MUNICIPAL SOLID WASTE MANAGEMENT STRATEGIES:

IMPACT OF WASTE GENERATION BEHAVIOURS IN RURAL AND URBAN COMMUNITIES.

by

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To my husband Jens.

A patient and supportive partner.

ABSTRACT

The waste generation characteristics of households was investigated in relation to waste management principles and philosophies in urban and rural New Zealand, to evaluate current practices regarding municipal solid waste at the national, district- and city council level.

Two selected councils, one rural and one urban, were studied in detail. A household sample from each council was surveyed to establish the trends in household waste generation. The results from these surveys were compared using statistical analyses. The initial results suggested that rural and urban households show significant differences. Further analysis, involving a detailed case study of a rural settlement, suggests that these differences arise from the economic signals received from the council and not from population structure and culture, although some subgroups in the population appear to ignore these signals.

A householders' survey analysis of waste designated for recycling proved to be unreliable and difficult to interpret. This was caused by the public's general inability to interpret plastic recycling numbers for correct sorting, and to measure volume and weight correctly. Conclusions were reached with regard to paper

and household organic waste. While there appears to be little difference in the amounts produced per person in either the wards or between the councils, a proportional analysis suggests that middle income households compost and recycle more than low income households. This has been interpreted as a possible effect of multi-family dwellings and the type of education material used to deliver the recycling messages.

An analysis of household waste delivered to the landfills by the collection system in the two selected councils shows that the rural household waste has a higher proportion of organics and a lower proportion of paper waste than do the urban households. The rural households also compost less and visit the landfill more. This supports the conclusion that economic signals dictate the waste generation behaviours of households.

The effectiveness, in light of sustainability and economics, of the systems in place in New Zealand were studied and compared with international trends in waste management systems. Economic signals appear to be a strong motivator for individual waste generation behaviours.

Composting as a potential waste minimisation system for New Zealand was also investigated. Green waste composting appears to be an economically viable method of waste minimisation for urban and some rural councils. The data

collected in the surveys suggest that home composting of household organics can offer a solution to reduce waste from the household source. The methods and effects of implementing this as a strategy require more study.

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ABBREVIATIONS

ARA	Auckland Regional Authority
ARC	Auckland Regional Council
ARWB	Auckland Regional Water Board
CAT	Centre for Advanced Technology
CBEC	Community Business and Environment Centre
DBC	Devonport Borough Council
DCC	Dunedin City Council
DTI	Department of Trade and Industry
EC	European Community
EPA	Environmental Protection Agency
HBUC	Hawkes Bay United Council
HCC	Hamilton City Council
HDC	Horowhenua District Council
IHC	Intellectually Handicapped Society
ISLR	Institute for Self Reliance
MCC	Manukau City Council
MDC	Masterton District Council
MfE	Ministry for the Environment
M-WRC	Manawatu-Wanganui Regional Council
NapierCC	Napier City Council
NelsonCC	Nelson City Council
NSC	North Shore City
NZISS	New Zealand Income Support Service

NZWSDA	New Zealand Water Supply and Disposal Association
PCE	Parliamentary Commissioner for the Environment
PNCC	Palmerston North City Council
RMA	Resource Management Act
TRC	Taranaki Regional Council
WSDA	Water and Disposal Association
WMI	Waste Management Institute
WDC	Wanganui District Council
WCC	Waitakere City Council
WCC	Wellington City Council
WSCC	West Sussex County Council

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CHAPTER 1

INTRODUCTION

1.1 The Background.

The constraints placed on mankind's[1] ability to survive are the same as those placed on all natural systems: Cyclic pathways through which chemical materials travel, retained temporarily by biological components using potential energies to maintain a state of low entropy [Odum,E., 1971]. A measure of man's success has been the ability to feed energy and materials into channels serving economic needs [Timmer, 1975]. The more energy used and the more materials consumed, the greater the economic growth of the human system[2]. In the process, entropy increases [Burness *et al.*, 1980; Rifkin and Howard, 1980; Ogawa, 1993]. This entropy loading has been an integral part of the western style economic culture since the industrial revolution and is reflected in solid wastepiles, water and atmospheric pollution [Ogawa, 1993; Pimental and Pimental, 1993].[3]

Whether it is middens of stoneage villages or landfills of modern society, human refuse is a reflection of the lifestyle of the people in those societies. As human beings settled into permanent communities, waste became a visible

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[1] As in 'humankind'. This word commonly takes the male pronoun in the English language. In New Zealand where two official languages are recognised, the Maori alternative 'ia', denoting he/she, can be used.

[2] This is a generalisation. In the developed world technological advances have led to energy efficiencies and lightweighting of materials used. It is, however, still true that GDP follows the trend of the energy and materials consumption curve.

[3] Each year a city the size of San Francisco disposes of more aluminium than is produced by a small bauxite mine, more copper than a medium copper mine and more paper than a goodsized timber stand [Powelson and Powelson, 1992].

and often annoying aspect of people's activities [Ruiz, 1993]. Traditionally, the responsibility for waste management rested on the individual household or industry. Disposal was often carried out by tipping a few meters from the dwelling , or site of production [Ruiz, 1993]. While refuse was mostly organic or mineral in nature and settlements largely rural, such practices were serviceable as the waste formed part of existing natural systems. As population density increased so did the health hazards from indiscriminate natural systems overloading. In some societies limitations on the practice were imposed by requiring deposits of municipal waste away from the city[4]. In spite of some visionary attitudes to waste management by some early societies, and some attempts of government control, for example that of the British Parliament which in 1388 prohibited the throwing of garbage into public waterways and ditches [Ruiz, 1993], waste management continued to be considered an individual responsibility well into the middle ages. In the early part of the 16th century the City of London prohibited the throwing of waste into the streets and a collection system was started, but it was not until the 1840s that waste management became a universally accepted responsibility of the state and various systematic approaches were taken, for example the building of refuse incinerators in England and America in the late 19th century. Low population densities, low levels of general affluence and partial salvage or reuse of some wastes, for example rags that were recycled for making paper, meant, however, that refuse volumes were low until the second half of this century. Modern materials and concerns over the environment means that waste management has become a complicated issue. Research can no longer be limited to the technological and physical sciences. Social and economic aspects of solid management are also necessary to better understand and design economic incentives, and information and economic programs [Haug, 1993]. It is with the management issues associated with domestic solid waste disposal that this thesis concerns itself.

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[4] Athens in 500 b.c. organised first municipal dump in the western world [Ruiz Jr., 1993].

1.2 The Objectives of this Thesis are to:

1. investigate waste management behaviour of households and councils in a small city and a rural district in New Zealand.

2. investigate innovative options for waste management available for use in these two areas.

3. make recommendations to achieve greater waste minimisation at the household and municipal level for the two sites studied.

In order to achieve the above objectives, the research set out to:

- investigate, in relation to waste management principles and philosophies, current practices regarding municipal solid waste at the national, district and city council level

- evaluate waste management behaviour at two selected councils , one rural and one urban [Chapter 3 and 4]

- analyse the effectiveness of the systems in place [Chapter 4 and 6]

- compare the New Zealand systems with selected international trends in waste management systems [Chapter 5]

- do a case study for the implementation of alternative waste management strategies in a small New Zealand community [Chapter 6]

- look at composting as a potential waste minimisation system for New Zealand [Chapter 7]

- draw conclusions and make recommendations in light of the investigated waste management systems [Chapter 8]

CHAPTER 2

DEFINING THE PROBLEM:

DOMESTIC SOLID WASTE

2.1 The Carrying Capacity and Economic Growth.

2.1.1 The Awakening of Environmental Consciousness.

Historically we know most about blatant consumeristic societies such as the Egyptians, the Greek, the Romans and the Incas. These societies left most behind for later archaeologists to study. Notably these are also societies that peaked and fell into decline very rapidly, as their resource base became depleted. Other societies maintained a close balance between their environment and their consumption: Birthrate and deathrate were set by the carrying capacity[5] of the system they depended on [Kormondy, 1969; Odum,E., 1971]. Western systems increased the carrying capacity of their environment by depleting that of others [Odum,H., 1971]. The Industrial and later 'Green' Revolutions allowed population growth beyond anything previously experienced. This increase in numbers, and consumption, represents classical economic growth. All resources were considered to be replaceable (having infinite substitutability) The possibility of resource scarcity was not given credence. [Brown, 1954, 1978; Brown *et al.*, 1957; Huberty, 1959; Goeller and Weinberg, 1976; Howe, 1979]. The planet was believed to be an 'open system'.

The growth of the Ecological Sciences in the 1960s and the emergence of 'Whole Earth Philosophies' of the 1970s and 80s, culminated in the United

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[5] The limit at which the population has reached an equilibrium with the life supporting components of the environment. This limit may change depending on changes in the environment. The green revolution increased the carrying capacity. Pollution lowers it [Kormondy, 1969].

Nations establishment of the World Commission for Environment and Development, and a warning that all human activity takes place in a closed system with finite resources [Carson, 1962; Krutilla, 1968; Meadows *et al.*, 1972; Royal Society, 1973; Miller and Tyler, 1975; World Commission, 1987; Wallich, 1989; Hueting, 1990]. This fuelled public questioning of how to define, recognise and mitigate environmental pollution and resource depletion. [Fisher, 1959; Kneese *et al.*, 1970; Erlich *et al.*, 1971; Goeller and Weinberg, 1976; OECD, 1985, 1991; Allaby, 1989; Amir, 1989; Erlich, 1989; Constanza, 1989]. Resources became redefined to include the 'commonly owned' resources: air, water and climate [Hahn, 1989; Hansen, 1989; Proops, 1989; Shaw, 1991; Repetto, 1992; Solow, 1992, 1993]. Attempts were made to manage exploration, use and disposal of resources and the environment [Baum and Parker, 1974; Blum, 1976; Common, 1977; Christensen, 1989; Charman, 1990; Ornstein and Ehrlich, 1990; Stead and Stead, 1992; Gilkison(a,b), 1992; Reppetto and Dower, 1993]. While people, in general, enjoyed the convenience and prosperity of the 'throw-away' society, they also started to question the consequences of such a lifestyle [Higgins and Higgins, 1979; Franklin and Franklin, 1992]. One of the environmental issues of greatest concern to the global economy appear to be waste management. Agenda 21 from the Earth Summit, Rio de Janeiro, June 1992, sets out aims for waste minimisation based on environmentally sound re-use and recycling, and promoting safe waste disposal and treatment [Warmer(k), 1994; Warmer(a), 1995;].

2.1.2 Legislative Attempts to Control Disposal.

By-products of human consumption also increased because consumption per capita increased [Packard, 1961]. Western capitalistic systems of the 1960s and 1970s, added drastically to the waste stream by 'built,in redundancy ' and 'added value' from packaging [Kilborn Engineering, 1974; Bridgewater and Lidgren, 1981; Royte, 1992; Warmer(j), 1994]. This consumerism was in direct conflict with the increased understanding of the impacts that disposal systems have on water and air.

The concern over the polluting effects of open air burning, ocean disposal and unmanaged landfills with leachates to groundwater and inland waterways peaked in the 1970s, as old toxic waste dumps started to affect the health of nearby settlements. This evidence of adverse effects of unmanaged waste disposal and the inability of local governments to deal with the larger implications of the issues led to the implementation of legislation from central governments to control emissions into air and groundwater [ARA, 1975; ARWB, 1989; Lund, 1993]. In New Zealand the Health Act of 1956 set the standards for allowed emissions. The Resource Management Act 1991, complements this and includes the concept of 'proven sustainability' of the proposed activity. [McEwen and McColl, 1988; PCE(b), 1990; PCE(a), 1991; RMA 1991; NZWSDA, 1992]. Agencies to deal specifically with concerns about the environment were established by several governments [Anon., 1992; Powelson and Powelson, 1992; Wingerter, 1992; Portney, 1993]. The 1989 European Community (EC) Waste Management Strategy followed by the Waste Framework Directive in 1991, set down a hierarchy of waste management options, placing waste minimisation at the top and safe disposal at the end of the chain of the waste management sequence [Croner(a, b, c and d), 1991]. Expanding on Agenda 21, the ECs fifth environmental action program "Towards Sustainability" set a series of targets for the countries in the European Union. These include national waste management plans and minimum recycling targets[6] [Anon., 1992; Warmer(a), 1995]. These are transposed into national laws by the various governments of the union [Croner(a and c), 1991].

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[6] The European Community has been interested in recycling since 1973 when the Environmental Action Program started. Initial directives dealt with specifics on waste and its disposal. Recent additions to the EEC Treaty set objectives on the treatment of the environment and natural resources, and incorporate the Polluter Pays Principle as part of EC law.[Directive COM/89/282], [Article 130R]. The Treaty allows member states to maintain or introduce more stringent protective measures compatible with the Treaty. The Single European Act's environmental principles forms the basis of the Fourth Environmental Action Program. The Commission agreed in 1990 to set up a European Environment Agency [EEA], which will have direct influence on waste management strategies. Altogether there are more than 200 EC environment directives, but only half have been implemented by member states. [Anon., 1992]

2.2 New Zealand and Waste Management.

2.2.1 Demand for Sustainable Use of New Zealand Resources.

The requirements that adverse environmental effects be minimised demand strict management of possible pollutants. The conflict between 'lifestyle' and 'environment' has often meant that society has opted for an 'out of sight , out of mind' solution to the problems due to consumerism [Savas, 1977; Wilson, 1977; Starr, 1991; Wane, 1992; Ruiz, 1993]. Some countries have faced this dilemma with legislation and the introduction of economic tools to encourage waste reducing consumer choices [Amir, 1989; Shaw, 1991; Anon, 1992; Cairncross, 1992; Sudol, 1992]. New Zealand as a producer for, and exporter to, more densely populated and industrialised countries, many with strict waste management laws, are faced with similar pressures [Rennes, 1991; Smith, 1991; Cairncross, 1992, MfE(c), 1992; Smith, 1993; Blakeley, 1994].

Further pressures that natural resources in New Zealand are used sustainably have arisen from the discovery of chemically polluted early industrial sites, arising from poor rural and urban planning [Rose, 1980; Hufschmidt *et al.*, 1990; RMA 1991; PCE(a), 1991; Crosson, 1993; Blakeley(b), 1993]. At present over 2.3 million tonnes of household and industrial wastes are disposed of annually to landfills in New Zealand. Of this 0.70 kg/person/day comes from private households [DTI, 1985; Willmot, 1993]. Peter Dunne, Associate Minister for the Environment in 1990, pledged that the government would commit itself to a waste reduction goal of 20% of the 1988 level by 1993 [Dunne, 1990], defining waste as a 'treatable' substance which can be managed using practicable methods following clear guidelines. A consensus was reached that central government should have the responsibility for the development of a waste management policy, appropriate instruments of policy implementation, with monitoring and performance assessment of waste management systems. Since then a Waste Management Policy with two key elements: 'Polluter Pays' and the 'Waste Management Hierarchy' [section 2.4.1], has been adopted. Central government is looking at regulatory and economic measures to assist recycling and has set a target of waste reduction

of 20% by the year 2000. Plans for a recycling trust have been considered, but rejected, subsidies for recycled oil stopped and no plans for subsidisation of recycling initiatives are planned. The 'Cleaner Production' program is encouraged, but left to voluntary participation by industries [Harris, 1990; MfE(c and e), 1992; Bailey, 1993; Bush, 1993; Stone, 1993].

2.2.2 Landfills and the RMA.

In the meantime unwanted materials continue to use up increasingly scarce landfill space [Hubick, 1991; Dolan, 1993; Guice, 1993; Thorstensen, 1993]. The RMA 1991, requires that consent applications for landfills have impact assessments on the sustainability of the landfill practices [CAT, 1992], including drainage, leachate, noise, dust and infringement of cultural values. The standards and policies involve the Ministry for the Environment, Department of Conservation, Regional, District and City councils. Those demanding legal and technical requirements will make consent applications more expensive and time consuming [White, 1993].

Stringent criteria mean that suitable space close to human habitation is difficult to find. Mixed industrial and organic materials composting anaerobically can give unpredictable and volatile products. This risk factor is not inherent in the material itself, but in the traditional disposal methods for that material. It accounts for the expenses incurred by the disposal standards required by the RMA 1991. These include containment of leachates by natural design or engineering measures, such as clay or plastic liners, collection monitoring and treatment of leachate, capping and reconstitution of finished landfill, landfill gas collection and monitoring, control and monitoring of surface water. All of these ongoing and continuing after the landfill is closed [ARWB, 1989; CAT, 1992; Evans, 1993]. Services to the landfill such as roads, power and water will add to the expense as well as creating their own environmental impacts [PNCC Landfill Site Selection Committee, 1993,1994; Mitsch, 1993]. Energy becomes an important factor the further the waste has to be transported [DTI, 1980].

2.3 Entropy and Sustainability.

The second law of thermodynamics states that entropy continues to increase. No conversion of energy is completely efficient and is irreversible. The implication of this is that a closed system will eventually use up its energy. Although the earth is not a closed system with respect to energy, the availability of solar energy puts an upper limit on the amount of energy available for human economic activities. Once stocks of fossil fuels and nuclear power are gone, the amount of energy available for economic activities will be determined by the ability to use solar energy directly or in stored forms.[Tietenberg, 1992]. Thus the scale and rate of matter and energy passing through the economic system is subject to the entropy constraint. Modern economics lack a guarantee that any economic optimum is associated with an ecological equilibrium[7]. There is a risk that some ecologically relevant externality may involve damage to the ecosystem itself. Some of these externalities related to economic activity lack a monetary value and are unlikely to be recognised in our present economic system, which aims ideally to allocate resources in accordance with the Pareto Optimality of Allocation of Resources Principle[8] [Pearce and Turner, 1990]. A working definition of sustainability should maximise the net benefit of economic development while maintaining the services and quality of natural resources over time [Pearce and Turner, 1990]. As many of natural resource services do not have a monetary value, the entropy content and changes of a system has been suggested as a measure of the sustainability of that system [Odum,H., 1971; Pearce and Turner, 1990; Tietenberg, 1992]

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[7] Referred to as the 'Existence Theorem' [Pearce and Turner, 1990].

[8] Allocations are said to be Pareto optimal if no rearrangement of that allocation could benefit some people without any deleterious effects on at least one other person. Or: The net benefits are maximised when the marginal benefit is equal to the marginal cost.

2.3.1 Energy and Waste.

Waste represents an inefficient use of raw materials [Kirk, 1984; Norton, 1989]. The most expensive component of all waste is energy [Brickell *et al.*, 1982]. Waste transport from source to process, absorbs energy. Paper, plastics and oil represent materials from which direct energy recovery, by combustion, is possible [Krol, 1990; Flood, 1994; Warmer(g), 1994]. Unused food and other organics are high entropy materials representing fertilisers, unused energy and transport fuels [Minnich and Hunt, 1979]. These high entropy materials could be stabilised to low entropy and reusable forms [Haug, 1993]. Other waste components in low entropy[9] forms are 'wasted' because their use is not recognised by the human economic system [Gibbs, 1993].

Secondary materials[10] represent lower energy investments than virgin materials[11]. The net value of available energy depends directly on the distance the material has to travel, the equipment available and the climate of the region or country generating the waste. Countries, such as Denmark, use energy from combusted waste to heat residences connected to a central waste-burner via long distance water pipes [fjernvarme]. In such instances the waste replaces imported fuel oils as a heat source [Thørgersen, 1990]. The economics of such a solution depends on the calorific value of the waste, that is, high paper, wood and plastic relative to organic and mineral components,

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[9] Materials present in pure forms , not requiring re-refining.

[10] That recovered from the waste stream and reused.

[11] Energy savings in comparison with production from virgin raw materials:

Material	Energy Saved: %
Aluminium	95
Plastics	80
Paper	50
Glass	25

[Powell, 1983; Anon., 1992]

the price of oil and the quantity of waste [Rouse and Lindley, 1978; Pavoni *et al.,* 1979; DTI, 1979; Krol, 1990; Johansson, 1991]. Recycling industries in countries using waste as fuel will have different criteria for collection of recyclables: Paper and plastic need not be separated as both are of high calorific value, whereas contamination of these by organic waste and vice versa, represent both a cost in filtration of compost and a loss of potential fuel [Johansson, 1991]. The disadvantage of these systems is that the waste-processing unit becomes waste-dependent [DTI, 1979; ARA, 1988; Hammonds, 1992]. This has been demonstrated by the Southeastern Connecticut Resources Recovery Authority, [Connecticut, USA]. Two elements of the local waste stream were tracked: Waste taken to a regional incinerator and bottles and cans processed through the authority's own materials recovery facility. The data showed that the amounts of containers recovered were increasing and the overall waste was decreasing. This means that the towns are disposing of less than their "minimum commitment" required under the incinerator contract, resulting in higher disposal fees for the 13 towns that have signed long-term contracts. The waste,to,energy plant takes in loads from outside the area at the market rate of less than half the cost charged the towns. Another incinerator is planned, causing concerns that disincentives to recycling will be created by under utilised incinerator capacity [BioCycle(e), 1993].

With the concerns over greenhouse gases and global heating, the trend, world-wide [Pavoni *et al.*, 1975; Thøgersen, 1990] has been to build fewer incineration plants than were originally planned [Regional Roundup(d), 1993]. New Zealand could perhaps usefully apply some waste-to-energy techniques to existing facilities, for example, the heating of large government institutions such as schools and hospitals using coal burning furnaces which can be relatively easily converted to include paper, wood and some plastics. There should be no net increase in entropy from burning combustibles from the waste stream if these replace fossil fuels.

2.4 Waste Management and Landfills.

2.4.1 The Waste Management Hierarchy.

Waste minimisation offers an obvious answer to the escalating expenses associated with disposal of waste in modern landfills. [Warmer(k), 1994]. This can be achieved using the worldwide accepted hierarchy of solid waste management:

reduce
reuse
recycle
recover
dispose (safely)

[Anon., 1992; Warmer(a), 1995; CAT, 1992]

Overseas experience shows that commitment to the first four, substantially reduces the fifth category [Johansson and Thøgersen, 1991]. Waste reduction is most effective when consumers vote with their dollars, either by purchasing products that do not contribute excessively to solid waste problems (pre-cycling), [Powelson and Powelson, 1992; Graeme, 1992], or by choosing waste minimisation services or products.

Next to source reduction, composting is the most desirable strategy for keeping solid waste from going to the landfill [Sekscienski, 1992; Street, 1993; Warmer, 1993; Schoenberg(a), 1994]. This method utilises a natural process to stabilise high entropy as low entropy, reusable materials. Garden waste can be reduced by 50-90% by composting [Chapter 7].

2.4.2 Recycling.

It is the concept of recycling, which has caught the public imagination most [Recycling, 1976, 1992; Peterson, 1983; National Research, 1990; Fishbein and Saphire, 1992]. The term 'recycle' was coined after the foundation of USEPA

and Earth Day in 1970. The concept, however, has been part of subsistence lifestyles for centuries.[12] The depression and the second world war made recycling a way of life for a whole generation in the western world, but waste as a possible environmental hazard was not the driving force for legislation until the 1950s when increasing industrialisation led to clean air and water pollution acts being passed.[13] public appeared willing to support legislation that regulated visible emissions because these were effects they could see, smell and feel in health terms. Solid waste legislation of the 1960s requiring sound disposal methods were harder to understand as the potential damage was not immediately visible [Powelson and Powelson, 1992; Warmer(n), 1994]. Increasing volumes of waste in a shrinking environment led to the formulation of the waste hierarchy thus putting the onus back on the individual. Closing the loop becomes the responsibility of the waste generator [Bridgewater and Lidgren, 1981] , initially the manufacturer, but after purchase , the householder. To send the correct message to the waste generator, legislative and economic tools have been designed [Butlin, 1981; Nordic Council of Ministers, 1991; Broad, 1991; Gow, 1993]. These tools, aimed at maximising waste minimisation practices, vary from region to region and from nation to nation depending on local geography, economics and needs. Early in the 1970s, government attempts at intervention to protect the environment from industrial excesses turned initially to regulatory controls. Old legislation was adapted and new legislation was written to cope with the problems arising from a deeper understanding of the interaction between man's activities and ia[14] environment and from innovative industries creating new products with unknown environmental side-effects [Barde, 1989].

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[12] America's first paper mill was built in Philadelphia in 1690. Rags were used to make newspaper [Powelson, 1992].

[13] In U.S.A. the Clean Air Act was passed in 1955, The Water Pollution Act in 1956. In 1965 the Solid Waste Act was passed [Powelson, 1992].

[14] see footnote 1.

2.4.3 Legislation and Waste Minimisation.

Legislation has by itself been inefficient in stemming environmental abuses. While serving a purpose in decreeing accepted emission standards, it is less successful in setting standards of accepted pollution [Kirk, 1984; Kummel, 1989]. Pollution is most often defined as environmental changes in terms of impacts on the biological systems. The accepted limits for this is the perception of what is 'acceptable' to us: the value we put on ecosystems in terms of amenities, services and ethics, and the degree of risk we are prepared to accept. The emission standards set are often artificial and bear little relationship to what is environmentally safe or what is acceptable to the people living in the vicinity of the polluting source [Randall, 1987; Coase, 1993; MfE, 1995].The criteria for safety and acceptability may not be identical. If they are not, policies pertaining to legislation may become contradictory and ill-focused. For example, legislation encouraging collection of recyclables will be ineffective, if local residents object to the setting up of recycling depots on the grounds that such depots are visually offensive and increase the traffic in the area to an unacceptable level. Such legislation may also be contradictory in that recycling and associated activities may have more environmental impacts than disposal of the materials into a landfill. For example, the recycling of plastics uses a large amount of fuel and water in transport and processing [Bailey and Miller, 1983; DTI(b), 1983; Conelly, 1992]. Life-cycle analysis of products should incorporate this cost, showing the relative cost to the environment of various goods. The environmental 'bottom line' [Brash, 1992; NZWSDA, 1992], has too often not been specified. Where this line is, is something that is still debated, but should be related to the overall entropy of the system in which mankind operates [Georgescu-Roegen, 1971; Dragan and Demetrescu, 1991].

2.4.4 Economic Tools and Waste Management.

Early legislation punished polluters by finesor imprisonment. The focus on pollution control depended on policing, proof and prosecution, and carried high administrative costs making the identification of polluters costly for

society while not acting as a real disincentive to pollute. While such fines can act as a focusing mechanism and a potential source of embarrassment to the transgressor, the fine remains a crude and economically inefficient tool.

The recent environmental policy approach in many developed countries is considered to be more efficient and effective over time [Barde, 1989]. This approach applies the economics of pricing environmental resources [Norgaard, 1989; Bebbington and Gray, 1990; Menell, 1990; Foy, 1991; Whitelegg, 1991; MfE(b), 1993; Solow, 1993; Krutilla, 1993], such that damage or depletion of these incurs a cost to the users or abusers of these resources [Freeman *et al.*, 1973; Environment, 1991; Khazzoom, 1991; Loske, 1991; Shaw, 1991; Moran *et al.*, 1992; Ackerman, 1992; MfE(b and c), 1993; Ruff, 1993]. While application of economic instruments has its own problems, relating to choosing the instrument which maximises efficiency and incentive, without becoming too cumbersome, their role in behaviour modification have nevertheless been extensively recorded [OECD, 1992]. They have been found to be successful in switching behaviour from polluting behaviour to pollution control, and a move towards preventative rather than curative measures. So far world experience with economic tools, has related mainly to discharge into air and water, with little emphasis placed on solid waste [Ackerman, 1992; Ruff, 1993; Kneese, 1993]. Germany has placed the onus on the consumer by charging directly for the waste generated [Schoenberg(b and c), 1994], as well as passing legislation making industry directly responsible for the waste their packaging generates.[15] This has led to consumer pressures for less, but more homogenous, packaging, thus decreasing waste and increasing recycling potential [BioCycle(a), 1994].

[15] The 'Duale System Deutchland [DSD]', described fully in chapter 5.

2.5 New Zealand and Waste Minimisation.

2.5.1 A Multiplicity of Objectives.

In New Zealand the solid waste management process still seems to be in its experimental stage with legislation changing from specifics [ARA, 1975, 1988; Tong, 1989; ARC, 1990], with little room for application of economic tools such as those used in Europe and USA [Bailey, 1985], to the less specific, but all-embracing RMA 1991, which specifies sustainability of resource use[16], with the onus of proof on the consumer [CAT, 1992; Consumer, 1992; Milne, 1992; McNeill, 1993]. As a member of the OECD, the principal proponent for the 'Polluter Pays Principle' [MfE(a), 1991; Warmer(m), 1994], New Zealand supports the principle in the first section of the Government's waste management policy. The Ministry for the Environment set a waste minimisation goal of 20% by year 2000, and has required waste audits from local bodies [Worley, 1992], but the implementation of the policies is voluntary. Local programs are funded by ratepayers and based on the good,will and education of consumers [Bedford, 1993]. Most local authorities fund solid waste disposal by a flat rate fee included in the rates. This fee does not reflect the real cost of collection and disposal [Mayes, 1992]. There has been an attempt by some to increase the marginal cost of increased waste production by introducing tipping fees and insisting on official bags purchased by the householder, or voucher use for which the consumer is charged.[17] Often these charges are set too low, for fear of illegal tipping behaviour, and do not reflect the real social cost of landfilling [McKerchar, 1993]. The Government's waste management policy aims to see an efficient recovery and trade in recovered materials take place [MfE(a and b), 1992]. The overall strategy used in the setting of this policy is the RMA 1991. This

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[16] Excepting minerals

[17] Examples of these systems: The Horowhenua District, Waitakere City and the old Devonport Borough

policy should also identify the means by which the stated goals can be reached. At present this has not been made clear.

A distortion in the real cost of waste disposal occurs because environmental services are not priced. At the moment this cost is borne by the recycling industries. The price of virgin stocks does not include a pollution cost [CBEC, 1993] and is unlikely to do so unless government formulates policies that take the life cycle cost of virgin materials into account [Curran, 1993]. This causes market failure by distorting consumer preferences as the individual does not have to pay the price of environmental degradation [Mayes, 1992; Randall, 1993; Meister, 1993].[18]

2.5.2 Local Waste Minimisation Systems.

The lack of clear policies and objectives at a national level has created distortions at local levels. Even so, well established waste minimisation systems have been in place in Devonport, Nelson and Christchurch for many years [ARA, 1981; DTI(a), 1983; RoydsGarden, 1992; Dolan, 1992, 1993; NelsonCC, 1993; Smith, 1994]. Some of these are no longer operating, but formed the model upon which new systems have been founded

Other areas have investigated the feasibility of waste reduction in their areas by various methods, for example: Palmerston North, Auckland, Wellington, Christchurch, Hamilton and Dunedin [ARC, 1990; HCC, 1990; PNCC, 1991; Clough, 1992, WDC, 1992; WCC, 1993; DCC, 1993; HCC, 1993; WCC, 1995]. The Ministry for the Environment has set waste audit requirements of local bodies aimed at establishing how much and what sort of waste is deposited into landfills in New Zealand [Mayes, 1991; NSC, 1991; PNCC, 1991; MCC, 1991; Worley, 1992; NapierCC, 1992; Kirby, 1993; McGowan *et al.*, 1993;; Ranacou(a and b), 1994; Hodge, 1994; Holley, 1994]. Such waste audits form the first component for a common vision for the country and give a set of

[18] Advance disposal fees try to account for this. See chapter 5.

indicators to follow with regard to sustainable waste management [MfE(a), 1994]. Further development of the audit may lead to a 'Resource Index' to determine the degree of resource waste presently occurring in this country.

2.6 Legislation and Waste Classification.

2.6.1 Waste Classification.

Legislation and classification of waste are closely linked. Waste can be categorised according to source (agricultural, industrial or household), type (for example, Glass, aluminium or paper), or effect (hazardous[19] or non-hazardous). This is, perhaps, the least useful categorisation as all waste, deposited carelessly and in large enough amounts, becomes hazardous. Most of these divisions are artificial and depend on set criteria, for example, agricultural, industrial and household consists of the same type of materials, but in different proportions. The usefulness of the classification lies in specifying which groups of waste producers to target for education and legislation about waste minimisation [Gunn and Francis, 1982; Dolan, 1992; Sinclair *et al.,* 1993].[20] Classification by kind remain the most useful as it allows examination of the percentage of raw materials within the waste stream and thus the possibility of assigning economic values to the raw materials and the energy this material represents.

2.6.2 Sources of Waste.

The two main sources of waste are the production system and the consumption system. [Bridgewater and Lidgren, 1981]

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[19] Where hazardous is defined as: "that which represents dangers to human, plant or animal life, or otherwise affects environmental quality adversely. " [CAT, 1992]

[20] Early classification of household waste divided it according to risk factors , most being considered as a volumetric problem, having no environmental effect, except in a negatively aesthetic way [Bridgewater and Lidgren, 1981].

Waste from the production system is minimised by the economic advantage of internal and external recovery. External recovery has traditionally been encouraged by fines and taxes, for example, the recovery of lanolin from wool scouring in the wool industry. Processing post consumption waste is expensive, in terms of raw materials, energy and environmental quality. These costs have to be paid by society either as taxes or environmental degradation. [Nordic Council of Ministers, 1991; Mayes, 1992; Ruff, 1993]. In reality few economic incentives such as 'green' taxes or subsidies are usually applied [Nordic Council of Ministers, 1991].

Consumption driven waste is only indirectly a function of increased productivity. It will increase with increased economic activity even when built,in redundancy and excess packaging is removed from the product. Thus waste generated by consumption is unlikely to decrease as long as there is economic growth unless there is a conscious will to do so, putting consumer demands on reusable and durable goods [Powelson and Powelson, 1992]. Source reduction by the manufacturer or user of goods, seems to offer the most efficient solution to solid waste management. Solid waste legislation in most countries, give relatively little attention to household source reduction, as it is difficult to measure [BioCycle(()), 1993]. The closer to the source materials can be reduced, separated, recycled or processed, the better [Pieters, 1986; Grogan and Schwartz, 1991; MfE(c), 1992; Thøgersen, 1992; Chandler, 1992; Wachtel, 1993]. This is unlikely to occur as long as market forces are distorted [Oldfield, 1989; Barde, 1989: Consumer, 1990; Public Policy Study, 1992; Fischetti, 1992; Shea, 1992; Rose, 1994].

2.6.3 Source Reduction.

Thus, source reduction seems to be the preferable waste management solution. A reduction in waste through a change in purchase and discharge behaviour cannot easily come about in New Zealand as long as policies allow hidden subsidies in favour of waste disposal. As the RMA starts to take effect in terms of stricter resource use controls, manufacturers are looking at

systems that will reduce the cost of paying for excess process pollution. The 'Cleaner Production' drive attacks the pre-manufacturing waste [Bailey, 1994]. The post manufacturing cost of excessive packaging and disposal costs have not yet been effectively attacked in New Zealand [Shea, 1992; Fletcher, 1992]. At this stage the cost is borne by society in general [Cording, 1992; CBEC, 1992], the responsibility for disposal falls at the local body level where the tendency is to accept the costs of disposal, but expect recycling to pay for itself [PCE, 1993]. The tradition of letting the local body pay for collection and disposal of recyclables has raised the question of whether projected energy savings from using recycled materials is in fact not counter-balanced by the use of energy in handling and transporting the used materials over long distances. Thus savings by the industry are in fact subsidised by the local bodies [Tickell, 1993]. Energy budgets for recycled products are almost non-existent [Dann, 1994].

