its nature and quantity, is potentially a threat to human health and/ or the environment and which requires special disposal techniques to eliminate or reduce the hazard.

A hazardous waste is, in addition, frequently any unwanted hazardous material, usually a by-product of an operation. However, a hazardous waste may be recovered or recycled if it is economical to do so.

A hazardous waste is, at present, classified primarily through the TDGA. If a hazardous waste is not included in one of the 9 classes (Appendix 4), then laboratory tests will determine what the most distinguishing physical and chemical features are.

3.3 HAZARDOUS WASTE REDUCTION

The following section will discuss the components of hazardous waste reduction: the hazardous waste audit and the various integral methodologies.

3.3.1 The Hazardous Waste Audit

Waste audits are an integral part of hazardous waste reduction techniques (Campbell et al., 1982). Comprehensive waste audits focus upon identifying sources of waste streams, characterizing these quantitatively and qualitatively, assessing operational procedures, and identifying raw materials or chemicals used in specific processes (Tsai and Nixon, 1988). Completion of a mass materials balance, a comparison of resource inputs with product and waste outputs, may be necessary in order to identify potential opportunities to reduce waste generation (Campbell et al., 1982). Recommendations from an audit would identify specific methods of waste reduction and waste handling (Campbell et al., 1982).

3.3.2 Hazardous Waste Reduction Methodology

There are a number of major reduction methodologies available for hazardous wastes. These are discussed below: hazardous material substitutions, housekeeping practices, process changes, hazardous waste recovery, contract recycling, hazardous waste reuse and waste exchanges.

Hazardous Material Substitutions

Material substitutions are potentially significant to hazardous waste reduction even though they are still in their infancy (Epstein et al., 1982). Some examples of substitutions are: soap-based detergents for alkyl halide solvents (Epstein et al. 1982), chlorinated paraffins for expensive PCB paint additives (Epstein et al., 1982) and cost-effective water-based products (eg. inks) for solvent-based equivalents (Campbell et al., 1982).

Without the careful preliminary research on substitution technology, however, unrecognized hazards may result (Epstein et al., 1982). This could happen, for example, by replacing PCB fluid in a transformer with mineral oil which is much more flammable (Epstein et al., 1982).

Housekeeping Practices

Good housekeeping is a manner of hazardous waste reduction which is less capital intensive than other methods. By routinely checking for process faults and by identifying unusual material losses, unnecessary hazardous waste streams are sometimes uncovered and prevented (Patterson, 1989a). Good housekeeping also extends to proper hazardous material stock rotations, minimization of slop-overs, waste segregational procedures, and those other practices which keep hazardous wastes out of the environment (Campbell et al., 1982).

Process Changes

Process changes are those changes in operations which lead to substantially less hazardous wastes. According to several manufacturers, process changes can lead to numerous benefits (Campbell et al., 1982). Most of the process changes are targeted towards either modifying existing equipment or enhancing operations through innovative practices.

An illustration of a process change which improves operations altogether is a photo processor which uses Rapid Access (RA) Chemistry. Unlike processing film with an EP-2 unit, this innovative procedure involves the addition of a chloride-based chemical to a developing bath to shorten development time from 3 minutes to 45 seconds (Eastman Kodak Company, 1989). A processor utilizing RA Chemistry also requires less developer and, therefore, reduced quantities of this photo chemical become hazardous wastes (Eastman Kodak Company, 1989).

Hazardous Waste Recovery

Recovery is a hazardous waste reduction measure which applies technologies to ensure that hazardous wastes are concentrated for reuse (Campbell et al., 1982). Companies which specialize in the marketing of resource recovery methods estimate that up to 80% of certain hazardous wastes could be recovered (Quinn, 1985). Successful efforts to recover hazardous wastes have been demonstrated in numerous case studies (Campbell et al., 1982).

Electrolytic units, for example, are frequently used for hazardous waste recovery. These are valued at $ 25,000 each, but recover roughly 95% pure silver (OWMC, 1990). When the price of silver is high, electrolytic units could be provided free-of-charge in return for a share of the metal (OWMC, 1990). In addition, some units in the marketplace aid in prolonging the fixer solution's utilization time (OWMC, 1990).

Photo processing firms, as another example, are actively involved with the recovery of silver. Black's Photography utilizes its System Crystal to not only meet governmental guidelines on silver but also to set the trend for environmental awareness (Black's Photography, 1992).

Contract Recycling

Recycling by contract is a venture initiated by many hazardous waste generators. Companies frequent the generator site to service recycling equipment which they provide and to remove the non-recyclable components of a hazardous waste. Contract recycling diminishes the risk associated with liability.

Hazardous Waste Reuse

Hazardous waste reuse can be sub-categorized into on-site and off-site applications.

On-Site Applications

Reusing industrial materials on location can significantly decrease hazardous waste quantities and has the following advantages: less need for new material purchases and custom-formulations to meet user specifications (Campbell et al., 1982). In-line recycling and retrograde reuse on the premises are further categories of on-site reuse.

In-Line Recycling

In-line recycling can be defined as the transfer of hazardous wastes directly back into the main industrial process which created them through a closed-loop system. In-line recycling, further, assists in the supplementation of these recycled hazardous substances for raw material equivalents (Campbell et al., 1982). System Crystal can also exemplify in-line recycling. Over 90% of the chemicals used during photofinishing are regenerated, virtually eliminating their discharge into the sewer (Black's Photography, 1992).

Retrograde Reuse

Reuse of a hazardous waste is possible for a secondary or lower grade function. Waste solvents can be reutilized in either parts cleaning or other minor industrial chores.

Waste oil could be reutilized as a fuel supplement in furnaces (Dharmavaram et al., 1988). Waste oil could be blended with incoming virgin oil once the waste oil is filtered to remove sludges which contain such metals as cadmium (Dharmavaram et al., 1988). However, some disincentives include the expenses and inconveniences to install waste oil furnaces, the stockpiling of waste oil on-site when the furnaces are non-operational and excess sludge buildup (Laird, personal communication).

Off-Site Applications

When a hazardous waste is needed by some other industrial sources, waste exchanges become a fundamental component for off-site reuse alternatives.

Waste Exchanges

Waste exchanges are another aspect of hazardous waste reduction (Campbell et al., 1982). These exchanges operate as information clearinghouses designed to put potential users of waste material in contact with similar waste producers (AWME Bulletin, 1987). A profitable symbiotic relationship may even develop when different hazardous wastes from two or more firms become the raw materials for others. Disposal costs are avoided in these instances (Campbell et al., 1982). Without waste exchanges, individual efforts to locate a waste trading partner would require a lot of time, money and considerable research (Dorn and Adams, 1982). Also, according to Dorn and Adams (1982), hazardous waste transfers are usually from large companies with continuous processes to small firms using batch processes, chemical manufacturers to formulators, and firms with high purity requirements (eg. pharmaceuticals) to companies with lower purity preferences (eg. paints). Waste listings in exchange catalogues or bulletins are broken down into three major categories: wastes available, wastes wanted and services available (AWME Bulletin, 1987).

In Canada, waste exchanges are established in most provinces. For instance, the Ontario Waste Exchange is operated jointly by the Ontario Waste Management Corporation (OWMC) and ORTECH International (Patterson, 1989b). The Manitoba Waste Exchange is operated by the Biomass Energy Institute, with federal support by the Manitoba Hazardous Waste Management Corporation (MHWMC), Manitoba Environment and the private sector (MWE, 1991).

3.3.3 The Barriers to Hazardous Waste Reduction

There are a number of barriers for implementing hazardous waste reduction, including lack of a complete definition for the concept of waste reduction, non-existent informational exchanges, minimal number of institutional courses regarding hazardous waste reduction, and low level of commitment by waste managers (Hirschhorn and Oldenburg, 1987).

First of all, there is no common consensus as to what waste reduction means. This term is used interchangeably with related terms: waste minimization or source reduction (Hirschhorn and Oldenburg, 1987). Waste reduction, as acknowledged by Patterson (1989a) is in a hierarchical classification and is a branch of waste minimization which encompasses the strategies of source reduction and source avoidance (Patterson, 1989a).

A second hindrance is that the public does not have access to information regarding hazardous waste reduction (Hirschhorn and Oldenburg, 1987). Waste generators should be informed that waste reduction is presently economically viable as an alternative to costly disposal methods (Huisingh et al. 1986). Unlike hazardous waste reduction, the costs of waste disposal do not adequately reflect the social costs of public protection; there are increasing clean up and third party liabilities, and adverse public reactions (NRC, 1985).

Hazardous waste reduction is also hindered through lack of changes at the institutional level (Oldenburg and Hirschhorn, 1987). New views affecting engineering design and basic research should be initiated to shape the development of new technologies with fewer and better understood adverse environmental consequences (Friedlander, 1989).

A fourth barrier to hazardous waste reduction is attitude (Hirschhorn and Oldenburg, 1987). Level of commitment is holding up the enormous potential of waste reduction (Basta et al., 1988). Hazardous waste managers at an industrial site have no motivation for reducing generated wastes since these officials are "end-of-pipe" oriented (Hirschhorn and Oldenburg, 1987) and are heavily inclined toward the control rather than the prevention of pollution (Oldenburg and Hirschhorn, 1987).

Hazardous waste reduction is, nevertheless, very much evident as exemplified by the 3M Company, one of the first enterprises to become aware of the merits associated with this hazardous waste management practice. Since 1975, the firm's "Pollution Pays Programme" has assisted in eliminating sludge, aerial emissions, water pollutants and wastewater (Campbell et al., 1982). This initiative has also saved the 3M Company and its subsidiaries millions of dollars annually through products and processes which pollute less and through less capital expenditures on "end-of-pipe" pollution control equipment (Campbell et al., 1982).

3.4 HAZARDOUS WASTE TREATMENT & DISPOSAL METHODS

This section will briefly describe options other than hazardous waste reduction. These include the various treatment and disposal systems.

3.4.1 Treatment Technologies

Treatment can enhance or facilitate the recovery or re-use of waste components (Milko, 1986). The selection of the most efficient technology depends upon this process (WDNR, 1983). There are several categories of treatment for hazardous wastes: physical, chemical and biological.

Physical

Physical treatment is used to separate hazardous waste-stream components from non-hazardous ones through the utilization of physical forces and devices (Milko, 1986). Technologies for this kind of treatment allow for a change of the waste's physical form without an alteration of constituent material chemical structure (WDNR, 1983). There are three specific physical treatments: mechanical, thermal and radiation.

Mechanical

Mechanical treatment techniques are beneficial for preparing a waste stream for detoxification and ultimate destruction. There are many methods of treatment by mechanical means, such as: carbon adsorption, steam stripping, sedimentation, centrifugation and reverse osmosis (Valdirio, 1990). No single treatment method is applicable to all hazardous wastes (Campbell et al., 1982). However, since this physical system of hazardous waste management does not offer 100% efficiency or recovery, hazardous waste disposal is still needed (Campbell et al., 1982).

Thermal

Thermal treatment is a method which vaporizes, oxidizes or otherwise destroys hazardous liquid or solid phase components (Milko, 1986) by subjection to temperatures ranging from 800-3000°F (427-1650°C) (WDNR, 1983). Generally, only organic chemical wastes are broken down into simpler and less toxic forms by combustion (WDNR, 1983). High temperature treatment can reduce the need for new landfilling capacity because of instantaneous degradation of hazardous wastes (WDNR, 1983). Problems with thermal treatment include toxic fume development and disposal of resultant residues (MEWSH, 1987). An inappropriate thermal system also may yield products which could be more potent than the original materials (Milko, 1986). Examples of thermal destructive systems are a cement kiln, fluid-bed incinerator, multiple hearth, rotary kiln, molten salt incinerator, plasma arc torch or a wet air oxidation unit (Campbell et al., 1982).

Radiation

Radiation treatment is slowly emerging as a successful procedure for destroying some types of hazardous wastes (Campbell et al., 1982). Ultraviolet light, for example, can assist in the breakdown of dioxins and PCB's (Campbell et al., 1982). Current radiation treatments, other than dehalogenation by ultraviolet light, include electron beam radiation, microwave discharge and photolysis (Campbell et al., 1982).

Chemical

Chemical treatment alters chemical structure and composition to produce a less hazardous material with a reduced potency (WDNR, 1983). Some of the distinctive characteristics of this treatment category include minimal air emissions and possible utilization in mobile units (WDNR, 1983). Commonly employed detoxification methods via chemical treatment are catalysis, ozonation, chlorinolysis, electrolysis, neutralization and ion exchange (Valdirio, 1990).

Biological

Biological treatment applies to the decomposition of dilute organic wastes by living micro-organisms (WDNR, 1983). These microbes are either present in the wastes or are injected into them (WDNR, 1983). The major significance behind this system is to maintain high microbe concentrations through regulation of their growth and activity (WDNR, 1983). Biological treatment does not, however, alter or destroy inorganics such as metals (Campbell et al., 1982). It is frequently utilized as the last step prior to municipal sewer discharge (WDNR, 1983). Industries such as breweries and refineries have conventional methods for biodegradable waste stream pollutants (eg. cellulose and grease respectively) (Campbell et al., 1982). Activated sludge, aerated lagoons, anaerobic digestion, landfarming and trickling filters are among the various conventional and innovative approaches for biological treatment (Campbell et al., 1982).