2.6.4 Impact Assessments.

According to the RMA 1991, the sustainable use of land and water resources, requires impact assessments before resource consents are given. Sustainability of resource use requires proof, usually given in the form of environmental audits setting the basis for an environmental management system specifying a record of environmental performance which can support future or additional consent applications [Friend and Rapport, 1991]. Standards and policies are set by the Ministry for the Environment and Department of Conservation, Regional, District or City Councils [Brash, 1992; Grey, Bebbington and Walters, 1993; Crosson, 1993]. Thus the real cost of waste must include:

- energy and labour for transportation
- handling and disposal of the waste
- running, closure and re,instatement of landfills

- external costs such as environmental degradation
- aesthetic depreciation
- opportunity costs in terms of benefits foregone from that environment such as increased traffic and loss of land use
- Other costs include decline in health from pollution as well as underused raw materials and wasted energy.

[CFE, 1991; O'Connor and Criner, 1994].

Presently these costs are carried by society in general, and are not part of the market structure.[21]

2.7 Waste Audits and Standards.

Waste management policies are set by international and national standards. A great deal of data and general information is available from international organisations, although this is often outdated, suffer from inadequate measuring tools and background data, or lack standardised data [OECD, 1983; Worley, 1992; OECD, 1992,1993; BioCycle(a), 1994]. Most of these deal with industrial and agricultural wastes, particularly hazardous substances which were recognised early to pose health and environmental risks [Open University, 1975]. Fewer audits are available for domestic waste, although this is an area that is growing relative to the rest. People recognise domestic waste as a problem, and feel they can actually make a personal impact [Recycle NSW, 1993]. As the potential for using waste audits as data bases for developing comprehensive waste management programs became obvious, more audits with greater detail were conducted. Fullerton in California was the first city in that state to conduct a waste generation study in compliance with the Integrated Waste Management Act. By collecting waste composition data separately for each subpopulation, the city was able to customise its waste plans to suit various groups and aims at its diversion target of 25,50%

[21] See chapter 5 for greater detail.

[Hay *et al.*, 1993]. New Zealand is also moving towards comprehensive data collection and comparisons in preparation for policy drafting and implementation [Worley, 1992; CAT, 1992; Towle, 1994].

2.8 Mechanism for Waste Reduction.

2.8.1 The five Elements of the Mechanism.

Mechanisms for waste reduction include five separate elements [MfE(b), 1991; CAT, 1992]. These elements can be considered either post, or preconsumptive depending on whether the mechanisms are aimed at preventing the production of wasteful materials, or at processing waste materials as part of a resource loop.

Element 1 disperses information on how to reduce waste. This has been very effective in decreasing industrial waste, internationally [TRC, 1991], and is impacting on household waste as householders make more informed choices. This can be considered both a post and preconsumptive measure, as cost-cutting occurs both at the minimisation of resource use and in the establishment of resource loops as consumer and producer become more interactive than has traditionally been the case.

Element 2 is the dispersement of financial incentives, varying from charging for environmentally damaging activities, by taxes and levies, or by grant schemes for development of waste reduction technology, for example, the Cleaner Production project [Bailey, 1993, 1994]. Most of this element is aimed at the pre consumption level, making the producer either charge more for wasteful products, or devise methods to reduce their environmental impact. Closely associated with the second element is element 3 which is research and development and usually also by financial incentives. This is aimed at the pre consumption level as well.

Element 4 is changing people's behaviour by education, training and public awareness programs. This element is closely related to the first element.

Without the other two elements, however, this component would probably not have a great impact.

Element 2 needs controls, regulations and laws, for example the Health Act 1956 and the RMA 1991. These form element 5 which sets the limits for the outcomes of waste behaviour.

2.8.2 National or Local Application of the Elements.

The New Zealand government's ratification of Agenda 21 [MfE(c), 1994; Mohamed, 1994] requires a commitment to sustainable development. Local government is seen as a vital link in establishing this within national boundaries. While local communities may face the same problems the solutions to these are seen as local and unique to each community [Patterson, 1993; MfE(b), 1994]. The five elements of waste reduction can equally be applied at a national and at a local level. However, if the use of policy tools in the form of economic instruments to transmit precise information on the real cost of waste disposal to consumers is left to local bodies at the post,consumption level they will too often be blunted by 'revenue raising' motives rather than imposing conscious 'waste behaviour' on the consumer.

2.9 Waste management from a Mixed Cultural Perspective.

Changing people's behaviour has to occur from the New Zealand mixed cultural perspective. The traditional Maori perspective on resource conservation and Tapu are compatible with the new perspective on waste management, that is, sustainability is maintained through social controls. Traditional European practices of dumping out of sight, and settlements in large impersonal cities, may be less so. Other cultures may not yet have developed the same stringent perspective applied under the RMA. New immigrants may need to be informed of the environmental standards set by the society here. The education system attempts to play its role in preparing future generations for the new standards by introducing subjects on conservation and resource management at various levels.

2.10 Summary.

Wastes are a byproduct of mankinds economic activity. The greater the complexity of this system the greater the potential for waste. Waste can be a measure of the entropy of the system, but material classified as waste does not always represent the highest entropy possible for that material. When such low entropy material is discarded there is a potential for the material to enter the economic system once again. Waste may thus be viewed both from its potential impact on the environment and from its potential alternative usage. Thus the waste, the producer and ia[22] relationship to the waste and the environment forms a complex equation. Waste is a reflection of lifestyle and attitude [Ruiz, 1992]. Industrial man has been conditioned to think of increased entropy as a measure of progress. Late twentieth century people have started to question this. The waste reduction hierachy presumes that the waste stream contains raw, reusable materials. Matching these resources with a user requires data on the waste stream composition.

Even though some districts have already carried out extensive waste audits on waste arriving at the landfills, and some have been involved with recycling schemes for years, there are big differences in the degree to which Councils have committed themselves to the recycling philosophy even though most will claim waste minimisation as a desirable goal. The techniques for achieving these vary with the philosophies held by councils, and with what is seen as economic and sustainable.

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[22] See footnote 1.

CHAPTER 3

WASTE SURVEYS

3.1 Historical Waste Surveys.

3.1.1 United Councils.

Regional Authorities were encouraged by grants issued by the Department of Health [DOH] to undertake waste audits and site investigations with the aim of providing waste management plans as a part of their environmental planning and management [Beca Carter and Hollings, 1988; ARA, 1988; Moss, 1988; PCE(a), 1990; PCE(b), 1991; WRC, 1990]. These were carried out under the brief of the United Councils and included examples of and opportunities for waste reuse and reduction, low,waste technology and hazardous waste treatment [HBUC, 1986; RoydsGarden 1986].

3.1.2 The Effect of Local Body Amalgamation.

By 1989 all of the then 22 regions had started waste surveys, but the process was interrupted by the Local Body Amalgamation in October 1989 [Bailey, 1991]. This resulted in the formation of 73 district and city councils, overseen by 14 regions which were based on the catchment areas and consequently overlapping in places. The new regions became responsible for water resources, rivers, lakes and coastal areas, noxious weed control and hazardous waste, all of which involve decisions of contradictory nature. Consequently for the next couple of years most of the energies of these institutions were redirected into administration, policy formation and realignment of loyalties.

A multitude of legislation made planning difficult, but with the formulation of the RMA 1991, which replaced more than 59 statutes, the approach to the

environment became more integrated [Blakeley, 1995], and the attention was focused on the sustainability of past waste practices. Commercial waste is responsible for two-thirds of the waste stream [Worley, 1992], but is easier to deal with as it occurs relatively concentrated and in large amounts. Legislation aimed at reducing this waste, can utilise business economics, by altering the profitability of wasteful practices relatively to cleaner practices [Bailey, 1993, 1994; McNeill, 1993]. In contrast, domestic waste has posed a greater problem for municipalities as waste management requirements altered. District and City Councils followed the earlier brief from DOH and that of the RMA, and examined the nature of local waste behaviour and landfills. The first District and Regional Plans setting out the waste management objectives with regard to the directives of the RMA are now published in their draft form [HDC, 1993; MWRC, 1993].

Municipal solid waste, like all waste, has an environmental and sociological impact if not managed properly. The management of waste also has its own impacts. Thus the environmental, economic, technological and sociological aspects of such waste and its management have to be considered as an integrated problem.

3.1.3 Small City and Rural Household Surveys.

The initial waste audits were followed by detailed and updated studies of the Auckland, Wellington, Dunedin and Christchurch wastestreams and householder behaviour [Dolan, 1993; Worley, 1992; DCC, 1993; WCC, 1995]. Very few detailed studies have been done on the waste production from households in small cities, towns and rural settlements, nor the systems the municipal authorities in these districts are employing to manage their waste. In an attempt to establish a base line with regard to what constitutes municipal waste and what waste behaviour are presently exhibited by populations in a small rural town and city, a survey using the survey forms in Appendix 1 was carried out. The aims of this survey are to establish

- the type and quantity of waste produced by Palmerston North, Levin and Tokomaru households,
- the amount of potentially reusable material deposited in landfills from domestic households in these centres,
- how households in the three areas see their role in waste management and
- how the waste services of the two municipalities, Horowhenua District Council and Palmerston North City Council, are perceived by the citizens.

3.2 Introducing the Project Survey.

3.2.1 Palmerston North, Levin and Tokomaru [Figure 3.1].

Palmerston North is a typical example of a New Zealand provincial small city. It has a population of approximately 63 000, with 23 808 private households [PNCC, 1992]. The city serves a large rural sector, but has a heavy concentration of educational, research and conference facilities as well, and is reputed as having an above national average of bars and restaurants per head of population.

Levin is an example of a rural town with a population of approximately 21 000 people in 5861 households [HDC, 1992]. It is the site for the Horowhenua District Council Offices. Its main function is as a service and retirement centre based on a mixed agricultural/horticultural sector. There is also some light industry, but the unemployment is above the national average[23] [NZISS, 1995].

Tokomaru is a small rural settlement with a population of 550 in 184 households. The village functions as a satellite centre for workers in

[23] By approximately 1%.

Palmerston North and Linton Army Camp, but is served by the Horowhenua District Council.

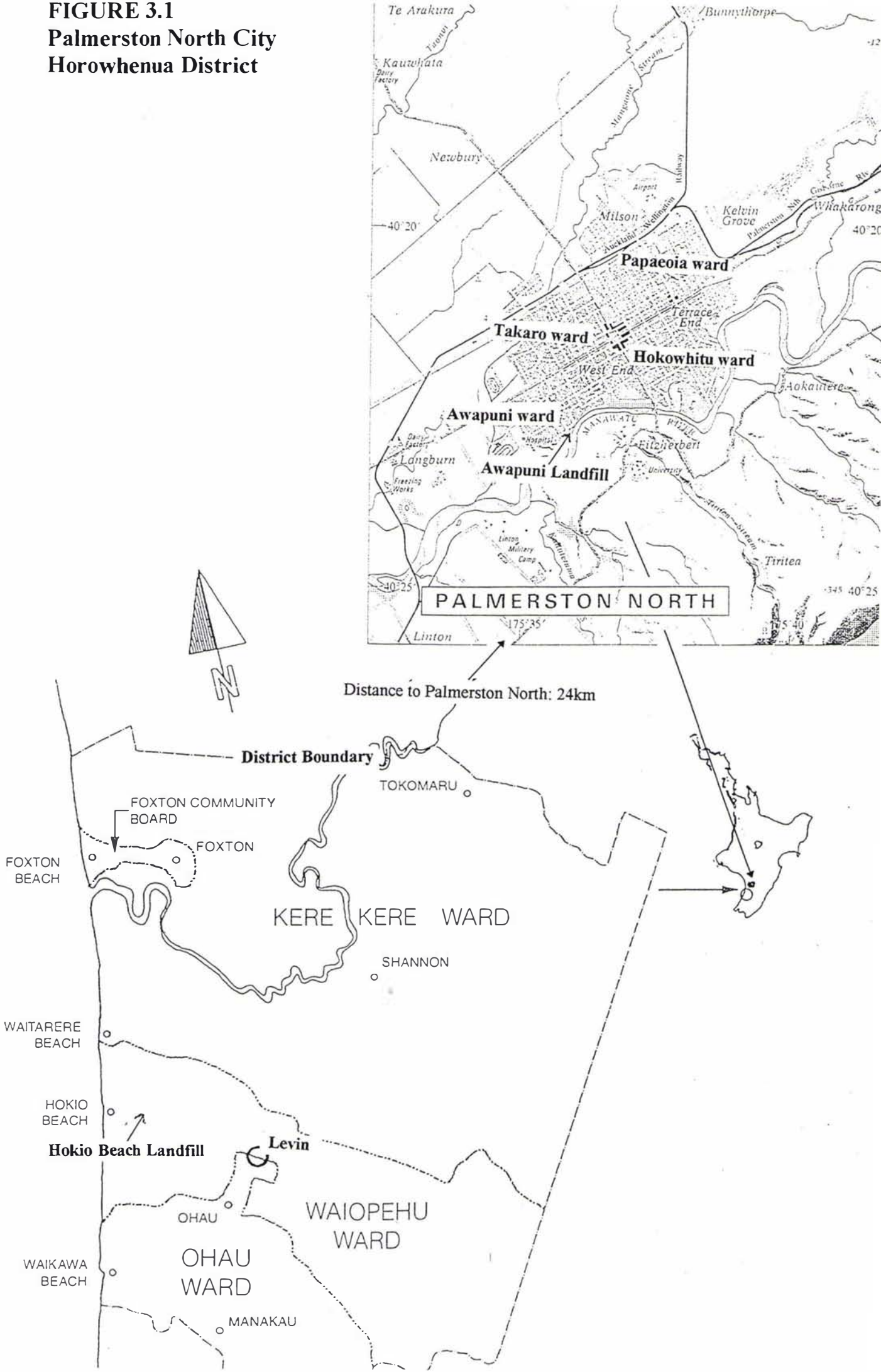
3.2.2 The Survey.

Palmerston North and Levin were surveyed using the questionnaire in appendix 1A. The form consists of two parts:

1. A questionnaire filled out in presence of the researcher relating to basic population statistics and to household waste management behaviour (behaviour survey).
2. A form left with the householder for 7 days on which waste designated for recycling was logged (householder's own survey).

Household waste reaching the landfills from the targeted population in both centres was then sampled by the researcher. In Palmerston North this took place at the Awapuni landfill, where 500 bags (125 from the four wards: Takaro, Awapuni, Hokowhitu and Papaeoia), were collected from the municipal trucks as they arrived after collection. In Levin 125 bags were sampled from the private contractor as they arrived at Hokio Beach landfill. The collection area was ascertained from the drivers and confirmed from bag material. Bags were counted, rejected and selected according to a table of random numbers. The material in the bags was sorted into categories: Organics, recyclable paper, tins, aluminium cans, glass, plastics: recyclable and non-recyclable, aluminium foil and 'others', representing mixed, dirty and non-reusable/recyclable materials. From this last category dry-cell batteries were kept separate as a matter of interest. The resorted categories were weighed on a household bath scale set horizontally with a carpenter's level. The volume of waste was recorded as well.

FIGURE 3.1
Palmerston North City
Horowhenua District



3.2.3 The Waste Analysis Protocol

The publication in November 1992 of the New Zealand Waste Analysis Protocol [Worley, 1992] coincided with the surveys of the above centres. The Protocol sets out clear and detailed objectives and methods for the analysis of MSW. The objectives of this thesis differ from those of the Protocol in that part of the focus of the thesis is on the behaviour of the waste producer and the factors that influence this behaviour. Where the Protocol concentrates on the end product, the thesis looks at the waste management systems that results in the method of disposal of the waste product. As part of this analysis it was necessary to look at the contents of the waste produced. The analysis of this is not as detailed as that set out in the Protocol. Although the study thus does not follow the Protocol methodology in detail, there is enough overlap in methods to allow the data to be presented in a comparable form. This is important in that it enables the data to form part of the regional authorities monitoring obligations under section 35 of the RMA 1991 [Worley, 1992].

3.3 Technical Survey Problems.

3.3.1 Sample Selection.

Ideally the sampling units should be selected randomly from a sampling frame such as the telephone book or the ratepayers' roll [Kish, 1965; Sukhatme and Sukhatme, 1970; Stuart, 1984]. This method was rejected on the grounds that this would immediately introduce a selection bias based on whether the household possessed telephones or had property ownership. Many rated properties have multiple residences on them which is not immediately apparent from the roll. Many residences do not have a phone or the phone is connected to a business. As the aim of the survey was to establish recycling behaviour of households in the centres chosen, the target population excludes businesses and industries. The study population had to, as closely as possible, represent the target population.

Using mail-out surveys was also rejected because of the difficulties of establishing contact with all the potential respondents and the complexity of the form requiring logging of waste over a seven day period. This form requires careful explanation to the participants, not easily achieved by mail. Misunderstandings would necessitate personal visits and call-backs. All of these would incur unnecessary delays and expenses, as well as user frustration.

As the aim of the survey was to gain information about the behaviour of the population, 'Cluster Sampling' was employed. In Palmerston North the clusters came from four urban wards: Hokowhitu, Takaro, Papaeoia and Awapuni. In Levin the clusters came from the East and West halves divided by Highway 1. Overseas waste surveys set the optimum sample size according to weight [Klee and Carruth, 1970; Higginson, 1964; Britton, 1972; Lohani and Ko, 1988]. This was unsuitable for the method chosen for the surveys in Palmerston North and Levin. Musa and Ho, 1981, report that a sample of 700 people out of 55000 is required to give a 5% standard error of the scaled-up total. This sample accounts for 1.3% of the population. Thus the total sample size for Palmerston North was set at 500. In this survey, where households were targeted, each household consists, on the average of 2.6 persons in Palmerston North, a total of 1300 people were targeted or 2% of the population. This gave a cluster size of 125 households per ward. In Levin with a population and households approximately a quarter of that of Palmerston North the sample size was set at 125, divided equally between each half of the town.

After selection of the sample size, a method of random numbers was applied [Meredith; 1976 Eton, 1980]. The first digit of the numbers in a table of random numbers was used. This meant that the 01-09 numbers read as zero, which was given the value of 10 resulting in a sequence of random numbers between 1 and 10. A starting point was chosen randomly (by getting a person unconnected to the study to close her eyes and sticking a pin in a map of the chosen ward). The researcher drove to the position marked, chose an

address and then visited households in random sequence after this. Where the street ended every second turn was made in opposite directions ,except where this entailed leaving the ward. If a household turned out to be a business or an industry, the domestic household next door was chosen.

Non-respondents are a problem of all social surveys [Fishbein, 1967; Moser and Karlton, 1971]. If not dealt with, these will cause biases in the resultant data. An attempt to deal with non-respondents was made in two ways: Those absent when called upon were revisited up to three times at different times of the day. If they continued to be absent, they were replaced by another household at the end of the initial sample. Those refusing to participate were logged as the survey progressed and replaced by another household at the end of the sample until the sample quota had been reached. The statistical methods outlined by Moser and Karlton [1971], were not used as they were felt to be too time-consuming.

The above method does not strictly represent random sampling where each household has statistically equal chances of being selected for sampling, but is justified in terms of survey techniques where the overall aim is gathering of descriptive, as well as quantitative data [Moser and Karlton, 1971].

3.3.2 Trial Survey.

To determine the workability of the survey itself and the validity of its method of application, a trial survey was carried out. The trial sample of 50 was carried out in the Highbury area of Takaro ward. To establish the degree of sampling skew of the final survey, the observed population data on ethnic proportion was tested for "Goodness-of-Fit" with the census data, [Appendices 2 and 3]. Questions 5 and 6 were discovered to lack detail and were adjusted accordingly by including a 'sometimes' (q5) and a 'probably' (q6) option.

The confidence limit of just above 0.5, for the trial Chi-square [Appendix 3], suggests that there is little difference between the sample population and the

target population, that is, the method appears to sample the population in the expected proportion.

3.4 Response to Survey.

With reference to table 3.1 and 3.2, in the category 'NON-PARTICIPANTS': 'NO'S' refer to householders that refused to participate. 'WILL' refers to households that expressed interest but regretfully declined participation for various reasons. 'ABS' refer to households that could not be contacted.

In the category 'COMPLETION': 'I' refer to the survey segment carried out by the interviewer. 'II' refer to the survey segment carried out by the householders themselves.

Table 3.1: Response to survey by householders in the four Palmerston North wards.

SAMPLE RESPONSE FOR PALMERSTON NORTH SURVEY

		NON-PARTICIPANTS			COMPLETION	
WARD	HOUSEHOLD	NO'S	WILL	ABS	I	II
Takaro	593	63	29	376	125	100
Hokowhitu	597	94	45	333	125	109
Awapuni	697	104	38	430	125	101
Papaeoia	468	44	56	243	125	108
TOTAL	**2355**	**305**	**168**	**1382**	**500**	**418**

In total, 2355 households in Palmerston North were visited of which 973 were actually contacted (41%). Within each ward 7 and 15 percent of households were visited: Takaro (10%), Hokowhitu (13%), Awapuni (15%), Papaeoia (4%).

Table 3.2: Response to survey by householders in Levin.

SAMPLE RESPONSE FOR LEVIN SURVEY

		NON-PARTICIPANTS			COMPLETION	
LOCATION	HOUSEHOLDS	NO'S	WILL	ABS	I	II
Levin	579	99	20	335	125	108

In total, 579 households in Levin were visited of which 244 (42%) were actually contacted. This is the same proportion of non-contact non-participants as found in Palmerston North.

3.5 Discussion of Errors.

3.5.1 Response Error.

The technique of one person interviewing all the respondents decrease the non-sampling error due to interviewee differences, that is, response error is minimised.

3.5.2 Coverage Estimate Errors.

Coverage estimation errors are considered to be small from the "Goodness-of-Fit" test on sample bias [Appendix 3].

3.5.3 Non-response Errors.

Non-response errors due to choice, need to be considered from two perspectives. Some non-respondents are willing to participate, but health and other circumstances prevented them from taking part in this survey. Their declaration of willingness is itself a survey result in that it expresses 'waste-consciousness'. The non-participants are more difficult to place: Their choice of non-participation could be interpreted as an indication of 'waste-ignorance', but could equally well be an indication of objection to surveys in general. The category for 'regretful willingness' is small, and errors due to this is probably of no significance. Refusal rate is high, 31% for the Palmerston North survey and 40% for the Levin survey. This suggests that some non-respondent bias is present in the results [Moser and Karlton, 1971]. No attempt was made to relate refusal of participation with ethnicity, age grouping or social status as recommended in Moser and Kalton, as such judgement was considered too subjective. Respondents, for example, often classified themselves as Maori or non-Maori in cases where visual judgement would have classified them differently. Health of the respondents often dictated a different impression of age than that of real age.

As the participating group is represented in its 'real' population proportions, according to the Chi-square comparison with the census data for the centres

tested, it can be concluded that the refusal bias does not appear to be related to ethnicity or age, but may be related to interest in the topic of the survey. If this is the case a bias in favour of 'waste-consciousness', that is recycling and waste management behaviour should be expected in the results from the householders' own surveys. Some of these surveys were completed so poorly that they could not be used. An analysis of these 'lost' forms was done in relation to age and ethnicity. There appears to be some overrepresentation of the elderly in this category. No ethnic bias was apparent.

3.5.4 Householders' Own Survey.

The data from the householders' own survey suggest that this survey was less successful due to variation in the interpretation and completion of the forms by the householders. The instructions given to the householder appear to have been insufficient and too often forgotten by the time the survey was completed. A written, detailed set of instructions would probably have improved the outcome. The problem did not become evident until the self-administered survey forms were compared with the surveyor administered forms during final analysis. Householders were logging a mix of waste designated for the landfill and waste designated for recycling. Rather than rejecting all the data, the forms were re-analysed to accommodate the choices the householders had designated in their waste management strategies. The amounts logged were then averaged out per person per week. It was then possible to calculate the amounts going to recycling and to the landfill by multiplying the numbers following certain waste management strategies. This further reduced the samples available, but still retained a valid[24] and reliable[25] sample number. Only two categories of waste logged proved consistently useful enough to get worthwhile data: Organics and paper. Glass

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[24] Where validity is defined as 'the degree to which the data is capable of achieving certain aims.'[Mehrens and Lehman, 1978].

[25] Where reliable is defined as the 'degree of consistency between two measures of the same thing.'[Mehrens and Lehman, 1978]

and metal was too often logged without weight or volumes. Plastics were not sorted according to recycling numbers.

3.5.5 Income Grouping Response.

The question on income grouping met with such resistance and uncertainty that it was dropped from the final survey. Resistance was related to suspicion that the information was not confidential. Uncertainty arose from households frequently being shared by individuals not otherwise connected to each other by relationships, and information about combined incomes became irrelevant or impossible to ascertain. The Tokomaru survey attempts to correct this by applying the Elley and Irving table of occupational groupings [1985]. Analysis of waste behaviour as related to income groupings is done in relation to that survey. This is further discussed in chapter 6.

3.5.6 Instrument Errors.

Bathroom scales were used for measuring the samples. The instrument errors were found to be negligible over the range of measurements made in the survey.

3.5.7 Collected Bag Survey.

The surveying of collected bags tended to oversample waste-producing households as these are likely to be represented by more bags in the collection than waste minimising households. This bias was estimated by testing the means of the two types of sampling by using the t-test. The means were found to be similar enough to draw the conclusion that the sample population is represented by the bag collection.

3.6 Discussion.

The analysis of the type, quantity and reusability of waste can be done quantitatively and objectively. Such analyses have been carried out in municipalities in many parts of the world to assess collection and disposal

practises, for planning and evaluating alternative or future schemes and estimating equipment and land needs. Limitations on money, time and labour have dictated that only the minimum number of samples, consistent with obtaining results of a high degree of accuracy, be analysed. Methods for establishing such sample numbers for analysing domestic waste have been developed by Australian teams [Musa and Ho, 1981]. These methods were re-established by a Phillipine research team in 1988 [Lohani and Ko, 1988]. The sample size determined by these researchers was applied for the surveys carried out for this thesis.

The analysis of behaviour involves both objective and subjective components. The aim of surveys administered for the purpose of establishing preferences and behaviour, is to minimise errors caused by subjective questions and techniques, while maximising objectivity by using valid statistical tools for analysis. Survey methods dealing particularly with sociological issues, such as health, education and welfare have been developed and used extensively in New Zealand and overseas [Fishbein, 1967, Moser and Karlton, 1974, Barnett, 1974, PNCC, 1992]. These survey methods deal with errors related to non-response, interviewer bias and respondent ignorance [Moser and Karlton, 1974]. The aim is to minimise errors while administering the survey at a realistic cost and within a realistic timeframe [Moser and Karlton, 1974, Musa and Ho, 1981].

Trial surveys ensures the survey itself is objective and applicable within the restrictions of time and cost [Biener *et al,* 1991]. After analysis of the trial survey this was considered to be an achievable aim. At the completion of the survey and closer scrutiny of the possible errors, it was considered that the aim was achieved. This conclusion is further supported by the analysis of the standard Chi-square "Goodness-of-Fit" test applied to test for sampling bias. According to common practise for these tests the classes below 5% were combined [Parker, 1973]. This gives two degrees of freedom for all the tests. The Papaeoia and Takaro Wards have probabilities between 0.5 and 0.1, with that of Takaro ward close to 0.5. The other wards have p values between 0.9

and 0.5, high probabilities that the deviation between the observed and expected (census.) values are insignificant. Thus there appears to be no sampling bias. This is supported by the combined Chi-square tests for all the wards in Palmerston North.

The Chi-square test for Levin gives a p value between 0.5 and 0.1 indicating that a small bias in sampling occurred. This may be caused by an undersampling of the Maori population. Whether this was caused by Maori householders in Levin being less likely to be home for the survey or whether the Maori householders from this location were more likely to decline participation in the survey, cannot be determined from the data.

CHAPTER 4

WASTE GENERATION BEHAVIOUR

PALMERSTON NORTH AND LEVIN

4.1 Statistical Analysis of Survey Data.

4.1.1 Target Population Grouping.

For the purpose of further analysis, the target population was divided into its household component parts relating to:

1) size of the household (designated 'groupsize'). Household sizes in the samples varied from 1 - 13 individuals.

2) type of households, as related to age of family members. Thus five family types were established:

a) Young Singles [YS] marital status irrelevant, as long as all householders fell within a certain age group: 18 - 25.

b) Middle Singles[MS], age group 25 - 65, as long as household members did not show a generational age difference.

c) Young Family [YF], with the majority of the children below 10 years.

d) Middle Family [MF], with the majority of the children between 11 and 25 years and any other older family group showing a generational age difference.

e) Older Residents [P] - age group >65, designated 'pensioners' for labelling purposes.

4.1.2 Hypotheses Tested.

The following hypotheses were tested using the General Linear Models (GLM) procedure of SAS, version 6.0 This procedure uses the method of least

squares to fit general linear models. It allows the specification of any degree of interaction of effects. Contrast statements provide a mechanism for obtaining custom hypotheses tests. The GLM analysis of the data provides the Pr>F value which indicates whether the parametes as tested against the Null Hypothesis are significantly greater than zero. A small Pr>F indicates a significant difference. The statistical analysis also uses the Multiple Comparison Procedure (MCP) which analyses differences amongst means. [Appendix 2].

1. There was no difference in recorded bags among the four Palmerston North wards.
2. There was no difference between the bags produced per person per week in Palmerston North households of different sizes.
3. There was no difference between the bags produced per week in the five different family type households in Palmerston North.
4. There was no difference in recorded bag numbers between Palmerston North and Levin.
5. There was no difference between the bags produced per person per week in Levin households of different sizes.
6. There was no difference between the bags produced per person per week in the five different family type households in Levin.

Data for group sizes 7 - 13 was not tested as the representative sample for the groups was too small with missing groups or less than 3 representatives in each sample. Where there was a significant difference between the means [$p < 0.05$], Duncan's, Tukey's or Fisher's LSD tests [Appendix 2] were used to identify if the survey data differed[26]. As these tests are most reliable for balanced designs, that is, where sample numbers are equivalent, so that all possible pairs of data can be compared, linear contrasts were carried out to test whether the means of each survey group differed, on the average, from

[26] Duncan's test controls the comparisonwise error rate at 5% confidence limit. As a precaution, p values between 4% and 10% should be further analyzed with Duncan's to test whether the difference is indeed significant [Ganesh, 1993].

the means of the other groups surveyed. The SAS output is found in appendix 4. Summary tables compiled from this output are included in the discussions below.

HYPOTHESIS 1. That there is no difference in recorded bags among the four Palmerston North wards.

The SAS output of the ANOVA [Appendix 4] provides strong evidence that there is no significant difference in the recorded bags between the four Palmerston North wards (Pr=0.2432). The sampling difference between Papaeoia Ward and the other three wards surveyed suggests that the above results should be treated with caution. The under-representation in the survey of households from the much larger Papaeoia ward could have introduced a sampling error which masks any differences between this ward and the others.

HYPOTHESIS 2. That there is no difference between the bags produced per person per week in Palmerston North households of different sizes.

The output [Appendix 4] shows strong evidence that the size of the household group in Palmerston North has an influence on the average amount of waste put out for collection (Pr=0.0001). This occurs across all the wards (Pr=0.7052), that is, geography has no influence on the sampled data [Table 4.1]. The MCPs [illustrated by Duncan's Multiple Range Test , appendices 2 and 4], provide supporting evidence that some groupsizes produce significantly different numbers of bags per person per week, with groupsize 1 producing most and groupsize 4 the least. The data pertaining to groupsize 1 (consisting of one individual) should be treated with caution[27]. The ambiguous nature of the groupsize 3 and groupsize 4 data was analysed

[27] The difficulty in estimating the bag volume on a weekly basis increases with smaller volumes. Single people households may over-estimate volumes by logging a half full bag as full. This problem is compounded when the householder is elderly and lacks the confidence in estimating. As single person households tend to be elderly person households, this error affects both the household size and family type analysis and may explain the high means for MS, P and GRPSZE 1 data.

using the SAS contrast statement [Appendix 2]. This output is summarised in table 4.2.

Table 4.1: SAS GLM summary: Hypotheses 1 - 6.

HYPOTHESES	SOURCE	DF	TYPE I SS	MEAN SQUARE	F VALUE	Pr > F
1	Ward	3	2.81446	0.9381533	1.40	0.2432
2	Group-size	5	5.56163544	1.11232709	24.55	0.0001
	Ward	3	0.06353056	0.02117685	0.47	0.7052
3	Family-group	4	3.27989753	0.81997438	16.24	0.0001
	Ward	3	0.3807855	0.01269285	0.25	0.8603
4	Location	1	5.68839093	5.68839093	9.25	0.0017
5	Group-size	5	23.4265781	4.68531562	0.98	0.4360
6	Family-group	4	0.40668858	0.10167214	1.15	0.3387

Table 4.2: CONTRASTS: Variable=Bags.

CONTRAST	Pr > F	SIGNIFICANCE
1 Vs 2,3,4,5,6	0.0001	High
2 Vs 3	0.1420	None
2 Vs 4,5,6	0.0001 , 0.0009 , 0.0119	High , Quite
3 Vs 4	0.0059	Quite
3 Vs 5,6	0.0411 , 0.1035	Little , None
4 Vs 5,6	0.8557 , 0.9840	None
5 Vs 6	0.8907	None

Table 4.2 supports the finding that groupsize 1 produce significantly more bags per person weekly, than do any of the other groups.

Groupsize 2 produce significantly more bags per person than groupsize 4, 5 and 6, while there appears to be no significant difference between this groupsize and groupsize 3.

Groupsize 3 produces a quite significant amount more than groupsize 4, but not significantly more than groupsize 5 and 6. There appear to be little or no significant differences between groupsize 4, 5 and 6.

These contrasts support the Duncan's output, illustrating the ambiguous nature of the groupsize 3 data, and indicating a tendency for small groups to record relatively large waste volumes per person per week. The note applying to the interpretation of groupsize 1 above, may also apply to groupsize 2, that is, the smaller the actual volume, the greater the error of estimating the volume becomes.

HYPOTHESIS 3. That there is no difference between the bags produced per week in the five different family type households in Palmerston North.

The SAS output [Appendix 4] shows strong evidence that the type of household is significant in influencing the average number of bags produced per week (Pr=0.0001). The geographic location of the household has no influence on this (Pr=0.8603). [Table 4.1].

The MCPs [Appendices 2 and 4], show a significant difference between older residents, singles and family households, forming three distinct groups. Thus older residents produce most bags per person per week and family groups produce least. Once again this apparent difference should be treated with caution. Duncan's Test is supported by Contrasts [appendix 4]

HYPOTHESIS 4. That there is no difference in recorded bag numbers between Palmerston North and Levin.

The comparison of the Palmerston North and Levin data shows evidence that there is a significant difference between the two [p=0.0017] [table 4.1]. This is supported by Fisher's Least Significant Difference test (LSD), [appendix 4].

HYPOTHESIS 5. That there is no difference in the bags produced per person per week in Levin households of different sizes.

The output shows no significant difference (Pr=0.4360) in the average number of bags produced weekly by Levin households of different sizes [Table 4.1]. This is supported by the MCPs and Contrasts (Pr>0.05). [Appendix 4].

HYPOTHESIS 6. That there is no difference in the bags produced per person per week in the five different family type households in Levin.

The SAS output for the family types in Levin households shows no significant evidence for different average bag production per week (Pr=0.3387). [Table 4.1].

The MCPs are ambiguous about the degree of significance: Duncan's [Appendix 4] declaring YS to be significantly different from the rest whereas Tukey's declare that there is no significant difference [Appendix 4]. This ambiguity is probably accounted for by the small sample number represented by the YS group in Levin[28]. The contrasts support this by showing no significant differences between any of the family types (Pr>0.07). [Appendix 4].

4.2 Discussion.

The ANOVA output shows that there appears to be a significant difference in the waste produced for collection between Palmerston North and Levin [Hypothesis 4], with Palmerston North producing more waste for collection per individual per week. There also appears to be a significant group size and family type effect on waste produced for collection in Palmerston North, but not in Levin [Hypotheses 3 and 6].

These differences invite a closer look at waste behaviour in the two centres. Part 2 of the survey [Appendix 1] asks householders to state choices made

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[28] The YS group in Levin is a different group from that in Palmerston North , where the proximity of the learning institutions ensure that this group constitutes mostly students, that is single, highly educated individuals.

with regard to waste management. These choices were graphed for easy comparison of Levin and Palmerston North householders.

4.2.1 Compartmentalisation of Waste.

The following analysis refers to the data obtained after administering the questionnaire in appendix 1A:

Question 1. The objective of this question was to determine the degree of compartmentalisation of waste taking place within the household. Knowledge of such behaviour can be important to waste managers, as they denote the degree of waste awareness present in the population. Three behaviour are of particular interest:

a) No compartmentalisation. This suggests that the householder concerned treats all waste the same.

b) Compartmentalisation. This suggests that the householder is segregating waste to a greater extent than the householders in [a].

c) Compartmentalisation in reused containers. This suggests some waste minimisation awareness[29].

[29] If the householder is not recycling plastics, the reuse of old plastic bags as waste receptacles are a form of waste minimisation. As 46% of the 500 householders surveyed in Palmerston North declared that they recycle plastics, at least sometimes, a 72.2% use of old plastic bags represent plastic lost to the recycling stream, in effect potential loss of revenue. The use of old bags in Levin where bags cannot be recycled via recycling stations represent one of the few options for reducing waste from this source. Such use has no economic impact on the recycling stream.

Figure 4.1
First Receptacle for Household Waste
Palmerston North and Levin Data

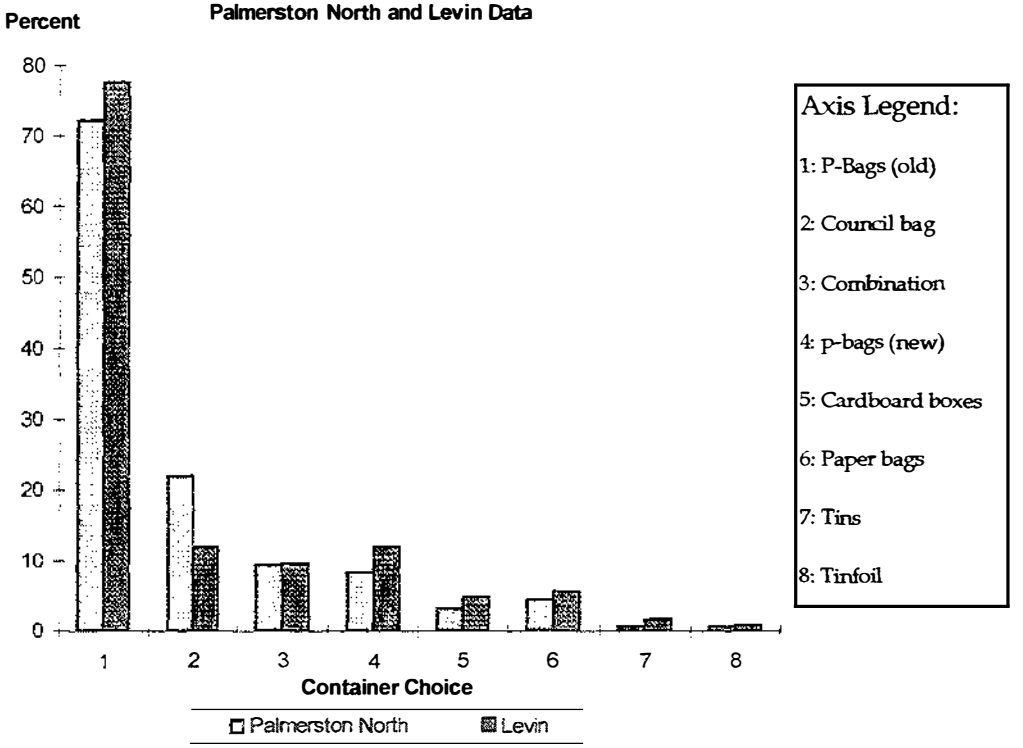

Figure 4.1[30] shows the response to question 1. From this graph it is clear that most householders in both Palmerston North (72.2%) and Levin (77.6%) compartmentalise and reuse waste before disposal[31]. Most householders follow one method (86% in Palmerston North, 90% in Levin)[32]. Palmerston North residents are much more inclined to dispose directly into the council bag. This may be explained by the 'free' provision of 52 council bags/year to householders in Palmerston North, whereas Levin householders have to purchase each separate bag. Thus Levin householders may attempt to

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[30] The legend for the Container Choices: Council-bag =official bags. CDBD-box =cardboard boxes. Combination =any mix of choices. New P-bag =New plastic bag. Reused P-bag =old/used plastic bags. Paper =Newspaper. Tins =old food tins. Tinfoil =Used cooking foil.

[31] The householders were free to specify any number of choices. Those with multiple behaviour were listed as 'combinations'. Only those with clear choices have been considered in the conclusion.

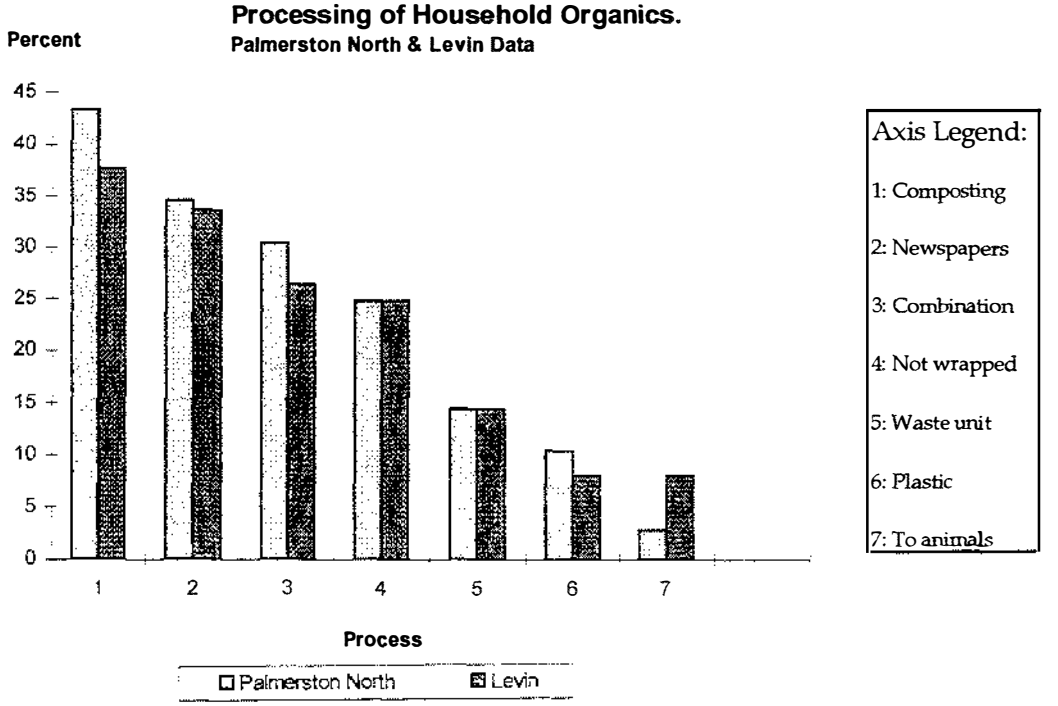
[32] Takaro Ward [Palmerston North] householders are least faithful to one method. [Appendix 6]

minimise the personal cost of waste by organising the waste and reducing volumes for collection, whereas the hidden costs of the Palmerston North bags do not encourage such behaviour.

4.2.2 Processing of Household Organics.

Question 2 and 8. The objectives of these questions were to determine how householders in Palmerston North and Levin process their household organics. As this component makes up approximately 40% by weight [Appendix 10] of household waste, improvements in waste reduction can be gained by expanding on existing organic waste minimisation behaviour[33]. The questions ask householders to specify how they treat organics before disposal[34].

Figure 4.2
Processing of Household Organics.
Palmerston North & Levin Data



[33] Where sewage is adequately treated, waste units represent a municipal form of composting. This is an expensive method that tends to overload treatment plants.

[34] Organics wrapped in newspaper are readily processed by composting methods, whereas those in plastic are more likely to decompose anaerobically giving rise to landfill gases.

Figure 4.2 shows that there is little difference in how householders in Palmerston North and Levin deal with this waste, although residents in Palmerston North are more likely to use a combination of methods[35]. A result of the survey shows that composters, animal feeders and waste unit users show specific other practices complementing these choices[36].

4.2.3 Waste Produced for Collection

Question 3. The objective of this question was to determine how much waste for collection the householders at the two locations produce.

Figure 4.3
Bags of Household Waste Produced per Week
Palmerston North and Levin Data

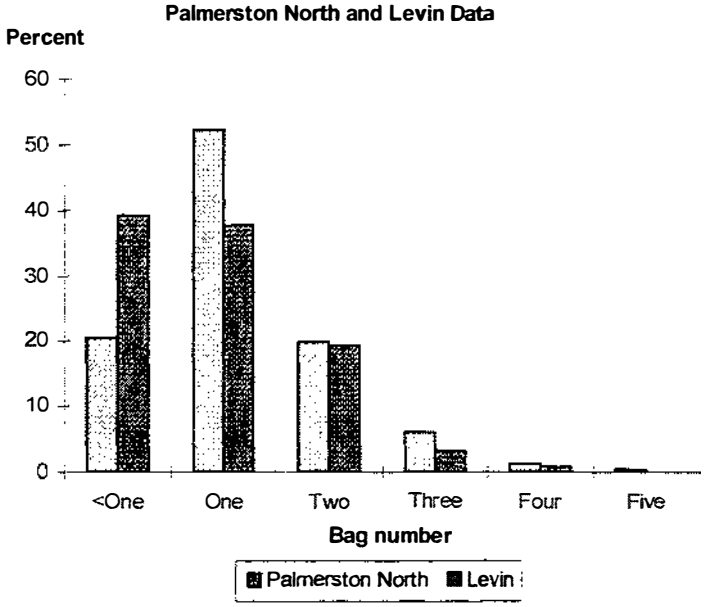


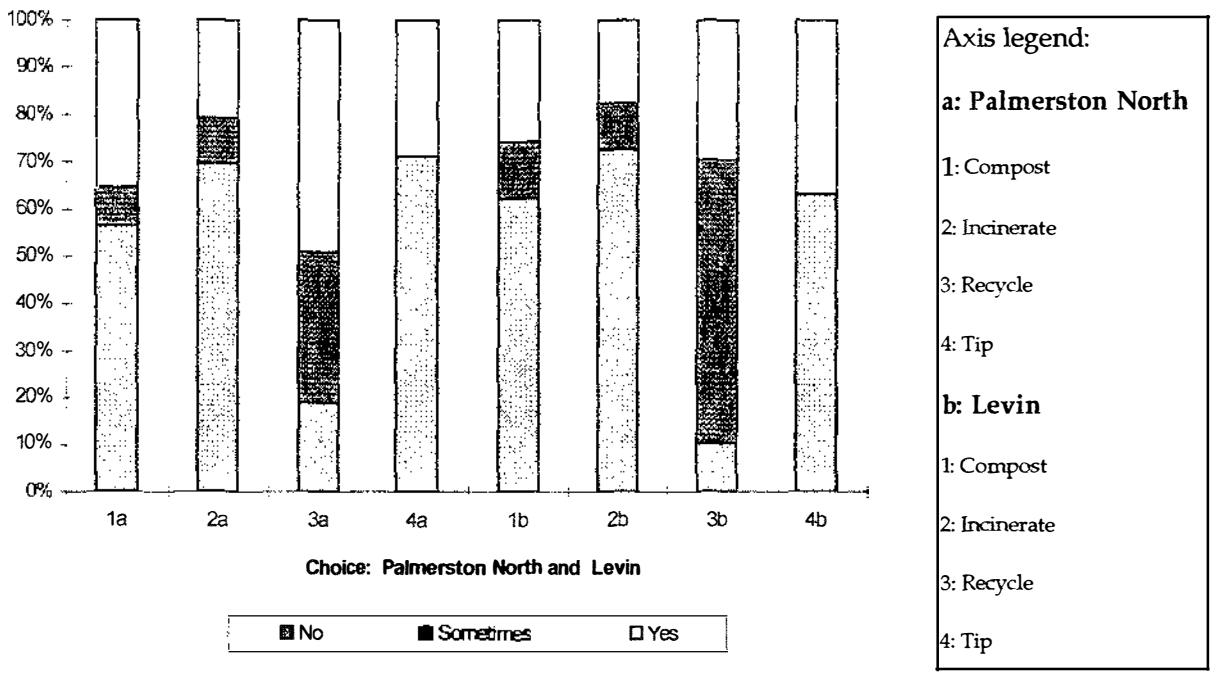
Figure 4.3 graphically illustrates the details of the statistical result for Hypothesis 4. Palmerston North produces significantly more bags per

[35] The householders stating a combination of methods often stated that the weather determined their choice, for example composters will use the Council service in inclement weather.

[36] The bars in the graph add up to over 100% , even excluding the 'combination' group. This is caused by the 'paper' and 'unwrapped' sections as householders that compost, feed to animals or use the waste unit also state that they do not wrap their organic waste. Composters often use paper as well, but never plastic.

household than does Levin[37]. This is probably caused by two important differences in waste management in the two locations: the 'hidden' price of Palmerston North waste bags and the tipping charges at Malden Street Transfer Station and Awapuni Landfill. This will encourage householders in Palmerston North to use the collection more than householders in Levin, who see the price of bags as a direct cost and probably visit the landfill more frequently because it is 'free'[Figure 4.4].

Figure 4.4
Tipping, Recycling, Composting and Incineration Behaviours.



4.2.4 Waste Behaviour Alternatives.

Questions 4,5,8 and 9. The objectives of these questions were to determine the waste behaviour alternative to that of collection of household waste [excluding garden waste]. Incineration of waste included the use of household heaters. Three possible answers were allowed for composting,

[37] The overall average for Levin is one bag per household per week. For Palmerston North it is 1.25 per week. Takaro ward produces a higher average number of bags per household per week than do any of the other wards.

incineration and recycling: 'Yes', 'no' and 'sometimes'. Only a 'yes' or a 'no' was allowed for tipping. With the 'sometimes', category included Figure 4.4 illustrates that Levin householders are more inclined to compost and use of a landfill than are householders in Palmerston North. The degree of uncertainty in the 'sometimes' category is much higher for Levin in all allowed categories except 'incineration'. The high incidence of uncertainty in the recycling category for the Levin residents probably reflects the lack of recycling facilities at that time in Levin[38]. The residents were committed to using the facilities that were already there, mainly for clothes and paper. If all the 'sometimes' answers are included as 'yes' , Levin householders are tipping and recycling more often than householders in Palmerston North. The difference in incineration may not be significant. Although there is little difference in the willingness to compost in the two surveyed centres, it appears that Palmerston North residents tend to use the collection system rather than alternative waste disposal methods. Levin residents are using the landfill more (36.8% In Levin against 28.6% in Palmerston North). This supports the theory that systems with 'hidden' costs will be used more.

4.2.5 Recycled Materials.

Question 6. The objective of this question was to ascertain which materials and combination of materials, are most often recycled[39].

[38] In both Levin and Palmerston North the householders stating that they never or sometimes recycle, close to 27% state that they would improve this if recycling was more convenient.

[39] All complete categories are worked as a percentage of the number of households declaring recycling behaviour , always or sometimes. Palmerston North=396, Levin=112.

Figure 4.5
Householders Stated Recycling Behaviours
Palmerston North & Levin Data

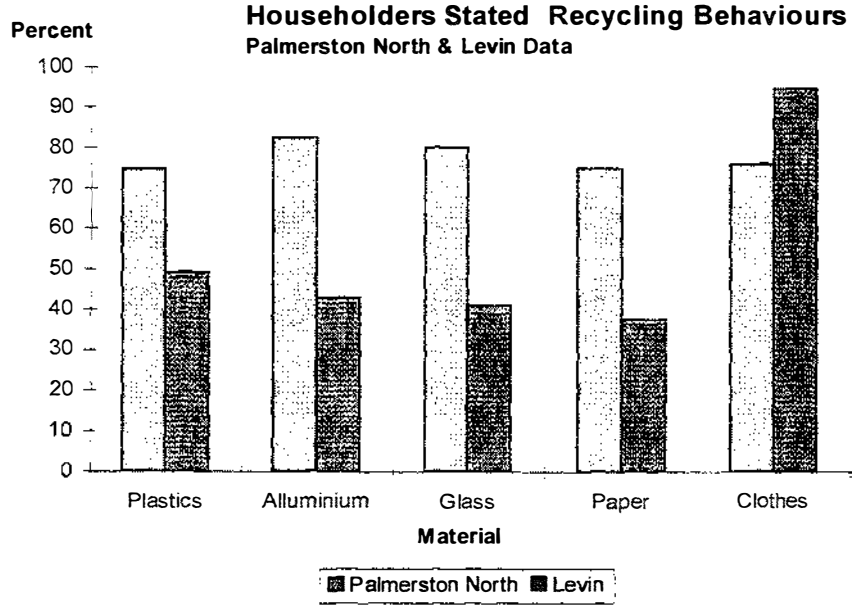
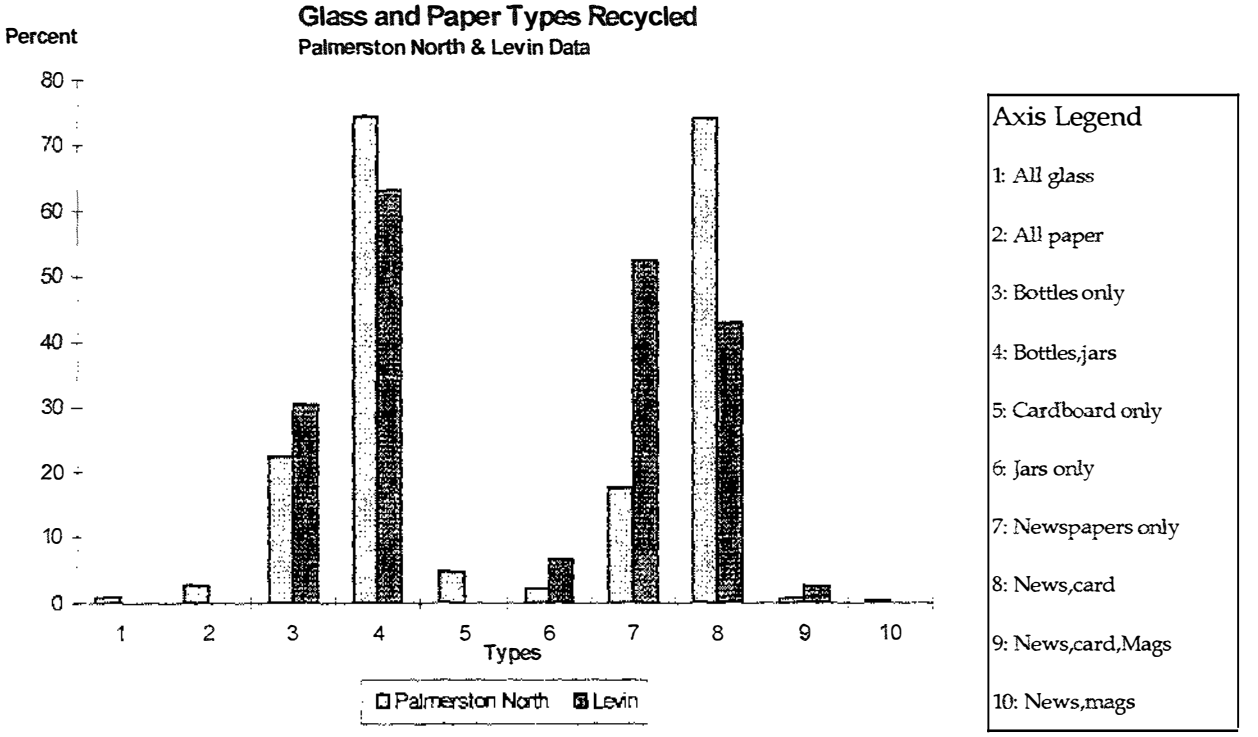


Figure 4.5 shows which materials are recycled by the residents surveyed. More Palmerston North residents recycle in all categories except clothes[40]. When the materials recycled are further analysed [Figures 4.5a and 4.5b], Levin residents seem to be more likely to recycle single types of plastics, for example, bags or milk bottles.

[40] All sub-groups are taken as a percentage of recyclers in the major group, for example, plastics=296 for Palmerston North.

Figure 4.5a
Plastic Types Recycled
Palmerston North & Levin Data

Figure 4.5b
Glass and Paper Types Recycled
Palmerston North & Levin Data



There was no plastic bag collection in Levin at the time of the survey. The recycling of these is probably tied into the charity business related to the clothing recycling, which the Levin residents participate in to a larger degree than The residents of Palmerston North. The separate recycling of milk bottles is probably a result of the start of a privately run recycling business (EVO) which coincided with the completion of the survey in 1992. Otherwise there is not a large difference in the percentage of householders in Levin or Palmerston North that recycle in all the recyclable plastic categories (58% in Levin against 65% in Palmerston North). The differences shown in Figure 4.5b pertaining to glass and paper recycling, illustrates the differences in the Levin and Palmerston North recycling businesses. Levin has traditionally collected newsprint for the IHC. This organisation has developed a business depending on the sale of shredded paper for animal bedding. The profits from this business depends on the free availability of used newsprint, and is used solely to finance a social institution. The business also employs intellectually handicapped as workers so fulfils a double function. EVO, on the other hand, is a private business and totally profit dependent. The management has chosen not to collect paper, in the expectation that residents will prefer to support the charitable organisation. This charitable connection probably explains the high recycling of newsprint in Levin and also explains why the recycling of other paper products is low. Palmerston North collects various paper types at its recycling centre, so householders recycle both cardboard and newsprint together.

Householders in both centres behave relatively similar with respect to the return of glass. When the recycling behaviour is analysed further [Figure 4.6a], it is seen that Palmerston North recyclers are more likely to recycle in all the groups of materials recyclable. For both locations it is clear that aluminium and clothes are the only two materials recycled to a significant extent by themselves. This can be explained by the householder's awareness of the economic value of these two materials. Clothes have traditionally been

related to the charity businesses in New Zealand, and aluminium has been actively promoted as a value commodity, for example, the scheme set up by the BP service stations: 'Spin-a-Can', where used cans could be inserted in a slot machine for a potential prize, the direct saleability of cans to metal recyclers or the collection and sale of cans by schools and scouts to raise funding.

Figure 4.6a
Choices of Combination of Recycled Materials
Palmerston North and Levin Data

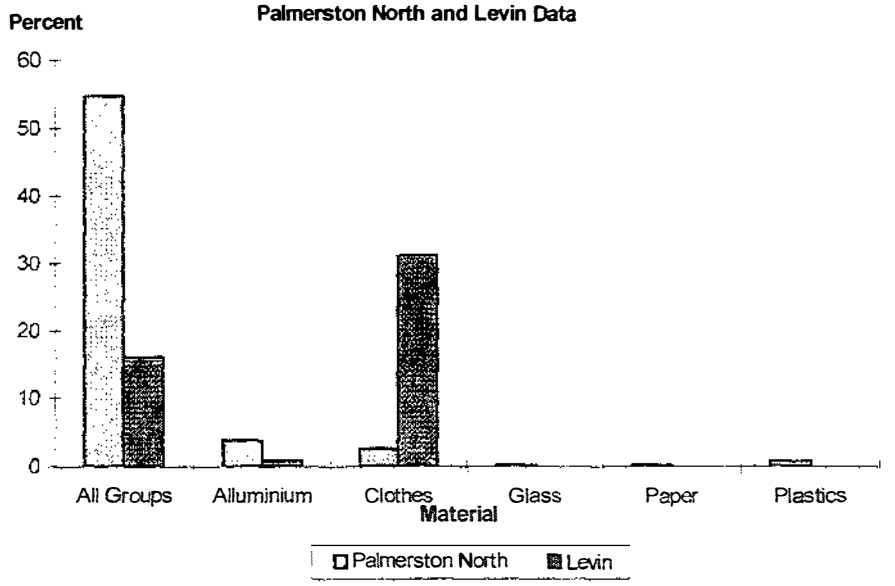
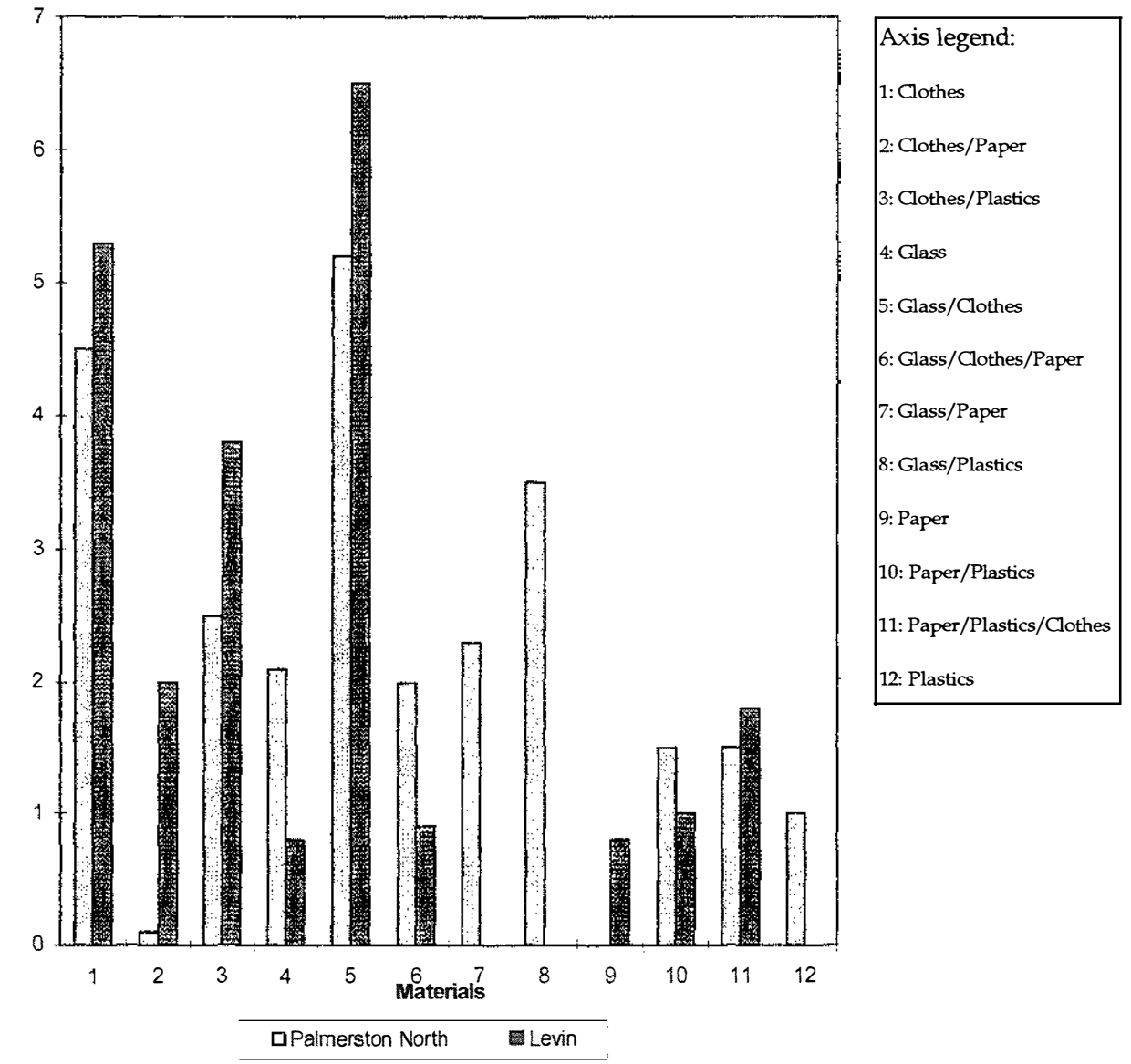
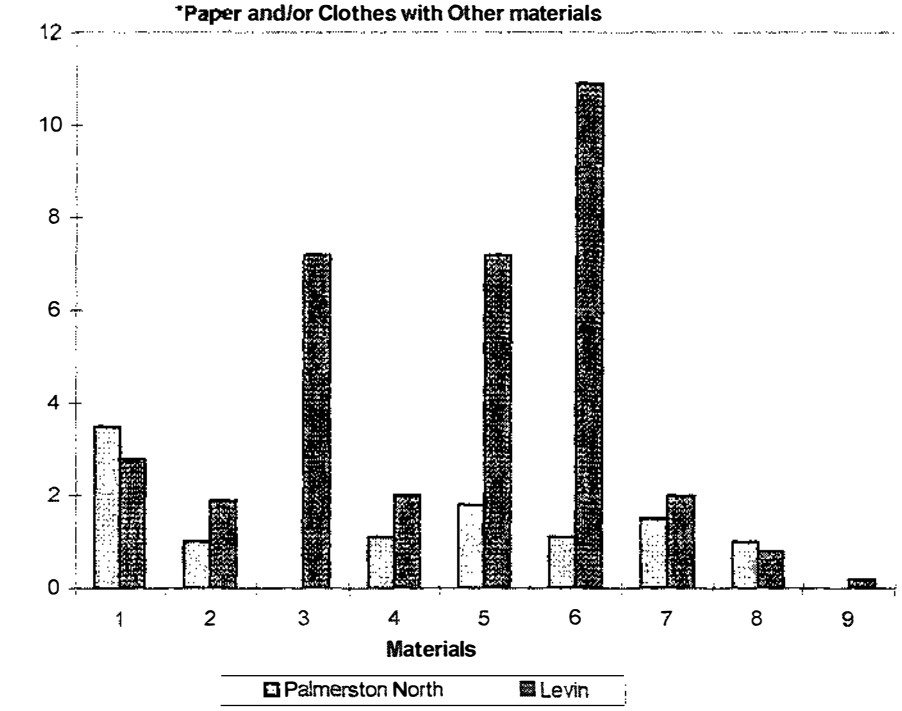


Figure 4.6b
Choices of Recycled Materials*
***Alluminium with Other Materials**



When the combinations of materials recycled, are looked at in greater detail [Figures 4.6b and 4.6c], it is clear that these two economic commodities drive the return of other recyclables. Figure 4.6b shows that this is particularly so in Palmerston North where aluminium alone drives the return of glass and paper in various combinations. In Levin, clothes appear to be the driving commodity. Thus aluminium appears to be only incidental to the return of paper and plastics in Levin. This appears to be supported by figure 4.6c. Clothes dominate the combination of materials recycled in Levin.

Figure 4.6c
Choices in Combination of Recycled Materials*
*Paper and/or Clothes with Other materials



Axis Legend:

1: Clothes/Glass

2: Clothes/Glass/Paper

3: Clothes/Glass/Plastics

4: Clothes/Glass/Plastics/Paper

5: Clothes/Paper

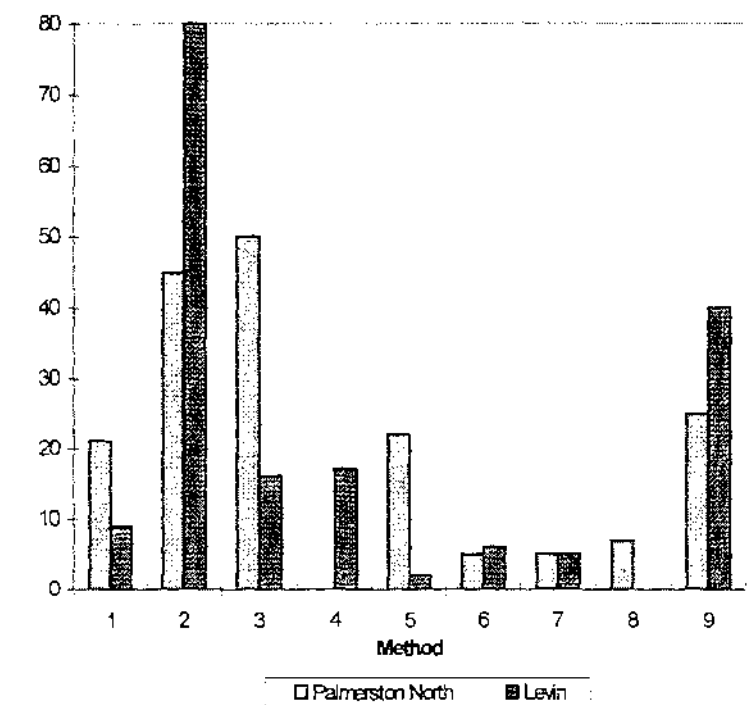
6: Clothes/Plastics

7: Clothes/Plastics/Paper

8: Paper/Glass

9: Paper/Plastics

Figure 4.7
Recycling Methods Used
Palmerston North and Levin Data



Axis Legend:

1: BP

2: Charity

3: Council

4: EVO

5: Glassbins

6: Own sale

7: School/Scouts

8: Supermarkets

9: Own Use

Figure 4.7 shows the recycling methods used in the two centres. Some of the methods have since become redundant, but are discussed here as they probably helped to educate people towards certain recycling behaviour, for example BP 'Spin-a-Can'. Some of the methods are found in one of the locations only, for example EVO, which is a Levin based firm and the supermarket collections, which are found in Palmerston North. There is a clear difference in the extent that charities, which include school and scout groups, influence recycling behaviour and the reuse of materials. Levin has a much higher incidence of all of these. In Levin the glass bins were operated by the Council at the landfill, and EVO is operating through Council paid collection points, so it is probably reasonable to combine these two with the column for Council data. If that is done there appears to be little difference in Palmerston North and Levin as to the use of recycling depots. Palmerston North has a high use of glass bins as an alternative. These are privately run and placed in many strategic places around the city where the public can conveniently use them.

4.3 Further Statistical Analysis.

4.3.1 Two New Hypotheses.

The breakdown and results of the statistical test pertaining to hypothesis 4 showed that there is a significant difference in the number of bags produced for collection in Palmerston North and Levin. This in turn gave rise to the hypotheses that:

a) There is no significant difference between Palmerston North and Levin in the waste disposal behaviour: composting, sink waste disposal units, landfilling and composting; and

b) There is no notable difference between Palmerston North and Levin with respect to the waste behaviour in (a) of each family group.

The latter hypotheses were tested by comparing the proportions associated with each behaviour in the two centres. To make the numbers comparable the samples were converted to a percentage. The overall mean for each

behaviour was estimated together with its standard error [Appendices 2 and 8]. As the sample numbers of behaviour listed for each group is small, the categories were defined by their means and standard deviations, [Appendix 8] and were converted to a z-score [Appendix 2], to allow comparisons between centres for the behaviour for each family type. As the results pertain to two different populations the interpretation of the z-scores must be done with caution. Hence z-scores that fall in either the upper or lower percentiles for both Palmerston North and Levin, are not considered to be indicative of significance in behaviour differences (For example, 5 and 14 for YS composting behaviour). Where the score falls in two opposing percentiles, the trend is probably significant enough to be considered as indicative of differences in behaviour for the two centres (For example, 90 and 14 for YF composting behaviour).

Within the same population the complete comparison of z-scores is valid. Thus low scores indicate low levels of a particular behaviour and high scores indicate high levels of a particular behaviour.

4.3.2 Comparisons of Waste Behaviour in Palmerston North and Levin.

Table 4.3: Proportional comparison of waste disposal behaviour in Palmerston North and Levin.