3.4.2 On-Site Treatment

On-site treatment can either be performed by the hazardous waste generator itself through standard procedures or by experts through mobile units.

Standard Applications

Standard treatment procedures usually involve any of the treatment means mentioned above which the hazardous waste generator can apply within the realm of technology, economics and safety. Those hazardous wastes which are not economical to treat on-site are sent off-site.

Mobile Units

On-site treatment could also include the incorporation of mobile hazardous waste treatment units to the generator site. Small-scale high temperature incinerators, as examples of mobile units, are frequently brought on-site for rendering harmless any large quantities of waste organic solvent, oil and paint sludge. Licensed firms or organizations with appropriate knowledge, mobile waste treatment equipment and staff have been known to assist in destroying all of a generator's hazardous wastes within several days.

3.4.3 Contract Disposal & Treatment

Contract disposal is described as the practice of entering into a contractual agreement with someone to pick up hazardous wastes.

In Canada, during the early 1980's, the average cost to domestic industries for contract disposal was between $ 6 to $ 24 per drum (Campbell et al., 1982). Nowadays, with the cost up to around $ 300 and still escalating, contract disposal appears less feasible. Disposal of hazardous wastes by contract, has with it, administration or transaction fees, abatement costs for post-disposal cleanup and compensation expenditures for incurred injury (Winston, 1985).

Contract disposal implies that the contractor remove dangerous chemicals from the generator site with the intent of transporting them to an off-site licensed facility either for reprocessing or ultimate disposal and treatment. There are, however, two distinct kinds of contract disposal firms or carriers.

Licensed Carriers

Legal hazardous waste transportation firms are those which must register in compliance with the TDGA. These waste transporters co-sign a provincial Hazardous Waste Manifest with the waste generator and the waste receiver to ensure that hazardous wastes are tracked from "cradle to grave".

Unlicensed Carriers

Unlicensed carriers cannot legally carry hazardous wastes in Manitoba. It is the responsibility of the waste generator to ensure that licensed carriers are used to transport the hazardous wastes away from the site.

Off-Site Reprocessing

Off-site reprocessing recovers a useful by-product from a hazardous waste. One example of a reprocessing operation is the re-refining of waste oil into original oil or lower grade diesel fuel through a process known as hydrocracking (Laird, personal communication).

Off-Site Treatment

Contract disposal to an off-site treatment location is the method of last resort. The facility which accepts a generator's hazardous wastes for destruction is legally-sound or reputable, and it usually has several treatment technologies available for hazardous waste streams from numerous generators (eg. the proposed Manitoba Hazardous Waste Management Corporation's multi-purpose waste complex). However, there may be only one treatment means at the off-site location (eg. cement kiln as an incinerator).

3.4.4 Landfill Disposal

Disposal in landfills is another widely practiced method for hazardous waste removal. There is, generally, a concern that improper disposal could result in environmental and health consequences, and that disposal sites will become more limited. Nevertheless, hazardous waste landfill disposal methodologies can be depicted: open dumping, secure landfills and solidification (Campbell et al., 1982).

Open Dumping

In Canada, some hazardous wastes, in particular household hazardous wastes, are still co-disposed with conventional refuse at municipal sanitary landfills (Milko, 1986).

Federal-provincial studies have identified a total of 5364 active and inactive disposal sites within the country, of which Manitoba accounted for 14.2% (Milko, 1986). Open dumping throughout the province is carried out with occasional waste compaction and limited cover material capping (Milko, 1986).

Environmental concerns are becoming noticeable for sanitary sites since hazardous liquids from containers and batteries likely leach into ground water (MEWSH, 1987).

Secure Landfills

Secure landfills are properly engineered facilities with relatively impermeable subsurface surroundings

(Campbell et al., 1982). Other features may include synthetic membrane or clay liners and a leachate (eg. leakage) collection system (Milko, 1986). Non-liquid chemical hazardous wastes are often disposed of at these sites and are covered with clay (Campbell et al., 1982). Problems associated with secure landfills are vulnerability of liners to disintegration by specific corrosives, enhancement of clay permeability by certain components (eg. organics, acids, and bases), and initiation of fires, explosions or toxic gas releases by mixing of certain noncompatible wastes (Campbell et al., 1982).

Solidification

Solidification implies that hazardous wastes are monolithically-formed into solids of high structural integrity (WDNR, 1983). A solid end-product results from either fixation or encapsulation (Campbell et al., 1982). The former uses an agent (eg. lime) to turn wastes into concrete-like material, whereas the latter needs an agent to physically surround waste particles and to make them stick to each other (Campbell et al., 1982). Solidification also limits the toxicity and solubility of waste contaminants without altering the physical nature of the waste (WDNR, 1983). Frequently, solidification and stabilization are used together. Both solidification and stabilization methods also improve hazardous waste handling and reduce pollutant loss by decreasing surface area (WDNR, 1983).

3.4.5 Sewering of Hazardous Wastes

Municipal sewers are the preferred route for liquid hazardous waste disposal by many industries and individual homeowners (Milko, 1986), but there is damage associated with high concentrations of chemical discharges (eg. toxic metals). Sewer lines and the normal biological operations of municipal sewage treatment plants are frequently disrupted from hazardous constituents (Milko, 1986).

CHAPTER IV - CFB SHILO SITE INSPECTION

4.1 INTRODUCTION

The following chapter illustrates the present methods of hazardous waste materials and waste management at CFB Shilo. In addition, this chapter will deal with classification of facilities and their operation as well as characteristics of hazardous materials and wastes.

4.2 FACILITY CLASSIFICATION & OPERATION

CFB Shilo is a Canadian military Base with approximately 220 buildings in total, excluding GATES, living quarters and other domestic facilities. Each military building and area was placed into one of 17 categories (Table 2.1), and each building category was sampled during the site visits.

Generally, hazardous materials arrive at selected locations, are distributed to other facilities, are used in processes and are disposed of through various means. The Base procedures are developed according to several guidelines such as the DND Hazardous Material Storage and Handling Guide (A-LM-187-004/JS-001). A Base Environmental Committee, consisting of numerous superior officers, monitors this overall effort. This Committee is chaired by the Base Commander and receives feedback through technical advisors from each section.

4.3 HAZARDOUS MATERIAL INPUTS

Hazardous materials are trucked into CFB Shilo from either local suppliers or military supply depots outside of the province. However, ammunition supplies are frequently brought to the site by train. Depending upon the product nature and final utilization demand, the hazardous material will be kept at a selected warehouse facility. Users (ie. facilities in need of the product) specify the quantity desired, and the warehouse provides them with the hazardous material. There are 6 warehouses which receive hazardous products (Fig. 4.1). From these primary storage sites, the hazardous materials are transported by truck or specialized vehicles to either secondary warehouses or to end-users. The Ammunition Dump distributes hazardous items when required.

A wide array of hazardous materials come into CFB Shilo on an annual basis. Slightly more than one million litres of bulk hazardous product, for instance, have entered the Base during 1991 (Table 4.1).

4.4 HAZARDOUS MATERIAL STORAGE

Most of the facility categories at CFB Shilo (eg. workshops, greenhouse complex) are storing their hazardous materials properly. Hazardous materials stored at any one particular time can be estimated to encompass 15 to 25% of materials purchased (Table 4.1), but these figures may vary because of the large annual product turnover rate. In some