PROPORTIONAL COMPARISON , WASTE DISPOSAL BEHAVIOUR								
SCORE	**PALMERSTON NORTH**				**LEVIN**			
	COMP[a]	**WU[b]**	**LAND FILL[c]**	**REC[d]**	**COMP[a]**	**WU[b]**	**LAND FILL[c]**	**REC[d]**
ΣX	30.8	13.6	27.8	70.0	31.2	13.6	36.0	84.8
	6.16	2.72	5.56	14.0	6.24	2.72	7.20	16.96
SD	2.98	1.75	3.45	5.52	5.04	0.99	3.82	7.8
CI[t0.05]	±3.12	±1.86	±3.67	±6.08	±5.37	±1.06	±4.07	±8.32
Lower	3.43	0.85	1.88	7.92	0.87	1.66	3.13	8.54
Upper	9.28	4.58	9.23	20.08	11.61	2.12	11.27	25.30
Z[YS]	-1.6	0	-0.9	-0.8	-1.1	0	-1.5	-1.7
Percentile	5	0	18	21	14	0	7	7
Z[YF]	1.0	0.7	0.8	1.3	-1.1	2.1	1.3	-0.4
Percentile	90	76	79	91	14	97	91	34
Z[MF]	1.0	1.9	1.6	1.1	0.1	0.5	0.6	1.3
Percentile	90	97	95	86	46	69	73	88
Z[MS]	-0.6	-0.12	-0.5	-1.1	1.0	-0.3	0.4	0.3
Percentile	27	46	31	14	84	38	66	62
Z[P]	0.2	-1.0	-0.9	-0.5	1.3	0.5	-0.8	0.4
Percentile	54	16	18	31	91	69	21	66

[a] Composting [b] Waste Unit [c] Landfilling [d] Recycling

The interval estimates for the four behaviour in Palmerston North and Levin show a large overlap in the confidence intervals. This suggests that the behaviour for these two centres cannot be declared to be different with any degree of confidence. There is, however, some interesting differences in the z-scores for the various family groups:

Table 4.4: Comparison of the waste behaviour in Palmerston North and Levin.

COMPARISON TABLE				
FAMILY TYPE	**COMPOSTING**	**WASTE UNIT**	**LANDFILLING**	**RECYCLE**
YS	NO DIFFERENCE	NO DIFFERENCE	NO DIFFERENCE	NO DIFFERENCE
YF	DIFFERENT (PN high, Levin low)	NO DIFFERENCE	NO DIFFERENCE	DIFFERENT (PN high, Levin Low)
MF	DIFFERENT (PN high, Levin low)	NO DIFFERENCE	NO DIFFERENCE	NO DIFFERENCE
MS	DIFFERENT (PN low, Levin high)	NO DIFFERENCE	DIFFERENT (PN low, Levin high)	DIFFERENT (PN low, Levin high)
P	DIFFERENT[41] (PN low, Levin high)	DIFFERENT (PN low, Levin high)	NO DIFFERENCE	DIFFERENT (PN low, Levin high)

Where the percentile groupings between Palmerston North and Levin for the four waste practises considered are summarised by the statements: 'different' and 'no difference'. Where no difference is found, the level of behaviour for the practise recorded, is considered to be the same for both centres.

Young Singles [YS] in both centres can be observed to be exhibiting low levels of all four waste behaviour sampled. Young Families [YF] and Middle Families [MF] in Palmerston North are more inclined to compost household waste than they are in Levin. This contrasts with the Middle Singles [MS] and Pensioner [P] groups where the Levin groups are more inclined to compost household waste than the corresponding group in Palmerston North. These groups then account for the greater overall level of household composting in Levin illustrated in Figure 4.2. The YF group in Palmerston North is more inclined to recycle than the same group in Levin. YF and MF groups in both centres otherwise exhibit high levels of the other behaviour types sampled.

The MS and P group in Levin also show a higher incidence of the other three waste behaviour sampled than do the corresponding groups in Palmerston

[41] The difference in percentile grouping in the composting behaviour of the P group is large enough to warrant a cursory conclusion that it is significant That is, 58 for PN and 91 for Levin.

North. It would appear from the z-scores that the MS group is the group that accounts for most of the difference in tipping behaviour shown in Figure 4.4.

In contrast to the Levin group, group P in Palmerston North show low recycling behaviour. As most of the Levin recycling is tied into clothes recycling, this is probably explained by an long and close association with church charities in the rural centre.

4.4 Discussion.

4.4.1 Comparisons with Overseas Studies.

Although differing from and lacking in detail of this study, an overseas study in Omaha in the United States which examined recycling participation by age groups, found similar differences between the groups [Regional Roundup(c), 1993]. The 55 and older age group were the most active participants, with participation rates close to 84%. The 25-34 age group was the worst, with a participation rate of 7%. The youngest group asked was 18-24. These had a participation rate of 35%. Although this survey did not include children and made no attempt to relate family status to the result, some parallels to the Palmerston North and Levin study can be drawn. In both centres the participation in recycling by 'Young Singles' was low. This corresponds with the two lowest participating groups in the US study being the youngest. The high participation by the MS and P in Levin corresponds to the high score by the 55+ age group in the US study. Palmerston North groups differ from this. This suggests that these groups may be responding to different waste management messages within society, for example, Palmerston North and Levin exhibit notable differences in the amount of bags produced per person per week for collection. This difference would appear to be related to landfilling fees in Palmerston North and to the up front costs of the bags in Levin.

4.4.2 Conclusions from the New Hypotheses.

Consider hypothesis 4a, that there is no overall difference in the waste disposal behaviour: composting, sink waste disposal units, landfilling and composting, between Palmerston North and Levin. This appears to be supported by Interval Estimations [Appendix 2 and Table 4.3].

When the family groups are looked at more closely the following differences in the two centres become apparent:

* The YS group in both centres produces high levels of waste for collection, but does not exhibit high levels of the other types of behaviour surveyed. Thus the high volume of collected waste from this group seems to be a direct indication of the waste produced.

* The family groups in Palmerston North exhibit high levels of alternative waste behaviour.

* The Levin YF group shows low levels of composting and recycling and may be disposing of such materials in the landfill.

* Levin MF also show low composting, but high recycling behaviour. This group shows a similar tendency to visit the landfill in both centres.

The survey did not specify the volumes of household waste taken to the landfill. If landfilling charges in Palmerston North are reducing the waste going directly to the landfill, the z-score for tipping behaviour in either centre should differ. The result show both of them in the high percentiles.

* Thus it appears that visits to the landfill by YF and MF groups in Palmerston North are as frequent as visits to the landfill in Levin by this group. Therefore it would appear that these groups are not influenced by the landfilling charges. The high level of alternative behaviour probably account for the comparatively lower number of bags produced by this group in Palmerston North.

* Landfilling charges in Palmerston North probably explain the difference in tipping behaviour of the MS group in Palmerston North as compared to the Levin group. In Palmerston North the MS group also produces significantly more bags per person per week than do any of the other family groups. This indicates that waste is put out for collection rather than recycled, composted or landfilled, that is, it directly reflects the waste produced by this group.

Thus hypothesis 4b: that there is no notable difference between Palmerston North and Levin with respect to the waste behaviour of each family group holds true for YS only.

The significantly lower overall volume of waste produced for collection by Levin householders may reflect the perceived ease of tipping in the Horowhenua district. It could, however, also reflect consumers' choices of buying fewer disposable materials, but no evidence to support this is available. The apparent higher indicated incidence of landfill visits in the Levin survey points to the first explanation.

4.5 Householders' Own Survey.

4.5.1 Relationship Between Non-recycling and Non-participation.

As mentioned earlier, the data of this survey had to be re-examined because of householders' misunderstandings of the requirements. This level of difficulty was not apparent from the pilot survey. The failure of the researcher to pick up the problems indicates that this particular form may have required a larger sample number in the pilot than the surveyer administered form did. The presumption made by the surveyer was that both forms fulfilled the requirements after the initial pilot.

Of the 500 survey forms issued in Palmerston North 80 were not returned. Of these, 24 (30%), represented non-recycling households , well above the 21% of self-proclaimed non-recyclers in Palmerston North [Appendices 5 and 7]. Of the 125 survey forms issued in Levin, 17 were not returned. Of these, 5 (29%) were from non-recycling households, more than twice the proportion expected. (10% being the self-proclaimed non-recycling household proportion in Levin), [Appendix 7]. Such over representation of non-recyclers in the 'missing form' group is not unexpected as this group either has no personal interest in the issues of waste management, or find convenience an important part of life.

When the population data for the missing forms are analysed, a relationship to the earlier results pertaining to waste behaviour for the different family types is found [Appendix 5]. A difference of ±5% is not considered enough to postulate a difference between the actual proportion of a group in the population and the proportion of that group represented by the missing forms. Nevertheless for Palmerston North the YS group is over represented in the non return of forms, and the P group is under represented. That is, the YS group was LESS likely to return the form and the P group was MORE likely to return the form than any of the other groups in the target population. In Levin the YF group is over represented in the non-return of forms, whereas the MF and MS groups are under represented.

4.5.2 Conclusions Based on Non-returns.

If non-return of forms is taken as an indication of waste-awareness or the importance of convenience, the data support the earlier conclusion that the YS group in Palmerston North[42] shows less inclination towards alternative waste-behaviour, suggesting that these households are either not aware or opt for convenience. Such conclusions could also be made with regard to the YF group from Levin. Based on the high level of non-returns, their low composting and recycling as well as high tipping behaviours could reflect low waste awareness or commitment.

The under representation of missing forms from the P (Palmerston North), MF, MS (Levin) groups probably represent a general concern about waste management within these groups. The P group may not show large alternative waste behaviours. Anecdotal evidence gathered during the personal contacts while carrying out the survey suggests to the researcher that this is probably often related to age and infirmities, rather than to lack of interest and concern. The MF and MS group in Levin also exhibit this interest:

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[42]The small sample representing this group in Levin, makes the interpretation of data for YS in Levin difficult to interpret accurately.

MF (Levin) shows high recycling behaviour compared to other groups in that population, and MS (Levin) shows high composting and recycling behaviour compared to the same group in Palmerston North.

Such conclusions cannot be drawn from the returned forms where data were rejected on the basis of how complete the forms were. The misunderstandings pertaining to these forms have been explained earlier in the chapter, and relate more to the poor design of the form than to householders' waste awareness.

4.6 Householders' Waste.

4.6.1 Statistical Analysis of Organic and Paper Waste Weights Logged by Householders.

Table 4.5: Amounts of household organic waste and potentially recyclable paper waste produced per person per week in Palmerston North and Levin.

LOCATION						
	PALMERSTON NORTH					LEVIN
WASTE VOLUMES	TAK[a]	HOK[b]	AWA[c]	PAP[d]	TOTAL SURVEY[43]	
ORGANICS	1252g	1911g	1211g	1460g	1433g	1118g
SD	1073	2119	1095	888	1326	815
CONFIDENCE INTERVAL	±276	±669	±324	±218	±182	±242
UPPER LIMIT[44]	1578g	2580g	1535g	1678g	1615g	1360g
LOWER LIMIT	976g	1242g	887g	1242g	1251g	876g
PAPER	1374g	879g	1617g	1173g	1283g	1404g
SD	1505	751	1941	1592	1557	1265
CONFIDENCE INTERVAL	±353	±175	±421	±335	±171	±291
UPPER LIMIT	1727g	1054g	2038g	1508g	1454g	1695g
LOWER LIMIT	1021g	704g	1196g	838g	1112g	1113g

[a] Takaro [b] Hokowhitu [c] Awapuni [d] Papaeoia

The values obtained per person per week for the two waste materials considered in the four Palmerston North Wards and Palmerston North and Levin were compared using the GLM procedure of SAS described in Appendix 2. Total output is given in Appendix 4.

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[43] Worked as a mean and standard deviation from the total Palmerston North sample.

[44] At 95% confidence limit.

Table 4.6: SAS GLM summary.

SUBSTANCE	SOURCE	DF	TYPE I SS	MEAN SQUARE	F VALUE	Pr > F
Organic	Ward	3	9700470.5810	3233490.194	1.87	0.1376
Paper	Ward	3	15939152.890	5313050.960	2.22	0.0865
Organic	Towns	1	2620992.120	2620992.120	1.66	0.1991
Paper	Towns	1	293095.7945	293095.7945	0.12	0.7313

The p values show that there probably is no significant difference between the wards or the two towns for the materials tested.

Organic household waste, excluding green waste, produced per person is more or less a constant related to the biological needs of the human body. This is supported by the overseas estimated production of 132-178kg annually of compostable foodwastes per average household [Newton and Burger, 1993, Steuteville(c), 1994]. The Levin and Palmerston North data gives an average of 136-170kg respectively. As the SAS GLM [Table 4.6] show no significant difference between the two centres, it can be concluded that neither are probably statistically different from the overseas study. Where this waste is produced depends on the degree that the householder utilises 'ready-to-eat' food. The by-products of the preparation of such food will form part of the industrial waste, but will engender a large proportion of packaging in the household waste stream. Similarly, households that grow their own will produce a large amount of biological waste on site. The statistics show no significant difference for household organic production in both Palmerston North and Levin.

Recyclable paper waste is dependent on reading habits. This too appears to have no geographical bias, although the p value for the four wards is small enough to treat conclusions based on the data with some caution [p=0.0865]. If the data is re-analysed excluding two very large values for Awapuni and

Papaeoia wards the p value approaches 0.05. Thus both situations fall within the limits within which Duncan's test should be applied.

Table 4.7: DUNCAN'S multiple range test: Variable=Paper.

DUNCAN GROUPING	MEAN	N	WARD
A	1616.7	61	3
B A	1313.7	50	1
B A	1220.7	63	4
B	878.9	52	2

The groupings with the same letter grading are not significantly different. Duncan's test suggest that there may be a significant difference between Awapuni Ward and the rest. This result is ambiguous as there is a large overlap between the gradings. If the two very large values for the two wards mentioned above are ignored, the gradings become clearer, with Awapuni and Takaro Wards being significantly different from the other two. The result, however, is too ambiguous to declare with confidence that there is no difference between the wards with regard to recyclable paper waste produced per person per week.

From the unit waste in the two categories under consideration it is possible to calculate the approximate amount of organic and recyclable paper waste produced by each locality per week, and how much of this is probably landfilled and how much is recycled. The calculations of the minimum and maximum weights were done for all locations and for recycling and landfilling.

4.6.2 Discussion of Data.

Although no significant differences could be proven for the wards or between Palmerston North and Levin for the amount of the two wastes produced per person per week [Table 4.6], there are large differences in the total amounts produced from each location. This is a reflection of the populations within

each ward. There are clear differences in the amounts produced for composting and recycling [Table 4.8]. When this is converted to a proportion [Table 4.9] it becomes clear that there is a very large difference in the behaviour of the wards with regard to these two materials. Hokowhitu residents recycle and compost more readily than residents of any other ward. Takaro residents compost and recycle less. This may be a result of socio-economic factors, and should be considered when programs aimed at increasing these behaviour are implemented. It appears that the present programs have been successful with residents in the more affluent wards and that different programs may be needed to target the less affluent wards. Overseas studies show that residents in multi-family dwellings have a poor understanding of the significance of recycling symbols. A high percentage of apartment dwellers recycled even though provisions had not been made for recycling locally [Regional Roundup(d), 1993]. This is supported by data for multifamily dwellings in Milwauke, USA, where it was found that these dwellings generate less waste per unit than single family units, but had a higher percentage of recycled waste [Brachman *et al.*, 1993]. The residents showed low awareness and understanding of recycling symbols. This low awareness may offer parallels with and support the suggestion that Takaro's low recycling and composting percentage is related to socio-economic factors. The high recycling achieved by overseas multi-family units, however, suggest that the ease of access to recycling centres probably also have high significance.

4.6.3 Data Extrapolated for Palmerston North and Levin.

Table 4.8: Organic and Paper Waste generated for recycling and tipping in one week by the population of households in Palmerston North and Levin.

LOCATION							
	PALMERSTON NORTH						
RECYCLING[45]	TAK[a]	HOK[b]	AWA[c]	PAP[d]	WARD TOTALS	CITY TOTALS	LEVIN TOTALS
COMPOST MAX	6t	17t	7t	9t	39t	38t	7t
COMPOST MIN	4t	8t	4t	7t	231t	29t	5t
PAPER MAX	8t	8t	14t	17t	47t	50t	8t
PAPER MIN	5t	6t	10t	9t	30t	38t	6t
TIPPING[46]							
ORGANIC MAX	19t	21t	14t	22t	75t	76t	14t
ORGANIC MIN	11t	10t	8t	16t	46t	59t	9t
PAPER MAX	18t	7t	13t	11t	50t	53t	18t
PAPER MIN	11t	4t	9t	6.t	31t	40t	12t

[a]Takaro [b]Hokowhitu [c]Awapuni [d]Papaeoia

Table 4.9: Proportion of totals composted and recycled in Palmerston North and Levin [declared by survey].

LOCATION							
	PALMERSTON NORTH						
WASTE	TAK[a]	HOK[b]	AWA[c]	PAP[d]	WARD TOTALS	CITY TOTAL	LEVIN
COMPOST	23%	45%	33%	30%	33%-35%	33%	33%
PAPER RECYCLE	30%	55-58%	51%	59%	48%-51%	49%	32%-33%

[a]Takaro [b]Hokowhitu [c]Awapuni [d]Papaeoia

[45] The numbers of householders that recycle and compost were obtained from the survey forms.

[46] The numbers presumed to be landfilling their waste was obtained from the forms.

4.7 Landfill Survey.

4.7.1 Introduction.

As described, the survey is conducted by an examination of bag content at the Awapuni and Hokio Beach landfills [Appendix 10]. The proportion of the potentially recyclable materials found in the bags are listed in Table 4.10. As the data from the householders surveys for most of the recyclables were not useable, only the organics and paper data are used in the following discussion. The upper and lower confidence limits for the amounts of these two materials found per bag at the landfills are listed in Table 3.11. As the survey data have been finalised as a total amount in tonnes produced from each locality, the same was done for the landfill data. This was done by multiplying the amounts found per bag by the average number of bags produced per household for the ward and then multiplying by the total number of households in that ward.

4.7.2 Analysis of Landfill Survey Data.

Table 4.10: Organic and paper waste found per bag at the landfills in Palmerston North and Levin.

LOCATION					
	PALMERSTON NORTH				LEVIN
WASTE VOLUMES	TAK[a]	HOK[b]	AWA[c]	PAP[d]	
ORGANICS	2164g	2183g	2090g	1952g	2730g
STANDARD DEVIATION	795	864	505	394	1004
CONFIDENCE INTERVAL	±434	±536	±293	±205	±956
UPPER LIMIT[47]	2598g	3047g	2383g	2157g	3686g
LOWER LIMIT	1730g	1647g	1797g	1747g	1774g
PAPER	1086g	1492g	1523g	1265g	1219g
STANDARD DEVIATION	300	553	394	284	289
CONFIDENCE INTERVAL	±90	±343	±229	±147	±275
UPPER LIMIT	1176g	1835g	1752g	1549g	1494g
LOWER LIMIT	996g	1149g	1294g	981g	944g

[a]Takaro [b]Hokowhitu [c]Awapuni [d]Papaeoia

Table 4.11: Estimated amounts of organic household and potentially recyclable waste produced per week in the four surveyed wards and Levin [from the landfill data].

LOCATION					
	PALMERSTON NORTH				LEVIN
WASTE VOLUMES	TAK[a]	HOK[b]	AWA[c]	PAPd	
ORGANICS [Upper limit]	20t	17t	14t	17t	22t
ORGANICS [Lower limit]	13t	9t	10t	14t	10t
PAPER [Upper Limit]	9t	10t	10t	17t	9t
PAPER [Lower limit]	8t	6t	7t	8t	6t

[a]Takaro [b]Hokowhitu [c]Awapuni [d]Papaeoia

[47] At 95% confidence limit.

Table 4.12: Proportion of categories of waste in Palmerston North and Levin - weight and volume [Appendix 10].

	LOCATION					
	PALMERSTON NORTH					
WASTE[a]	TAK[b]	HOK[c]	AWA[d]	PAP[e]	TOTALS	LEVIN
ORGANICS	46:17	42:17	42:16	43:13	43:15	49:21
PAPER	23:33	28:35	31:36	27:47	27:39	23:32
AL.CANS	1:2.	1:2	1:2	1:3	1:2	1:2
TINS	3:4.	4:5	4:5	4:5	4:5	3:5
GLASS	5:5	5:4	4:5	6:3	5:4	6:4
RECYCLABLE PLASTICS	4:13	5:12	4:14	5:11	5:12	6:15
NON-RECYCLABLE PLASTICS	3:8	3:9	3:11	4:8	3:7	2:9
MIXED	17:17	13:16	10:13	11:11	13:13	12:13

[a] Given as Weight percentage:Volume percentage ratio

[b]Takaro [c]Hokowhitu [d]Awapuni [e]Papaeoia

4.7.3 Discussion .

To achieve some insight into how successful the surveyed householders were at estimating their waste, the landfill survey data in Table 4.11 was compared to the extrapolated data of householders' own data in Table 4.8. It appears from these tables that householders in Palmerston North have estimated the organic component of the household waste fairly accurately. The Levin landfill measure is much lower than the estimated volumes. The paper waste figure shows a much greater variation between the landfill measure and the householders' estimation, particular in Takaro and Levin. The explanation for the Levin discrepancy is probably that the Levin householder, while logging waste destined for the landfill, delivered it there themselves, and consequently the bag survey will show a much lower score. The Takaro discrepancy is harder to explain, but may relate to difficulties experienced in

classifying which papers were potentially recyclable, thus getting a much higher score if papers were logged indiscriminately.

Weight and volume of waste are both important components. The density of waste often determines how economic the freighting is. It also determines how much compaction is required and, if the weight is caused by excess water, leachate amounts and quality. While organics, by weight, account for nearly half of the household waste, by volume they account for less than one fifth of the waste. Table 4.12 shows little difference in the organic component of household waste between the four Palmerston North wards. Levin's waste contains more organics than any of the Palmerston North wards. Paper waste constitutes approximately one third of the waste , by weight and volume. The Papaeoia paper waste shows lower density (0.5, compared to 0.7-0.8 for all the other localities). No particular explanation is to be found. It is probably an experimental error caused by low compaction into the measuring bag. All the other categories of waste, except for the 'mixed' category, show little differences. The differences that do occur are probably errors caused by the difficulties associated with measuring low density materials occurring in relatively small quantities. The mixed waste component for Takaro is very high. This indicates a high level of convenience behaviour and purchases of goods with a high waste potential.

4.8 Garden Waste.

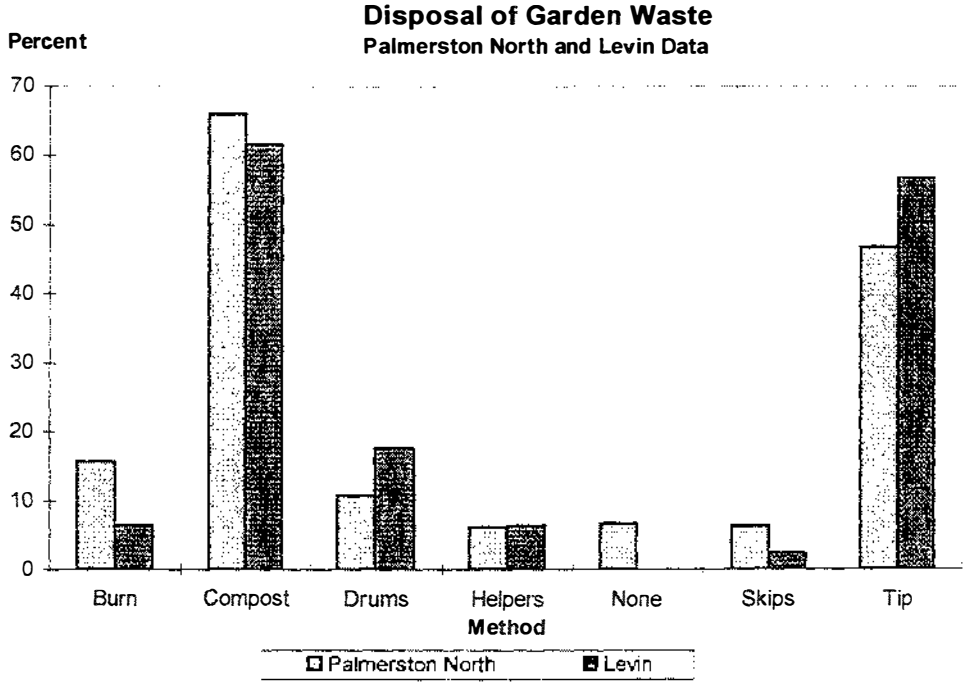
4.8.1 Introduction.

Garden waste, such as lawn clippings, prunings, weeds and leaves, constitute a significant amount of the waste produced by householders in New Zealand [Chapter 7]. This waste is very difficult to quantify as householders frequently combine it with other household waste when going to the landfill, or have contractors or family members taking care of it.

The objectives of questions 10-11 in the survey [Appendix 1A] were to arrive at an estimated quantity for this waste, and to gain an insight into household behaviour with regard to garden waste.

4.8.2 Composting in Palmerston North and Levin.

Figure 4.8
Disposal of Garden Waste
Palmerston North and Levin Data



Palmerston North householders seem to be more likely to compost garden waste [Figure 4.8]. This indicates a preference of choice rather than a measure of whether Palmerston North householders compost more (in quantity). The probable explanation for this preference could be the cost of using a landfill or a transfer station and the regulation that garden waste is not to be put into collection bags.

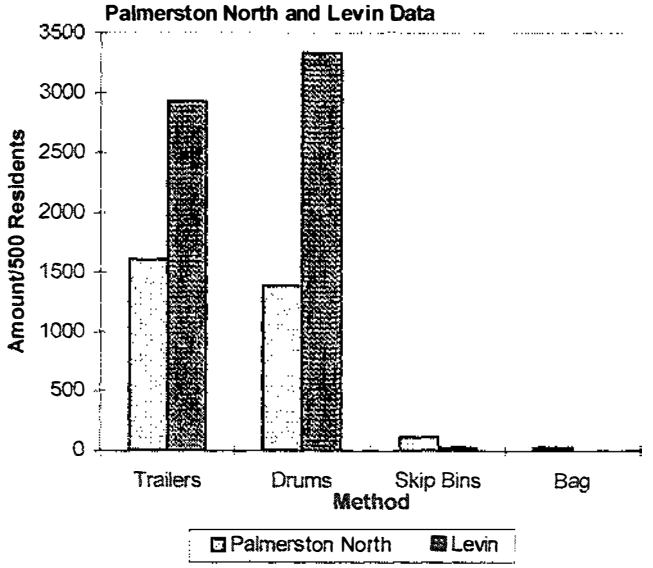
For Levin residents the cost messages were the opposite. They have 'free' access to a landfill, but are charged per bag for the collection. Hence a probable explanation for the difference in composting behaviour. The rural nature of Levin accounts for the absence of householders with no garden waste to dispose of.

4.8.3 Estimated Quantities from Households.

While most householders were able to specify the frequency with which they ordered waste bins provided by private contractors or took garden waste to the landfill, most could not specify the size of the trailer or the bin. Where the householder specified 'carload', this was translated into fractions of a standard trailer size: (6x4x1.5)ft or approximately $1m^3$ by the researcher. The total volume of garden waste arriving at the landfill via trailers was set as a fraction determined from information from the landfill and transfer station operators. From this information the estimated frequency of standard trailers is set at 80%. The remaining 20% is considered to consist of an equal number of larger and smaller trailers. Thus it was thought to be a reasonable assumption that a declared trailer load averages out to $1m^3$.

This information was derived from Palmerston North landfill and transfer stations. The Levin data has been extrapolated from this as the landfills in the Horowhenua District are not manned and thus the information was not readily available from this area. It was, however, considered reasonable to assume that the size and frequency is the same for the two localities. It is much less reasonable to presume that the trailers contain the same amounts. As the visit to the landfill is 'free' in the Horowhenua District it is likely that the trailers contain less than those in Palmerston North. Thus the data in Figure 4.9 should be treated with caution, although a clear indication of preference towards landfilling behaviour in Levin is shown.

Figure 4.9
Estimated Amounts of Garden Waste
Palmerston North and Levin Data



A similar method was used to determine the use of skips. The contractors were contacted and asked to estimate the frequency of use of their most popular skip-bin size. The most popular size is the $2m^3$ and the frequency estimate ranged from 80% - 90%. One contractor offers only $2.5m^3$ bins, but as most of their business is in providing 44 gallon (205L) drum waste collections to householders, the skips were rarely used. The amount of waste delivered to the landfill via private contractors was then estimated by multiplying the householders using this option with the fraction 85x2/100. The remaining 15% was considered to use the $2.5m^3$ bin.

Figure 4.9 shows clear differences in the use of contractors and self-delivery to the landfill. The Levin residents use the landfill more. This is probably a direct result of the landfilling charges imposed on the use of Palmerston North landfills and transfer stations. The use of contractor 44 gallon drums may be related to the type of population. Levin has a high proportion of retired people and beneficiaries compared to Palmerston North. The distance to the landfill is similar in both localities, although the Palmerston North landfill is less easily accessible because of traffic congestion through the city streets. This is unlikely to be the explanation for the big difference in tipping behaviours.

4.9 Contractors Perspective.

4.9.1 Survey Methods and Aims.

The contractors offering waste removal services in Palmerston North and Levin were surveyed by post using the questionnaire in Appendix 1B. The six contractors operating in Palmerston North at the time were contacted. Three of these chose to participate, one declared an unwillingness to participate and two ignored the questionnaire and consequent inquiries. Three contractors were operating in Levin, all of which participated [Appendix 9]. The small sample number and the high level of refusal in Palmerston North makes these data subject to bias, but a general indication of trends may be inferred.

The aim of the questions asked was to establish how much, and what kind of household waste is handled by contractors. The responses were summarised in table form in Appendix 9. This table shows that the main differences in the waste handled by contractors in Palmerston North and Levin are in the proportion of household versus industrial waste handled. Levin contractors get approximately half of their business from private households. These data are probably affected by the Horowhenua District Council using private contractors as waste collectors, whereas PNCC has their own waste collectors. This explanation probably also accounts for the high proportion of mixed waste handled by Levin contractors. One of the Palmerston North contractors deal specifically in clearing sections and handles a very high level of unmixed garden waste. None of the contractors in either Levin or Palmerston North see 'pure' loads as economically advantageous to the householder, as the contractor invests as much energy in these loads as in 'mixed' loads.

4.9.2 Estimated Quantities from Contractors.

The total estimated quantity of household waste from Palmerston North going to the landfill via contractors is approximately three times that of Levin, which is the same proportion expected in relation to the difference in population sizes of the two centres.

A rough estimation of the amount of garden waste arriving at the landfill via contractors can be made from the contractor's estimated household waste volume or tonnage, and their estimated proportion of garden waste handled[48]. The estimated quantities of garden waste for Levin is nearly twice that of Palmerston North [footnote 48]. This is not unreasonable bearing the rural nature of Levin in mind.

4.10 Summary of Conclusions

- There is a significant difference in the amount of waste produced per person per week for collection in Palmerston North and Levin. Palmerston North produces more.
- The four Palmerston North wards surveyed appear to produce similar amounts of waste for collection.
- In all four wards it appears that larger household groups produce less waste for collection per person per week. This difference does not appear in Levin.
- Young and middle family types produce less waste for collection per person per week than do any other family group in the surveyed areas of Palmerston North. This difference does not appear to exist in Levin.
- Palmerston North residents are more likely to use the bag collection system and less likely to use the landfill than are the people in Levin. This has been explained in terms of the cost structure of the collection and landfill systems.
- Levin residents show greater willingness to recycle, but Palmerston North recyclers are more likely to recycle in all the groups of recyclable materials. This reflects into larger volumes from each Palmerston North recycler. The reason for this is probably the voluntary nature of the Levin operations and the greater access to facilities in Palmerston North.
- Some recyclable materials seem to 'drive' the return of others.
- Most recyclers recycle more than one material.
- Composting of household waste is more common among the middle and young family groups in Palmerston North than it is in the corresponding

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[48] Palmerston North: [3150+1250/2]x6=1320m^3. Levin: [750+840+1280] =2870m^3.

groups in Levin. The elderly in Levin are more likely to compost than is the same group in Palmerston North.

- Palmerston North householders are more likely to compost garden waste than are the residents of Levin. This may be explained in the different cost structures for collection and landfills in Palmerston North and Levin.

- There appear to be large differences between the Palmerston North wards in recycling and composting behaviour. Hokowhitu ward appear to compost and recycle most, Takaro least. Although this may be a socio-economic effect on behaviour, it may also be an artefact of accessibility of recycling facilities and multi-family dwellings.

- The landfill survey showed a difference between householders' own waste estimations and actually occurring waste. Where this difference was large, the landfill values were lower than the householders' own estimations. This has been explained in terms of private tipping.

- There appears to be little difference in the waste proportions turning up at the landfill in collection bags. The biggest difference occurs in household organics, which is very high at the Levin site, and in the 'mixed' category, which is very high from the Takaro locality.

Overall Conclusion:

The waste management strategies already in place in the surveyed areas have given rise to different user responses. Depending on the aims of the waste management outcomes, the observed responses can be used to establish the best waste management options for a particular area. The cause for the differences in responses can be theorised to be related to user pays differences. Differences in responses within groups of the same population may be related to lifestyles or suitability of education material made available to the respondents. The cause of such differences may be important in designing a flexible and optimal waste management system for a particular area.

CHAPTER 5

MUNICIPAL SOLID WASTE MANAGEMENT ALTERNATIVES.

5.1 Waste Management Internationally.

5.1.1 Waste and the GDP.

Waste is the end-product of all economic activity. The European Union's statistical office in Luxembourg has noted an apparent correlation between the amount of waste a nation generates and it wealth: USA tops the heap, producing 720kg of municipal solid waste (MSW) per person per year, which is twice the EEC's average of 350kg per person per year [Eurostat, 1994; Warmer[a], 1995]. The highest per capita rates of waste generation in Europe is found in Holland and Denmark, at 430 and 423 kg/year respectively, approximately 60% of the USA per capita rate [Anon., 1992][49] In contrast each person in New Zealand is recorded as producing approximately 255kg/year of municipal waste [Willmott, 1993].

5.1.2 Disposal Options in Europe.

Until recently landfills received all the municipal solid wastes. In the European Community the amount landfilled varies from 35% in Denmark to

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[49] The Szech republic produces 250kg per person per year. In contrast, Sweden, usually considered wealthy, produces only 370kg per person per year (Anon, 1992).

90% in the United Kingdom [Anon., 1992]. This appears to be related to the availability of environmentally acceptable landfills. In the UK suitable space for landfills is still relatively cheap, whereas in Denmark the space is at a premium. Profit levels on landfill operations in the UK in 1990 was 50% or more. Margins are lower for incineration at approximately 25%, reflecting regulations that require higher capital investments in response to countering stronger public objections. At present, two waste to energy plants operate in London, one of these, SELCHP, is the first new household waste incineration plant to be built in Britain for more than 20 years. This plant receives a preferential price for its electricity until 1998 and will not expand its heating potential until the electricity agreement runs out [Wallis, 1994; Warmer(e), 1994]. If incineration with energy recovery is accepted as another form for recycling MSW, the forecast is that it will become more important as a waste management strategy as it requires no source separation prior to kerbside collection [Anon., 1992].

Often the real cost of waste management is not reflected in the waste user charges. This has led to export of waste from some EC countries, into perceived cheaper areas, for example to the UK [Anon., 1992]. The cost of landfilling is continuously rising as the EC issues stricter environmental directives on waste management [O'Keeffe, 1993]. This gives rise to national laws of increasing strictness. In many cases the regulatory control of waste disposal has become centralised. For example, in the UK, local authorities cannot operate or police a landfill or incinerator site. This will affect the profit margin for landfills. To avoid distorting free competition by having varying

national waste management standards, a directive introducing civil liability for waste and a landfill directive to harmonise standards was considered by the EC environment ministers. In June 1994 they reached agreement on the directive. The final version does not include reference to a landfill aftercare fund nor civil liability clauses [Warmer(l), 1994]. Until the unification of Germany, the west deposited 6 million tons per year of waste into East Germany. This gave unified Germany some of the worst waste management problems in the western world. Other Eastern states have offered to take the waste in exchange for Deutch-marks, but the EC has declared that this will not be permitted[Anon., 1992]. The move in the EC is away from landfills, for example, the Netherlands plans to decrease landfilling from 55% to 10% by the turn of the century. The EC officially sanctioned "Move from Landfills" has met with protests from countries such as Greece, Spain and the UK who claim to have tracts of unused landfill capacity and want to retain their right to use it [Anon., 1992], but a survey in South East England shows that the amount of space set aside for solid waste disposal declined by 27% in 1993. At current waste generation this space will be full in 2004 [Warmer(l), 1994]. Incineration with energy recovery in Europe will probably increase to 50% by the year 2000 [Anon., 1992]. The French government has decreed that more than 50 new waste incineration plants will be built within 10 years [Waste Observer, 1994; Biod *et al.*, 1994]. A new waste to energy plant, just opened in the Danish municipality of Kolding, is claimed to utilise up to 85% of the energy content of the waste, producing enough heat for 10,000 households and electricity to meet the needs of 11,000 households. Ash and slag from

these plants may be used in road construction and paving blocks after being mixed with clay or cement [Warmer(h), 1994].

5.1.3 Disposal Options in America.

In America more than 70% of the solid waste goes into landfills [Kelly and Hart-Williams, 1993]. In 1984 the American congress ordered the USA Environmental Protection Agency (USEPA)

, to develop new landfill standards because of groundwater contamination problems. These standards became operational in 1991 and resulted in 70% of existing landfills having to close within the next 20 years, [Schaffer and Malia, 1993] with 1000 closing in October 1993. As very few landfills had been built over the 7 years that the changing standards were being discussed and finalised, this left an acute shortage of landfill space [Powelson and Powelson, 1992] and the USEPA allowed an extension until April 1994 to municipal landfills receiving less than 100 tonne/day [Steuteville and Goldstein, 1993]. The closure of landfills has coincided with a drop in the amount of waste landfilled. This has meant a stable waste:landfill capacity. The regulatory and legal deadlines have forced landfills to use discounted prices in order to attract enough waste to fill the landfill space before these deadlines force closure. There is evidence that this draws waste from other disposal facilities and that it has negative impacts on plans for expanding recycling programs by decreasing the sense of urgency to seek responsible alternatives, by translating into stable costs for municipalities, and by giving

contractors, where landfills are privately owned, an economic interest in landfilling as much as possible before closure [Bonini, 1993].

Fewer facilities mean longer haulage for waste destined for landfills. To transport waste over long distances requires that it be baled. For bales of approximately 1000 kg, transportation costs of US$0.05 and US$0.10 per mile per ton are typical. It costs US$25 to US$50 per ton to ship wastes 500 miles. Some landfills across the country charges US$15 to US$20 per ton, others charge more than US$100 [Powelson and Powelson, 1992; Steuteville(d), 1994]. With these differences in pricing it makes economic sense to send waste out of town unless legislation dictate otherwise. In May 1994 the US Supreme Court decided that it was a violation of the commerce clauses of the US Constitution, for local governments to direct wastes exclusively to certain sites or plants for recycling or disposal. Such flow control was found to create economic protectionism. The finding of the court will have impact on long-term contracts for recycling and disposal and may mean that towns and cities are unable to ensure that enough waste is directed to facilities to maintain their viability [Warmer(i), 1994]. Areas of a low population density and cheap land prices may be able to bid for waste from highly populated areas. The economic advantage will depend on the cost of transport and the proximity to roads and rail.

5.2 Waste Costs.

5.2.1 Diversion: Costs and Savings in the United States of America.

The realisation that waste represents costs, in terms of lost resources [energy and raw materials], has offered a solution to part of the problem associated with the disposal costs of the unwanted materials [Chapple, 1992; USEPA, 1978]. If these resources can be prevented from entering, or be recovered from, the waste stream, the volumes requiring traditional, and costly, disposal should diminish [Regional Roundup(b), 1993]. The potential for recovery, and the methods chosen, depend on the total volume of waste, its composition, its calorific value and the rate at which it is generated Thus Ann Arbor, Michigan diverted 35% of its wastes from landfills in the period from July 1992,June 1993, by recycling 22% and composting 13% of the waste [Regional Roundup(e), 1993]. Composting programs in Plano, Texas collect garden waste from kerbside at $13/ton which is $4/ton cheaper than landfilling it. This resulted in a 20% decrease in landfilled green waste in that municipality in 1992,93 [Owen, 1994]. In Europe, it has been estimated that recyclable materials recovered from one tonne of MSW have a monetary value[50] of US$54, which gives a total potential value for waste generated in the whole of Western Europe as US$5357 million [Anon., 1992]. How this relates to the cost of recycling is difficult to estimate. A recycling scheme in Seattle, USA costs US$91/ton, which would suggest that recycling is an expensive option. However, a study sponsored by the Clean Washington

[50] 1990 values.

Centre, a government agency in Washington State, USA, compared kerbside recycling costs to disposal costs in four cities. The study showed that in all cases, the cost for recycling (collection and sorting, minus revenues for products), is less than the cost for disposal, with the difference ranging from US$13/ton to US$65/ton [Steuteville(a), 1993; BioCycle(d), 1993]. The variation arose from differences in haulage, landfill and incinerator fees.[51] Seattle was the only city of the four that also had kerbside collection of yard waste at US$116/ton, a saving of US$20/ton. The particularly low cost of the Seattle system is attributed to the competitive system arising from the city being divided into sections that are bid separately. The contractors are also given considerable freedom to implement their programs. It also showed that the recycling expenses correlated directly with the amounts of material diverted per household annually. Seattle, with the cheapest program, diverts the most (approximately 650lbs)[52]. All four cities offer variable rate collection fees, so residents can lower their bills by recycling [BioCycle(d), 1993; Cuthbert, 1994]. A study commissioned by the Reason Foundation of Los Angeles, California, has shown that variable rates have become more common since the 1980s. Towns with this type of fees structure routinely show a 25-45% decrease in tonnage going to disposal facilities. The study concluded that while these fees are not a panacea for waste problems and are

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[51] This effect will initially be extreme as condemned landfills discount to attract waste, but should level out as regulations create a level playing field for all landfills.

[52] While showing a comparative price structure for waste management costs in the four cities, the study does not necessarily prove that the cities are saving money by recycling, compared to what they would be spending if they disposed of all their waste , this determination cannot be made, because there is no way of knowing how a complete change back to disposal would impact on the cost structure [Steuteville(a), 1993].

unsuitable under certain conditions, they are, nevertheless, a powerful tool for influencing behaviour. Variable rates may result in a conflict in goals for the municipality; namely loss of revenues versus waste reduction [Higgins, 1994].

5.2.2 Diversion Targets in the UK.

In Britain landfilling has been the preferred method of municipal solid waste disposal [West Sussex County Council, 1989]. EC directives are forcing the British government to reconsider the waste management options and all waste collection authorities in England and Wales have been instructed to prepare recycling plans under the Environmental Protection Act 1990. This involved identifying household and community waste, drawing up plans for recycling the household portion, setting targets and estimating costs. Targets were set at 25% of the residential waste stream by the year 2000. At present the results from the kerbside pilot schemes programs show that the recovery rates vary from 6% to 27% and net costs are in excess of 100£/ton weekly. Wheeled bins report 50% diversion rate at a net cost of £68/ton weekly and green plastic bag collections report 18% diversion at a net cost of £75/ton bi-weekly. Drop-off programs report profits of £6-12/ton with a diversion rate in the 4% to 8% range. The diversion rate is low compared to aggressive goals set, and reached, in the USA. The curb-side collections are expensive compared to the Seattle program sited above. A December 1992 report by Environmental Resources Ltd, for the Department of the Environment (UK) and for the DTI (UK), considered the cost of household waste recycling and the lack of effective markets for secondary materials [Coggins, 1993]. The

report recommended four types of fees for further study; those levied on raw materials, on products, on the waste collection and on the disposal. It was also proposed that the government looks at placing an obligation on manufacturers to take back waste or supply recycling facilities. This would suggest a system closely related to the Duale Systeme Deutchland (DSD)[53] in Germany. Another report for the Department of the Environment (UK), 1993, looked at imposing landfill levies on waste and the impact this could be expected to have on waste management in Britain. At £20/ton the report predicted a decrease in landfill from 83% to 50%, recycling to increase from 2% to 12% and incineration to increase from 15% to 38% [Coggings, 1993].

5.3 Economics of Recycling.

5.3.1 Resource and Energy Conservation.

The controversy over the costs versus benefits of recycling arises from the historical origin of recycling. Scrap dealers could make a living by collecting and selling metals and other useful components. [Powell, 1992]. As another waste management strategy, recycling has an impact on the total waste management system. If a ton of materials is not recycled, then something else will have to be done about it. Overall costs of the waste management system has to be considered. Too often the cost of collection and sorting of recycled materials is quoted in isolation. If recycling means that the overall waste management cost has decreased, the waste manager has been successful

[53] See later in this chapter for an explanation of this system.

[Steuteville(a), 1993]. Recycling means a decrease in actual waste volumes, causing a decrease in transport and use of landfill space [Lassila, 1992]. Conservation of resources cuts down on the need for virgin materials and thus decreases the energy consumption[54] and pollution discharges associated with mining and processing of stock [Becker, 1992]. The decrease in these 'externalities' represent 'avoided costs' and should be part of the cost equation. These costs are real, but difficult to calculate at the municipal level. Using New York City Region data it has been estimated that if 50% of the waste stream was used as manufacturing feed stock, instead of virgin raw materials, there would be a decrease of environmental impact by almost US$1 billion in the region and 30,000 new jobs could be created [Steuteville(a) and (b), 1993]. It has been estimated by the Institute for Local Self-reliance that preparing recyclables for end markets creates 5 times as many jobs as incineration and 9 times as many jobs as landfilling the same amount of materials [BioCycle(a), 1993], and that a city of 1 million inhabitants, which diverts 43% of its waste can accumulate sufficient recyclable materials to supply 29 factories employing 1800 people [Steuteville(c), 1993]. The institute also estimated that the recycling industry has contributed US$600 million to the Massachusett's economy in 1992 and employed up to 1000 people [BioCycle(() and (f), 1993]. Another analysis for the Maine Waste Management Agency by Land and Water Associates and Market Decisions Inc., concluded that in 1992 recycling added approximately US$300 million

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[54] See footnote 11

and over 2000 jobs to the Maine economy via wages, profits and secondary impacts. The estimation was that in processing operations where collected materials such as glass and plastics are separated, approximately 270 people could be employed per 1500 tons processed daily[BioCycle(a) and (c), 1993].

5.3.2 Life-cycle Assessments versus Traditional Economics.

The difficulty in assessing the true worth of many of the recycled materials comes from lack of knowledge about the life cycle of the products being made from them. Life-cycle assessment goes some way to remedy that, and some of the first analyses, prompted by EC legislation are beginning to appear [Coggings, 1993; Warmer(k), 1994; Warmer(e), 1995], but it is a slow and expensive process, vulnerable to new technologies and lack of proper parameters [Wigon *et al.*, 1992]. Until the information available is full and balanced, most decisions about recycling must of necessity be based on common sense and an understanding of 'closed system' economics [Kelly and Hart-Williams, 1992]. The conclusion to a working paper titled: "Does the Solid Waste Management Hierarchy make Sense?" done at the Yale University's School of Forestry and Environmental Studies, which examined the usual hierarchy for solid waste management (waste reduction, recycling and composting, energy recovery and then landfilling was that the hierachy formed a technically feasible, cost-effective and environmentally desirable approach to solid waste management [Moore, 1993]. Managing wastes according to the hierarchy decreases costs and environmental impacts, with the added benefit of a significant reduction in environmental impacts from production using virgin materials.

5.3.3 Waste Management Plans and National Resource Policies.

In view of energy and resource conservation, it is critical that any solid waste management plans be addressed as part of a national resource policy. For example, it is considered uneconomical to recycle low density materials as the return per volume is too small compared to handling costs. This assumption depends on the traditional method of working out the pricing structure for a ton of material. When the net recycling cost for a particular material is calculated per container large enough to deliver 12 oz of product, the cost-effectiveness perspective alters [Table 5.1].

Table 5.1: Estimated materials recycling costs.[a]

Material	Collection[b]	Processing[b]	Revenue[b]	Net[b]	Carrying Capacity[c]	Net Cost[d]
Alumini	400-800	100-200	300-600	200-400	275	0.44-0.88
Glass	40-80	60-120	20-40	80-60	30	1.60-3.20
Plastic	400-800	120-240	80-60	440-880	527	0.50-1.00
Steel	200-400	50-100	30-60	220-440	99	1.33-2.66

[a] *Created by Ron Perkuks, at the American Plastics Council.*

[b] US Dollar per ton.

[c] Cost in US dollars per pound of packaging.

[d] Cost in US dollars per container to deliver 12oz product.

[Patricia Moore, 1993]

The last column showing net recycling costs per 12 oz delivery container is clearly an argument against the assumption that heavier metals are more cost-effective to recycle than lighter ones. Thus when disposal costs were calculated per weight instead of volume, Seattle found that it costs $40/ton less to recycle

than it had previously budgeted for and overall waste management expenses were less [Grogan, 1993].

5.4 Waste Generation Worldwide.

5.4.1 The Effect of Industrialisation on Waste.

Although there are quite significant differences in the volumes of waste generated throughout Western Europe and the States, there are relatively small variations in the composition of the waste. This is not so with waste from widely countries differing in economic development. Here, not only the amount, but the constitution of municipal solid waste differs with the level of economic development of a particular society. Where resources are scarce, scavengers recover a great deal of material from the waste stream. It used to be the case in Britain and other western cultures where the 'Rag and Bone' man was (and still is, in some areas of Britain, for example Leeds) [Scrap, 1991], a useful link in the resource recovery cycle [Henstock, 1974]. In poor developing countries scavengers still fulfil this function [Lardinois and van de Klundert, 1993]. Lifestyles and consumer choices further affect the type of discards, and the result is a municipal waste stream that looks quite different from that of a developed economy [Table 5.2].

Table 5.2: Comparison of category analysis of MSW from developed and developing countries.[55]

CATEGORY	USA	PARIS	HANOI	KATHMANDU
	WEIGHT%			
Paper	34	40.9	2.7	7
Kitchen Waste	22	16.3	51.9	67
Metals	13	3.2	0.9	5
Glass	9	9.4	0.5	1
Tex les	4	4.4	1.3	7
Plastics/Leather/Rubber/Wood	14	9.3	1.3[a]	4
Dust/Ash/Other Material	4	16.5	41.4	10

[a] No value for plasti s included.

5.4.2 Waste Management Strategies for Different Countries.

Table 5.2 illustrates the differences that occur in waste composition between countries in certain developed and developing economies. Organic waste, in particular, makes up a much higher percentage in the developing economy MSW than it does in that of a developed economy. Such differences are important in formulating strategies for management of the municipal waste streams. The MSW arriving at landfills in Kathmandu and Hanoi [Warmer(c), 1995], can be more than halved by managing the organics using composting, anaerobic digesters (methane production) or as stock feed.

An integrated urban organic waste system operating in Calcutta utilises sewage and other organics for animal fodder, (fish and pigs), growing vegetables and irrigation. A similar system operating in Cairo, includes pig-

[55] Combined from two sources of information, one using rounded figures (USA and Kathmandu) [Krol, 1990], and one using decimal fraction of percentages (Paris and Hanoi), [Warmer(c), 1995].

raising on organic waste, co-composting of pig manure and MSW and re-processing of other waste materials such as paper and plastics [Lardinois and van de Klundert, 1994]. In contrast a high proportion of the MSW arriving at USA and Paris landfills is potentially combustible, which may require a different strategy, although air emissions continue to raise concerns. An example of waste management tailored to suit needs can be found in Tennessee, USA, where a new landfill was needed close to the National Park and where the tourist influx to the region is 8 million per year. To cope with the waste produced, a 100 acre site was needed for landfilling. A site of 35 acres was approved which would have had a life of 10 years without a waste reduction alternative. Incineration was rejected on environmental grounds, kerb-side recycling for economic reasons. Co-composting with the aim of capturing 100% of food and paper waste from the waste stream was chosen. Metals were to be collected as the waste passed through the plant. The plant processes 150tonnes per day of mixed municipal waste and 75wet tonnes per day of biosolids. The annual operational budget, without debt servicing is US$900,000. With the plant operational the life of the landfill has been extended to 60 years [Goldstein,N., 1993].

In Europe the lack of suitable land for landfills, has meant a greater planned reliance on incineration for energy exchange in some countries [Table 5.3].

Table 5.3: Projected trends in municipal waste disposal in some European countries.[a]

	1990			1996		
COUNTRY	LANDFILL	INCINE[b]	OTHER	LANDFILL	INCINE[b]	OTHER
SWEDEN	40	55	5[c]	40	55	5
HOLLAND	41	40	19	30	50	20
GERMANY	60	35	5	45	45	10
UK	90	9	1	85	13	2

[Anon, 1992]

[a] In Percent.

[b] Incineration.

[c] Includes composting.

For comparison the 1992 figures for the total of USA was 72% landfill, 11% incinerated and 17% recycled [Steuteville(a), 1994; Steuteville *et al.*, 1994]. Considering that some states in America have very aggressive recycling rules , with 8 having achieved close to 30% and over, there is a large variability in the goals achieved by different states [Steuteville, 1995].

5.5 Legislation and Recycling.

5.5.1 Commitment to Recycling in the USA.

In the industrially developed economies, high wages make labour intensive sorting and processing expensive. High automation involves large capital investments and puts a large cost on the end product. Even so, there has been a steady increase in the commitment to recycling world wide. In the United States of America the driving force for recycling seems to be legislation, although there seems to be no real national commitment to recycling [Powelson and Powelson, 1992; Powell, 1993]. The USEPA suggested a nation

wide 25% recycling goal, but legislation, funding and enforcement is largely left up to individual states. Most states have passed laws in the five years prior to 1992 mandating or promoting recycling, with 1992 being a year mostly of fine-tuning existing waste laws, such as banning specific materials, for example, garden waste from landfills. These laws have ensured increasing amounts of secondary materials on the market [ILSR, 1991; Jessop, 1992]. Although industry has expanded recycling capacity, it has not been able to keep up with the supply, giving low scrap prices and low returns to recyclers [Jackson, 1993; Khator and Huffman, 1993; Grogan, 1993]. Federal tax laws are currently structured in favour of virgin industries, by allowing these companies to deduct depreciation and depletion of resources as a business expense. Through this, income is sheltered and the virgin material producers receive a benefit from consuming these resources. That means that companies who use recyclable materials operate at a disadvantage from those using virgin materials [Powelson and Powelson, 1992]. Thus the increase of interest in recycling has been based more on environmental philosophies, than on economic incentives [Newman, 1993]. State legislation in the US is increasingly aimed at attracting re-manufacturing firms by giving tax credits for purchases of machinery or material used in recycling, or by passing procurement laws, generally expanding existing programs to buy recycled products [Jessop, 1992; Regional Roundup(d), 1993; BioCycle(g), 1993]. Some US states also give financing initiatives such as loans, guaranteed bonds and direct grants [Steuteville and Goldstein, 1993].

5.5.2 Recycling in the EC: The German Experience.

The EC is similarly adding force to the recycling move by the legislative process, for example, the Duals System Deutchland (DSD). The name refers to a "dual system" because the system is distinct from the MSW collections. The presence of a 'Green Dot' on the product signals that the manufacturer has paid a licensing fee, depending on the type and weight of the packaging material, towards its recycling. This places the responsibility for recycling on the manufacturer [Fishbein, 1993]. The German Packaging Ordinance went fully into effect from January 1993 when 50% of all packaging material was to be recycled, by July 1995, 80% of plastics, glass and paper and 90% of other packing materials have to be recycled. In 1990 25% of MSW was recycled. If the DSD system does not meet the stringent recycling quotas the industry may face a mandatory deposit and take-back system. Thus the management of a third of the nation's waste stream is being shifted from local budgets and taxpayers to industry and the cost is built into the price of products through the green dot fee. The government took care not to destroy the existing structure for municipal recycling in the form of drop-off bins for glass and paper. The DSD provides yellow bins to residents for packaging which is then picked up free of charge while the consumer pays for the collection of other waste. Only 60% of all products sold are licensed with the green dot, but 90% of the products come back via the DSD system. This means that the collection and storage costs have been much higher than expected. The program will probably have a strong impact on future EC legislation. Plastic packaging may be limited and non-regulation packaging is likely to be

forbidden. Variations on this system are already being adopted by other countries, for example, Canada and France [Steuteville(c), 1993]. The success of the programs has, by now, caused its own problems, as the systems in operation collected large amounts of recycled materials with nowhere to go, for example in Poland only 9% of collected plastics are purchased for reuse [Rybarkiewicz, 1995]. The plastics industry is resisting an increase in recycling capacity and insists that incineration for energy should be allowed as part of its recycling quota.

The green dot itself is controversial as the consumers are led to believe that the dot indicates environmentally sound material use, even though the packaging is designed for use only once. This goes against the waste minimisation by source reduction principle [Fishbein, 1993]. The whole system also appears to cause disruptions and dislocations in the markets by delivering recycled materials free to the manufacturers, for example, the glass industry in Britain claims that the DSD system is a subsidy for the glass industry in Germany because the cullet is free. Private recyclers who used to collect and sell to cover costs cannot do so anymore [Warmer(b), 1994].

5.6 Recycling Markets.

5.6.1 Green Consumerism.

In Europe and the United States of America the year 1993 was distinguished in the recycling industry by a pre-occupation with markets [Steuteville(c), 1993]. This pre-occupation has been both industry driven as economic

incentives to reusing materials became evident, and consumer driven by 'green consciousness' choices made on purchase [Hill and Clemes, 1980; Earle, 1990; Sambrook, 1990; Alexander, 1992; Elliott, 1992;]. An international survey conducted by MORI Social Research Institute in London tested 'Green' responses in more than 20 countries, and found a high percentage of respondents had made 'green consumerism' responses, when given a choice, for example, 64% of New Zealanders claim to have selected one product over another because of its environmentally friendly packaging, formulation or advertising [Warmer(b), 1995]. This supports the controversy associated with the 'green dot' of the DSD system.

Economic development programs at the state level in the USA have promoted recycling investments by a variety of grants, tax credits, procurement programs and advertising availability of feedstocks. Laws setting recycling mandates had provided some problems by lack of consideration of markets for the recycled goods. [Alexander, 1992; Sudol, 1992; Steuteville(c), 1993; McMahon, 1993;]. The procurement laws at the state level and federal initiatives towards creating markets have gone some way to alleviate this, for example, President Clinton set minimum levels of 30% by 1998 of recycled content in printing and writing papers purchased by federal government [BioCycle(f), 1993].

5.6.2 Transportation Costs and Markets.

Another disincentive to recycling is the cost of transportation of the sorted material. Added costs of transportation and labour makes marketing difficult

regardless of the product [DTI, 1980; Schoenberg(c), 1994]. In Calcutta and Cairo this has led to urban agriculture where the composted material is used close to the source. For this reason, home processing of organics may be the only economic alternative in some sparsely populated western economies, for example, New Zealand.

5.7 Cost-benefit Considerations for MSW Facilities.

5.7.1 Economic and Environmental Factors.

Clearly, there are other points besides the category proportions to be considered when formulating MSW management strategies. Estimation of the marginal treatment and disposal cost of each facility must take into account the volume of waste in total, the volume produced per household, both now and in the projected future, the availability of landfills or plans for centralised processing plants, transport costs, now and projected, in time and distance, and the ability of society to afford assessed costs to pay for the proposed systems. These are all economic factors relatively easy to measure and evaluate. Other items in the waste management equation such as those associated with environmental effects, are harder to assess [Krol, 1990]. These often tend to be long term and result in revenue loss due to resource depletion, loss of amenities, loss of alternative land use and degradation of health, life expectancy and lifestyles of the population. The increasing concern about the impact of a degraded environment on human health [Warmer(n), 1994], the realisation that the environment has crucial life support functions, the recognition that other species have economic

importance either as genetic pools or as environmental filters, have resulted in greater costs being placed on some MSW management systems.

Management options have to be realistic to the economies of the societies they serve and operate in without undue degradation of the environment[56]. Systems, which in the past, were considered panaceas to waste management, are thus no longer considered feasible. For instance, in Denmark incineration was considered the solution to both the MSW problem and the high cost of imported heating fuels. This led to the building of waste incinerators that combusted 48% of all MSW and provided energy for hot water and heating for local homes. This has proven more expensive than other options and resulted in the progressive development of alternative systems (4% composted, 19% recycled), [Johansson and Thøgersen, 1991; Anon., 1992; Warmer(d), (e) and (f),1994; Warmer(a), 1995]. The awareness that incinerators may release toxic fumes and cinders, and the increasing concern over greenhouse gases have made this option less popular and given the impetus for research into alternatives [Johansson and Thøgersen, 1991; Warmer(d), 1994].

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[56] This definition is deliberately vague. Environmental 'soundness' depends on the acceptance level of the society that defines it. New Zealand's RMA specifies 'sustainability' as a measure of environmental soundness and depends on the user to prove that the operation is sustainable before consent is given. The most often heard complaint against this piece of legislation is that it lacks teeth. The EEC issues directives to its member countries based on impact to human health and the environment, but leaves it to the individual countries to formulate 'daughter directives' and tools with which to implement these.

5.7.2 Integrated Solid Waste Management.

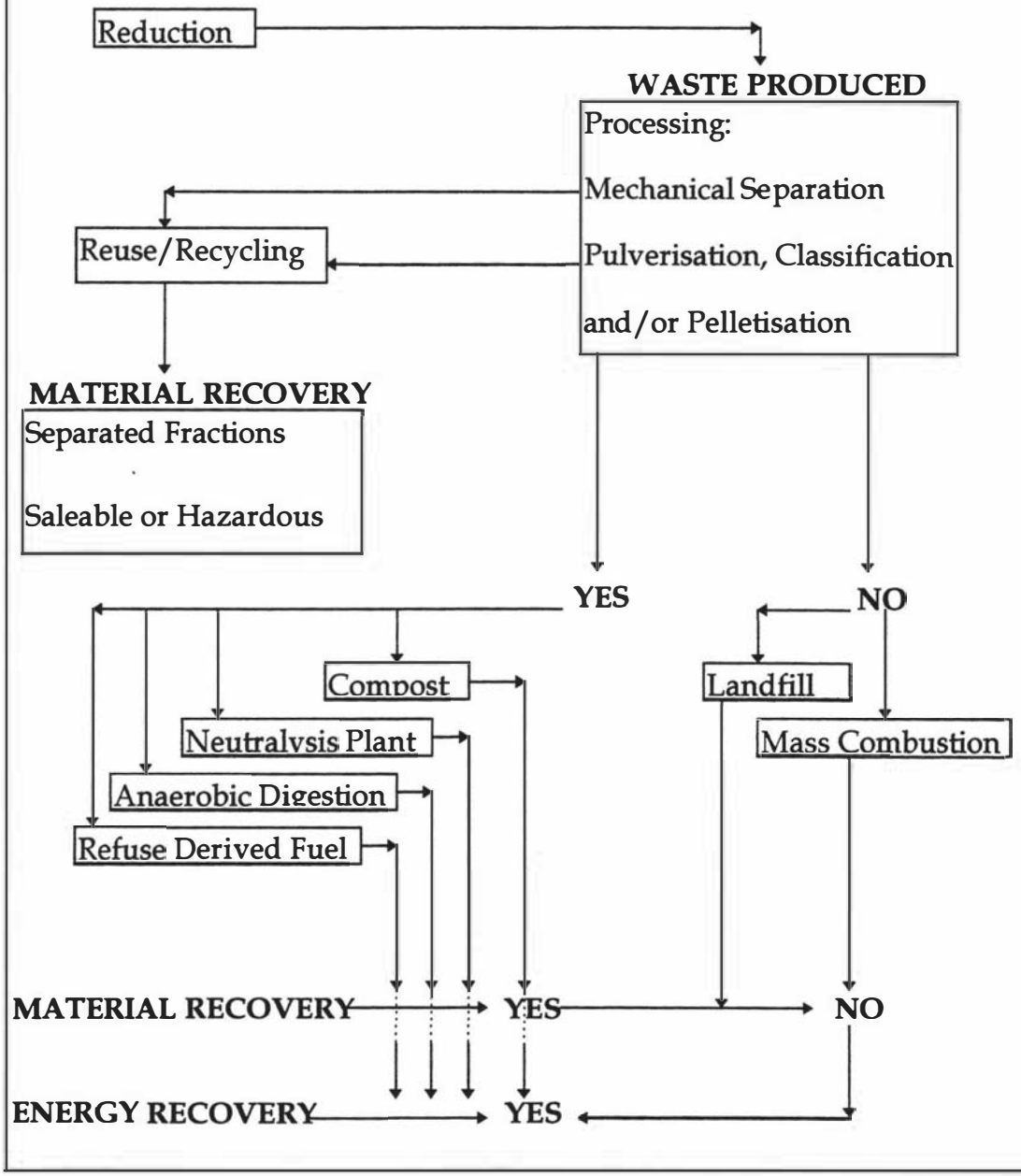
Although traditionally MSW has been considered as: "something worthless requiring disposal" [Krol, 1990], more and more countries are taking a broader view. This is often a slow and difficult change as it requires co-operation between government departments in order to arrive at the appropriate technological mix for the waste management plan of a particular area. Such co-operation may in the long term enable the true cost/benefits of a particular management plan to be formalised by making clear whether materials and energy recovery are having an economic and environmental impact [Powell, 1983; Krol, 1990; Footnote 11].

The main waste management options in use in various parts of the world, which can be regarded as being able to operate in an environmentally acceptable manner [Krol, 1990], have been shown in Figure 5.1 which summarises municipal solid waste management options in terms of material and energy recovery. This looks like a deceptively simple equation of input of waste giving output of energy and materials, leaving the waste management decisions to hinge upon which waste treatment system is most suitable in terms of space, alternative uses, availability of capital and expertise, and environmentally acceptable impacts.

Figure 5.1

CHOICES IN MSW MANAGEMENT

Adapted from Krol, 1990, 1991



If waste management decisions are to include the overall costs and benefits to society and to the environment, each step has to be analysed carefully as to its effect on other possible solutions in the chain. While it may be

environmentally desirable to prevent resources (raw materials, energy and landscape) from 'going to waste', the costs[57] associated with recovery programs may be more than the recovered resources are worth in environmental, social and economic terms. In contrast to noticeable landfills and the 'feel-good' [Young, 1985, 1986] piles of recycled materials, these other costs may not be immediately obvious to the public and the pressures on local bodies and government may push decision making toward less economic efficient approaches than would otherwise be the case [Ciriacy-Wantrup, 1959; Kummel, 1989; Norgaard, 1989; Norton, 1989; Pearce *et al.*, 1989; Barbier, 1990; Bartone, 1990; Nichlaisen *et al.*, 1990; Brown *et al.*, 1992; Penny, 1992].

5.8 Waste as High Entropy Material.

5.8.1 The Effect of Sorting on Entropy.

One of the characteristic of municipal solid waste is its mixed nature which gives it a high entropy. This makes it difficult to utilise in its delivered form. To reverse this takes a high input of energy. The application of the 4R's (Reduction, Reuse, Recycling and Recovery) lowers the entropy of the material being separated out and increases its value. The first three of these are often pre-collection, by household sorting and consumer choice, the energy expense involved in sorting is mostly manual and only enter the municipal waste budget where manual employed labour replaces the

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[57] 'Costs' are those measured in energy use, other resource use, capital investment and loss of amenities.

household voluntary labour. Replacing voluntary labour with paid labour and capital investment may increase the volumes of recovered materials and thus be justifiable in those terms. However, if the price of recovered materials is high enough, the voluntary labour input would probably increase because of the personal gains from private sales. This would decrease the profitability of the municipal fraction of the waste. The difficulty in measuring the effects of source reduction means that this gets very little attention in most solid waste legislation [MFE, 1990; Grogan and Schwartz, 1991; Guice, 1992/93; BioCycle([c], 1993; Grogan, 1993].

5.8.2 The Entropy Cost of Sorting.

Regardless of how the first three R's are implemented the removal of relatively pure components, such as aluminium, paper and glass, from the waste stream will increase the entropy of the rest. This can be defined as an 'Entropy Cost' in that this will make the fourth R (Recovery), more expensive. A 1993 report on Sydney's waste [Recycle NSW, 1993;], concluded that 23.8% of the MSW stream was potentially recyclable. This did not include organic household waste. Waste reduction targets set for 50% by year 2000 will require strategies involving the organic component. [Recycle NSW, 1991; Prince, 1993]. An earlier waste analysis done in 1988, estimates that the potential in Australia for reducing landfill usage by recycling and composting is probably between 30-40%[58] [Krol, 1990]. As mentioned earlier, such reduction incurs a cost elsewhere in terms of energy usage and labour,

as well as a loss in potential energy recovery from landfill gases. Where the landfill is small, such a loss of gas production potential may be an advantage, as the capital investment in setting up a gas collection plant may be above the commercial return from the landfill gas, and expenses occurring in otherwise controlling the gas emissions, will be minimised [Kingston *et al*, 1983].

Pre-collection sorting, which removes metals from the waste stream will be of benefit to mass combustion of MSW. Where paper and other high calorific components are also sorted out, the amount of energy recovered drops and the whole incineration operation may cease to be economically viable even though landfill space is saved.

High volumes within the waste stream of components in unmixed states, such as metals, would seem to benefit waste management systems aimed at returning profit, or reducing costs, by materials and energy recovery. The higher the content of easily recoverable components, the higher the returns of the recovery operation. As mentioned above, the degree of purity of a particular component of MSW, is based on the value of this component to the householder. The higher the value, the less likely it is to turn up in the waste stream. The lower the value, the more likely it is to arrive in an impure form, requiring processing before treatment in one of the materials or energy recovery systems.

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[58] In New Zealand this figure appears to be higher. See Chapter 4.

Table 5.4: The effect of sorting on the calorific value (CV) of MSW.

MATERIAL REMOVED FROM MSW	CV[net]MJ/kg	H_2O[%]	Ash[%]
No Sorting/Raw Refuse	7.06	33.0	7.5
Metals, Glass, non,combustibles	9.20	39.0	8.5
The above and >10mm fines	10.50	39.0	8.3
The above and organics	12.90	28.0	8.5
Everything except Plastics	26.00	20.00	7.5

[Krol, 1990]

Table 5.4 illustrates what happens to the energy value and waste remnant of MSW after various degree of sorting has occurred. The highest returns of energy and least returns of ash and water per kg of waste are obtained after organics, metals and glass, etc. are removed, leaving paper, textiles, plastics and other combustibles. The highest return per kg of waste, is obtained by combustion of plastics alone. This comparison of energy value and remnant waste per kg of domestic refuse is simplistic in that it offers no method for contrasting which volume of domestic waste mixture represents an economic unit in terms of handling, transport and turn-over costs. Neither is there a measure of the degree of toxicity of the ash component. The comparison does allow a tentative conclusion, that the profitability of the high energy content[59] of the purer fractions will be affected by the cost of separating them from the other fractions.

[59] The profitability of the energy content will be a function of the energy dependence of the nation in which the method of incineration is proposed.