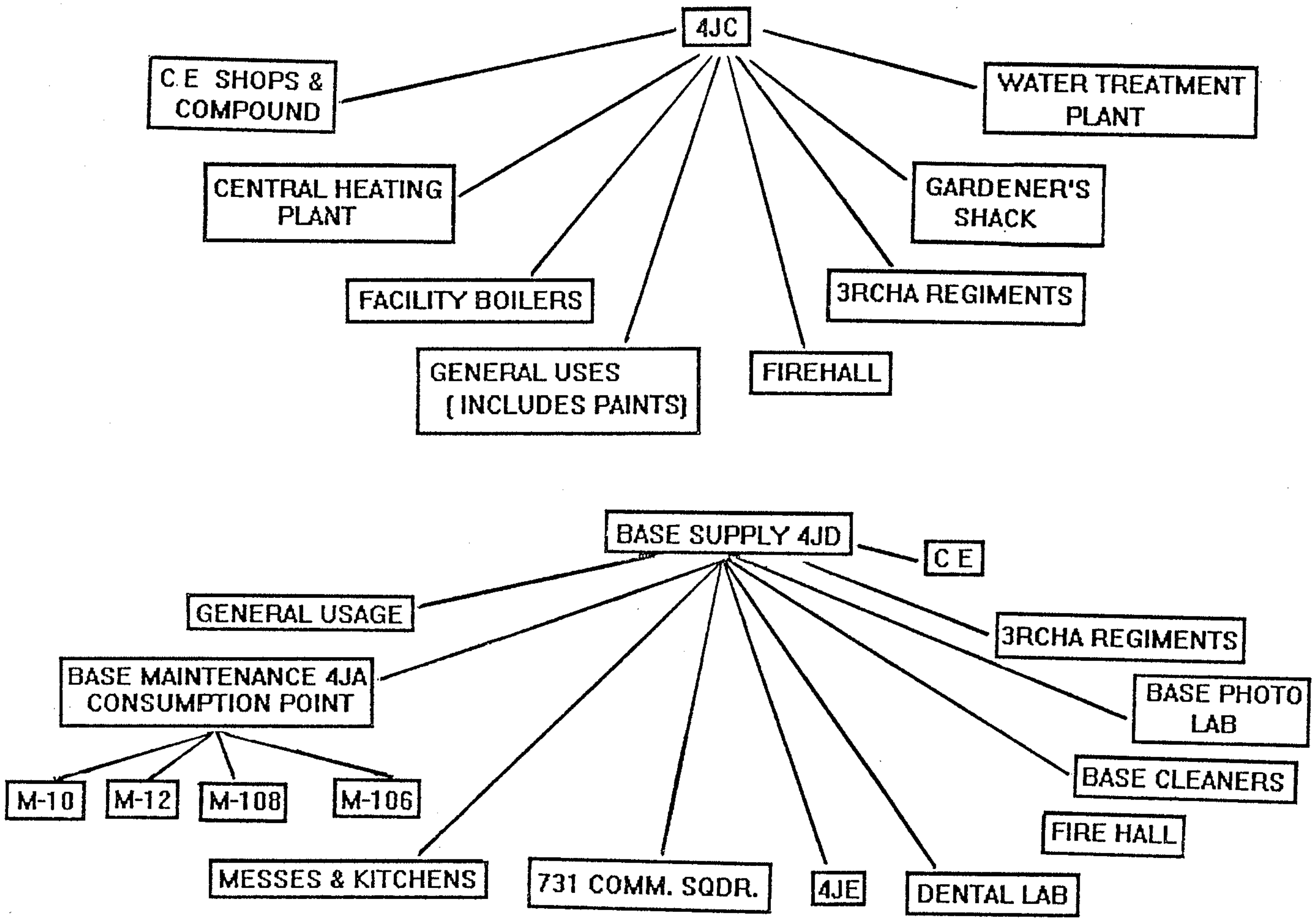


Fig.4.1 Warehouse Distribution of CFB Shilo Hazardous Materials

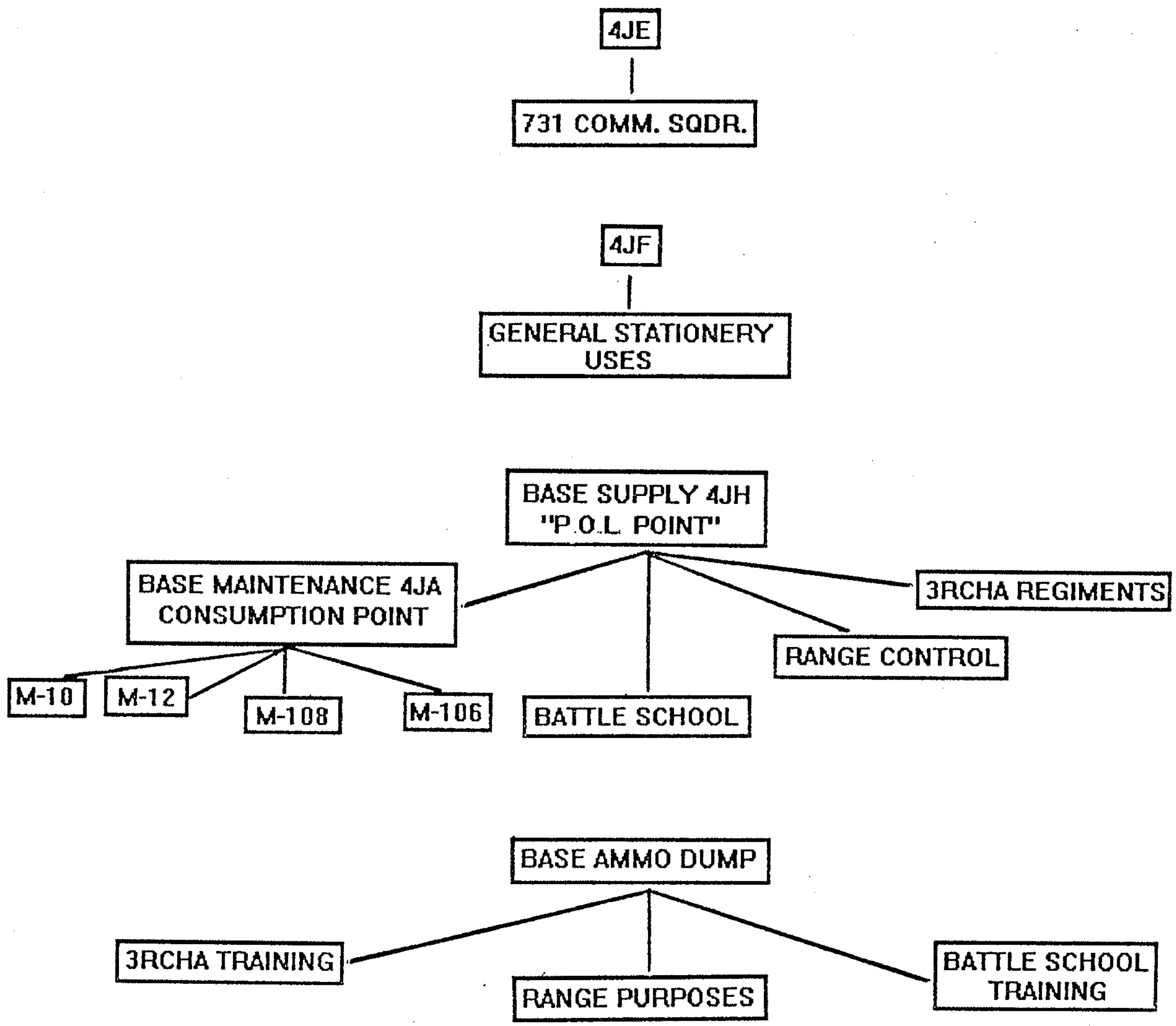


Fig.4.1 Warehouse Distribution of CFB Shilo Hazardous Materials (continued)

Table 4.1 Hazardous Material Purchase, Storage & Usage Estimates, CFB Shilo, Jan.-Dec., 1991

Hazardous Material[a]	1991 Purchases[b]	Dec. 1991 Storage[c]	1991 Usage[d]
Paint Thinners (Non-Petroleum)	N/A	N/A	700 L[e]
Oil & Water-Based Paints (Non-Spray)	N/A	N/A	12,000 L[e f g]
Petroleum Solvents (Distillates)	4000 L	3000 L	10,150 L
Heating Oils & Fuels	13,660 L	minimal	13,660 L
Propane	72,180 L	minimal[h]	72,180 L
Lighting Naphtha	17,130 L	minimal	17,130 L
Kerosene	7120 L	minimal	7120 L
Gasoline (Unleaded)	368,130 L	minimal[i]	368,130 L
Diesel Fuel	495,010 L	minimal[j]	495,010 L
Motor Oils & Lubricants	64,500 L	16,125 L	48,375 L
Brake Fluids	300 L	35 L	265 L
Hydraulic & Transmission Fluids	12,450 L	3100 L	9350 L
Glycol (Anti-Freeze)	14,580 L	3645 L	10,935 L
Sulphuric Acid (for Batteries)	3350 L	200 L	3150 L
Alkali Detergent (for Vehicles)	1640 L	410 L	1230 L
Windshield Washer Fluid	3100 L	775 L	2325 L
Denatured Alcohol	1160 L	290 L	870 L
Photo Chemicals	1100 L[k]	100 L[k]	1000 L[k]
TOTAL >	1,097,410 L	27,680 L	1,073,680 L

[a] excludes restricted items (eg. ammunition), cleaning products and those hazardous materials with minimal annual quantities such as herbicides, boiler additives, spray products, chemical reagents among others.

[b] derived mainly from purchase records (Base Supply).

[c] through observations, figures reflect the fact that hazardous materials stored at any one particular time comprised approximately 15-25% of hazardous material inputs; high turnover rates of Base hazardous products prevented an accurate quantification.

[d] derived from past stocks plus present purchases; amounts were aggregated for all facilities visited.

[e] includes the fact that several facilities outside of CE use minimal annual amounts.

[f] water-based paints are used three times more annually than oil-based paints.

[g] excludes contracted-out work.

[h] kept in two above-ground 5000 L (litre) tanks at the POL Point for short-term storage.

[i] kept in one above-ground 13,000 L (litre) tank at the POL Point for short-term storage.

[j] kept in three above-ground 13,000 L (litre) tanks at the POL Point for short-term storage.

[k] values reflect the amounts before the incorporation of the Base Photo Lab's RA Processor.

storage sites, there were hardly any hazardous material containers (eg. Gas Chamber), whereas in others, the only hazardous products were those in the cleaner's closets (eg. administration buildings or offices). By and large, most facilities have a wide variety of hazardous materials which are maintained in designated locations.

Most of the smaller-sized containers of hazardous materials were either kept inside facility lockers or on the floor (Plate 4.1). Flammables were stored in their own lockers as a precaution against potential hazards (Plate 4.1). When hazardous materials were shelved, it was done according to product type and chemical nature (Plate 4.2). Nearly all of the smaller hazardous items had their labels intact with either product name, NATO stock number and/ or manufacturer number seen. There were an average of less than three unopened boxes of hazardous materials noticeable at the bottom of most lockers.

Cartons of hazardous products are frequently kept in additional smaller buildings (eg. Firehall Supply Storage) or secondary warehouses (eg. Battle School QM Stores). In addition, the POL stock was seen, in most instances, in specialized POL sheds since these provide extra storage space.

Drums of a 205 litre capacity had the product name and stock number printed in small lettering in the front. If not stored in POL sheds, many were found in the facilities

Plate 4.1 Hazardous Materials Storage at the Gardener's Shack

Plate 4.2 The CE Paint Shop's Storage Room

themselves or outside. When drums are kept inside, they are found adjacent to the building walls and foundations, and contain small amounts of product. Not many of these bulk product drums are situated in open space and along aisles where they could be punctured or toppled. When the drums are kept outside, they are usually full or unopened. During winter, these are brought inside the facility. In other instances, it was apparent that the bulk 205 litre drums are in the immediate vicinity of hazardous waste storage areas (Plates 4.3 & 4.4). Also evident near some of these hazardous waste storage sites are those hazardous products which were wrongfully ordered or shipped and which must be made readily available for proper disposal.

There are areas, however, where appropriate storage methods are not adhered to. In some lockers, hazardous materials were placed in the wrong shelves. Sometimes, hazardous products are taken from their original containers, and they are then poured into empty containers of other products without removing original labels, thus confusing matters. The true nature of the hazardous contents can thus only be obtained through direct enquiry. At times, hazardous materials of one kind were purchased while the same type of hazardous material was becoming outdated on the shelves. As an example of this problem, in several instances, facility supervisors had no idea of when products originally came there. Further, other facilities had hazardous products

Plate 4.3 The Hazardous Waste Storage Area For Facility N-118

Plate 4.4 The Hazardous Waste Storage Area For Facility M-12

which were no longer used, but which had been on-site for at least 3-12 years. For instance, the Base Dental Lab had renovations done, but large quantities of contact cement were still very much apparent in the storage locker for hazardous laboratory agents. Although the Repair and Disposal Division does locate and pick-up some of these, the onus remains with the facility supervisor to report materials with exceeded shelf-life or old hazardous materials to the Repair & Disposal division.

4.5 HAZARDOUS MATERIAL SAFETY AWARENESS

At CFB Shilo, the necessary precautionary WHMIS measures have been implemented to ensure that hazardous material handlers become even more aware of safety and emergency procedures. All facilities have military-issued HMGS and similar MSDS records for every hazardous product, and a small percentage of these buildings even have short supplementary compilations of product name, MSDS features, NATO Stock or manufacturer's numbers.

Nevertheless, not all MSDS are immediately available at hazardous material storage and user locations. It was presumed that some materials were newly ordered and that information for them was not initially obtained from the supplier firms. It was also noticeable that MSDS sheets at primary warehouses (eg. Base Supply) were available on the floor, but the entire array could only be obtained once their associated stock or manufacturer numbers are retrieved from microfiche.

Proper clothing was used to protect workers against potential hazards. For acid handling, gloves were worn to prevent skin burns. In addition, during asbestos removal, specialized suits and masks were worn for protection against asbestos particles.

According to facility supervisors, most facility workers are acting appropriately in the event of spills and leakages. For instance, when radioactive leakage is detected, the instrument containing the radioactive material is immediately bagged and shipped to Facility M-106 in Base Maintenance. Additionally, when mercury spills out of instruments, a specialized activator kit is utilized to help reduce occupational exposure while cleaning up. Oil spillages are contained with an absorbent or with spill trays, and during vehicle battery acid filling, the corrosive is poured slowly into the battery casing to avoid splashes or eye injuries.

The prospect for leakages of underground storage tanks also is being addressed. For example, the underground gasoline and diesel tanks at the POL Point will be removed as a safeguard against soil contamination. Presently, there are four 13,000 litre above-ground tanks which are temporarily serving as safe replacements for the worn-out underground ones.

4.6 HAZARDOUS MATERIAL USAGE

The Base uses alot of hazardous materials, with fuels and POL petroleum products representing most of these (Table 4.1). Some restricted hazardous materials which are being phased out can still be found at CFB Shilo, such as PCB's, asbestos and ozone-depleting substances.

Firstly, PCB material was seen at two facilities, the 3RCHA Meteorological Section (Facility RP-101) and outside of the designated hazardous waste storage building (Facility A-20). From discussion with the Meteorological supervisors, it was determined that PCB's were contained in small amounts in the monitoring equipment here. With respect to the latter, transformers with 210 litres of PCB liquids below 50 parts per million were observed.

Secondly, asbestos is continuously being removed from heating pipe insulation and wallboards for analysis. All asbestos above toxic standards are double-bagged and buried in a designated Asbestos Landfill Area within a day after removal from facilities. Even though this is evident, asbestos was still used as a product in at least two locations. Base Maintenance's Facility M-12 utilizes this hazardous component in brakepads. The Base Water Treatment Plant still had approximately 68.1 kilograms of the graphitized asbestos variety in the basement for use as a pump shaft wrapping sealant.

Thirdly, ozone-depleting substances are found on the

Base as refrigerants, fire extinguishing agents, foam packaging chemicals and as anti-static sprays. Approximately 525 kilograms of refrigerant chlorofluorocarbons (eg.R-12), hydrochlorofluorocarbons (eg.R-22) and isotropic mixture (eg.R-502) are kept in the Base's 185 small-scale commercial and domestic equipment such as water coolers and air conditioners. An on-site refrigeration recycling unit for R-12 with reclaimer cylinders has been purchased and will be in place shortly. Three different-sized halon extinguishers (eg. 1, 2 and 7 kilograms) in computer rooms and ammunition-containing vehicles are gradually being phased-out and replaced with dry chemical. Foam packaging agents such as urethane foam resin have contributed to ozone depletion in the past, but the by-product chlorofluorocarbon (CFC) emissions will no longer be generated since the foam packager in Facility C-101 was removed. Anti-static sprays containing ozone depleters, such as those in flux removers, were still utilized in many Base facilities.

In addition, a number of other hazardous materials, found in small quantities and in equipment, are also used at CFB Shilo (Table 4.2). These hazardous materials are purchased as required, and have a high turnover rate. Since many similar product brands have the same NATO stock reference numbers it was not possible to quantify their amounts purchased and on-hand.

Table 4.2 Additional Hazardous Materials Used At CFB Shilo

1) COMPRESSED GASES

- Carbon Dioxide
- Oxygen[a]
- Acetylene[a]
- Nitrogen
- Ammonia[b]

2) FLAMMABLES & COMBUSTIBLES

- Fuel Additives
- Starter Fluids
- Carburettor Cleaners
- Fuel Injection Cleaners
- Wood Cleaners & Polishes
- Wood Polishes
- Paints (Sprays)
- Linseed Oil
- Methyl Hydrate[c]
- Adhesives & Glues
- Grease
- Liquid Waxes
- Methyl Methacrylate[c]
- Rust Solvents
- Liquid Digestants (Most)[c]
- Acetone[c d]
- Methyl Ethyl Ketone[c d]
- Diethyl Ether[e]
- Polyethylene Glycol[c f]
- Methanol[c g]
- Corrosion Inhibitors[c]

3) OXIDIZERS

- Peroxide Bleaches
- Hypochlorite Bleaches[b]
- Toilet Bowl Cleaners (Some)
- Scouring Powders[b]
- Chlorine & Fluorine[c]
- Dishwashing Chemicals[b]
- Fertilizers
- Potassium Permanganate
- Calcium Hypochlorite[b h]

4) TOXICS[i]

- Insecticides
- Pesticides
- Herbicides
- Fungicides
- Wood Preservatives
- Cement Cleaners
- Wood Fillers
- Soldering Flux
- Metal Polishes[a]
- Calcium Chloride
- Liquid Digestant (Containing Bacteria)[j]
- Pharmaceuticals
- Carpet Cleaners
- Disinfectants[b]
- Tear Gas (For Masking)
- Chlorinated Paint Strippers
- Silver (Amalgams)
- Mercury (Thermometers)
- Lead (Battery Cores)
- Nickel-Cadmium (Batteries)

Table 4.2 Additional Hazardous Materials Used At CFB Shilo (continued)

5) CORROSIVES

- Drain Openers
- Oven Cleaners
- Metal Cleaners[a]
- Cement Powders
- Reagent Acids
- Hydrochloric Acid[c]
- Sulphuric Acid (Non-Battery)[c]
- Caustic Soda
- Tile & Grout Cleaners
- Ammonia-Based Cleaners
- Plasters

6) DANGEROUSLY REACTIVE MATERIALS

- White Phosphorus
- Lithium (Batteries)[a b]

7) EXPLOSIVES

- TNT (Trinitrotoluene)
- DM-12 (Plastic Explosive)
- C-4 (Plastic Explosive)
- G-12 (Black Gun Powder)

8) RADIOACTIVES

- Tritium (Compasses & Wristwatches)
- Radium (Old Museum Showpieces)
- Cobalt 60 (Meteorological Equipment)
- Krypton 85 (Meteorological Equipment)

[a] also flammable

[b] also corrosive

[c] also poison

[d] one of several oxygenated ketones

[e] one of several oxygenated esters

[f] one of several oxygenated glycols

[g] one of several oxygenated alcohols

[h] also dangerously reactive

[i] includes poisons and irritants

[j] also biohazardous infectious material

4.7 HAZARDOUS WASTE STREAMS

Although some hazardous materials are becoming hazardous wastes in one way or another, a large number of the former are being used up in their processes. The annual quantities of those hazardous materials at CFB Shilo likely to become hazardous wastes can be seen (Table 4.3). A total of 12 distinct hazardous waste groups were described for CFB Shilo. Their annual generated quantities were tabulated (Table 4.3), and their overall handling was assessed. Most hazardous wastes are being properly disposed of by the Base. However, some potential problems could still surface if precautionary actions are not implemented.

4.7.1 PCB'S

Solid materials with waste PCB's above 50 parts per million include PCB-contaminated capacitors, resistors and ballasts. Presently, 43 kilograms of these are kept in CFB Shilo's designated hazardous waste storage building (Facility A-20). Waste PCB solids were bagged in 4 millimetre plastic, placed into one of two 205 litre drums (Plate 4.5) and interspersed among vermiculite. No more than 30 of these bags were put into the drums which were ring-locked all of the time.

4.7.2 Herbicides & Pesticides

Herbicide wastes arise mainly from contract and in-

Table 4.3 CFB Shilo Hazardous Waste Streams Generated From Facility-Specific Hazardous Materials, Jan.-Dec., 1991

Hazardous Material		Hazardous Waste[b c]						
Group	Approx. 1991 Usage Quantities[a]	Type	Generating Facilities	Approx. 1991 Waste Quantities[d]	Final Base Destination	Disposal Firm	Waste Stream Disposal Cost By Quantity	Total Waste Stream Quantity Costs
NON-HALOGENATED AROMATIC SOLVENTS								
a) Paint Thinners (Includes Lacquer Thinners & Blender Reducers)	500 L							
PAINTS								
a) Automotive Paints (Includes Polyurethanes & Camouflage Paints)	650 L	Contaminated Thinners With Paint	Base Maintenance Spray Booth (Facility M-12)	1000 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 50.00[e]
b) Furniture Paints (Includes Polyurethanes, Varnishes, Alkyds & Oil-Based Enamels)	215 L							
	3600 L							
PETROLEUM SOLVENTS		Contaminated Distillates With Paint Sludge	CE Paint Shop Finishing Booth	650 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 32.50[e]
Naphtha-Based a) Distillates (As Paint Thinners)	1650 L							
(As Degreasers)	8500 L	Contaminated Distillates With Traces Of Petroleum Wastes	Base Maintenance Regiments Battle School	6850 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 342.50[e]
AUTOMOTIVE FLAMMABLES								
Naphtha-Based a) Kerosene	7120 L	Contaminated Kerosene	Base Maintenance	300 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 15.00[e]
b) Diesel Fuel	243,460 L	Diesel & Motor Oil	Regiments	450 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 22.50[e]
c) Gasoline (Unleaded)	224,280 L	Gasoline & Motor Oil	Regiments	900 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 45.00[e]
Hydrocarbons a) Motor Oils & Lubricants (Mainly 15/40, 80W90, 15W40 & SAE 10W)	48,375 L	Waste Oils & Lubricants	Base Maintenace Regiments Battle School	28,000 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 1400[e]
b) Brake Fluids (Glycol-Based)	265 L	Contaminated Brake Fluids	Base Maintenance Regiments Battle School	245 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 12.25[e]
a) Hydraulic Fluids (Mainly Dextran II & Transmission Fluids)	9350 L	Contaminated Hydraulic Fluids	Base Maintenance Regiments Battle School	6800 L	Contract Disposal	Brandon Septic	5 Cents/ Litre	$ 340.00[e]
POISONS								
a) Glycol (Anti-Freeze)	10,935 L	Contaminated Glycol (Anti-Freeze)[f]	Base Maintenance Regiments Battle School	6800 L	Contract Disposal	Brandon Septic	40 Cents/ Litre	$ 2720[e]
		Gasoline & Glycol	Regiments	150 L	Contract Disposal	Brandon Septic	40 Cents/ Litre	$ 60.00[e]
b) Photo Chemicals	1000 L[g]	Silver-Containing Developers, Fixers & Bleach Fixes	Base Photo Lab Hospital & Dental Labs	1000 L[g]	Sewerage			
c) 2,4 D-Amine, Dy-Clear & Pesticides	N/A	Herbicide & Pesticide Equipment Rinseate[h]	Gardener's Shack	50 L	Disposal By Tender	MHWMC[i]	N/A	N/A

Table 4.3 CFB Shilo Hazardous Waste Streams Generated From Facility-Specific Hazardous Materials, Jan.-Dec., 1991 (continued)

Hazardous Material		Hazardous Waste						
Group	Approx. 1991 Usage Quantities	Type	Generating Facilities	Approx. 1991 Waste Quantities	Final Base Destination	Disposal Firm	Waste Stream Disposal Cost By Quantity	Total Waste Stream Quantity Costs
SOLIDS								
Metallic a) Mercury (Amalgams)	N/A	Mercury Amalgams	Dental Lab	120 kg	Recovered For Scrap & Sent to 1CFSD Downsview			
b) Lithium (Batteries)	As Required	Used Lithium Batteries[h]	Facility M-106	63.5 kg	Stored in Facility A-20 (250 kg)	MHWMC[i] (designated)		
CORROSIVES								
Acids a) Sulphuric Acid	3150 L	Neutralized Lead-Containing Battery Acid	Battery Shops In Facilities M-12 & M-101	3000 L	Contract Disposal	Laidlaw Environmental	$ 3.23-3.41/ Litre	$ 9690-[j] $ 10,230
				20 L	Sewerage			
Caustics a) Alkali (Vehicle Detergent)	1230 L	Alkali Vehicle Detergent With Dirt	Base Transport (M-102)	1230 L	Sewerage			
MEDICAL PRODUCTS								
a) Pharmaceuticals (Includes Pills, Capsules, Ointments & Lotions)	N/A	Expired Pharmaceuticals	Base Hospital	68.5 kg	Returned to R-Med (Calgary)			
				91 kg (12 Boxes)	Contract Disposal	Browning-Ferris Industries	$ 35.25/ Box	$ 423.00[k]
		Pathological Wastes (Syringes, Tissues, Gloves & Accessories)	Base Hospital	1542 kg (204 Boxes)	Contract Disposal	Browning-Ferris Industries	$ 35.25/ Box	$ 7190[k]
RADIOACTIVES	In Equipment	Leaking Radioactives	Many Facilities Send These to Facility M-106	three 45.6 L containers (136.7 L)	Sent to 202 Workshop (Montreal) & to AECL (Chalk River, Ontario)	Motorways[i]	Determined By NDHQ	N/A
OZONE-DEPLETING SUBSTANCES								
a) Refrigerants (CFC's & HCFC's)	525 kg	Leaking Refrigerants	All Commercial Base Facilities	very minimal	Atmosphere			
b) Halons	Being Replaced With Dry Chemical	Fire Retardants	All Base Computer Rooms & Ammunition Vehicles	very minimal	Atmosphere			
c) Foam Packaging Agents (Included Urethane Foam Resin)	No Longer Used	Foam Packaging By-Products	Foam Packager Facility C-101 (4JD)	none				
POLYCHLORINATED BIPHENYLS (PCB's)								
a) Solids Above 50 ppm	In Equipment	Waste Solid PCB's	Many Facilities	5 kg	Stored in Facility A-20 (43 kg)			
TOTAL >	564,280 L 525 kg		TOTAL >	57,445 L (from Hazardous Material Usage) 136.7 L (from Radioactives In Equipment) 1890 kg (includes other Hazardous Wastes)				

[a] usage amounts were derived from past stocks and present purchases.

[b] quantities of cleaning solutions being sewered, oil-water sludges, paint particulates, solvent fumes and other atmospheric emissions were not determined in this study.

[c] expired shelf-life herbicides, utility reagents and other hazardous products are disposed of as required through tender.

[d] amounts were derived from facility supervisors, Repair & Disposal (Base Supply) and waste manifests; quantities also reflect the fact that some facilities do not keep track of hazardous wastes.

[e] does not include $ 250 Call-Up and $ 10 Pick-Up Charges.

[f] not considered a hazardous waste in Manitoba but is in other jurisdictions.

[g] values reflect the amounts before the incorporation of the Base Photo Lab's RA Processor.

[h] one of many small-quantity hazardous waste streams disposed of by tender.

[i] one of the firms which either are presently or potentially will be involved with a particular hazardous waste stream's disposal by tender.

[j] does not include $ 200 Call-Up Charges.

[k] does not include monthly $ 450 Pick-Up Charges.

Plate 4.5 Waste PCB Solids Storage at Facility A-20

house applications. The in-house spraying of lawns and shrubbery generates an aqueous residue, which is diluted with water during rinsings of the sprayer equipment. One 205 litre drum is used to collect the 50 litres of contaminated rinseate generated over a year. The drum is disposed of through pick-up by tender. Expired chemicals in the Gardiner's Shack (Facility HP-101) are reported to the Repair and Disposal division.

4.7.3 Radioactives

Most of the radioactive wastes on-site come from leaking calibration devices, compasses, wristwatches and related items. At Facility M-106, the damaged radioactive product is tested for the presence of tritium, radium and cobalt under ultraviolet light. Prior to off-site shipment to either the 202 Workshop in Montreal, Quebec or to Chalk River, Ontario, the disposal procedure at facility M-106 for radioactives is as follows: packaging in leak-proof and heat-sealed 4 millimetre plastic wrap, confinement in specialized welded 45.5 litre drums (Plate 4.6) and storage in a restricted room. A tendered contractor removes approximately 3 such radioactive waste-filled containers from the Base per year.

4.7.4 Hydraulic Fluids, Motor Oils & Glycol

Most of the vehicle-related hazardous wastes originate from bulk POL products. All of these wastes had been blended

Plate 4.6 Radioactive Waste Storage at Facility M-106

together several years ago, but now most are segregated at the consumption point (eg. central waste storage location for an area) where their contents are removed from storage containers and tanks by a contractor. The only times when blending still occurs is when all of the POL wastes amount to just one 205 litre drum, or through inadvertent pouring of a specific POL waste into the wrong drum.

The consumption points for POL vehicle wastes are located outside (Plates 4.3 & 4.4). The following POL vehicle hazardous wastes are stored in 205 litre drums: hydraulic fluid, brake fluid, glycol and kerosene. Waste glycol is also poured into above-ground 1136.5 litre tanks. Waste motor oils, usually stored in above-ground 1136.5 and 2273 litre tanks, may also be kept in 205 litre drums or be utilized for fire-fighting training. Separate waste drums are used as well for potential mixed components, such as oil-glycol combinations which are occasionally generated from blown head gaskets. No housing of POL wastes against the weather elements was witnessed. Annual rainfall and snowfall could corrode the steel drums or tanks, and precipitation could cause leakage through rusty sections.

Spill prevention is appropriate not only at consumption points, but also inside vehicle servicing facilities. Outside the Gun Park (Facility N-118), for instance, ground spills at the consumption point are contained by a plank confinement with a sand base. Spill dispersion is further prevented through drip pans below the drums. Nevertheless, some slop-overs occur even though safeguards were initiated. Inside facilities, POL wastes are contained through drip pans and an absorbent.