5.8.3 Considerations for Minimum Cost Solutions.

Thus a possible minimum cost solution for waste management in a particular region needs to include information about which facilities are necessary, where the facilities should be located in relation to the waste production, the degree of environmental sensitivity required, energy and product prices and the cost of borrowing money. The integration of these points is difficult and may require the use of computer models. [Krol, 1990]. In terms of orthodox economic calculations, alternative waste management systems may be difficult to justify. The World Bank, however, is moving towards a realisation that all economic systems are subsets of a closed, finite system, where man-made capital no longer sets the limits on operations, but natural resources and space do [Daly, 1990; Brown *et al.*, 1992]. Thus previously unpriced resources may aquire a monetary value and influence the cost-structure of traditional resources, for example, Carbon Taxes on the CO_2 emission from combustion [Barett, 1991; Loske, 1991] will affect the cost of waste incineration, and make the economics of this operation more marginal depending on the prices of the other energy sources it is replacing.

5.9 New Zealand's Position.

5.9.1 New Zealand as a Western Economy.

New Zealand is a western nation in South Pacific setting. As such we share a consumption pattern with other western cultures [OECD, 1993], but have a unique climate, geology and population distribution. The administrative division of the country has been described in chapter 2. Per head of population New Zealand consumes energy and raw materials on par with Britain and Australia

[OECD, 1993]. Its two narrow main islands are situated across the 'roaring 40,s' wind belt, giving strong and prevailing westerly winds. Relatively low population densities and lack of urbanisation have meant that the effects on the environment of economic activities have not been immediately obvious. Recently the rapid growth of some urban centres has given rise to similar problems associated with population conglomerations overseas.

Overseas models for waste initiatives arising in response to commercial operations, have been relatively easy to follow in New Zealand. In contrast, the diffuse nature of domestic waste and the unique geography and economy of this country have made it more difficult to find overseas models to fit the New Zealand situation. Although, by definition, a western economy, transferring waste management technology directly into the New Zealand situation is probably not appropriate, as the type and composition of waste is likely to differ because of lifestyles and climate [Warburton, 1993; Table 5.5].

5.9.2 The New Zealand MSW Stream.

Table 5.5: Comparison of components in NZ MSW stream with those of the USA, Germany, Denmark and the UK.

MATERIALS	NEW ZEALAND	USA	GERMANY	DENMARK	U.K.
Organics	45	22	44	22	30
Paper/Cardboard	33	34	18	19	
Metals	5	13	3	6	33
Glass	3	9	9	7	9
Plastics	4	14[a]	5	5	8
Other	10	4	21	41	11

[a]Contains leather, etc as well as plastics [Anon., 1992; Worley, 1992; Warmer(c), 1995]

Although the above data should be treated with caution because of the varying standards applied when setting the sorting categories, for example, countries, such as Denmark, with a long-standing deposit system for returned bottles will have less glass in the MSW from that source [Warmer(j), 1994], there are nevertheless some value in comparing the various MSW streams with that of New Zealand. Thus the data suggest that New Zealand shares some waste component characteristics with Germany in the organic section, the USA and the UK in the paper and cardboard section and varies strongly from the USA in the metal component of the waste stream. These similarities and differences are of importance when considering waste management alternatives based on models developed in those countries [Bailey(b), 1994]. As the profitability of various systems seem to be related to the amount handled in a particular time span, [Steuteville(a), 1993] the population density becomes a critical factor in the equation. The low population density in rural New Zealand means that smaller centres lack the capital needed for high tech solutions and the need for employment generation in some outlying regions may offer an alternative solution to high capital and high tech investments, for example, the unemployment in Northland is 13% compared to the national average of 7.5%. [NZISS, 1995]. The cost of benefits, training programs, landfills and environmental degradation should be balanced against the cost of setting up small volume processing waste units [Lardinois and van de Klundert, 1993]. This dovetailing of purposes is made difficult by the seeming lack of integration between local body and central government policies [Storey, 1993, Mohammed, 1993]. Gold River, Canada, is an example of a low tech approach working for a

community of 2500 residents. This village has succeeded in a diversion of 70% of their waste from the landfill, with a future goal of 80% [Fleming, 1993].

5.9.3 Policies and Strategies.

A confusion of goals, gives rise to further difficulty by preventing clear policies and strategies [Christensen *et al.*, 1980]. For example, some local bodies struggle with clarifying whether waste minimisation or waste handling efficiency is the ultimate goal [Bartone, 1990; MFE[a], 1992; Patterson, 1993; Waste Minimisation Network, 1993; McNeill, 1994]. Some councils are operating landfills using LATEs[60] or contractors using private landfills. This gives a vested interest in landfilling and optimisation of equipment usage which pushes goals towards waste maximisation [McNeill, 1993, Bonini, 1993]. The Resource Management Act 1991 states that sustainability must be part of landuse consent planning. This clearly pushes goals towards waste minimisation [Brash, 1992; Young, 1992]. This is further emphasised in the Government's Environment 2010 Strategy [MfE (a) and (b), 1994]. Local bodies that do not clarify these goals will have conflicting policies and will find it difficult to apply the correct tools for either extreme. That means that neither efficiency nor sustainability will be achieved. Local bodies in New Zealand have little guidance with regard to how to achieve sustainability and efficiency in the handling of MSW [PCE(c), 1991; Patterson, 1993; Young, 1993; PCE, 1993; McNeill, 1993]. The government has until now used a hands-off approach allowing local bodies to develop systems suitable for their particular

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[60] Local Authority Trading Enterprise.

requirements. The problem with this, however, has been that local bodies are attempting to set up waste minimisation schemes in a distorted market. Such a market is caused by lack of outlets and a competion against virgin stock that does not reflect its real price [Schools Brief, 1986; Bartone, 1990; Sambrook, 1990; Earle, 1990; Powelson and Powelson, 1992; Stavins and Whitehead, 1992; Sudol, 1992; Grogan, 1995].

5.10 The State of Waste in New Zealand Municipalities.

5.10.1 The Survey.

In an attempt to establish where local bodies are at with regard to recycling and waste minimisation a questionnaire [Appendix 1D], was sent to all City and District Councils. Of the 73 forms sent out in late 1993, 68 were returned within three months. This survey was followed by a telephone survey in April 1995 in which 73 councils were phoned and asked five questions relating to the economic tools used in solid waste management by that council. Of the 73 councils 15 were unable to respond.

5.10.2 Summary of Survey Results.[61]

Eleven of the Councils did not have a recycling policy in place. Nearly half of these are from the South Island. The South Island Councils are more likely to either organise, or depend on voluntary organisations to organise, recycling[62].The

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[61]Detailed results in Appendix 11.

[62] This is often the case in small and remote communities overseas, as well [Anderson, 1994, LeBlanq, 1994].

North Island councils are more inclined to use contractors than their South Island counterparts. City councils in both islands are forming co-operative groups for the marketing of recyclables [63]. This strategy is in agreement with overseas studies showing that the biggest barrier to successful recycling is not access to markets, but regional co-operation [Steuteville(b), 1994]. Glass is the most consistently recycled commodity in both islands. Paper, aluminium cans and food tins as well as plastics are most commonly recycled in the north island. Organics and green waste are not frequently "recycled".

Only eight councils organise the selling of the collected recyclables, three pass the material on to a regional council group and five give the material away. The rest sell via contractors. Surplus not sold is landfilled. In all cases marketing is done by those that are responsible for selling. Most sell to industries, op-shops or dealers. Only five councils listed a middle person as taking stock off their hands. Market research is carried out by eight councils - the same councils that carry out direct selling. Waste volumes decreased in thirty-one councils, ranging from 1 - 40%, with the most common values being 10 - 15%. One council reported a 95% decrease in green waste content destined for the landfill since composting started. Three councils were not sure a waste decrease had occurred and fourteen councils reported no change in volumes. Recyclables are considered non-profitable by most councils. This is probably because the profitable items are handled by private enterprise, leaving the less profitable items to council, or

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[63] Overseas studies have found that marketing cooperatives and 'Buy Recycled' alliances can overcome economic barriers in marketing collected recyclables [Prete, 1993]..

because the councils are not calculating landfill space saved as part of the equation. If this is done, then the profitability should increase with higher population density and higher land-value for the landfill.

Opinion is neatly divided on whether recycling has made waste management more expensive. This also appears to be related to saving the value of landfill space, or to the type of recycling system used. It is more likely to be seen as more expensive in the South Island and in districts away from the markets. The most commonly perceived obstacles to recycling are the distance to, and the unreliability of markets. Overseas and local studies suggest that these obstacles are fallacious and easily overcome by regional co-operation [CFE, 1993; Steuteville(b), 1994]. Pilot program studies in America have shown that a recycling contractor covering a 36,000 square miles area with a population of a minimum 60,000 people, with drop off sites served 2,4 times per month can be operated for a net annual cost of US$1.50 per person [Steuteville(b), 1994].

Home composting is encouraged by 33 councils, but only three provide financial incentives to do so, in the form of reduced or free green-landfilling fees or subsidies on compost bins. The rest either depend on information and education (18), or do nothing at all (12). The use of units installed in sinks to grind organics into fine particles and washing it into the sewage system was seen as possible solutions by two councils only, both of which reported excess sewage treatment capacity.

Of the sixty-eight councils, fifty-four had no policy for the use of recycled materials. Some used recycled materials on an *ad hoc* basis, although most

reported that recycled material is more expensive and of poorer quality. In spite of this most declared the saleability of recyclables as 'extremely important' or 'very important' to the success of recycling in their districts. Clearly there is a way to go before the loop is closed in the New Zealand recycling system. Some councils have a clear understanding that the pricing structure of the recyclables is wrong, and distorting their marketability. These councils have been involved in a program of lobbying central government for changes to legislation. Most councils have not yet become involved with the markets for recyclables [Coats, 1993]. The rest are applying their own economic incentives, using education or co-operating with other councils on the issue.

Many of the councils subsidise landfill expenses from the general rates, but most are moving towards making landfills economically self-supporting. The use of economic disincentives in the management of domestic solid waste appears universal in the city councils, by charging fees or banning public access to landfills. This also appears to be the norm in North Island district councils. The more rural and further south the council, the less likely the council is to have, or to be considering, landfilling fees. The fees vary from $2.50 to $20.00 for a standard 1 cubic meter trailer. The lower of these fees are set by councils weaning the public on to the fee structure, and are most commonly found in rural districts. The development of transfer stations are in an explosive growth stage with 18 councils being at the planning or building stage. Most of this growth is in the rural districts, with most activity in the North Island. Rural districts are also more likely to use skip-bins as part of the rural service. The use of these is free,

whereas fees apply to all other transfer stations. Most have a bonus system built in if the depositor bring 'pure' waste for recycling or composting.

Although there seems to be a clear move towards making landfills self-funding through charges, there seems to be great reluctance to apply the principle to domestic waste collections. Of the fifty-eight responding councils forty-eight apply some form of uniform annual charge for the domestic waste collection, levied equally over all the households that have the service available, and two fund it from the general rates. Only one council permits residents to opt out of the system. Eight councils fund the collection system completely from bag or coupon sales. Of the forty-eight councils using annual charges, fourteen issue official bags[64] and insist on the use of these. Extra bags can be purchased. These reflect the price of the collection plus the landfilling. Most of the councils admitted that unofficial bags are often included in the collection.

5.10.3 Conclusions from Survey Results.

New Zealand local bodies have not come to terms with MSW management in light of the RMA, 1991 and overseas developments. The reluctance to apply the 'user-pays' principle to the waste collection systems is probably caused both for political reasons, and by a belief that charging the consumer what it costs will result in increased littering and illegal dumping, although there is no evidence to support this belief. The councils that have applied total 'user-pays' systems report that they have not experienced long term problems with this. Waste minimisation behaviour, however, are not rewarded when the

[64] Twelve issue 58, and two issue 26 bags per year.

costs are charged equally across all ratepayers, regardless of waste production [Versteege, 1994].

One of the largest components of the domestic waste stream, organic household waste and garden waste, receives little attention, while a lot of effort goes into removing other components which have relatively little impact on the waste volumes. Local bodies have very little control over the pricing structure of some of those materials, but have to fund the cost of disposing of them. South Island councils reported that glass recycling was successful mainly because the industry has taken responsibility for creating a cost structure for the cullet that incooperates the cost of transport from remote areas. Thus contractors are able to collect and return this material from all over New Zealand. Conversely, the removal by councils of low cost materials such as plastics recycling them delivers the material to the recycling industries at a subsidised cost, and the loss between collection and recycling of such non-profit materials is carried by the ratepayer. This amounts to a subsidy to the virgin material user, and ensures that the material will continue to be used as a limitless resource, with subsequent disposal problems. As long as the pricing structures are skewed in favour of the manufacturer, recycling of low cost materials will make domestic waste management very expensive. Most of the councils that recycle see this as an acceptable expense in terms of public training, and subsidise it in various ways, either by increased charges for mixed waste arriving at transfer stations and landfills, by annual waste charges or by the general rates. These subsidies amount to a subsidy on the virgin material and will delay the reformation of the pricing structure.

5.11 The New Zealand System Compared to Systems in Other Countries.

5.11.1 Possible Solutions to the New Zealand MSW Problem.

Possible solutions to the New Zealand waste management problems, can be considered from the perspective of similar cultures, geographies and economies.

Of various countries with similarities to New Zealand in these fields, Denmark, Holland, Norway and Australia were thought to be the closest. Norway has the same elongated geography as New Zealand with mountains dividing the country into relatively isolated communities. In spite of this similarity the country was rejected for comparison by the researcher on the grounds that its severe climate has roads and communities under snow for 6-7 months of the year. Holland was included for comparison because of its environmental legislation which is similar to the New Zealand legislation (Blakely, R, 1993) and Australia was also considered to be a worthwhile comparison because of its cultural similarities and its proximity to New Zealand.

Denmark was used to compare MSW management systems with those in the communities studied in New Zealand. The Horowhenua region has a highly developed agricultural system as does Denmark. Palmerston North is a city with gardens and light industry, similar to the cities used in the Danish study used for comparison purposes. The island geography of Denmark can be considered parallel to New Zealand's community divisions caused by rivers and mountains. The population distribution is skewed towards a big city in both countries and the rural:urban population ratio is similar in both countries. It differs in climate, although parts of New Zealand have the same cold temperate conditions as Denmark, geology, population density, educational levels and racial and cultural mix as well as the administration of local versus central government. Denmark has a well-developed technical research capacity, but little social scientific research in relation to recycling of household waste. This aspect of work is gaining greater emphasis as the need for optimisation of recycling and protection

of the environment is seen as increasing in importance [Thøgersen, 1990; DanishEPA, 1991].

5.11.2 The Danish System as a Model.

Denmark has a stable population of 5.2 million [1992] in an area of 48,177km^2. The terrain is mainly flat, distributed among a peninsular bordering Germany at it most southern point and 474 islands of which approximately 100 are inhabited and connected by ferries and bridges. The railroads are important, agriculture intense and good land is at a premium. The climate is cold temperate with occasional winter ice closing roads and freezing the sea making transport difficult. Population density is approximately 120.4 /km^2, with 84.9% urban and 15.1% rural dwellers. Over 50% of the population lives in the larger metropolitan area of Copenhagen, the capital city. Average household size is 2.9 [1991] with an annual average income of US$29,613. Literacy is 99% with more than 50% reaching higher vocational or academic training [European World Yearbook, 1995][65].

Administratively the country is divided into communes and counties [large and small municipalities]. Each of these is responsible for handling the local waste.

Often this is achieved by intermunicipal waste co-operation or by a subsidised waste company. Thus the handling of household waste and its reuse is also a municipal responsibility. Usually this involves a cost-benefit balancing operation.

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[65] NZ density 13 /km^2, with 75.9% urban, 3 per household and US$23,760 average annual income. Literacy virtually 100% with less than 50% with more than High School Certificate.

Traditionally separation, collection and reuse of waste was carried out by voluntary organisations, animal owners, enthusiastic gardeners and 'Rag-and-Bone' merchants, that is they were only recycled if they were perceived as giving economic benefit. Among existing schemes is the collection of paper , and sometimes glass, by voluntary organisations, who then sell the materials to the recycling industry. These schemes are often subsidised by the municipalities [Thøgersen, 1990]. Traditionally most of the household waste has until recently been deposited in landfills. In 1985 only 9% was reused. With an eye to the recovery of recyclable materials, some municipalities have, since 1985, set up experiments in the source-separation of household waste into two or more fractions, the compostables in a green bag, and the rest, in a grey bag. Some of these experiments have since become ongoing operations. Householders may ask for dispensation from participation in the new system based upon whether they are pensioners (as this group is not considered to be a large producer of compostable materials), are farmers (as they are considered able to compost on the property) or by purchase of a municipal compost bin, in which case a small reduction in the levy paid towards waste disposal is given to the householder [Johansson, 1991]. The municipalities themselves receive their strongest motivation for implementing sorting and reuse programs from the regulations imposed on landuse by the central government in the form of laws and subsidies pertaining to reuse of materials, support programs, levies and restrictive directives on waste. Central government is responsible for the money used to ensure the environmental safety of the waste. Part of this cost is carried by the taxpayer and part is levied on the waste as it arrives at the landfill which means

that the local government also faces increasing expenses related to the waste. In 1989 a ton of waste at a landfill on the peninsula of Jutland, cost approximately NZ$100 per ton[66], at the same time incineration costs were 1.5 times higher, even when energy extraction has been accounted for [Johansson and Thøgersen, 1991]

As well as the funding, Central Government is also responsible for overall policy implementation,[67] but leaves the municipalities free with regard to how they are to achieve the overall goals. This has resulted in a variety of systems. Where these were set up to specifically suit a particular population, the results have been good, but where the system was adopted simply because it was a success elsewhere , the result has been less satisfactory [Johansson, 1991]. Since 1990 the municipalities have been directed to collect glass and paper for reuse from residential conglomerations of more than 2000 households. In 1991 this was expanded to include "Environmentally Hazardous Substances" [Johansson and Thøgersen, 1991]. The aim is to increase reuse of household waste from 10 to 40,50% during this decade. The latest Danish household waste census in 1985 showed a production of 1 900 000 tons per year or 1kg per person per day, not counting the waste leaving the household via the sewage system, for example, in sink disposal units. This amount is increasing with increasing production and

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[66] The 1994 real cost per tonnage of waste arriving at the Awapuni Landfill, Palmerston North is $15.00 per ton, which includes $3.00 per ton for landfill aftercare. Commercial operators are charged $17.00 per ton, private people $27.00 per ton which subsidises the cost of running the Malden Street transfer station. The projected price per ton for the new landfill is $35.00 per ton which includes costs of operating the landfill at the standards set by the planning tribunal. The ARC estimates cost per ton of waste arriving at their landfills to be approximately $40.00 per ton which includes the cost of transferring the waste [McKerchar, 1994].

[67] Denmark follows the EC Directives and has regulations more stringent than many other EC states. The country does not have an overall environmental plan [Thøgersen, 1990]. cf. The Netherlands and New Zealand [Blakeley, 1993].

consumption.[68] According to the Danish waste census, waste generated by households falls into three categories. Daily waste, that produced by the daily housekeeping and disposed of via the collection bags. This constitutes 63% of all waste from households. Garden waste (22%) and other large waste (15%), which is seasonally dependent, come from fewer households and have to be dealt with using a different system than the daily waste component. Analysis of the household waste shows that 1/3 is organic waste, 1/3 is paper and cardboard, 1/3 is other types such as metals, plastics and glass. This category also includes a small, potentially hazardous component such as batteries and paints[69] [Johansson and Thøgersen, 1991].

The goal of reuse of 40-50% of household waste is a long way from being achieved. Market researchers have long been aware that motivation of consumers affects the choices made. For householders to achieve the stated Reuse of Household Waste goals on an ongoing basis, it is important to understand their needs and wishes with regard to their waste and the environment. This became the premise for the project: *A Behavioural Science Framework for Source-Separation Systems for Household Waste,* carried out at the Department of Marketing, the Aarhus School of Business, Denmark. Some of the founding statistics for this project were obtained from Nyborg Municipality, 1991, where they had just introduced a new source-separation program for compostable material. The analysis includes the content of the 'grey bag', constituting the remnant fraction

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[68] In contrast the New Zealand population is still increasing. This means that waste volumes will probably increase naturally as well as by increasing individual consumption.

of the waste after the compostables have been removed, the effect of variations in the collection service[70], and the degree of non-conformity that may occur in the households that had dispensation from participation in the 'green bag' system [Thøgersen and Johansson, 1991].

The grey bags were collected from 167 households. From 86 households participating in the source-separation for compostables, the green bag was collected. The grey bags were sorted into the fractions: compostables, reusable glass, reusable paper and cardboard, environmentally damaging materials, plastic, metals and others. Vacuum cleaner dust was included as environmentally damaging material[71], although the householders were receiving conflicting messages about this from the information pamphlets issued by the municipal body. The green bag was sorted into two compostable fractions , garden waste and other compostables, reusable glass, reusable paper/cardboard, environmentally damaging materials and others. The fractions from each address were weighed [50 gram interval], and logged as weekly tallies [Thøgersen and Johansson, 1991], [Appendix 12].

Using Pieters' [1989] *Specific Performance Measure* [SPM][72], [Thøgersen and Johansson, 1991], the analyst was able to ascertain that the grey bags contained

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[69] This compares with New Zealand household waste surveys [Awapuni Landfill Analysis, Chapter 4.].

[70] Whether the recoverable materials are collected from the household, whether the householder has to deliver the materials and how far the householder has to travel to deliver it.

[71] In New Zealand this material can be considered 'organic' in semi-rural areas, but has to be treated with caution in heavily industrialised areas.

[72] SPM=[weight of correctly placed material in bag/total weight of bag]x100

47.6% of material which should have been deposited in alternative systems [Table App.12.1, Appendix 12]. The analysis gave the opportunity to compare the ease of recycling defined as the level of service provided by the local body, with the amounts of the recyclable materials deposited into the bag. The collected samples were divided into two groups. Those which had easy access to collection boxes were designated as 'High Service' households and those which had a long distance to collection boxes were designated 'Low Service' households. There was no difference in the average size of households.

The analyst found that the bags from the households receiving low service contained more glass and paper than the bags from households receiving high service. This was found to be significantly different at 95% confidence level for glass only [Table App.12.2, Appendix 12]. Not apparent from the table, but reported by the analyst was that 44% of the bags from normal service households contained glass in contrast to 20% of the bags from the high service households. This was found to be statistically significant. The corresponding values for paper was 82% versus 67%. This difference was not found to be statistically significant.

In contrast to the grey bag, there was found to be very little fault-sorting in the green bags. Calculating by SPM [footnote 72], shows that the green bags contained 98.5% correctly placed materials [Table App.12.3, Appendix 12]. On average the bags contained 48% garden waste, although this had to be an estimate only considering the difficulty in separating garden waste from the rest.

At the time of the analysis 31% of the participating households had received dispensation from the green bag collection. The samples were divided into two

groups according to whether the householders participated or not, and the compostable content of the grey bags analysed [Table App.12.4, Appendix 12]. Although it appears that there is more compostable materials in the bags from households that had obtained dispensations than from households that had not obtained it, there was little statistical evidence to suggest that this difference is real. When this is analysed further using the De Jonge and Oppendijk van Veen's [1982] *Standard Discriminatory Success* [SDS][73] [Thøgersen and Johansson, 1991] index which accounts for degree of purity as well as degree of response to source-separation. When the results were analysed using this index there appears to be no statistical difference [Table App.12.4, Appendix 12].

The result of the preliminary source separation study suggests that the householders in Denmark have started to conform to the Ministry for the Environment's demands for collection of "significant parts of the reusable materials" [Thøgersen and Johansson, 1991]. This behaviour appears most significant with respect to glass. All the waste fractions considered in the grey bag depended on the householders' own delivery to collection points, or on voluntary organisations for collection at the address. The green bag collection of compostables appear very successful. This waste fraction is collected as part of the weekly collection. The conclusion reached by the analyst is that degree of participation in the return scheme depends on the ease with which the householder can participate [Thøgersen and Johansson, 1991].

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[73] SDS=[(A/A+B + D/C+D)-1]x100, where A represents the targetted waste in the special container, B represents the targetted waste in the general container, C represents general waste in the special container and D represents general waste in the general container.

The reuse policy of the Danish government is a move away from incineration of waste which was so popular in the 70's and 80's, to the point where 'reuse' and thus freedom from levies does not cover waste destined for incineration [Thøgersen and Johansson, 1991]. Many Danish communities are piped with heating and hot water provided by a central waste burner unit. This reduces the volumes and take the pressure off landfill sites, which are a scarce and expensive commodity in a densely populated, highly cultivated country, and saves precious imported fuels, while potentially also giving rise to some serious environmental problems [Thøgersen and Johansson, 1991]. In a densely populated country, with a highly trained population and a democratic electoral system, environmental problems and their impact on human health and quality of life are easily communicated throughout the population. The public outcry against living in a polluted environment gives political motivation to counter visible sources of environmental degradation such as incinerators and landfills.

The drive to carry out source-separation of household waste, however, depends on personal motivation. Behavioural research [Pieters, 1986], shows that complex behaviour is not just a question of attitudes. Modern consumer-behaviour theory related to buying behaviour does not fully explain people's behaviour with regard to waste [Thøgersen, 1992]. Source-separation is a continuing activity without instant gratification in terms of perceived costs and expected benefits [Thøgersen and Johansson, 1991]. The more abstract and long-term benefits accruing to recycling would appear to be one of the factors inhibiting better participation [Young, 1985, 1986].

5.11.3 The Danish Model Compared to the Palmerston North and Levin Survey.

Although more detailed, and aimed specifically at examining source-separation behaviour, the Danish analysis shares enough data characteristics with the survey done on household solid waste in Palmerston North and Levin to allow comparisons between the two results. As is the case for the Danish waste, the household solid waste in New Zealand can also be divided into three categories: daily waste arising from housekeeping, seasonally dependent gardening waste and bulky waste that will not fit the collection bags. Unlike Denmark, the seasons are less marked and the growing season much longer, so the gardening component has the potential to be much larger. When the survey data for this project were compared with those done by the Danish research team, it appears that the proportions of the components that make up the waste in the waste bag are approximately the same as those found in Denmark. This is in contrast to the official data compiled in Table 5.5, and may be caused by clearer division by the researchers of the 'other' category, which is very large in the data for Table 5.5.

5.11.4 New Zealand's Position in Relation to European Models.

Similar to New Zealand, the Netherlands have replaced hundreds of laws with a national environmental policy, taking an integrated approach to dealing with environmental decisions. This "green plan" has now been set as a framework for other EC countries to follow [Blakeley, 1995]. Although New Zealand has no officially named "Green Plan", the RMA 1991 and Environment 2010 Strategy [MfE, 1994] are long-term, comprehensive and integrated approaches to

environmental management, thus fitting the same criteria that the Dutch environmental policy fits [Blakeley, 1995]. Although New Zealand and Holland are different in every physical and ethnographic respect, this similarity in policies gives New Zealand the same framework for solving environmental problems that Holland has. Holland has an advanced system of source-separation and recycling for household waste and Dutch researchers are well advanced in the studies of "source-separation behaviour" [Pieters, 1986; Thøgersen and Johansson, 1991].

Neither Denmark nor Holland have systems that will be easily transferable to New Zealand [Dutch Ministry of Housing, 1990]. While sharing the same environmental philosophies, the New Zealand laws lack the legislative clout of the national acts of, for example Holland, Germany and Denmark, which set out in detail what the standards and goals are, how to achieve them, and offer a framework for discouraging non-compliance. The New Zealand RMA is focused on effects and negotiations and thus tends more towards the British philosophies that support the European Commissions objectives, but not their methods.

5.12 Market Forces and Legislation.

5.12.1 The Waste Oil Market Failure.

The British Government tends towards market forces to satisfy the goals set for particular substances, for example, waste oil [Armishaw, 1991; Anon., 1992]. New Zealand government removed intervention from the waste oil market in the late 1980s. This resulted in a drop of collection of waste oil for recycling [DTI,

1979]. The reason for this drop was a distortion in the market caused by the lack of real cost reflection in the price of virgin oil. In contrast to the New Zealand Government, many of the national governments in the EC have shown willingness to apply economic tools to further the waste minimisation doctrine set out in the EC directive [Nordic Council of Ministers, 1991; Anon., 1992]. This suggests that the success of the waste management systems operating in Germany, Holland and Denmark arises from legislation correcting distortions in market forces. The same appears to be the case for the successful systems operating in the United States of America.

5.12.2 Economic Tools in the USA.

In contrast to the EC countries there appears, in America, to be an emphasis on post-consumer waste reduction and not on source reduction. The German packaging laws and the Dutch new national policy objectives [BioCycle(e), 1993; BioCycle(a), 1994] encourage source reduction as the first principle of the waste management hierarchy in accordance with the EC directive on solid waste management [Anon., 1992].by making manufacturers directly responsible for their own packaging. The DSD system is probably the one most successful at reducing post-consumer waste by introducing an economic incentive for reducing secondary packaging. Indirectly this has probably also had an effect on American manufacturers exporting to Europe. The 'take-back' provisions in some state laws mimic this system to some extent. For example, since 1992 fifteen states have had legislation that makes it mandatory for wholesalers and retailers to take back vehicle batteries [Steuteville and Goldstein, 1993]. Variable waste fees, based on the amount of refuse collected, have been introduced in some countries

of the EC and in some of the states in America as a waste reduction incentive [Steuteville and Goldstein, 1993;Cuthbert, 1994; MacMahon, 1994]. In some cases the gradated fee is based on basic unit sizes determined by the "average small quantity generator", in others volume based rates, set with 90 gallon bins as the smallest unit available, which is much larger than the average family require. Some states have imposed disposal surcharges on solid waste disposal to fund recycling programs, some have a sales tax on solid waste services and others have protected recycling facilities by exempting them from these levies even when the facility produces residual waste. Advance disposal fees (ADF), are used in 22 of the American states. Consumers pay a fee when purchasing a certain product such as tires or oil. This money goes into a waste management fund [Steuteville and Goldstein, 1993; Regional Roundup(a), 1993].

5.13 Recycling in Australia.

The Australian experience with recycling seems largely centred in New South Wales. The motivation for the programs was reduction of waste going to the landfills [Recycle NSW, 1993, Johns, 1993]. Of particular interest to New Zealand waste minimisation planning is the system adopted by Wingecarribbee Council. The area covered is mixed rural and urban, with many small towns and villages. The economy is based on dairy, beef and tourism, with minor artisans around the district [Johns, 1993]. Faced with increasing waste volumes and decreasing landfill space, the Council introduced a "Waste Management Strategy" setting progressive waste reduction goals. The first steps involved improving its kerbside recycling program. The service collects in major towns, village areas and rural "recycling stations", where residents deposit recyclables. The next step

to reducing waste is a composting program. Indications are that the program is succeeding, instead of increasing waste volumes as predicted in extrapolated trends, there has been an overall reduction of waste arriving at the landfills. There appear to be five important reasons for the success of this program: education and information, smaller bin sizes for mixed waste, provision of recycling crates, landfill and transfer station charges, and commitment of Council to the program [Johns, 993].

5.14 Conclusion.

The lessons that come through most strongly from all the systems considered above are that people have to get clear messages about the costs of the waste management systems before they respond appropriately. This not only involves education, which may be important to rally quick support for proposed changes, but economic messages that allow free choices based on the cost to the consumers of the services. This will ensure that the behaviour change permanently. These economic messages must be given via the purchasing price of goods (not done anywhere, although Germany and those countries following the German DSD model are trying to do this) and through charging for the waste collection system: Where this pricing is set correctly[74] as part of the waste management strategy, there is a decrease in the amount of waste disposed of [Fishbein, 1993, Thøgersen, 1991]. In some communities adopting variable rate systems,

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[74] 'Correctly': refers to the relationship between standard of living and the economic tools. If fees are set too low, the volume of waste will be larger as the producer can easily afford to dispose of it. If they are set too high, the producer may resort to illegal means for getting rid of the waste (Germany).

experience has shown that it is common to observe reduction in waste in the range of 25-50% and an increase in recycling of 50-100% [Higgins, 1994].

New Zealand is in the happy situation of being able to study a variety of solid waste management systems and select the ones that may be useful to the situations here. The planning and implementation of an integrated community waste management program involving waste minimisation, efficient processing and economic justifications can be frustrating and complex because of the many, apparently unrelated components of such a program. The process calls for expertise in commodity markets, resource economics, engineering, public finance, environmental law and human behaviour [Jones and Thomas, 1993]. If this expertise is used New Zealand can establish a waste management system, which satisfies the demands of the RMA 1991 and Agenda 21, and ensures that the system is designed to fit the needs of the different and widespread communities, while integrating the supply and demand of resources and markets for the most efficient use of recovered materials.

CHAPTER 6

A CASE STUDY

6.1 Planning an Integrated Community Waste Management Program.

6.1.1 Introduction.

Planning a program involves implementing ideas when goals and broad concepts of the program options are developed [Davis, 1986]. Then comes the formulation of the overall plan: the choice of options based on the goals and available resources for the program. The working stages are assigned a schedule (a logical sequence), a time frame and allocation of resources to each step. No matter which method is used for this stage , either a loose 'plan-as-you-go', or a rigorous quantitative approach, the plan should provide guidance to the staff, the community leaders and the citizens [Jones, 1993]. It is illogical to develop goals after components of a program has been determined. This is a general problem with many alternative waste management programs. The lack of goal definition is a handicap to planning as priorities become confused and the outcomes cannot be assessed.

6.1.2 Setting the Goals.

Where alternative waste management strategies include recycling as a waste minimisation solution, two broad types of goals appear to be used to justify the management strategies [Jones, 1993]. The first type is economic and relates to

landfilling fees and scarcity of landfills. This means that recycling can offer a cost-effective way to reduce the solid waste stream. The other goal is energy and natural resources savings by materials recovery. Programs operating exclusively with the second goal are often termed 'environmental'. An example of this is the 'Green Party's' collection of plastics in Levin during 1990. Even though goals can to some extent be shared by both types of programs, priorities are ordered quite differently between the two. A program driven primarily by economic returns will be developed, evaluated and justified in terms of avoided costs that is, related to the avoided landfilling fees resulting from recycling and the cost of the recycling contract [O'Connor and Criner, 1994]. Financial analysis plays an important part in determining the priorities [Jones, 1993]. The environmentally driven program is determined by concerns that are much harder to quantify, such as minimising environmental impact and conserving resources. If these goals are not clearly stated, the decisions that follow will be confused, and frustration, anger and wasted resources will be the outcome.

Setting the goals for a waste minimisation program should involve a process involving public awareness. If a member of the public believes recycling is carried out as part of an economic goal ia will become as distressed when finding out that recycling plastics "is a waste of money", because it may cost more to recover the material than is gained in the sale of it, as will a person recycling for environmental reasons, when ia recognises that sometimes recycling may cause more pollution than landfilling. In both cases anger and frustration can create resistance to the program. Unfortunately, public awareness often forms the last component of the municipal decision making chain, and is often only

implemented when the damage has been done. Part of the reason for this lies in the multiplicity of skills required for the planners, mentioned in paragraph one of this chapter.

The following report is a case history of a waste management strategy implemented for the village of Tokomaru, in the Horowhenua District, in response to a brief from the Department of Health and the implementation of the Resource Management Act, 1991, which necessitated the closure of the local, unmanaged landfill in 1993 [RoydsGarden, 1992]. Three perspectives were considered in the case study:

1. - of the ratepayer: How are the present systems perceived, and what services are wanted?
2. - of waste minimisation: Which systems are most likely to achieve this?
3. - of policy making: What decisions will council have to make to implement their stated goals of equity and waste-minimisation?

6.2 The Village of Tokomaru.

6.2.1 Present Day Characteristics.

Tokomaru is a small rural settlement (population 540) situated on the northern border of the Horowhenua District, on what used to be Highway 57 (now Makerua Rd), approximately 24 km south of Palmerston North, 16 km north of Shannon [refer to Figure 3.1]

The settlement consists of a village, originally established in 1890 as part of the railroad construction project, and a diffuse rural population . The settlement went into a decline in the 1960s and 1970s, but has seen a revival as a result of Massey University's growth, the establishment of lifestyle blocks on the south-

eastern border of the village, and the redeployment of the army to Linton Camp. This resulted in an upsurge of new residents looking for cheaper land-values,and rural life style.

At the time of the survey the properties in Tokomaru were Rural Rated on land values, plus a Uniform General Rate of $63 per year, with the village paying additional amounts on service loans taken out by Council to establish sewerage and water systems in compliance with the Health Act 1965. A renewal of the sewerage loan and a 5% general rate increase resulted in a 1993-94 rate increase of 23% for the ratepayers within the village. A flat rate of $11 per year for solid waste collection was paid in addition to the basic General and Uniform rate and service loans [HDC, 1993-94].

6.2.2 Historical Background.

When the village was established people were each responsible for disposing of their own solid waste. Later a rural 'dump' was established in a old quarry on Albert Rd. Although this 'dump' was later maintained to some extent by the then Horowhenua County Council, which provided fencing, planting of trees and the occasional bull-dozing and clearance of access, the landfill was otherwise unmanaged with a great deal of indiscriminate dumping, spontaneous fires, freely breeding rats and windblown materials from uncovered landfills.

In the late 1980s the 'landfill' was considered to be nearing its capacity and a household collection system was introduced within the rural village, initially rating householders $10per year and done by Council Employees who removed any manageable items householders put out for collection. This was all deposited

in the Shannon landfill. After the Local Body reorganisation in 1989 the waste collection was tendered out to a private contractor. The uniform annual charge increased to $11per year and the council introduced the use of compulsory bags, all purchaseable from local outlets at $0.44 per bag. The contractor did not support this effort of revenue raising and picked up any bag householders put out. Surprisingly more than half the householders still persisted with the Council bags, which are more expensive compared to those sold in supermarkets.

After much public debate and proposals for alternatives [RoydsGarden, 1992, 1993] the Council finally closed and reinstated the Tokomaru Tip to pasture in February 1993. The initial proposal for alternatives included a promise of a transfer station to replace the local landfill, but in the interim Skip-Bins were provided on the first weekend of every month for waste not disposed of by the collection system. The bins were rental bins from Palmerston North, carried to and from the Awapuni Landfill by contractors. Initial bins were left at a cost of $100 a bin, extra bins brought in over the weekend cost $120 per bin The overall result was a waste management disaster: overflowing bins, smells, windblown debris, and a steady stream of waste arriving from the southern end of Palmerston North to use the 'free' system. Each 'bin-weekend' required a Council person and truck to clean up after the event. Even so, the system was estimated as 1/3 of the expense that it would have taken to run the landfill during the equivalent time [Yorke, 1993].

In the meantime the landowner adjacent to the Shannon landfill refused to let land for the extension of Shannon Landfill [Boyle, 1993] resulting in that landfill

having to close within an approximately 6 months period. A RoydsGarden consultants recommendation that a transfer station at Tokomaru would be uneconomic in terms of serving Shannon [RoydsGarden, 1992] resulted in the decision that Tokomaru receive a recycling facility and become the 'testing ground' for a new waste management system involving the MGB wheely bins[75]. The collected waste was to be carried, initially to the Shannon Landfill, later to the transfer station at Shannon. The trial covered a larger area than the old collection system and was initially to run from 1st October 1993 to 1st February 1994, every fortnight [8 collections], costing the householders nothing extra, the extra costs for this 'pilot' scheme being borne by the whole district. As the trial progressed it became possible to extend the period within the price for the first tender and the trial continued to June 1994.

6.3 The Survey.

The investigation for this report consisted of a survey [Appendix 1C] of residents within the new waste-collection area. Each household was visited personally and asked to fill in a questionnaire with the surveyor. There are 162 households within the new boundary. Two shops, 1 service station, 1 church hall and play centre and 1 training centre also received bins although they had not participated in the earlier collection service.

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[75] 'MGB' is short for 'Mobile Garbage Bins', These bins are on wheels, with a hinged lid, holds five times the volume of normal rubbish bags and are emptied by contractors using a hydaulic lifting mechanism. They are hygienic and easy to handle.

An attempt was made to contact all households. In the end ten households could not be contacted during the survey period, three declined to participate on the grounds that they were new residents, and two houses were unoccupied. This equates to 9.3 % of the total households.

The survey was constructed and performed according to Standard Survey Techniques [Department of Statistics, 1992]. Unfortunately, time restrictions prevented a pilot survey to ascertain the suitability of the questionnaire form, but this was felt to be of little importance as the questions were asked by the same person

In the analysis of the answers the upper value was taken where people gave a range of values for example, $10-$20 would result in $20 being recorded. This, it was felt, is a better indication of the total value people place on that service.

The transport expenses were worked out using the cheapest public service rate per km [as operated by Massey University for student travel reimbursements] at $0.50/Km. This value probably overestimates the actual cost of operating a small vehicle but probably underestimates the cost of a larger vehicle.

Other values for the cost of the waste management system were obtained from the official HDC Annual plan, The HDC Budget 1993/94, from council employees direct [Boyle, 1993], Councillor Olga Scott, [1992] and from the Draft Solid Waste Management Strategy [RoydsGarden, 1992, 1993; HDC, 1993-94].

6.4 Population Statistics Summary [Appendix 13].

The average number of people per household (3) is smaller than that of Levin (3.6), but larger than that of Palmerston North (2.5)

The population has more than 50% below the age of 24 years, with 34%, below 15 years, that is, the families tend to be young.

Of the 147 households surveyed, 10.2% receive superannuation and 12.2% receive social welfare: 5.4% unemployment and 6.8% DPB[76], student allowance or sickness benefit. The six earning groups[77] show that 29.8% of the 114 earning households receive earnings in the top 2 income groups, 18.4% receive earnings in the lowest income groups. The remaining 51.8% are earning in the middle income bracket. Thus the Tokomaru community could be deemed above the national average for income and qualifications, [Elley and Irving, 1985].

For the purpose of analysis of the present waste behaviour, the population of Tokomaru was divided into the same sub,groups as those used in Palmerston North and Levin. The proportion of these groups in the various populations [Table 6.3] show that the Tokomaru population is closer to the Palmerston North population than it is to the Levin population in group characteristics. The Tokomaru population has the largest proportion of young families of the three sampled populations. The proportions of the different household sizes are nearly equal for Palmerston North and Tokomaru, but Levin has a much higher

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[76] Domestic Purposes Benefit.

[77] The social earning groups 1-6 are those specified in Elley and Irving [1985]. The national distribution of these groups are: 1=7.5%, 2=11.0%, 3=23.0%, 4=33.0%, 5=17.0%, 6=8.5%. (1 representing the highest income group, 6 representing the lowest.)

proportion of single and two-person households. That probably correlates with the higher proportion of pensioners in that town.

Table 6.1: Proportion[a] of family groupings and household sizes in Palmerston North, Levin and Tokomaru.

FAMILY GROUP	PALMERSTON NORTH[b]	LEVIN[b]	TOKOMARU
YS[c]	15	4	13
YF[c]	25	16	31
MF[c]	29	32	28
MS[c]	16	26	21
P[c]	14	22	7
GROUP SIZE			
1	8	17	10
2	27	32	26
3	21	20	19
4	25	13	25
5	11	13	10
6	5	2	6

[a] In percentage rounded values. Group size 7 and 8 are not included as the sample numbers are too small.

[b] It has been presumed that the samples are representatives for these divisions in the whole population.

[c] The definition of these terms are in chapter 3

6.5 Waste Behaviour in Tokomaru, 1993- 1994.

Waste behaviour related to Irving and Elley's earning groups [footnote 77] were worked out for Tokomaru. Other groups were the superannuitants and the social welfare beneficiaries. The sample number of sickness beneficiaries and students was too small to allow reliable data, and has been excluded from the following analysis. Earning group 1 and 5, the unemployed and those on DPB also have small sample numbers, but have been included for comparison purposes

between the groups. Conclusions from these data must therefore be treated with caution.

Table 6.2: Tokomaru waste behaviour in relation to social groups.

INCOME GROUP	WASTE VOLUME[A]	RECYCLING[B]		COMPOST[B]	LANDFILL[B]	WTP[C]
		Now	Future			
1	.3 - 1	43	86	100	43	12 -.[d]
2	0 - .6	52	74	85	63	0 - 100
3	0 - .8	37	79	58	79	0 - 150
4	0 - 1	47	81	69	53	0 - 150
5	0 - 2	33	78	100	89	0 - 52
6	0 - .6	28	61	89	72	0 - 140
Superannuitants	0 - .6	50	86	79	57	0 - 60
Unemployed	0 - .8	22	100	44	89	0 - 120
DPB	0 - 1	33	67	100	67	30 - 100

[a] In bags produced per person per week.

[b] In the affirmative.

[c] 'Willing to Pay' in dollars.

[d] 'Whatever it costs'.

From Table 6.2 it can be seen that the unemployed, DPB beneficiaries, earning group 5 and 6 were less likely to recycle under the old system, where recycling required some means of transport. All groups showed high agreement with the possibility of recycling in the future, given a more convenient system. This may be an artefact of being face to face with the interviewer and seeking approval for socially 'good' behaviour. Composting behaviour are highest in the earning groups 1,2,5 and 6, the DPB beneficiaries and the superannuitants, and lowest in

the unemployed. The unemployed and earning group 3 and 5 are most likely to use the landfills; earning group 1 was the least likely.

When asked what the household considered reasonable to pay for the sort of service they required, the answers ranged from 0 to 'whatever it costs'. The superannuitants and earning group 5 were the only groups that set a low price on the service, with a top price of $50 (group 5) and $60 (superannuitants). These groups also had the highest proportion stating that the present system was satisfactory (22% of group 5 and 64% of superannuitants). When asked to specify which services the householders required for their stated price, the most common requirement was "somewhere or something to get rid of the big rubbish." Most notable in the response to this question was the lack of correlation between the price the householders were willing to pay and the service they required. In other cases, the householders stated a willingness to pay a much larger waste levy for extended services.

Thus there appears to be little evidence that social position influences waste behaviour. The differences that do occur follow no particular patterns related to these groupings and are probably closer related to the family distributions within each social group, for example, social group 1 and the pensioner group tend to be single or two adult households, the DPB group tends to consist of one adult with young children, and social groups 5 and 6 often have large families. These are observations from the data available from the survey, and explanations are outside the scope of this thesis.

When the waste behaviour are examined per family type there appears to be some clear differences between the groups. These differences are distinct from those shown by the same groups in Palmerston North and Levin. The incidence of composting for all groups is much higher and the incidence of recycling is much lower in Tokomaru than it is in the other two centres. This is probably a reflection of the lack of access to full recycling facilities experienced by the village at the time. The incidence of tipping is also much higher in Tokomaru than in the other two centres, particularly in the young family group. This makes this group behave similarly to the one in Levin, and is probably a reflection of the 'free' access to landfill or landfill replacement such as council provided skip-bins. The high reliance of Tokomaru residents on tipping as a waste management strategy is probably a residue of the traditional relationship the village had with its local dump until its closure in 1993. This high incidence of tipping explains the relatively low volume of bags produced in the village. The high incidence of tipping among young families explain their over representation in the MGB hirage scheme.

Table 6.3: Waste behaviour[a] in the family groupings in Palmerston North, Levin and Tokomaru.

Fam grp	Palmerston North[b]			Levin[b]			Tokomaru		
	com[c]	landfill	rec[d]	com[c]	landfill	rec[d]	com[c]	landfill	rec[e]
YS	23	17	70	17	33	100	58	53	42
YF	33	33	78	33	57	81	73	71	38
MF	32	39	82	28	38	95	68	68	42
MS	35	25	85	42	33	82	87	60	53
P	50	17	83	56	24	100	90	60	40

[a] In percentages from data in appendices 6 and 7.

[b] These behaviour have already been analysed and commented on in chapter 4.

[c] Composting.

[d] Recycling.

[e] Recycling at the time of the survey.

The same trends are shown in a comparison of waste behaviour of the household sizes between the two centres and Tokomaru. Tokomaru has a much lower recycling rate and much higher composting and landfilling rate for all the groups than do Palmerston North and Levin, [Appendices 6, 7 and 13]. The explanations used above apply here as well.

The volume of waste produced per person per week in Tokomaru is very difficult to estimate. A large number of households stated that they neither put waste out for collection nor use a landfill (12%). The presumption made is that these households have access to waste disposal at their place of employment, for example at Linton Camp or on a farm and misunderstood the survey as referring to official dumping only. The influence of dumping on the measure of waste recorded is large: Residents that use the landfill record an average of 0.03 bags per person per week. Residents that do not use the landfill record an average of

0.3 bags per week per person. The probable conclusion to this is that the 0.3 bags is representative of the waste produced per person per week for the non-tipping component of the Tokomaru population. This is lower than the average bags per person per week for either Palmerston North and Levin (0.5 and 0.4 respectively). The explanation for this may be the large incidence of composting in Tokomaru. Conversely, the 0.03 bags per person per week for the tip-using component of the population may only be an indication that other waste is deposited privately.

6.6 Past and Present Costs of the System.

Several systems were evaluated for the Council in terms of costs and benefits for Council or for ratepayers, and was then summarised in a ratepayers' cost-benefit table. Rates are transfer payments paid by ratepayers to Council for services provided. Thus they are real costs against the ratepayers, but have been calculated on the benefit side of the Council as well in order to establish whether the system is paid for by the rates collected in the area where the systems under consideration are operating.

The hidden costs of environmental and social impacts are more difficult to quantify. These have been listed, and suggestions for methods of quantification of their impact made where possible.

The landfills and general expenses pertaining to rubbish, including expenses for the collections over and above that gathered through the sale of bags, and rate-revenue of $11 per household, are paid for by a blanket fee of $30.00 per ratepayer 'hidden' in the general rates [HDC, 1993-94].

SYSTEM 1: Keeping the landfill open and weekly collection.

Table 6.4: The cost/benefit analysis for the old and upgraded operations of Tokomaru landfill.

Old Operation Cost/Benefits	COST	BENEFIT	1993/94 loss
Council Estimate	$12,240.00	$5140.33	-$7099.67
RoydsGarden [Compounded present cost] [78]	$ 6050.00	$5140.33	-$ 909.67
Upgraded Operation Cost/Benefits			
Council estimate	$36,720.00	$5140.33	-$31,579.67
RoydsGarden [Compounded present cost]	$18,150.00	$5140.33	-$13,009.67

Table 6.5: The cost/benefit analysis for the Tokomaru bag collection, [Appendix 13].

	COST	BENEFIT	1993/94 loss
Council estimate	$3800.00	$3279.00	-$521.00
RoydsGarden	$5687.00	$3279.00	-$2408.00

DISCUSSION: Appendix 13 provides estimated cost of operation of the Tokomaru landfill. There is an apparent discrepancy between the values quoted by Council and those used by RoydsGarden. The values do provide valuable minimum and maximum estimates for the extra year the landfill could have remained in operation. It is clear that the landfill would have had to be heavily subsidised by the rest of the district for all values except the absolute minimum.

The bag collection also has to be subsidised by the rest of the district even when not considering the cost of the landfill. This value is difficult to incorporate except

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[78] The RoydsGarden values were obtained from Council the previous year, whereas the Council estimate is on this years dollar value. To avoid any discrepancy caused by this, the RoydsGarden estimate is presented as a compounded present cost.

as an estimate. Landfill costs have been estimated anywhere between $6.00 per tonne to $100 per tonne depending on location [CBEC, 1993]. As the bags are not weighed but can be presumed, based on the Palmerston North and Levin survey, to average out at approximately 6kg each [Chapter 3, Appendices 6 and 7] and as a total of 7952 bags per year[79] are collected from the area then 5.5 tonnes of household rubbish from Tokomaru has to be accommodated in a landfill. At the price quoted for old landfills in [CBEC, 1993] at $10.00/tonne[80], this would add $55.00 to the cost above, which would amount to no more than approximately 10% of the total collection cost, using the council estimate.

The original analysis of the Tokomaru landfill as undertaken by RoydsGarden was done under the Department of Health brief [RoydsGarden, 1992]. This meant that the original perspective was that of the community health impact of operating an unmanaged landfill. With the publication of the Resource Management Act 1991, this perspective broadened to include the environmental impact as well. Council's original justification for closing the landfill was that it had reached the end of its life and that it did not comply with the Department of Health regulations. Although the state of the landfill was such that its continued operation in its original state could not be justified under the RMA 1991 as the local body amalgamation and the new act were still so new and affected so many different areas of policy making that old permits as at 1992 were being allowed to

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[79] Based on the number of bags sold.

[80] This is supported by the estimated costs for the Tokomaru landfill. Although all collected rubbish at the time of the survey went to the Shannon landfill, the volume of waste deposited at the Tokomaru landfill was 1300 tonnes/year. At the old cost of operating the Tokomaru landfill this works out at approximately $10.00 per tonne. At the upgraded cost it would have cost almost $30.00 per tonne.

roll over. Thus operation under the new regime could have been possible for another year. Without upgrading it would have cost the Horowhenua District ratepayers between $1000 and $7000 [Table 6.4] to keep the Tokomaru landfill open for another year. Although the main reason cited for closure by the Council was that the landfill was full, it was conceded that it may have been possible to extend the life for another year. The impact on the neighbours of the landfill from the factors mentioned in the introduction to this case study would have continued, and perhaps increased, as tipping fees in Palmerston North [Chapter 3] started to take effect, encouraging residents from Palmerston North to dump in Tokomaru[81].

As well as the nuisance value of tip-users dumping materials indiscriminately on the access road to the tip-face and on the road verge outside the landfill when the gate was locked, giving rise to the aesthetically offensive problem of litter, the health of residents close to the Tokomaru landfill may also have been affected. Health hazards occurred from frequent rat-plagues [HDC, 1993], for which the Council provided poison when it was asked, from the smoke of frequent fires, from insect carried contaminants and from hazardous wastes dumped without supervision and control. Their livelihood may also have been adversely affected by windblown plastic getting on to the paddocks and being eaten by cattle. All of these reasons were cited in the supportive submissions lodged at the Council meeting to discuss the landfill closure [HDC, 1992]. General environmental

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[81] After the landfill's closure, several loads of refuse were deposited outside the landfill illegally. Investigations tracked down the offenders. They were found to be from Palmerston North [Scott, 1993].

considerations were not raised by the public, but became the Council's main arguments for closure as the RMA became better understood. The landfill was originally located in a gully, and groundwater contamination was thought to be highly likely but never proven. The atmospheric contamination from smoke was not an issue at the time, as the Manawatu Wanganui Regional Council's Policy statements on air quality were not formulated until 1994.

The extension of the landfill's operations for another year thus could not easily be justified from economic, environmental or health reasons. The loss of a social service struck deep in a population that had had free access to a very conveniently placed landfill. The Council bought quiescence from the Tokomaru population by promising the replacement of the lost service with a monthly skip-bin service for the area. The outcome of that exercise suggests that it may have been preferable to operate the landfill under the old regime for another year while investigating other alternatives fully.

SYSTEM 2: Providing monthly skip-bins and a weekly bag collection.

Table 6.6: The cost/benefit analysis for a monthly bin service and a weekly bag collection.

	COSTS	BENEFITS	1993/94 loss
Council estimate (skips)	$6580.00		
Clean-up	$1224.00		
Council estimate [collection]	$3800.00		
Bag sale		$1970.00	
Levy		$1309.00	
General rates		$5140.33	
TOTALS	**$11,604.00**	**$8419.33**	**-$3185.00**

DISCUSSION: The cost of operating this service falls between the RoydsGarden and the Council estimates for the unmanaged operation of the Tokomaru landfill. This service would also have had to be subsidised by the general district if the system had persisted.

The clean-up cost was very high because of the unexpected high volume of waste arriving at the bins. This required the delivery of several bins during a weekend and a considerable effort to clean the site afterwards. The bins were placed at the top of Tokomaru Road with access from four different directions. By observation of residents in the vicinity, most of the waste seemed to arrive via a steady stream of cars from the north side of the village. As Tokomaru is situated on the Horowhenua District's northern boundary this would suggest that much of the waste was delivered from the Palmerston North city area. This was probably caused by the public notice advertising the presence of the bin placed in all the local papers prior to each 'bin weekend' and the public's perception of a 'free'

dumping facility, even where this involved driving for considerable distances. The energy costs to the individual did not appear to be large enough to offset the social need for 'free' dumping. The environmental impact of such energy consumption is a concern on the national level, and may respond to measures set out in the Environmental Strategy 2010 [MfE(b), 1994]. At the local level the increased waste volume arriving across the District boundaries added expense and nuisance to the Horowhenua District council and Tokomaru residents. The residents along the main route to the bins complained of litter dropped along the road, smells and flies from the waste dropped in the bins and speeding cars and noise from the increased traffic volume. The bins were never present long enough to attract rats and other vermin. The immediate main health hazard probably arose from insect contamination.

SYSTEM 3: A fortnightly MGB collection system combined with a recycling system.

MGB Bins were provided by the contractor for the trial. The trial initially ran at one collection per fortnight for 8 collections. This equates to $706/collection, thus 26 collections would cost $18,356.00.

The trial was then extended for another 6 months within the approved budget. This gave another 12 collections for the same price i.e. $282.38 per collection.

The recycling system was run by EVO, a private firm. Benefits accruing to this system went to them. However the Horowhenua District Council opted to provide the system, emptying it and transporting the materials to Levin. Costs

were estimated as 4 man-hours per month, a truck and transport to Levin[82]. At the recycling rates achieved by other areas at 1% to 25 % [PCE, 1993] the savings to Council from 'avoided costs' of landfilling arising from the recycling[83] will vary from $0.55 to $41.25 total, depending on whether the old cost or the new cost for landfill operations are used. In either case the added benefit is negligible. The refuse levy is presumed to be levied over the new area participating giving a total revenue of $1782.00.

Table 6.7: The cost/benefit analysis of a fortnightly MGB service combined with a recycling centre.

	COSTS	BENEFITS	1993/94 loss
Recycling system. [Capital cost]	$ 2700.00		
Recycling system. [Running costs]	$ 2118.00		
MGBs	$ 7341.88		
General rates		$ 5140.33	
Levy		$ 1782.00	
TOTAL	**$12,159.88**	**$ 6922.33**	**-$5237.55**

DISCUSSION: When the calculations are done using the expanded trial expenses, the cost discrepancy is not as high as it is with the initial trial. The Council suggested a rate increase of $50.00 to cover the difference between the cost and the money already levied from the community [HDC, 1993]. This would bring in

[82] 12{4[20]} + 12{4[16]} + 12{0.5[65]} = $1158.00. Where 12=number of trips per year, 4=hours per trip, 20=hourly manning expenses, 16=hourly vehicle expenses, 0.5=petrol costs per km, 65=distance [Yorke, 1992].

[83] Worked as a percentage of the number of bags produced in Tokomaru and the maximum volume each of the official bags can hold [Appendices 7 and 13].

a total new levy of $8,100.00[84]. This amount more than covers the new estimated costs but not the previous one. Hence the need for levying and the profitability of the system depends on the ability of the contractor to keep the price down.

A possible cost to the district, which a local body may have to consider, would be a monopoly arising from the loss of the local contractors if an outside firm is favoured by a council contract to provide a system outcompeting the private contractors. An environmental advantage of the MGBs could be that they provide enough volume for householders that usually visit the landfills regularly with gardening and household waste. If these families instead use the collection service, traffic on the road and at the landfill is reduced, saving energy, wear and tear on cars and roads and making management of the landfill easier. Where householders have not developed good waste management skills, or on commercial premises where a great number of individuals use them, the bins have great environmental and health advantages. The design of the bins make them easy to handle and not prone to animal and wind damage or accidental spillages. Thus littering, smells and insect breeding are reduced where the bins are in common use

A possible adverse effect of the MGBs is an increase in waste volumes as the householder uses the convenience of the wheelybins rather than sorting waste for alternative waste management strategies [Waste Minimisation Network, 1993]. The possible introduction of a higher flat rate would also appear to discourage

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[84] 162 x $50.00 = $8100.00

waste minimisation behaviour as present day small waste producers will be charged as much as large waste producers. This would appear to penalise the behaviour preferred by the council and encourage 'consumption' of the landfill space. In a district or a where suitable landfill space is becoming premium, either or both of these effects counteract the goals set by the RMA 1991, and by councillors attempting to operate a least cost/biggest benefit program for their district/city.

SYSTEM 4: Private contractors combined with a recycling system.

The collection will cost the council nothing as the individual ratepayers contract privately for their own solid waste.

Table 6.8: The cost/benefit analysis of using private contractors for waste collection in Tokomaru.

	COST	BENEFIT	1993/94 profit
Recycling system	$4818.00		
General rates		$5140.33	
TOTALS	**$4818.00**	**$5140.33**	**+$ 322.33**

DISCUSSION: The analysis for 1993/94 for this system includes the capital cost for the recycling system, which in the case of the Tokomaru bin is a once only expense. The following years will only have the running expenses and thus a larger profit for Council. The special waste levy has been dropped for this proposal. The general rates cover the expense of the recycling system.

The advantage of using private contractors is that the waste production is open to market forces. The largest producers pay the most. Market forces can also give

the wrong signals, particularly if monopolies exist [Meister, 1993]. This problem could become a factor in system 3, where Council may buy a service from a particular contractor, giving an operational advantage to one to the detriment of other contractors. Other market imperfections occurring at the time of the survey and this report was free access to the Shannon and Hokio Beach landfills. These costs are subsidised by the ratepayers. This is not considered to be influencing the cost of Tokomaru resident's waste collection contracts, as the geographic position of the village gives Palmerston North contractors the economic advantage when tendering that is, the cost of depositing at the Awapuni landfill is offset by the energy savings in reduced distances. This offers a great advantage to the Horowhenua District Council: Waste is taken to the Awapuni landfill and saves space in the Hokio Beach landfill. Levin contractors can offer the same service to residents closer to the Hokio Beach landfill and future transfer stations. The pricing structure will not reflect the true cost of waste disposal until landfill charges have been finalised.

This system offers the advantage of System 3 while removing some of the disincentives to waste minimisation behaviour. As the system is open to market forces, waste producers receive economic signals related to their consumption of the service. This allows them to make adjustments according to the cost they are willing to bear. The system offers alternative solutions in the form of a recycling bin which is 'free' to the user. This in effect is a subsidisation of preferred behaviour. The disadvantage of such subsidisation is that it gives a 'feel good' signal for alternative waste behaviour that may not be true waste minimisation behaviour. In effect, the public changes its behaviour with regard to what

happens to the waste, but there is no real incentive to purchase with waste minimisation in mind.

SYSTEM 5: Bag-collection, Recycling System and twice yearly kerbside collection of large waste.

When bags are considered, the effect of recycling on waste volume becomes directly noticeable [Appendix 13].

Table 6.9: Cost/benefit analysis of a bag-collection, recycling system and twice yearly kerbside collection.

	COST	BENEFIT	1993/94 profit
Collection	$3,800.00		
Recycling	$4,818.00		
Kerbside[2xyrly]	$1,360.00		
General rates		$5,140.33	
Levy		$1,782.00	
Bags		$2,475.00	
TOTALS	**$9,978.00**	**$9,397.33**	**-$580.67**

DISCUSSION: If the capital cost of the recycling system is excluded the system returns a profit to Council of $2,119.33 per year. The flat rate of $11, although smaller, has the same disadvantages as the larger flat rate discussed under System 4. Although this system has the advantages of providing a service for larger waste and thus reducing the need for private visits to landfills, that is reducing management problems and energy consumption, the system is paid for by the ratepayers in what amounts to hidden subsidies. This provides no feedback on the real cost of individual waste behaviour to the householder. This is a disadvantage to waste managers that intend to send clear signals about the cost of producing waste and will not encourage waste minimisation behaviour. This in turn can result in escalating waste management costs which will siphon

more and more of the general rates into the waste management field. This will reduce the amount of money available to provide other services in the district. The lack of appropriate economic signals may necessitate legislative tenets, which are likely to be inefficient[85] in scope and will be expensive and difficult to police. The existing markets, in spite of some of the problems with the present pricing structures, give clearer signals about management and environmental costs to the waste producers (consumers of landfill space) and thus offers the greatest opportunity for the consumers to make the choices ia consider appropriate [Young, 1985].

Table 6.10: Summary table of cost/benefits to Council of the five systems discussed.[86]

SYST	GENERAL RATES	LEVY	BAG SALE	INCOME [A]	COST [B]	A - B
1	5,140.33	1,309.00	1,970.00	8,419.33[87]	32,100.67[88]	-23,681.34
2	5,140.33	1,309.00	1,970.00	8,419.33	1,1604.00	-3,185.67
3	5,140.33	1,782.00	-	6,922.33	9,729.00[89]	-2,806.67
4	5,140.33	-	-	5,140.33	2,388.00	+2,752.33
5	5,140.33	1,782.00	2,475.00	9,397.33	7,548.00	+1,849.33

[85] The marginal benefits will not equal the marginal costs [Tietenberg, 1992].

[86] The actual expense of the system to the ratepayer is represented by PROFIT [A] plus the expense of personal transport to and from the landfills. This is the value the householder is presumed to be willing to pay for a waste care system. [See appendix 13 for summary tables and graphs of householders preferences and present waste disposal expenses.]

[87] Profit [A] for all systems, is the summation of all rubbish related revenue received by Council from Tokomaru.

[88] Council upgraded cost for landfill + council bag cost estimation.

[89] Cost for system 3,4 and 5, includes capital costs of recycling systems , spread over ten years, a reasonable life expectancy of the system.

DISCUSSION: Although systems 1,2 and 3 were favoured by the public at the time, because of familiarity and/or convenience, they would cost the Council more than was received in revenue from Tokomaru. This suggests subsidies from the rest of the district or increased levies on Tokomaru.

Systems 4 and 5 cost the council less than that collected from Tokomaru ratepayers and represent an overall saving for the council.

When information from Appendix 13 is considered, it is clear that there is an anomaly between services wanted, the perceived costs and the actual expenses of the services. As the cost of dumping is 'hidden' in the general rates, the consumer fails to see the real cost and oversubscribes to the services.

This may explain a waste survey based on traffic at existing disposal sites in the Horowhenua District carried out in January 1991 which shows very high waste quantities by national standards [RoydsGarden, 1992]. This is in direct contrast to the finding that those inhabitants that do not use the landfill, produce less waste than do the Palmerston North and Levin residents. The results of a survey done by Council at the end of the first trial period of the MGB [HDC, 1994] show a strong support for the new system, probably reflecting the convenience and attractive appearance of the bins, but reluctance to have the rates increased to pay for the system.

The avoided costs due to the recycling system set up is minimal in the overall cost/benefit calculations. This recycling system could include a composting component. The 'clean green' waste account for as much as 25% of the total waste going into the landfill (325 tonnes),[Hale, 1995]. At the old cost this would give

$3250 in avoided costs. At the new cost the price is $9750. If green waste is collected, it is reasonable to expect this volume for processing. This gives a boundary for the maximum cost that can be incurred to install a system to deal with green waste from Tokomaru. If, however, the Council opts for encouraging home composting, an initial reduction of 20% of the green volumes may be all that can be expected. This gives a saving of approximately $500 for waste coming from Tokomaru.

It is apparent that waste should impose a direct economic cost on the individual and, in the case of externalities (effects on the environment and the wider community), that the true cost is brought home to the generator. Some people see a landfill as a positive externality, full of exciting scavenging potential, but it also presents a classical NIMBY[90] problem.

Waste treatment is, on the whole, not a public good, that is, it should be open to market forces. The markets should be allowed to operate without interference such as those presently operating within the Kapiti - Horowhenua Districts and PNCC. Horowhenua District has no landfill charges in place, and contractors on the northern and southern borders of the other districts have been able to use these 'free' landfills, giving them an economic edge over other contractors less conveniently placed. With 'hidden' expenses the consumer is not free to make the correct choices. The externalities imposed by operating waste systems are now required by the RMA 1991 to be measured and minimised, imposing economic

[90] Not in My Back Yard!

costs unheard of in the past, and requiring inspired and lateral thinking with respect to waste disposal in the future.

As mentioned in the previous chapter, in contrast to overseas countries (Denmark, USA and Germany), the New Zealand government has not yet progressed to formulating legislation to specify waste minimisation goals. In the absence of waste minimisation legislation, such as decreeing recycled content for manufactured products and prohibiting landfilling of some materials, the pricing structure for materials sold could reflect the cost of disposal of that material. This has been done by deposits and advance fees overseas [Regional Roundup(a), 1993]. Although these policies have their own problems, the absence of reflection of disposal costs in the price of purchased goods moves the cost from the user on to ratepayers at local levels. In effect this amounts to a general subsidy on all consumption, the more disposable the object, the greater the subsidy.

In the absence of Central Government policies to encourage waste reduction, local bodies are left with few options to implement waste minimisation policies. These may include:

- Imposing realistic user charges for visits to landfills/transfer stations with unsorted waste.
- Extending rate relief for ratepayers taking responsibility for their own waste either as
  - * a sliding scale for rates depending on weight and volume of waste produced and policed by contractor as part of the contract.
  - * a tiered system where the ratepayer purchases the service required at the beginning of the year and is issued with 'stickers' indicating the service purchased, for example none, small, medium or large bin service.

* rate reductions for 'composters'. This can be administered along the same lines as the dog registration fee.

- Moral persuasion, in the form of education to follow the 5 Rs, and do the 'right' thing. While education and public information is extremely important at the start of a new program, and is required to maintain high levels of citizen commitment, it has no built-in mechanism to achieve an efficient balance between the level of waste minimisation and the marginal benefits derived from it.

The absence of a reflective pricing structure is likely to render all the solutions above inefficient. The consumer receives no signals that directly relates the cost of ia waste with the purchases made. Using market forces to price the cost of waste volumes gives clearer signals than the old systems depending on subsidies and other hidden costs. These signals are more likely to result in altered waste behaviour, which reduce the private costs, rather than in true waste minimisation behaviour, which will be reflected in reduced purchases. The exception to this is composting, which is a true waste minimisation behaviour [Chapter 7].

6.7 Follow-up.

As from July 1, 1994 the HDC introduced its new solid waste collection policy [Boyle, 1994; HDC, 1994]. The new system covers the full cost of the collection system, while allowing some feed-back for waste volume reduction at source. Key aspects of the new policy are:

- Official bag prices fully reflect the cost of disposal: A half sized bag costs 65 cents, a full sized bag costs 85 cents and a garden waste bag costs $3.00, GST inclusive.
- Only official bags are collected.
- The uniform annual refuse charge levied in the rates was dropped. A comparison of costs shows that those using half sized bags pay $33.80 per

year, while those using the large bag pays $44.2 per year. There is no limit on the bags that can be put out.

- A private contractor continues to operate an wheelie bin system at a cost of $30 every second month ($180 per year), collected fortnightly, for householders in the district who wish to use it.

The MGB system appears to be very popular, particularly with the young family group. This was the group found in the survey to be most likely to use the landfill, that is 40% of the MGB users are from the YF group. This group constitutes 31% of the general Tokomaru population [Table 6.1]. It is presumed that the MGBs replace visits to landfill, although this can not be proven without further surveying. The prices of these bins for Tokomaru residents reflect the cost of landfilling at Awapuni. Other charges in the district are set to increase as landfilling charges are about to be introduced.

Kerbside recycling was introduced district wide, with co-collection of specified materials collected weekly with the general waste. The collection costs are borne by Council, who has to set 'avoided costs' against this expense. All marketing and profits from sale of materials go to EVO.