Some POL wastes drip on the floor and are washed into floor drain sumps. There was the incorporation on-site of only one oil-water separator, which was constructed in Facility M-101 for containing large oil volumes and which was connected to two sumps. The features of the waste found in the sumps generally include a sludge which results from the combination of oil with the mud from vehicle washoffs. The waste in the separator can be described as an oily component which became segregated from the aqueous washwater medium. Both the sump and separator contents are removed regularly. Problems had existed with the separator in the past since no monitoring for waste oil and dirt overflows into the sewage had been exercised. Nevertheless, the situation is now more stringently scrutinized.

4.7.5 Acids

Acid wastes are mainly of battery origin. Vehicle lead-sulphuric acid batteries are drained at CFB Shilo Battery Rooms (Plate 4.7). The only two Base Battery Rooms seen were in Facilities M-12 and M-101. Sulphuric acid is neutralized with sodium bicarbonate powder and then poured into a 205 litre polyethylene drum which is disposed of by contract.

Plate 4.7 The Battery Room of Facility M-101

However, some acid still remains in the 300 battery casings when these are annually shipped to a scrap-metal dealer. A previous neutralizing procedure had been the direct pouring of battery contents into a vat and sewerage, but this practice had been abandoned since acid had splashed onto personnel.

Other acids employed during Base cleaning (eg. toilet bowl cleaners) likely find their way into the sewage lagoon. Nevertheless, these pose minimal hazard since they are diluted or biodegraded.

4.7.6 Alkalies & Bleaches

CFB Shilo generates a wide variety of corrosive alkali and bleach wastes which eventually enter the sewer. Hypochlorite bleach wastes originate from the kitchen areas and from Base Cleaning. Waste alkali industrial detergent, which is also comprised of sulphonates and phosphates, originates from vehicle washings, is not collected once it enters the drains, nor is it neutralized before it finds its way into the waste water system. This detergent, however, also poses no great threat since only 1230 litres are used.

Household batteries, such as alkali D-cells, which were apparent at several facilities on-site, are thrown into the garbage once utilized. In the past, these had likely been transported to the landfill site for final disposal, but are now taken away by Browning-Ferris Industries (BFI).

4.7.7 Cleaning Solvents

Most spent solvents are disposed of through contract and are picked up in 205 litre drums outside their user facilities. Solvents, if not used up or vaporized, are becoming waste streams from at least two Base applications: degreasing and painting.

Degreasing Solvents

Solvent wastes from degreasing operations and vehicle parts cleaning consist of petroleum distillates. Traces of motor oils, brake fluids, grease and dirt could possibly be found in spent petroleum distillate contents since washing in a bath removes contaminants from numerous parts. A chlorinated aliphatic hydrocarbon degreasing agent, 1,1,1-trichloroethane, may have been a constituent of the petroleum distillate waste stream in the past, but since 1990, this secondary degreaser is no longer utilized as a dipping material for carburettor cleaning.

Painting Solvents

Painting operations constitute the second source of CFB Shilo's hazardous solvent wastes. Two different paint thinner solvent classes are used at the Base, so the hazardous waste content varies. In the CE Paint Shop, brushing and rolling account for roughly 650 litres per year of waste petroleum distillate-containing oil-based paint sludge.

Traces of lead, chromium or cobalt could possibly be found in the sludge since these metals are present in certain pigments. Paint spray gun washings from the booth in Facility M-12 account for the 1000 litres per year of urethane and lacquer-containing waste toluene and xylol (eg.non-chlorinated aromatic hydrocarbons). Very minimal sludge quantities, however, result from Facility M-12's spray booth.

4.7.8 Photo Chemicals

Spent photo chemicals such as developers, silver-containing fixers, reducers and blenders arise from photo processing in two Base locations.

The Base Photo Lab's Kreonite, Black and White and Rapid Access Chemistry (RA-4) Processors contribute approximately 220 litres of photo chemical concentrate per year to the Base sewage prior to dilution. However, before September, 1991, when the RA-4 had replaced the former EP-2 one, 700 litres of photo chemical concentrate were sewered annually. Therefore, roughly 90% less photo chemical wastes are now being generated with the RA Processor since most of the previously utilized chemicals for the EP-2 Processor now are replenished in the RA-4 unit to substantially minimize ammonia, biological oxygen demand (BOD), chemical oxygen demand (COD), sulphides and thiosulphates (Eastman Kodak Company, 1989).

Photo chemicals arise at the Base Hospital as well. An approximate yearly total of 320 litres of these concentrated hazardous wastes are sewered from X-ray film processing at the facility's X-Ray and Dental Labs.

Even though photo chemicals contain some biodegradable components, spent photo chemicals are still potentially hazardous if they accumulate for long periods of time.

Aqueous silver ions in the Photo Lab's chemical effluent, although only slightly toxic because of the minimal quantities generated and the dilution factor, are, nevertheless, not presently recovered for economic merits. Silver recovery for the Base Hospital's X-Ray Labs was deemed as not feasible by supervisors from this facility.

4.7.9 Toxic Metals

Most toxic metals are being sold at CFB Shilo for scrap, which includes the mercury and silver amalgams in dental fillings.

Used lithium batteries are brought to Facility M-106, where their terminals are taped, placed into a plastic bag and heat-sealed. From there, the spent lithium batteries are brought to the designated Base hazardous waste storage building, Facility A-20, where the lithium battery-containing bags are laid into a 1.13 cubic metre cardboard and vermiculite-lined plastic box filled with additional vermiculite (Plate 4.8). Presently, there are 250 kilograms of

Plate 4.8 Waste Lithium Battery Storage in Facility A-20

spent lithium batteries housed here.

Other toxic metals include nickel-cadmium in batteries and mercury in thermostat bulbs. The former can no longer be recharged and arise from range finders. Both are brought to Facility M-106 for bagging, but a storage location is yet to be determined. Both will be removed from the Base by the Manitoba Hazardous Waste Management Corporation (MHWMC) once sufficient quantities are attained.

4.7.10 Medical Wastes

Pathological wastes are handled accordingly at CFB Shilo's Base Hospital (Facility HP-3). First of all, any syringes, needles and broken glass tubes, contaminated with blood, urine or saliva, are placed into red "sharps containers". Secondly, any contaminated human tissues, linens or biochemical dry test equipment material were put into special autoclavable disposal bags which were placed into pails. Each Hospital room had autoclavable bags lining the pails. When these bags were filled up, they were placed into regular garbage bags, and brought to the designated storage room in the Base Hospital. Prior to monthly pick-ups by Browning-Ferris Industries (BFI), the medical wastes were put into plastic-lined 0.23 cubic metre boxes (Plate 4.9). Approximately 214 of these boxes (1633 kilograms in total) are being taken away from the military site annually.

Medical wastes originated from three areas in the Base

Plate 4.9 Medical Waste Storage at the
Base Hospital

Hospital. Roughly 55% of the medical waste total came from the Dental Clinic. It encompassed mainly teeth extractions, bone tissues, contaminated latex gloves and other accessories. The remaining medical wastes arose from the Ward Treatment Room and the Pharmacy. Pharmaceutical wastes were comprised of such items as pills, lotions and creams. If the shelf lives had expired, pharmaceutical wastes were either contract removed as above or were sent back to the manufacturer for credit through the Base Hospital's supply depot in Calgary, Alberta (R-Med).

It was just one year ago that half of the above mentioned medical wastes had been brought once weekly to Facility A-15, where they had been treated through the Base's natural gas-fuelled paper-combusting incinerator (Plate 4.10). The remnant ash from incineration had been disposed of in garbage bags destined for the landfill.

4.7.11 Atmospheric Emissions

Most hazardous waste emissions at CFB Shilo are being liberated into the atmosphere in compliance with all existing government requirements. There is, however, at least one combination of aerial contaminants which may pose problems.

Paint particulates and solvent fumes are not monitored as these leave the paint finishing booth in the CE Paint Shop (Plate 4.11) and the larger paint spray booth in Facility M-12. According to facility officials, these booths have

Plate 4.10 CFB Shilo's Incinerator at Facility A-15

Plate 4.11 The CE Paint Shop's Finishing Booth

been described as at least 30 years old, improperly functioning and containing no pollution control equipment whatsoever, except for collecting dust.

4.7.12 Leachates

Leachates from Base activities no longer pose a threat in the Base Landfill site since discarded containers with hazardous material residues (eg. motor oils and solvents) and alkali batteries are taken away from CFB Shilo by Browning-Ferris Industries (BFI). Although this practice has been in place for at least a year, a possibility remained that some of the containers could have previously been found at the Base Landfill since, during March, 1991, several of these were seen at this location. Prior to last year, one does not know, however, how much hazardous residue had already leached into the Base Landfill from military operations. What was known was that all of the older domestic hazardous chemical containers had been fully drained for several years at the Base Service Station prior to their disposal to the Base Landfill.

Leachates from the Base Lagoon, located two kilometres from the Base, is distinctly possible. As stated by Base Water Treatment Plant personnel, the four cells have no clay bottom, are tested for coliform content <u>only</u> and were never pumped out (refer to EPS Report 5-NW-78-1). Wastewater flows into the lagoon at a rate of approximately 18,000 cubic metres per day during the summer and 10,000 cubic metres per day during the winter (Dugan, personal communication).

4.8 PRESENT BASE HAZARDOUS WASTE DISPOSAL PRACTICES

Contract disposal is the current practice for most of CFB Shilo's hazardous waste streams. Trucks come onto the Base and either extract the hazardous wastes directly from the drums or take the drums with them. On average, 205 litre drums have their contents removed by disposal firms twice a year. Waste motor oils are extracted six to eight times a year from the 1136.5 and 2273 litre above-ground tanks. Even if a drum is only half full, a firm still would remove the contents. Nearly all of the Base's liquid hazardous wastes are handled by Brandon Septic, but there are three other firms which assist in the disposal effort (Table 4.3). The waste battery acid is picked up by Laidlaw Environmental Services Ltd. The medical wastes are removed by Browning-Ferris Industries (BFI). Hazardous wastes of smaller quantities (eg.herbicide and pesticide rinseate) and products with exceeded shelf-lives are accumulated with other such minimal hazardous waste streams and are removed through tender since contracts do not exist for these. The organization which performs most of the Base's tender disposal is the Manitoba Hazardous Waste Management Corporation (MHWMC).

Some of CFB Shilo's hazardous wastes are not contract disposed of, but rather enter the environment.

Sewerage from photo development and vehicle washings have hazardous components in them and are not treated prior to discharge into the drains since there are presently no federal regulations to account for such an action.

Other hazardous wastes such as paint particles or solvent fumes are liberated into the atmosphere unmonitored, but the Base is complying with all existing governmental guidelines for emissions.

CFB Shilo pays variable hazardous waste quantity prices for different hazardous waste streams, but 5 cents per litre is the general price paid (Table 4.3). Lack of a treatment facility within the province for specific hazardous wastes (eg. medical wastes) signifies that CFB Shilo is paying higher disposal costs, of which transportation to treatment facilities out of the province must be added.

4.9 SUMMARY OF BASE-SPECIFIC GUIDELINES & LEGISLATION

CFB Shilo is complying with all existing federal and provincial guidelines and regulations pertaining to hazardous materials and wastes (Table 4.4). As new guidelines and legislation emerge for hazardous materials and wastes, the Base will have to monitor their ability to adhere to acceptable procedures.

Table 4.4 Guidelines and Legislation Pertaining To Base Hazardous Materials & Wastes

OVERALL HAZARDOUS MATERIALS AND WASTE MANAGEMENT

- DND Order CFAO 36-50 (Environmental Protection Management)
- DND Hazardous Material Storage & Handling Guide, Vol.4 (A-LM-187-004/JS-001)
- Canadian Environmental Protection Act (CEPA)
  - Present and Future Regulations

HAZARDOUS MATERIALS

- DND Order CFAO 36-55 (Hazardous Materials)
- The Dangerous Goods Handling And Transportation Act (C.C.S.M.c.D12) (takes effect for TDGA)
- Atomic Energy Control Act (R.S.C. 1970, C.A-19)
- Explosives Act (R.S.C. 1970, C.E-15)
- Pest Control Products Act (R.S.C. 1968-69, C.z50)
- Manitoba Environment Act's Regulation 94/88R (Pesticides)
- Environmental Code of Practice For Underground Storage Tank Systems Containing Petroleum Products-1989 (C.C.M.E.)
- Manitoba Environment Act's Regulation 97/88R (Storage & Handling Of Gasoline & Associated Products)
- Code of Practice for the Reduction of Chlorofluorocarbon Emissions from Refrigeration and Air Conditioning Systems (EPS-1-RA-91-1)
- Manitoba Ozone Depleting Substances Act's (C.C.S.M.c.080) Regulation 15/92
- WHMIS

HAZARDOUS WASTES

Storage & Off-Site Disposal

- Guideline for the Management of Waste Material Containing Polychlorinated Biphenyls (EPS-1-EC-78-1)
- Guideline on Central Collection and Storage Facilities for Waste Materials Containing Polychlorinated Biphenyls (EPS-1-EC-78-8)
- The Dangerous Goods Handling And Transportation Act (C.C.S.M.c.D12) (takes effect for TDGA)
- Atomic Energy Control Act (R.S.C. 1970, C.A-19)
- Explosives Act (R.S.C. 1970, C.E-15)
- Manitoba Environment Act's Regulation 94/88R (Pesticides)
- Guidelines for the Management of Biomedical Wastes (C.C.M.E., EPC-WM-42-E)

Table 4.4 Guidelines and Legislation Pertaining To Base Hazardous Materials & Wastes (continued)

HAZARDOUS WASTES

Treatment

- National Guidelines on Physical-Chemical-Biological Treatment of Hazardous Wastes (C.C.M.E., TRE-27F)

Sewering & To Lagoons

- no federal guidelines nor legislation
- Adjacent Municipal Sewering By-Laws (could be adopted)

Leaving Lagoons

- Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments (EPS 1-EC-76-1)
- Fisheries Act's Provision for Deleterious Substances Directly Entering a Watershed

Landfills

- Manitoba Environment Act's Regulation 98/88R (Waste Disposal Grounds - Class II Site)

Aerial Emissions

- Air Pollution Guidelines Applicable to Boilers at Federal Establishments (EPS 1-EC-79-1)
- Air Pollution Guidelines Applicable to Incinerators at Federal Establishments (EPS 1-EC-78-5)

CHAPTER V - OPTION ANALYSIS

5.1 INTRODUCTION

This chapter will address the third objective of this study and will assess, through practicability, economics, wherever possible, and other criteria, which of the presented options (Chapter III) are suitable for the operations seen during the CFB Shilo site inspections (Chapter IV). Some of the preceding options should be discussed in the context that there will be ever-changing market prices (eg. raw material purchases and disposal costs), compliance with regulations, safety emphasis and efficiencies in implementation.

5.2 HAZARDOUS WASTE REDUCTION OPTIONS

Several options in hazardous waste reduction are available to CFB Shilo. These focus primarily upon source avoidance and other source reduction techniques.

5.2.1 Source Avoidance at CFB Shilo

Source avoidance options such as managing the inventory, promoting substitutions and implementing process changes are all possible for the Base.

Inventory Management at CFB Shilo

CFB Shilo staff, in general, follow stock rotation procedures. In certain instances, stock is not rotated properly, leading to the accumulation of expired hazardous products. Not all of the hazardous chemicals are reported as soon as they exceed their effective use date. The option for CFB Shilo here would be to educate personnel through presentations for appropriate stock management procedures. In addition, posting of information signs to serve as a reminder to Base staff of routine awareness for stock status could be beneficial. The associated cost of this option would be negligible.

Hazardous Material Substitutions at CFB Shilo

An option that does not appear to be fully considered for CFB Shilo is hazardous material substitutions. Although substitution with non-hazardous chemicals is one of the most preferred ways to achieve minimal hazardous waste streams, appropriate substitutes are not always available. However, for others, less hazardous substitutes are being developed on a regular basis. Solvents, paints, lubricants, ozone-depleting substances and metallic batteries have shown the most promise for being replaced, but the costs of their replacements is presently expensive.

Cleaning solvent substitutions are viable options for CFB Shilo. Hydrocarbon solvents can, in some cases, be substituted with non-organic products (GAO, 1989). Also, petroleum-based solvents could possibly be replaced with non-hazardous steam cleaning compounds (GAO, 1989).

Water-based colloidal degreasers have been deemed as substitutes for petroleum distillates (Gargan, personal communication). Some of these aqueous compounds have non-corrosive, non-volatile and non-flammable properties. Other merits such as indefinite shelf-life, almost 100% bio-degradability within half a month, multi-purpose applications and immediate breakdown of water tension are, however, offset by the product's inability to remove scale or lime (Gargan, personal communication), inability to provide the degree of cleaning desired, requirements for additional drying (Dharmavaram et al., 1988) and high purchase prices (Gargan, personal communication).

When compared to product petroleum distillates ($ 27-$ 32 per 205 litre drum), water-based degreasers such as Siege and 3D Supreme, both at $ 700 per 205 litre drum, are each 23.3 times more expensive (Gargan, personal communication). Non-hazardous De-Solve-it may be sold as high as $ 1650 per 205 litre drum (Gargan, personal communication). Even though this appears cost-intensive, if diluted properly, prices will be better reflected since dilution with an aqueous degreaser will, unlike conventional solvents, enhance the product's cleaning effectiveness (Gargan, personal communication).

Used water-based degreasers must also be disposed of since there are heavy metal contents in them (Gural, personal communication). The disposal cost is $ 550 more expensive from that of conventional spent solvents (Gural, personal communication). It has been suggested that aqueous degreasers be reused once the product is segregated from the grease which settles out (Gargan, personal communication), but it becomes cost-prohibitive to filter out the grease on-site from the aqueous material (Gural, personal communication).

Despite the disadvantages for water-based degreasers, cleaning agents, such as Citrikleen, have been acknowledged as acceptable by the American military (GAO, 1989). One such degreaser could even serve as a soil decontaminant as well (OWMC, 1988).

Paint strippers of the methylene chloride or phenol varieties could be replaced with some of the less toxic ones (Dharmavaram et al., 1988). Non-volatile ester-based strippers have merit since they are almost odourless, safe to breathe and less likely to irritate the skin. These paint strippers also provide facilitative paint clean-up by light scrubbing with a wet rag (Consumer Reports, 1991a). Even though 4.55 litres of a non-solvent stripper covers 4.88 metres, there are drawbacks such as longer drying-out times, five times longer paint coat removal time and an estimated 36% more average cost (eg. $ 30 versus $ 22) than hazardous strippers (Consumer Reports, 1991a). These disadvantages, however, are not significant where only small amounts of materials are processed.

Paints and primers with less hazardous ingredients could, at times, be further introduced as reasonable substitutes for those epoxies, alkyds or lacquers which pose environmental risks. Non-phenolic, lead-free or chromate-free varieties could be purchased instead of the phenol-based or metal-laden ones (GAO, 1989). In addition, the usage of more water-based latex at the Base could be implemented since these paints have been shown to release limited volatile organic solvent vapours during drying as compared to oil-based alkyds (Consumer Reports, 1990). Besides being applicable to damp surfaces, drying faster, requiring only soap and water (eg. no mineral spirits) and being calculated to cost approximately 21% less per 4.55 litres than alkyds, latex products do have their detriments, including inferior properties (eg. less adhesion, toughness or glossiness) and possible mercury content as an anti-mildew agent (Consumer Reports, 1990).

Lubricants of a synthetic or bio-based (eg. from animal or plant origin) nature could become substitutes for Base cutting oils, greases or motor oils. Besides containing biodegradable material and incurring no associated disposal cost, synthetic lubricants have variable properties, depending upon the product: a wide temperature tolerance range, evaporation without any residue, water-solubility and minimal additives such as chlorine or sulphur (Brock, personal communication).

The synthetic motor oils, in particular, have additional meritable attributes: less carbonization and a volatility factor 12% lower (eg. less volatile organic compounds) than general petroleum lubricants (Brock, personal communication). The main drawback for synthetic lubricants is the price, which is, in most circumstances, two and one half times the cost of ordinary lubricants (Brock, personal communication).

Ozone-depleting substance replacements are becoming available, but these are deemed as only partly effective. If, for example, a replacement for refrigerant R-12 is to be fully effective, it must be miscible with a compatible refrigerant oil, yield a specific heat and have a desired boiling point and saturation temperature (La Plante, personal communication). R-134a could substitute for R-12, but it is still being tested because it loses 15% efficiency over R-12, costs 25 times more per kilogram than R-12, and utilizes an oil at $ 80 per 4.55 litres (La Plante, personal communication). Further, usage of R-134a would require that cost-intense changes be made to some parts of the refrigeration equipment and would signify that a refrigeration unit may become too small because of capacity lost between the two refrigerants, R-134a and R-12 (La Plante, personal communication).

Batteries with toxic metal materials could be replaced with less toxic varieties at CFB Shilo.

Nickel-cadmium batteries could be substituted for with nickel-hydroxide ones. These latter batteries would cost the same as or be cheaper than those containing nickel-cadmium and would perform just as well or even better (Duracell Ltd., personal communication).

Gel batteries could replace existing lead-acid batteries for Base vehicles. These innovative batteries are leak-proof, have a safety factor, generate less hazardous fumes, are maintenance-free (eg. no water additions) and provide the same power in a smaller space (Duracell Ltd., personal communication). The main disincentive, however, is a purchasing price of $ 250, five times more than that of conventional lead-acid batteries (Duracell Ltd., personal communication).

Other potential substitutions for CFB Shilo include: 1) insecticides with active ingredients of either fatty acids, Bacillus thuringiensis or pyrethrins/ piperonal butoxide for the more hazardous chemical equivalents (Consumer Reports, 1991b) and 2) man-made fibres (MMF) and sintered iron for asbestos insulation and brakepads, respectively (Epstein et al., 1988).

Process Changes at CFB Shilo

Because of the minimal amounts of some generated hazardous wastes, applicability for the task at hand, capital intensiveness, effectiveness and other factors, some process changes do not apply as options to a Base the size of CFB Shilo. However, the process changes which are potentially possible for reducing hazardous wastes at this military site are illustrated in the upcoming sections, and these encompass modifications in equipment and adaptations to innovative operational approaches.

Equipment Modifications

Modifications in present equipment function at CFB Shilo could lead to a reduction in the amount of hazardous wastes. These could be geared mainly for paint particulates and for photo developing wastes.

New booths for paint finishings and for spraying could be installed into Facility M-12 and the CE Paint Shop to replace the present inefficient systems. For a purchase price of around $ 30,000, a 3.05 metre high booth with accessories would allow for a proper air intake, cut down overspray and, therefore, generate less paint particulates (Marino, personal communication).

The existing spray booth in Facility M-12 could have its exhaust fan covered with appropriate filters to prevent paint emissions from entering the atmosphere. Not only are dry overspray collectors cost-effective and assist in performance, but these are also made up of kraft material layers which are not only non-hazardous and biodegradable but which are also highly effective in absorbing particulates (Columbus Industries, Inc., 1989). The only concern would be whether the paint-laden collected wastes are themselves hazardous.

Resin column adsorption with an anionic exchange system could be adopted for the Base Photo's C-41 Processor. The halide anion, which is a by-product of film development and which originates from the film itself, is found in the overflow solution as replenisher is added to the tank (Eastman Kodak Company, 1991). Because developer regeneration is impeded by the presence of the halide, this ion should be removed (Eastman Kodak Company, 1991). A styrene-divinylbenzene resin (eg. Rohm and Haas Ira-400 variety), once installed into the C-41 equipment, can effectively take away halide and other photo development decomposition products from the overflow (Eastman Kodak Company, 1991). As halide ions are adsorbed onto the resin column, bicarbonate anions are added to the overflow to replace the halide (Eastman Kodak Company, 1991).

Even though this option offers the initial step for developer regeneration in the C-41 Processor, there are associated problems which include a large capital requirement, pH adjustments, loss of resin efficiency and mechanical malfunction of the column (Eastman Kodak Company, 1991).

Operational Enhancements

New methods can be investigated at CFB Shilo which achieve the same end as those Base operations which presently generate hazardous wastes. These could particularly be incorporated in Base vehicle servicing garages and painting operations.

A Fast-Lube Oil Change System (FLOCS) has evolved as a commercial technique for transferring and draining oil from vehicle crankcases (Dharmavaram et al., 1988). The American military is considering this vehicle maintenance option as a means of keeping hydraulic fluid and motor oil contamination at a minimum (Dharmavaram et al., 1988).

A water-based low volume-low pressure (LVLP) paint sprayer could be used in both Base painting booths and for cleaning brushes and rollers in the CE Paint Shop. The LVLP system has a non-conventional spray gun costing $ 877, uses non-hazardous urethane, requires less paint, increases paint transfer efficiency, has low cleaning costs (eg. $ 29.22 per litre of paint) and generates less hazardous emissions and waste (Senick, personal communication). In general, the LVLP paint sprayer offers financial savings within a year and a half after being purchased since it does the same amount of work in a shorter time (Senick, personal communication).

The option of using a paint sludge dewatering system to separate paint from a water mixture by returning clean water to the wash tank (OWMC, 1988) is not feasible on the Base.

Even though this equipment costs about $ 8000 and is capable of reducing large waste volume amounts (OWMC, 1988), it would become ineffective at the CE Paint Shop since the annual 650 litres of painting solvents containing sludge is non-water-based and of low quantity.

Cryogenic cleaning is a process which air-blasts dry ice particles onto a dirty surface such that, at reduced temperatures, contaminants become brittle and can be easily removed (OWMC, 1988). This alternative to alkali detergent usage at Base Transport is, likewise, ruled out for CFB Shilo since minimal 1230 litres of per year of caustic detergent are generated.

5.2.2 Additional Source Reduction Options

Other means for achieving the same end as source avoidance exist for CFB Shilo. Recovery, contract recycling, in-line recycling and reuse are all potential source reduction ventures for the Base's hazardous wastes. Some of these options are presently being used or are under consideration.

Hazardous Waste Recovery at CFB Shilo

Most hazardous waste recovery methods, other than those mentioned for metals in an aqueous media and for solvents with contaminants, are not feasible for a Base of this size.

Ion exchange units could be considered for silver recovery at the Base Photo Lab. Ion exchange cartridges could be incorporated here for a cost of approximately $ 3000 each (Edmunds, personal communication) so that silver does not become part of the pre-sewer network. Their implementation, however, requires that they be shipped to the United States for refining (OWMC, 1990).

Low volume solvent collection systems, such as distillation units or evaporators, are popular recovery options (Dharmavaram et al., 1988). Either of these could be used at CFB Shilo. An on-site distillation unit, for instance, could accept a wide variety of solvents, including petroleum distillates, if a vacuum is attached to the unit (Marino, personal communication). On-site distillation units can be purchased for less than $ 8500 (The Hazardous Waste Consultant, 1989). Additional costs on top of the unit's purchasing price include 7-10 cents of electricity per 4.546 litres processed, a half hour of semi-skilled labour per shift (The Hazardous Waste Consultant, 1989) and extra floor space.

Contract Recycling at CFB Shilo

Contract recycling of spent petroleum distillates is an option for CFB Shilo. Firms such as Safety-Kleen Canada, Inc. assist in the recycling of this waste on-site. They supply the generators of spent petroleum distillates with a recycling unit, handle the servicing aspect of it and provide a new product in exchange for waste petroleum distillate which has exceeded its recycling capability (Safety

Kleen, Inc., 1990).

In-Line Recycling at CFB Shilo

Several in-line recycling options are available for hazardous waste reduction at CFB Shilo. These pertain to the waste glycol coolant seen at vehicle servicing facilities and the spent photo chemicals from two of the Base Photo Processors.

Waste glycol could be recycled through a portable filtration unit such as a suitable power flusher. By attaching directly to the vehicle's cooling system in a closed-loop fashion, corrosives and particulates are removed from the used coolant and the glycol is rejuvenated (Wynn Oil Company, Ltd., 1988). However, the unit requires maintenance flushing chemicals and filters for proper functioning (Wynn Oil Company, Ltd., 1988).

Regeneration of Base photo chemicals is possible. For the RA-4 Processor, individual in-line recycling of either bleach or fixer could lower BOD, COD, sulphates, iron and ammonia in the wastewater by an additional 12% (Eastman Kodak Company, 1989). This individual recycling could only arise if <u>separate</u> bleach and fixer are utilized during RA-4 operations (Eastman Kodak Company, 1989).

For the C-41 Processor, once halide ions are removed from the overflow, the developer can be regenerated with the addition of a specialized photo chemical product (Eastman

Kodak Company, 1989).

In a similar fashion, the bleach needed during C-41 activities can be recycled with the addition of a photo chemical product specifically designed only for bleach regeneration (Eastman Kodak Company, 1989).

Once an electrosilver fixer is added to the C-41 Processor, the fixer replenishment rate could be reduced by 50%, photo chemicals in the processing effluent would be minimized and silver ion removal could be made easier (Eastman Kodak Company, 1991).

Hazardous Waste Retrograde Reuse at CFB Shilo

Hazardous waste reuse options for CFB Shilo could be considered for motor oils, hydraulic fluids and non-chlorinated solvents. Most of the Base's lubricant wastes could be reused as secondary lubricants after they have been filter-pressed to remove dirt constituents. Petroleum distillates and paint thinner aromatics, once isolated and filter-pressed, could be carefully catamized into the numerous Base natural gas boilers (Gallop, personal communication).

Off-Site Recycling of CFB Shilo's Hazardous Wastes

CFB Shilo may be able to take advantage of the Manitoba Waste Exchange. For just an annual fee of $ 25, hazardous wastes being disposed of (eg. waste oil or glycol) could be made available at such an exchange. However, it would be CFB

Shilo's responsibility to make sure that the hazardous waste's chemistry and nature conform to the user's specifications (Lohvinenko, personal communication).

Another off-site recycling option could be for CFB Shilo to directly consult with local firms which may need some of the Base's discarded chemical substances and hazardous wastes. For instance, firms such as soft drink or textile manufacturers in either Brandon or Winnipeg may require CFB Shilo's waste battery acid as a neutralizing agent for their alkaline wastewaters.

5.3 HAZARDOUS WASTE TREATMENT & DISPOSAL OPTIONS

Several alternatives exist for either treating the Base's hazardous wastes on-site or for improving the manner in which disposal is performed.

5.3.1 On-Site Hazardous Waste Treatment at CFB Shilo

Treatment for some of CFB Shilo's hazardous wastes could be implemented. The following physical and chemical treatment suggestions merit attention.

Physical treatment could be geared towards oil-water mixtures. If more operations become predominant in vehicle servicing areas, additional oil-water separators could be constructed in garage facilities to minimize potential oil sewage discharges. Filter presses, which remove dirt from waste oil, can be purchased for $ 5000 to $ 10,000 (Laird, personal communication). For $ 4500, a centrifuge-like de-emulsifier could be incorporated as a means to separate the water content of waste oil (Brock, personal communication). The sludge cake which is left behind contains microelement additives (eg. zinc and cadmium) and could be made available to mining firms (Brock, personal communication).

Chemical treatment for some of CFB Shilo's aqueous waste streams could be considered. Precipitation is based upon the conversion of soluble metal ions to hydroxides of lower solubility once caustic soda, hydrated lime or quick lime is added to the effluent (Cheresiminoff, 1990). Even though drawbacks associated with precipitation are addition of excessive numbers of treatment ions, pH dependence and precipitate removal via another chemical method (Cheresiminoff, 1990), this option is still worthy of mentioning. Precipitation of silver from sewered spent photographic developers is possible at the Base Photo and Hospital X-Ray Labs. Precipitation of lead from waste battery acid is, likewise, possible. This would ensure that no lead becomes part of the neutralization process.

Waste alkali detergent rinsings in Base Transport (Facility M-102) could be neutralized with appropriate acid. This neutralization could, potentially, be implemented if facility supervisors remove contaminants beforehand and comply with the chemical principles of such a practice.

Flocculation is a low-cost chemical treatment method

(Valdirio, 1990) which is also a potential option for the Base if water-based paints become more predominant. Flocculation allows for aluminum salts (eg. alum) and iron salts to assist in the agglomeration of small colloids (eg. unsettleable liquid-suspended particles) into larger settleable flocs (Cheresiminoff, 1990). The only negative aspect of flocculation is the likelihood of liquid being contained in the concentrated solid (Valdirio, 1990).

If the task for treatment exceeds Base capabilities, firms in the private sector could be consulted with to periodically come onto CFB Shilo. For instance, engineering companies in Minneapolis have all of the latest technologies available on mobile units to treat most of the Base's hazardous waste streams (Gallop, personal communication).

5.3.2 Hazardous Waste Disposal Options for CFB Shilo

The present situation of preparing for the actual removal through contract of numerous Base waste streams could be improved.

CFB Shilo's hazardous wastes could be picked up when the same contractor visits and removes hazardous wastes from nearby industrial sources. Joint disposal can be a cost-saving measure which reduces hazardous waste transportation expenses. Instead of contract disposing by itself, the Base could accordingly tie-in its hazardous waste stream disposal once the disposal frequencies of local firms are known. For example, when radiator repair shops in Brandon dispose of their waste glycol, this similar hazardous waste could be collected from the Base at that time. The Manitoba Hazardous Waste Management Corporation (MHWMC) in Winnipeg could be consulted to act as a broker for finding suitable firms to perform this joint disposal effort.

Reprocessing of some CFB Shilo's hazardous wastes is a viable hazardous waste disposal alternative which ensures a coverage for liability while at the same time being cost-competitive with standard disposal by contract. All waste hydrocarbon lubricants (eg. motor oils and hydraulic fluids) or non-petroleum distillate paint thinner solvents (eg. xylene) could be picked up from the Base so that these can be treated off-site for eventual re-use elsewhere. However, off-site reprocessing of either waste brake fluids, naphtha fuels, anti-freeze or petroleum distillates are not deemed as worthy options.

Reprocessors will not accept alcohol-based brake fluids and naphtha-based gasoline, diesel or kerosene since the reprocessing system is geared solely for lubricants (Laird, personal communication).

For waste anti-freeze, the nearest market would be in south central Ontario where Safety-Kleen/ BresLube had just recently expanded its operations to encompass ethylene glycol reprocessing (Sinclair, personal communication). This firm charges 35 cents a litre to pick-up both waste oil and glycol from vehicle servicing centres (Sinclair, personal communication). However, the transportation costs to bring CFB Shilo's waste glycol to this nearest reprocessor would be too expensive relative to the present Base disposal system.

For waste petroleum distillates, the market is saturated since there are too many waste generators with excess spent quantities of this hazardous waste (Lohvinenko, personal communication).

When contract disposal is no longer feasible, other alternatives could be taken into account. Solidification looms on the horizon as one noteworthy hazardous waste management option of medium cost (Valdirio, 1990). Paint sludges, once flocculated, could be mixed with either pozzolan, silicate or other agents as a means of solidifying these for landfilling (Schoenberger and Dunkel, 1990).

CHAPTER VI - SUMMARY, CONCLUSION & RECOMMENDATIONS

6.1 SUMMARY

This study documents effectiveness of hazardous materials and waste management at CFB Shilo, analyzes possible options in hazardous materials use and waste reduction and also provides solutions for improving the management of these at the Base.

The methodology adhered to in this study consisted of: 1) a literature review which identified possible options, 2) a site inspection, based on 17 distinct CFB Shilo facility categories, conducted during December 10-14, 1990, March 4-8, 1991 and April 21-24, 1992, 3) an option analysis which identified additional hazardous waste minimization and disposal alternatives for the Base and 4) recommendations which were formulated through practicability, costs and effectiveness.

Observations of the facilities at CFB Shilo showed that hazardous materials were categorized according to at least 8 features, but restricted hazardous items were also evident. The Base's hazardous wastes encompassed 12 categories. Fuels and POL products represented the most predominant hazardous materials, with the latter generated as a large proportion of the Base waste stream. An approximate total of 564,000 litres per year of CFB Shilo's hazardous materials gave rise to an approximate total of 57,500 litres per year of Base hazardous wastes (Table 4.3). The remaining amount of hazardous chemicals yielded unavoidable losses (eg. from combustion or evaporation).

CFB Shilo is complying with all existing federal and provincial regulations and guidelines (Table 4.4). However, one situation may require further attention at the Base. Atmospheric contaminants could be emitted from specific facilities (eg. CE Paint Shop).

All in all, hazardous waste reduction and other source reduction techniques for hazardous wastes could, potentially, be further implemented at CFB Shilo. Some of these, including non-hazardous material substitutions, however, are too costly with respect to hazardous waste disposal, the most convenient management procedure. Therefore, ways to improve the present disposal practice, including contract disposal, are deemed as the most feasible.

6.2 CONCLUSIONS

The following section presents several conclusions from this study. Each conclusion will correspond accordingly with each of the three objectives.

(1a) CFB Shilo was found to be an active military site in southwestern Manitoba. A total of nearly 220 military-use facilities are used for a wide variety of different Base applications. Annual hazardous material inputs to the Base are slightly more than one million litres. Approximately half of these hazardous materials become part of unavoidable losses and do not contribute to the Base's measurable hazardous waste stream. CFB Shilo was found to be meeting all existing governmental regulations and guidelines with respect to hazardous materials and wastes.

(1b) Hazardous materials and wastes from Base facilities were characterized with respect to their storage procedures, final destinations and yearly quantities.

A majority of hazardous materials are received from suppliers and are kept in warehouses for storage (eg. 4JH Section for POL products). Then, hazardous materials are allocated to users (eg. Base Maintenance, 3RCHA and Construction Engineering among others).

The hazardous materials which are used the most during the year are fuels, POL products (eg. motor oils, hydraulic fluids, brake fluids, battery acid and glycol), cleaning solvents (eg. petroleum distillates and aromatic paint thinners) and various paints.

The most prominent hazardous wastes on CFB Shilo likely originate from the above hazardous materials. On-site hazardous waste streams which are contract disposed were: waste motor oils (28,000 litres per year), waste hydraulic fluid (6800 litres per year), waste glycol (6800 litres per year), waste battery acid (3000 litres per year), waste petroleum distillate-containing paint sludge (650 litres per year) and waste aromatic thinners containing paint (1000 litres per year). Mixtures of these are, in some instances, disposed of in their own separate drums.

There are other hazardous waste streams which enter the environment directly on a yearly basis. These include spent photo chemicals with silver (540 litres per year), waste alkali vehicle detergent (1230 litres per year), and aerial emissions.

What cannot be portrayed in tabular form is: 1) whether these hazardous materials were all present at the same time as the audits took place since a high product turnover rate is a frequent situation, 2) whether some hazardous wastes were generated in minimal amounts or not and 3) whether some quantities of the hazardous waste streams were contained in other hazardous waste stream categories.

(2) CFB Shilo is presently utilizing and should consider a number of options in managing their hazardous materials and wastes. Hazardous waste reduction is being implemented at the Base wherever possible. Source reduction practices were frequently practiced, but these can still be improved.

Firstly, segregation of hazardous wastes was not being carried out adequately. As an example, motor oil wastes were still blended with hydraulic fluids and brake fluids at several facilities. Paints with metal-containing pigments could have been collected and segregated from non-metal comprising paint wastes. By doing so, chromium and lead would have been kept from mixing with other hazardous wastes.

Secondly, hazardous material stock was not optimally rotated at all Base facilities. Some hazardous products were sitting on the shelves for 3 years, with some unused for more than 12 years.

Thirdly, even though non-hazardous materials are on the marketplace, substitutions for these were not fully considered for all Base facilities. As a result, there were still some solvent-based paints on-site and more on-site parts washing baths with petroleum distillates in them than with water-based degreasers.

(3) As part of CFB Shilo's overall hazardous materials and waste management plan, several features, still in their infancy, should be implemented for improving progress. These recommendations are listed in the upcoming section.

6.3 RECOMMENDATIONS

The following recommendations for proper hazardous material and waste handling practices can be considered as possible enhancements in attaining an optimal hazardous waste management plan at CFB Shilo. The recommendations are prioritized and are based on what is practical, economical and possible for the Base.

1) Contract disposal should be continued as the most convenient practice for the Base's waste brake fluids, naphtha-based compounds and petroleum distillates. However, firms which ensure the aspect of waste stream liability (eg. off-site reprocessors) should be examined in greater detail and potentially sought out in the future as environmental costing procedures evolve in society.

2) The Manitoba Waste Exchange should be used, wherever possible, as a source for making the Base's acid, oil and glycol waste streams available to potential industrial users. The annual $ 25 fee would be cheaper to pay than the existing numerous waste stream quantity, call-up and pick-up charges.

3) Continuing education of Base personnel regarding hazardous waste reduction should be considered as an inexpensive way to increase environmental awareness. Hazardous waste reduction information could be offered through seminars, pamphlets and audio-visual aids to further expose Base Staff to appropriate action.

4) A central hazardous waste coordinator with a background in chemistry and engineering should be appointed to plan appropriate actions for the Base. This federal civilian employee should be a participant at the present Base Environmental Committee and should report regularly to the Base Commander.

5) The removal of all restricted hazardous products from the Base is highly recommended when standard-approved and cost-effective substitutes become available.

6) Prior to purchase of a hazardous material, non-hazardous substitute equivalents should be fully considered when based upon costs and application at hand.

7) Prior to purchase of a hazardous material, less hazardous substitute equivalents which can serve multiple Base applications should be fully investigated. The problem of different stocks of chemicals with similar functions as well excessive shelf-lives of expired products could be resolved through purchase awareness, if costs permit.

8) The situating of hazardous waste drum storage sheds nearby most facilities should be assessed as a meritable way to house bulk hazardous POL wastes for no longer than two months. An ideal structure would be one which would have all the safety features and which would protect hazardous waste containers from the weather.

9) Uniform colour-coding of hazardous waste drums at every Base facility (Perry, personal communication), in addition to naming, should be noted as a possible manner of making these more easily identifiable from any excess product drums stored outside. The following colours could be suggested:

GREEN	- WASTE ANTI-FREEZE
BLACK	- WASTE MOTOR OILS
BLUE	- WASTE GASOLINE, DIESEL & KEROSENE
RED	- WASTE HYDRAULIC FLUID
CRIMSON	- WASTE BRAKE FLUID
ORANGE	- WASTE PETROLEUM DISTILLATES FROM DEGREASING
OLIVE	- WASTE PETROLEUM DISTILLATES WITH PAINT SLUDGE
YELLOW	- WASTE AROMATIC SOLVENTS WITH PAINT

Any mixtures of the above could have combinations of these colour-codes.

10) For those hazardous wastes which fill up only half or less of a 205 litre drum, longer retention periods for storage should be considered since contractors charge the same amount for a drum which is a fraction full as one which is completely full.

11) The 50 litres of herbicide-pesticide rinseate should be reapplied as a lawn spraying supplement.

12) Monitoring for potential leaching of hazardous constituents into the underlying Assiniboine Aquifer from the Base sewage lagoon should be investigated.

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Sinclair J., Professor, Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba, May, 1992.

Appendix 1

LIST OF ACRONYMS

AECL - Atomic Energy Canada Limited
AWME - Alberta Waste Materials Exchange
BFI - Browning-Ferris Industries
BOD - Biological Oxygen Demand
CATC - Canadian Air Training Centre
CE - Construction Engineering
CEPA - Canadian Environmental Protection Act
CFAO - Canadian Forces Acting Order
CFB - Canadian Forces Base
CFC - Chlorofluorocarbons
CFSD - Canadian Forces Supply Depot
COD - Chemical Oxygen Demand
DND - Department of National Defence
EC - Environment Canada
EPS - Environmental Protection Service (Environment Canada)
FLOCS - Fast-Lube Oil Change System
GAO - General Accounting Office (United States)
GATES - German Army Training Establishment Shilo
HMGS - Hazardous Material Guide Sheets
LVLP - Low Volume-Low Pressure
MEWSH - Manitoba Environment and Workplace Safety and Health
MHWMC - Manitoba Hazardous Waste Management Corporation
MMF - Man-Made Fibres
MSDS - Material Safety Data Sheets
MWE - Manitoba Waste Exchange
NATO - North American Treaty Organization
NDHQ - National Defence Headquarters
NRC - National Research Council (Washington, D.C.)
OWMC - Ontario Waste Management Corporation
PCB - Polychlorinated Biphenyl
POL - Petroleum, Oil & Lubricants
ppm - parts per million
QM - Quartermaster
RA - Rapid Access
RCA - Royal Canadian Artillery
RCHA - Royal Canadian Horse Artillery
TDGA - Transportation of Dangerous Goods Act
WDNR - Wisconsin Department of Natural Resources
WHMIS - Workplace Hazardous Materials Information System

C-41 - Photo Processor Type
EP-2 - Photo Processor Type
RA-4 - Photo Processor Type
4JA - Base Maintenance Supply Consumption Point
4JC - Base Supply Warehouse (For CE)
4JD - Base Supply Warehouse (General)
4JE - Base Supply Warehouse (For 731 Comm. Squadron)
4JF - Base Supply Warehouse (For Stationery Items)
4JH - Base Supply Warehouse (POL Point)

Appendix 2

DEFINITION OF TERMS

WASTE MANAGEMENT - the handling, transportation and storage of hazardous materials (Oldenburg and Hirschhorn, 1987).

POLLUTION CONTROL - all actions that affect wastes and pollutants after they have been generated (Oldenburg and Hirschhorn, 1987).

WASTE MINIMIZATION - the reduction of any solid or hazardous waste that is generated or subsequently treated, stored, or disposed of; it includes volume reduction as well as reduction in the quantity of toxic constituents (Patterson, 1989a).

WASTE REDUCTION - a broad range of actions that take place within the confines of a specific process before a waste is generated (Hirschhorn and Oldenburg, 1987).

- on-site cost-effective strategy aimed at lessening waste quantities by identifying pollutant origins at the earliest onset (Patterson, 1989a)

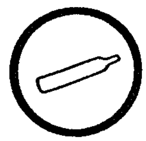
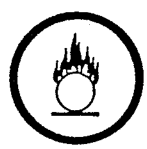
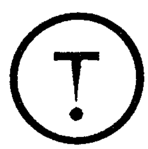
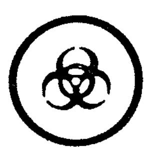
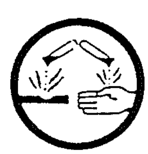
SOURCE REDUCTION - the actual reduction of the amount of waste that comes into existence as chemicals are produced (Basta et al., 1988).

- on-site strategy component of waste reduction which emphasizes recovery and recycling as well as source avoidance (Patterson, 1989a)

SOURCE AVOIDANCE - several practices under source reduction which include a waste audit, hazardous material changes, technological innovations and good housekeeping (Patterson, 1989a)

Appendix 3

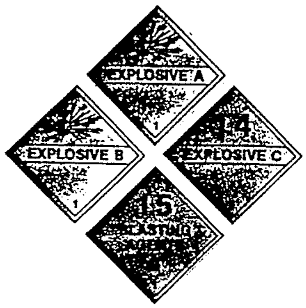
FEATURES OF THE WHMIS CLASSIFICATION

The symbol represents ...	It means that the material ...
 **Class A — Compressed gas**	☐ poses an explosion danger because the gas is being held in a cylinder under pressure ☐ may cause its container to explode if heated in a fire ☐ may cause its container to explode if dropped
 **Class B — Combustible and flammable material**	☐ is one that will burn and is therefore a potential fire hazard ☐ may burn at relatively low temperatures; flammable materials catch fire at lower temperatures than combustible materials ☐ may burst into flame spontaneously in air or release a flammable gas on contact with water ☐ may cause a fire when exposed to heat, sparks, or flames or as a result of friction
 **Class C — Oxidizing material**	☐ poses a fire and/or explosion risk in the presence of flammable or combustible material ☐ may cause fire when it comes into contact with combustible materials such as wood ☐ may react violently or cause an explosion when it comes into contact with combustible materials such as fuels ☐ may burn skin and eyes upon contact
 **Class D, Division 1 — Poisonous and infectious material: immediate and serious toxic effects**	☐ is a potentially fatal poisonous substance ☐ may be fatal or cause permanent damage if it is inhaled or swallowed or if it enters the body through skin contact ☐ may burn eyes or skin upon contact
 **Class D, Division 2 — Poisonous and infectious material: other toxic effects**	☐ is a poisonous substance that is not immediately dangerous to health ☐ may cause death or permanent damage as a result of repeated exposures over time ☐ may be a skin or eye irritant ☐ may be a sensitizer, which produces a chemical allergy ☐ may cause cancer ☐ may cause birth defects or sterility
 **Class D, Division 3 — Poisonous and infectious material: biohazardous infectious material**	☐ may cause a serious disease resulting in illness or death
 **Class E — Corrosive material**	☐ causes severe eye and skin irritation upon contact ☐ causes severe tissue damage with prolonged contact ☐ may be harmful if inhaled
 **Class F — Dangerously reactive material**	☐ is very unstable ☐ may react with water to release a toxic or flammable gas ☐ may explode as a result of shock, friction or increase in temperature ☐ may explode if heated when in a closed container ☐ undergoes vigorous polymerization

(Occupational Safety Canada, 1991)

Appendix 4

FEATURES OF THE TDGA CLASSIFICATION



Class 1 Explosives

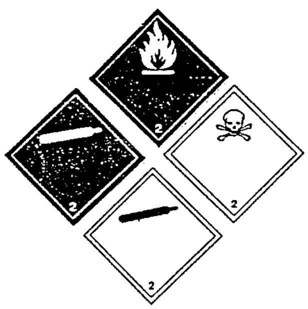
1.1 — A substance or article with a mass explosion hazard

1.2 — A substance or article with a fragment projection hazard, but not a mass explosion hazard

1.3 — A substance or article which has a fire hazard along with either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard

1.4 — A substance or article which presents no significant hazard — explosion effects are largely confined to the package and no projection or fragments of appreciable size or range are to be expected

1.5 — A very insensitive substance which nevertheless has a mass explosion hazard like those substances in 1.1



Class 2 Gases

2.1 — A flammable gas

2.2 — Other compressed gases

2.3 — A poisonous gas

2.4 — A corrosive gas

Class 3 Flammable liquids

3.1 — A liquid with a closed-cup flash point of less than -18°C

3.2 — A liquid with a closed-cup flash point not less than -18°C but less than 23°C

3.3 — A liquid with a closed-cup flash point not less than 23°C but less than 37.8°C

Class 4 Flammable solids, substances liable to spontaneous combustion, and substances that on contact with water emit flammable gases

4.1 — A solid which under normal conditions of transport is readily ignitable and burns vigorously and persistently or which causes or contributes to fire through friction or from heat retained from manufacturing or processing

4.2 — A substance liable to spontaneous combustion when in contact with air or liable to spontaneous heating to the point where it ignites when in contact with air

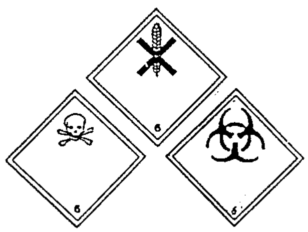
4.3 — A substance that on contact with water or water vapour emits flammable gas(es)

FEATURES OF THE TDGA CLASSIFICATION (cont.)

Class 5 Oxidizing substances and organic peroxides

5.1 — A substance which causes or contributes to the combustion of other material by yielding oxygen or other oxiding substances whether or not the substance itself is combustible

5.2 — An organic compound that contains the bivalent "-O-O-" structure which is a strong oxidizing agent and may be liable to explosive decomposition or is sensitive to heat, shock or friction



Class 6 Poisonous (toxic) substances and infectious substances

6.1 — A solid or liquid that is poisonous through inhalation of its vapours, by skin contact or by ingestion

6.2 — Organisms that are infectious or that are reasonably believed to be infectious to humans and animals

Class 7 Radioactive materials

Class 8 Corrosive substances

Class 9 Miscellaneous products or substances

9.1 — Miscellaneous dangerous goods

9.2 — An environmentally hazardous substance

9.3 — A dangerous waste

(Transport Canada, 1989)