6.8 Conclusion.

In relation to the three perspectives considered in this chapter the following points arise:

1. A minority produces the majority of the waste [appendix 13]. If Council removes all information barriers between the 'waste consumer' and the 'market' the true cost of waste management can be carried by the consumer, avoiding cross subsidisations.

2. People need an incentive to reduce waste volumes. Waste reduction can apparently be achieved by providing financial incentives such as direct costs, rate or levy rebates. This may encourage 'home-processing', recycling and buyer awareness. Not all of these are waste minimisation behaviour.

3. The national implementation of policies using economic tools, for example, getting the price of raw materials, such as petrochemical products, to reflect the real cost of its impact on the environment, may ease the local burden of solid waste management and increase marketability of recycled materials [Nordic Council of Ministers, 1991].

4. Councils that attempt to minimise waste problems (externalities) by decree and rate subsidies and by introducing greater bin sizes may contribute to the problem by seeking a physical solution to what is basically an economic one [MacMillan, 1993, Waste Minimisation Network, 1993].

5. In spite of not being actively encouraged by the council [Chapter 7], composting behaviour are high in the Horowhenua District. This represents a potential for increased waste minimisation in the district which could be encouraged by Council policies.

CHAPTER 7

THE COMPOSTING OPTION

7.1 The Case for Composting.

7.1.1 Entropy in Biological Systems.

Organic waste is a result of living systems and their constant exchange of metabolic materials, resulting in a "dynamic steady-state" condition where the rate of formation of a component is balanced by the rate of conversion to another component [Haug, 1980]. Two considerations arise from this: The first is that "steady-state" conditions reached are characterised by the achievement of the minimum rate of entropy production for a given substrate use rate [Haug, 1980], that is, irreversible thermodynamics caused by the flow of energy through the system and its conversion from high grade energy to low grade heat in the progress from chemo, or photosynthesis to respiration. The second is that biological systems maintain closed[91] materials cycles, where high entropy molecules enter the cycle and become low entropy molecules during one of the synthesis processes. Thus photosynthetic cells have the ability to lower the entropy of the environment by forming glucose from CO_2 and H_2O.

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[91] Although systems studied within a limited framework will have some 'leakage' of materials, the global effect, ignoring the escape of hydrogen from the atmosphere and the addition of materials via meteors, is mostly that of a closed system.

The characteristics of all living cells is that they represent low entropy units using enzyme catalysed chemical reactions to maintain their organised state while increasing the entropy of the surrounding environment. This is illustrated by the simple uptake of and conversion of a glucose molecule and its subsequent breakdown and release as CO_2 and H_2O molecules as a result of aerobic respiration. Microbiological cells such as fungi and bacteria are particularly adapted to exploit available sources of free chemical energy [Haug, 1993]. It is these types of cells combined with the chemo, and photosynthetic cells that maintain the homeostatic cycle of the biosphere.

7.1.2 History of Composting.

Composting is, in its broadest definition, the biological reduction of organic wastes to humus by the action of micro organisms. Thus compost and composting are, like water and air, essential to life and span the entire course of life on earth [Minnich and Hunt, 1979]. The more common definition of composting requires man's participation in the process and can be classified as a form of waste stabilisation[92]. Composting is usually applied to solid and semi solid materials making composting unique among the biological stabilisation processes used in sanitary and biological engineering [Haug, 1993]. Composting is an old technology [Rynk, 1992]. It has been used as land fertility enhancers in Asia for over 4000 years [CSIRO, 1978]. The oldest existing references to use of

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[92] One definition for man-assisted composting may be: "The biological decomposition and stabilisation of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, with a final product sufficiently stable for storage and application to land without adverse environmental effects" [Haug, 1980].

soil fertility enhancement in agriculture by use of manures is found in a set of clay tablets of the Akkadian Empire in the Mesopotamian Valley a thousand years before Moses was born [Minnich and Hunt, 1979]. Compost was known to the Romans, the Greeks and the tribes of Israel [Minnich and Hunt, 1979]. Numerous references to composting can be found in the Bible [Rynk, 1992]. Arabs of the 10th and 12th centuries expounded the virtues of it, the medieval church kept the knowledge of composting alive during the dark ages and the Renaissance literature contains numerous references to it [Minnich and Hunt, 1979]. The 18th and 19th century farmers in England and Europe used compost to maintain the fertility of their land [Rynk, 1992].

As far as can be ascertained, the old methods of composting differed little from the decomposition processes occurring naturally. It was not until the 20th century, when a British agronomist in India, Sir Albert Howard, devised the Indore Composting Process, that scientific principles were applied to composting, allowing control of the processes and ensuring a product high in nutrients, and with little adverse environmental impact [CSIRO, 1978]. This process is now most widely used in a modified form called the Bangalore method in India, Malaya, China, Ceylon, South and East Africa and Costa Rica [Minnich and Hunt, 1979]. In general Indore modifications have emphasised the use of nightsoil, sewage sludge, garbage or green matter as substitutes for manure. In 1942 J. I. Rodale pioneered the organic farming/gardening system in America, assimilating the ideas of Sir Howard and adding knowledge gained

from further experimentation [Minnich and Hunt, 1979]. In 1951, the University of California was given a grant from the State of California to investigate the feasibility of using composting methods to reclaim municipal refuse [Minnich and Hunt, 1979]. The resulting process known as 'the Berkeley Method' depends on the frequent turnings of the pile, the correct C/N ratio and the correct moisture content and can produce good compost in 14 days [Minnich and Hunt, 1979].

Commercial operations generally uses three approaches to composting: windrows, static piles or in-vessel processes. These methods involve various forms of aeration, either in static piles or combined with mixing and may be carried out outdoors or in enclosed buildings to control moisture and odour levels. Various degrees of sophistication can be applied to the windrow systems, from infrequent turnings using front-end loaders to windrow turners producing an end-product in 90 days or less. The in-vessel structures used contain either trenches or circular reactor type vessels that are filled with the organic feedstock which is turned and mixed periodically to turn it to compost. This system is best where space is limited and odour must be controlled [Haug, 1981; Hlavka, 1993].

7.1.3 Composting and the Environment.

The developments in farming methods that started in the middle of last century involving chemical fertilisers, mechanisation and large scale mono-cultures removed the emphasis from composting as a farming practice. The concerns for the environment, in terms of shrinking space available for landfills, air quality

controls, ground, and surface water contamination caused by run-offs from farmland and leachates from landfills, impoverished soils vulnerable to salination, crustation and erosion, have once again focused the attention on the production and uses of compost [Balfour, 1975; Rynk, 1992; Ettlin and Stewart, 1993;]. The cost of a degraded environment has not previously been thought to have a monetary value in cost-benefit analyses and conversely, neither have factors that improve the environment [Veeman, 1986; Pearce *et al.* 1989; Barbier, 1990; Pearce, 1990; Reeves, 1992; Gray *et al.* 1993]. Farming methods utilising composting offer several benefits not reflected through the price mechanism, such as improved soils [Vine and Bateman, 1981]. This lack of price reflection has hampered the acceptance of composting as an economically feasible proposition to reduce municipal waste going to landfills. Some of these intangibles could be made tangible by carrying out lifecycle analyses of the finished organic product [Gray *et al*, 1993]. This would incorporate chemical and energy costs of growth, harvest, manufacture and disposal of an organic item. Thus the advantage of lowering the energy budget of the item by showing how energy and nutrients can be conserved by composting and replacing artificial fertilisers[93] with the organic material can be formalised in conventional terms [Leach, 1975; Huettner, 1976; Hyman, 1979; Webb and Pearce, 1975, 1977; Mathews, 1978]. For example, resources are conserved by returning wastes in the form in which they can most efficiently be used and because the need for artificial fertilisers is reduced. Other

[93] Although most composts are too low in nutrients to be classified as fertilisers, nutrients such as nitrogen are organically bound and slowly released throughout the growing season, making them less susceptible to loss by leaching compared to soluble fertilisers [Haug, 1980].

benefits may be harder to quantify. For example, soil with an increased humus content holds heat better and forms aggregations of 'crumbs'. This increases the moisture absorption capacity [Pieters, 1927; Shewell,Cooper, 1972; Haug, 1980]. The water enters gently and stays longer in the soil. The 'crumbing' improves aeration and prevents hardpan formation. Colloidisation increases the nutrient holding capacity, neutralises soil toxins and alters the pH towards neutral [Minnich and Hunt, 1979]. Some of these factors take time to come into effect and may seem divorced from the application of the compost [Oelhaf, 1978]. Thus it is very likely that they will not be considered in the economic equation of the cost-benefit analysis of the composting process as an effective waste management tool.

7.1.4 Composting and Entropy.

The principles of thermodynamics add another dimension to the understanding of the processes and economics of composting. The application of thermodynamic laws reveal much about the limitations and expectations of composting systems [Haug, 1980]. It has been argued that the end result of man's economic activity is low energy diffuse waste which cannot be used further in its present form [Meister, 1993]. Recycling aggregates this energy into an economically reusable form by separating and combining pure fractions out of the conglomerate, reducing the need for mining and reduction of ores. Organic waste poses the opposite problem: large amounts of material that cannot easily be used in their presented form (chemically reduced), and are stabilised completely only when fully oxidised into the high entropy molecules of CO_2 and H_2O. Because of its bulk in present civilisations, organic waste cannot be allowed

to oxidise in an uncontrolled fashion, so is either processed to a more stable form in composting facilities or held in landfills, where anaerobic conditions arrests the degree of oxidation reached. Compost as a product is a compromise between the necessity for stabilisation and maintaining as low an entropy level as possible. Table 7.1 illustrates the reduction in carbon and oxygen occurring in the composting of sewage sludge. This reduction represents an increase in stability of the product and increase in the environmental entropy. The remaining carbon in the digested sludge represents a potential for entropy within the stabilised material.

Table 7.1: Comparative chemical analysis of sewage sludge before and after composting (United States) [Haug, 1980].

Constituents	Raw Sludge[a]	Digested Sludge[a]
Carbon	37.51	24.04
Hydrogen	5.54	3.98
Oxygen	22.56	12.03
Nitrogen	1.97	2.65

[a] Percent weight

Several measurements of the degree of stabilisation are used, for example: the decline of temperature at the end of batch composting, oxygen uptake and the presence of particular constituents such as nitrate, and absence of others such as ammonia and starch. The more stable compounds that remain at the end of composting are still degradable [Haug, 1980].

7.2 Alternative Organic Waste Management Methods.

The justification for composting has until now been explained in terms of the use of the end product. Organic wastes can also be disposed of by chemical and physical means, that is, by burning and landfilling. By burning, organics can be converted to alternative energy forms. This may be a valuable resource recovery method where the organics are relatively dry, the quantities are large and the energy requirements and prices are high [Haug, 1980]. Incineration increases the entropy loading of the environment. This could perhaps be defined as the ultimate in environmental pollution [Kummel, 1989]. At present there is no technique by which the economic cost of increasing the environmental entropy can be estimated. The nearest we can get to this is the consideration of carbon taxes [Barrett, 1991; MfE(b), 1994]. This tax is set by the estimated effects of "greenhouse" gases on the climate and has only indirect consequence on the question of entropy. High environmental entropy disturbs the biological "steady-state" and diminishes the materials cycles within the biosphere. Without compost (humus), plants grow less vigorously and are less able to utilise the high entropy molecules. By using biological means to stabilise organic waste the plant nutrients are conserved to the advantage of the whole ecosystem [Minnich and Hunt, 1979,].

The unused energy bonded in complex molecules, contained in this type of waste, can be utilised by microorganisms in the composting process releasing a large amount of heat, which can be used to generate electricity [Thostrup, 1984], or, where the quantities are too small to make this practical, just be allowed to disperse into the atmosphere. In anaerobic composting one of the end products is

methane, which can be used in the alternative fuel industry, as well as carbon dioxide and numerous organic intermediates which can be very odiforous [Haug, 1993]. In all cases the overall product is a low-volume, stable low-energy product which can be reused at the beginning of the foodchain.

7.3 Other Justifications for Composting.

Environmental justifications may not be as important to the waste manager as the overall reduction that may occur in the waste quantities arriving at the landfills if composting becomes universally accepted [Goldstein,N., 1994]. Other waste management objectives involves the destruction of insects, insect eggs and human pathogens. This is particularly important where sewerage sludge is composted. Where the endproduct is aimed at the market, destruction of plant seeds and pathogens are also important.

From the municipal waste manager's perspective, backyard composting is the first and the easiest step to reduce waste that needs to be handled and stored. Farm-scale composting is more difficult to effect, but potentially far more beneficial to society as a whole [Minnich and Hunt, 1979]. For example the European Economic Community States produce nearly 10 times as much agricultural waste as household waste [Ferrero and L'Hermite, 1984]. Municipal composting is the most far-reaching and potentially beneficial of all [Minnich and Hunt, 1979], as it may include all household, industrial waste, sewage sludge and inner-city green waste [Haug, 1993]. An illustration of this can be seen in Table 7.2, a comparative estimate of all the organic wastes generated and

collected in the US in 1980. Although the figures are old they indicate that the potential for composting materials is large [Haug, 1993].

Table 7.2: Estimates of organic wastes generated and collected in the USA in 1980 [Haug, 1993].

Waste Type	Generated[a]	Collected[a]
Agricultural crops and food waste	355	21
Manure	180	24
Urban refuse	115	65
Logging and wood manufacture residues	50	5
Miscellaneous organic waste	45	5
Industrial waste	40	5
Municipal sewerage solids	11	2
Totals	**796**	**127**

a Units in one million metric tons per year. dry weight

7.4 The International Scene.

A dramatic shift in mindset has occurred in organisations such as the US Department of Agriculture now fully committed to land preservation and the use of compost [BioCycle(b), 1994]. Recycling programs in the United States increased 19% and composting programs nearly 22% in the years from 1988 to 1992[94] [Steuteville(c),1993]. USEPA has reported that the 1993 materials recovery via recycling and composting increased nearly 7.5 times from its 1990 level [BioCycle, 1995] and effort are made to identify and evaluate markets for composts [BioCycle(a), 1994]. The production of combined residential and commercial refuse in the US is estimated at approximately 2.0kg per day per

[94] The North Carolina Recycling Association shows an increase in material recycled from 243 789 tons (1990-91) to 473575 tons (1991-92). This consisted of: 57% organics, 26.7% paper, 7.5% metals, 6.6% glass, 1.7% plastics, 1.1% miscellaneous.

person [Haug, 1993]. Paper, wood, food and garden wastes are major components and are all suitable composting substrates. Garden waste rank behind paper as the second largest component in the USA solid waste stream [Kelly, 1993]. The same is true for many European countries [Haug, 1993]. A 1986 USEPA study reported that the USA discards of garden waste averages out at 11% of the total waste stream annually. In some states this can be as high as 40%, with seasonal peaks of over 50% [Kelly, 1993]. Roughly 70% of this waste consists of grass clippings. Leaves make up 25%, the rest is brush and miscellaneous. Grass has a large nitrogen and moisture content and easily collapses into anaerobic piles, giving odour problems and nitrous oxide emissions if commingled with other refuse at refuse to energy projects.

Initial commingled municipal solid waste composting facilities in the U.S. failed because of a high degree of contamination, odour problems and competition of the product with low cost landfills. This caused the closure of facilities in the 1950s and 60s. Municipal composting meanwhile progressed in Europe, Middle East and S.America probably because of better facility designs, higher costs of alternative management practices and specialised markets for products. This success led to a resurgence of municipal solid waste composting in the US in the beginning of the late 1980s when the relative purity of components such as leaves and grass made them very popular composting candidates [Haug, 1993].

Source separation is a growing trend and composting of organics are progressing well as profitable waste management methods for commercial operators such as dairy farmers, produce managers, nursery owners and food

processors [Kelly, 1993; Goldstein,J., 1993; BioCycle(a),.1994; Goldstein,J., 1994]. Many States in America are issuing farm composting grants, linking commercial, institutional and municipal organic streams with farm-based composters [BioCycle(a), 1994; Regional Roundup(a), 1994]. There is a rapidly increasing interest in the use of quality compost by farmers worldwide [Rynk, 1992]. The motivation for farmers to start composting can be as varied as saving landfill fees, avoiding odour problems from decomposing manures, earning landfilling fees from municipalities, saving fertiliser costs and 'going organic'.

The objective of 'sustainability' lies at the heart of organic farming, determining the acceptability of the farming practices used [Oelhaf, 1978; Lampkin, 1994]. The recent development of popular interest in the environment and the concept of sustainability has led to the development of 'ecological farming' which is not the same as 'organic farming'[95]. Ecological farming may apply some organic principles only, such as using compost [Vine and Bateman, 1981]. For most farmers economic gains form the strongest motivator for using organic methods [Vine and Bateman, 1981; Lampkin, 1993; Anderson, 1993; Bateman, 1994; Padel and Lampkin, 1994]. For example, in Tulia (USA) some farmers farming 3500acres have been able to replace almost all the nitrogen fertilisers[96] they used to purchase, with the compost made from their sideline business of composting manure, cotton gin wastes and municipal garden trimmings [BioCycle(h), 1993].

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[95] Organic farming follows rigid principles in methodology, standards and certification, legislated and voluntary, which clearly separate organic farming from other sustainable farming practices [Lampkin, 1993]. Organic farming cannot easily be embarked upon from one year to the next due to poor soil structure, chemical residues and lower initial yields [Oelhaf, 1978, Padel and Lampkin, 1993].

Some experiences show that pesticide problems decrease and crop yields and profits increase when compost is used [BioCycle(a), 1994; Goldstein,J., 1994]. A container growth nursery experimenting with added compost made from municipal trimmings found that the mix significantly reduced fungicide usage and decreased additions of fertilisers and water [Welti, 1994]. Experiments have shown that a 38% increase in the yield of tomatoes is possible when compost is used [BioCycle(d), 1993]. It appears that colonisation by beneficial microorganisms during the later stages of composting appears to be responsible for inducing disease suppression in the compostable soils [Haug, 1993]. The beneficial returns to the environment seem to be incidental to the personal economic advantage gained by the use of compost. For policy makers these positive externalities may be valuable enough to offset marginal costs [Section 2.3, Chapter 2], when the decisions on organic waste treatments are made.

7.5 New Zealand and Composting.

7.5.1 New Zealand Standards.

Although New Zealand has had a long history of involvement with communal composting [Mulcock and Johnson, 1971; DBC, 1981], many of the initiatives were abandoned because of economics and operational problems [McKerchar, 1994]. This process has again become part of the solid waste management program for many New Zealand municipalities. Of the 73 district and city councils, 13 are carrying out composting of garden wastes [Appendix 11] and 8

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[96] See footnote 93.

more are thinking about it. Growth experiments are in progress on compost outputs from the different systems [Fietje, 1995]. Although the health department in New Zealand has set statutory obligations on sewage sludge compost because of its potential for adverse effects, other compost operators in New Zealand have as yet no official standards for their finished product. Such product standards are first of all necessary to protect public and environmental health and to give a measure of commercial acceptability [Johnson *et al.* 1993; Haug, 1993; Hoitink and Keener, 1995]. Of most concern to human health are the secondary pathogens such as spore producing fungi, and the heavy metals and trace organics that may enter the food chain [Haug, 1993]. A plenary of standards for the finished product from overseas have meant that New Zealand operators use a voluntary standard related to operational standards applied to the manufacturing process. Some of these standards are vague. For example, the Biogrow standards do not define the temperature at which composting should take place [Fietje, 1995]. There are no official guidelines to ensure that conditions in the pile is such that pesticides are reduced to harmless residues. The operations have been experimental 'hit and miss' for each operation to ensure the best system for the raw material, the site and the tools. This gives no quality assurance to the end-user [Fietje, 1995].

7.5.2 USA Standards.

United States standards are generally based on health risks assessments of exposure pathways. The limits are set below the levels expected to produce an adverse effect to a reasonably exposed individual. European standards are more stringent with heavy metal limits nearer the natural background in soils. The principle behind this is an attempts to limit the change from the natural occurrence in the environment. For example the standard for some heavy metal concentrations for composts in different countries are as follows:

Table 7.3: Comparison of heavy metal concentration[a] standards for composts in Florida and New York states, Canada, England and Germany [Haug, 1993].

Element	Florida	New York	Canada	England[b]		Germany
Copper	450	1000	60	400[d]	50[e]	100
Lead	500	1000	150	250	100	150
Mercury	,	10	0.15	2	1	1

[a] mg/kg dry weight.

[b] Maximum permissible levels for use in organic farming.

[c] Voluntary standards for composts to bear the German RAL label.

[d] Manures and Fertilisers.

[e] Seed, Potting, Blocking and Mushroom Compost.

From these comparisons it is clear that standards vary considerably between countries. Those standards that are set by the concentrations in the environment can be presumed to have the least environmental impact. For example, US soil concentrations for copper and lead are 18.0 and 10.6 mg/kg dry weight respectively [Haug, 1993]. This is well above the standards set for composts. The

unrestricted use of composts containing such high concentrations could be suspected of causing a build-up of heavy metals in the environment.

7.5.3 European Standards.

To avoid future confusion and to ensure a uniform product quality for composts across all the members of the EC and the European Free Trade Association, the Technical Committee 233 of the European Committee for Normalisation is developing standards for 'soil improvers' and 'growing media' [Haug, 1993].

7.5.4 Composting and Commercial Benefits.

As yet there have been few official attempts in New Zealand to establish whether compost will increase commercial profits from farms. Most of the data that exist on this come from organic and biodynamic[97] growers. Comparison of physical, biological and chemical soil properties and economic profitability of adjacent, commercial biodynamic and conventional farms in New Zealand has shown that the biodynamic farms had better soil quality and were as financially viable on a per hectare basis as the neighbouring conventional farms [Reganold *et al.*, 1993]. This study does not measure the impact of compost alone on the soils and financial returns for a grower. Such studies have not been done in New Zealand except on an ad hoc basis supporting historical anecdotal evidence from traditional gardeners and growers [Fietje, 1995]. In New Zealand as overseas, the use of some data values, such a soil structure improvements, microbiological

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[97] The biodynamic farmer differ from the organic farmer by adding eight specific preparations, made from cow manure, silica and various plants. The organic farming principles are based on the philosophies of Sir Albert Howard, Lady Balfour *et al* in the 1930s and 40s. Bio-dynamic principles are based on the philosophies of Rudolph Steiner [Vine and Bateman, 1981, Reganold *et al*, 1993].

activity, mineral balances and increased earthworm counts have not yet been accepted as economic indicators in traditional cost-benefit analyses of farm returns.

7.6 Composting and Waste Minimisation in New Zealand

In New Zealand, domestic refuse makes up between 10% and 12% of the total municipal waste stream. It has been estimated that 40% of the domestic solid waste that enters the landfills in New Zealand is organic [Dolan, 1993]. A 1992 study of refuse composition of waste taken to transfer stations in Christchurch found that 49.7% of residential bagged refuse was organic , with 36.8% kitchen waste and 11.8% garden waste. Of other waste taken to the transfer station the percentage by weight of organic waste was 61.7%. [Blakeley,J., 1993]. For Levin and Palmerston North the percentage of organic waste in the bagged refuse is: 49% and 43% respectively [Chapter 4]. This compares with an Illinois food waste composting trial where food waste was found to comprise up to 29% of the residential waste stream and 17% of the total waste stream [Newton and Burger, 1993]. This fraction is often very wet, mixed with meat, fats and oils and cooked food remnants. An anthropological study carried out at the University of Arizona found that the average middle-income household disposes of 10% of the food brought into the home [Minnich and Hunt, 1979]. While the survey at Awapuni [Chapter 3; Appendix 10], did not divide bags into family types, nor separate non-perished and edible foods from the other organic wastes, the observation made at the time of the survey was that food was often disposed of for no obvious reason. Whole pottles of yoghurt, kilo blocks of cheese, half loaves of bread and bags of whole fruit were encountered frequently. While merely of

passing interest here, it may form the basis for another study in waste behaviour by the New Zealand consumer. This edible 'waste' represents loss of usable nutrients, energy waste as the crops are grown, processed and transported and then again as they are transported to the landfill.

In general, half of the organics entering the landfills in New Zealand from the domestic source is a relatively pure fraction consisting of green or yard waste , mostly grass clippings. All together, 'clean green' waste amounts to approximately 22 to 25% [Mckerchar, 1995] of the total waste stream. The composting process reduces the waste entering the landfill considerably by increasing the density of the material and by removing materials via the composting process in the form of carbon dioxide and water resulting in a finished product of 25% of the original volume[98]. For the household composter, most of the two components, household organics and garden waste, can be relatively easily handled as a compostable mix. For the municipal waste manager, the two organic components require different approaches and techniques. It has generally been found that to decrease the quantity of waste at source is the most enduring and cost effective method available , particularly where the landscape is green all the year around [Shuley, 1993]. This perspective may have relevance to the New Zealand situation.

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[98] With or without shredding, composting results in smaller particle sizes and increased densities. Changes in density from 30 - 60kg per cubic meter to 930 - 1100kg per cubic meter for finished compost are typical [Hlavka, 1992].

7.7 Home Composting Overseas.

Although almost half of the central composting facilities in Canada have opened within the last four years [BioCycle(h), 1993], the cheapest disposal of household organics is thought by officials in that country to be done by householders themselves [Shuley, 1993]. Regional governments in Ontario and Vancouver continue to stress the importance of home composting schemes. Ratepayers are kept informed of money saved through avoidance of not disposing of their organic waste into landfills [BioCycle(h), 1993; Regional Roundup(b), 1994]. Home composting is seen as important to Canada's waste management solution and many councils distribute subsidised compostbins. An Ontario community which has gone as far as banning collection of any "compostable waste", has distributed 200 cedar composters to households and expect to save $85,000 per year. The bylaws provide for a system of fines for offenders that put out organic waste [BioCycle(c), 1994]. In England calculations have shown that many local authorities in that country could, economically, buy a composting system for every house with a garden. This would reduce costs on vehicle and incinerator repairs and reduce the waste stream by as much as 28% [Gray, 1993].

In response to high levels of apartment dwellings, some of the municipalities in Denmark operate a dual system of biowaste collection combined with a home composting system complete with subsidised bins and/or worms [Thorstensen, 1993; Warmer(d), 1995]. In Germany home composting programs have been widely accepted as a waste reduction measure with 5.3 million tons/year currently composted. In most US states backyard composting is exempt from

regulations which apply to other compost facilities, because the potential for adverse environmental impact is thought to be minimal [Haug, 1993].

7.8 Composting Systems.

7.8.1 Introduction.

Composting systems overseas operate a combination of source reduction of organic waste by backyard mulching and composting of grass and leaves, and the use of central facilities that handle the materials that householders and contractors either cannot , or will not handle [Hlavka, 1993]. The central facilities can vary from very simple set-ups requiring very little in the way of equipment and handling, to very sophisticated operations using state-of-the-art equipment and methods. The costs and benefits of the various approaches depend on the area, need and desired product. Windrow turners are generally thought to be costeffective for volumes larger than 10,000 tons per year [Hlavka, 1993]. Such high volumes would also justify high capital investment in other specialised equipment. Thus a site serving Auckland and desiring a saleable, high quality product would require the use of a shredder, a windrow turner to give a fast turnover of high volumes and a screening system such as a trommel, to give a uniform, marketable product, sold in relatively small quantities at a time. Such a system has been established by the Living Earth Company in Auckland, marketing a series of products from mulches to highgrade compost utilising all the components of the green waste stream. On the other hand, for Levin and the rest of the Horowhenua District where space is not a problem, where relatively small quantities of compost are produced, rendering the production of a saleable

end-product uneconomic, a low tech system may be all that is necessary, using front-end loaders and low windrow turning frequencies allowing the product to mature for a longer time. The advantage of lowtech methods is that it can be decentralised and operate close to small settlements in low population density districts. Such districts may also find an economic advantage in using transportable equipment such as shredders that can travel from site to site and maybe even be leased to citizens requiring the service after tree removals or site clearance [CFAE, 1992]. In some cases, it is more efficient to reduce greenwaste volume on site than to transport low density material for several miles [Hlavka, 1993].

7.8.2 Source Separation.

Effectively used in Canada and Europe is the source separation of household waste into a wet (organics food waste, yard waste, pet droppings) and a 'dry' stream (all other non-compostable materials). In USA experiments aimed at making higher quality compost than that typically resulting from mixed municipal solid waste composting, have a handful of communities in Connecticut trying wet bag composting where food scraps and other organic materials are separated at point of generation and collected in designated box or bag [BioCycle(d), 1993]. This allows for the evaluation of collection systems and potential landfill diversion rates and determination of the quality of the finished product [Spencer, 1994; Newton and Burger, 1994].

Further valuable data are obtained from pilot and full-scale European programs for collecting source separated organics. In Germany 148 communities with a

total population of 12 million people are served by a separate biowaste[99] collection [BioCycle(h), 1993]. The Technical Rules for Household Waste, passed in Germany 1993, include a specification that sets limits of 5% organic matter for residuals delivered to the landfill site. Such regulations mandate the separation, recycling and treatment of biological wastes from the waste stream [BioCycle(b), 1993]. Results of German communities that collect and compost household organic waste materials show that in the three year period from 1988 - 1991 there was an increase of over 50% in composting projects composting organic matter and soiled paper from house and kitchen. This accounts for 2-5% of the total household waste stream [BioCycle(e), 1993]. The States in the USA tend towards official collection and composting systems. A report [Glenn, 1993], on four mandatory programs for collecting organics cited 95% or better participation, and conclude that source separation and collection of organics has the capacity to dramatically affect the current solid waste streams. When composting is combined with effective recycling, a 70% diversion can be obtained [BioCycle(d), 1993].

7.8.3 Garden Waste.

Alternative methods of disposal for garden waste have been investigated, suitable solutions depending on climate and concentration of the woody to green components of the waste, for example in Pensylvania, the Brubaker Agronomic Consulting Service Inc. investigated the feasibility of applying grass clippings

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[99] In Germany 'biowaste' refers exclusively to kitchen and yard waste collected separately from other household waste. Organic materials sifted from MSW no longer qualify [Haug, 1993].

directly to farmland as fertiliser. Well nourished surburban lawn clippings were found to have as much nutrient value as an equivalent amount of fowl manure. The grass was applied with ordinary manure spreaders. To landfill the grass would have cost US$60 per ton. Farmers got paid half that to take it. The results were so good that farmers now compete against each other to get the grass, and the cost of removal is getting as low as $5-$8 per ton and no higher than $18-$20 per ton giving considerable savings in disposal costs [Logsden, 1993]. When a San Jose composting scheme closed down temporarily due to odour and suspected health problems, farmers in the vicinity were asked to participate in an experiment involving direct land spreading of garden trimmings to avoid interruptions to the city's green collection routine. The overall results were that uncomposted mulch were excellent as anticrustation agents, increased organic materials in the soil while yields remained satisfactory [Grotse, 1994]. Other councils encourage householders to leave the grass on the lawn by subsidising mulching mowers, resulting in a 16.2% decrease in lawn trimming disposal, [Regional Roundup(b), 1993] run seminars on homecomposting to stop homeowners raking leaves and grass into drains and streams thus causing eutrophication in the local water reservoir [BioCycle(d), 1993], and run an education program as part of a "Don't Bag It" lawn care campaign. This campaign was responsible for a 28% reduction of garden trimmings collected between 1991 and 1992 in spite of above average rainfall amounts in both of those years [Owen, 1994]. The householders who choose to bag grass and leaves must do so in purchased Kraft bags that are collected together with brush and tree trimmings. The amounts collected, and the number of Kraft bags sold, have

decreased since separate collection was initiated, indicating source reductions through backyard composting and the "Don't Bag It" program [Owen, 1994].

7.9 Central Composting.

Where source separation is not thought to be effective enough, or where volumes can justify the capital investments, there are three types of separation approaches that can be used for the composting from a mixed municipal waste stream. Two systems use a high degree of front-end separation, which can be capital intensive, as it requires equipment for screening and sorting. One of these systems sorts the compostable fraction as a by-product in the production of refuse derived fuels [Warmer(a), 1994]. Modern facilities of this type shreds the MSW and allows for the recovery of both an organic and the marketable recyclable materials fraction. The other option consists of screening and materials picking, before finally grinding what is left of the waste stream for composting. The third approach used, is to shred the entire waste stream and then composting with minimal screening and materials recovery, while attempting to clean the material up after the composting process is complete. The end product contains considerable physical contamination in the form of small pieces of plastic and glass. This product is very difficult to market. None of the methods above have found favour in New Zealand, probably because the economics of large capital investment and low refuse stream makes them uneconomic options.

7.10 New Zealand Operations.

7.10.1 Councils and Home Composting.

As well as the 13 councils that run or finance green waste operations in New Zealand, one or two others use 'green fill' as landfill cover by either leaving the material in static piles to break down naturally on top of the landfill, or by infrequently turned windrows on the landfill site. For example, the Hokio Beach landfill operation, Horowhenua District Council, has turned the windrows once in two years, after they caught fire [Hale, 1995]. The end-product of these processes is of a very low quality because of the anaerobic conditions operating at the centre of the piles. All of the operations take green waste and in one instance sewage sludge (Rotorua). None of the operations deal with household organics, although several councils actively encourage backyard composting by education, for example Palmerston North, none of the Councils subsidise home composting systems. This may change as the economics are considered. For example: Palmerston North city householders have been estimated to deliver between 59 and 76 tonnes of compostable household waste (kitchen waste) to the landfill per week [Table 4.8]. The weekly delivery of garden waste via contractors and private tipping is close to 800 tonnes[100]. Although declared composters may occasionally deliver organics to the landfill, most of this waste is produced by the proportion of the city's householders who declared that they never compost. These amount to 57-60% of the total households [Appendix 6]. At

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[100] Calculated from contractors delivered volumes, householders estimated amounts of garden waste landfilled [Appendices 7 and 9], converted to cubic meters according to contractors and landfill operators estimations [Appendix 9], and converted to tonnage by using an estimated average density of 0.25 for green waste [Fietje, 1995].

$30.00 per tonne landfill operation cost, these households cost the Council $25,875 per week or $1,345,500 per year. A composting drum can be bought from a garden centre for $49.00, an anaerobic composter with a bottom drawer costs $139.00 and a tumbler costs $299.00 [Phoenix, 1995]. If Council, by subsidising any of these, increases the composting householders by, for example 20%, Council could afford to buy a drum for each of the new composting households[101]. In districts where compostable materials are transported over large distances before it reaches transfer stations and landfills, an education program aimed at informing householders of the economics of transporting compostables versus the economics of other options will most likely have a greater impact on backyard composting than more abstract messages about saving landfill space and saving Council funds. For example, a Seattle backyard composting scheme, which involves distribution of rodent proof garden waste bins is estimated to cost $88/ton, while the avoided costs are nearly $94/ton [Steuteville(c), 1994]

7.10.2 Home Composting Systems.

Thus the economic analysis of backyard composting in Canada, Germany, England and Holland [Pieters, 1987; Steuteville(c), 1994] as well as in New Zealand, suggests that this may be a viable solution to reducing the New Zealand household organics waste entering landfills, particularly in small communities,

[101] 20% of 14285 households is 2857. A drum for each of them would come to $139993 at the retail price. This is almost the same as the money saved from not landfilling the organic waste they can be expected to produce.

where the methane release from anaerobic combustion of buried organics is not large enough to justify the capital investment of a biogas energy facility, but which may still require burn-off for safety reasons. There are considerable benefits to be gained from backyard composters:

- They are cheap , compared to the large capital investment required for centralised composting systems. This needs to be offset against the potential loss in volume of greenwaste to a central facility, which may lower the efficiency of the equipment used there. This may be counteracted by the value placed on the absorption of household organics into the backyard systems and by the educative value of composting on overall waste minimisation behaviour [Fietje, 1995].
- They are efficient , in that the processing and subsequent use occurs on the site of production of the waste.
- The material produced will improve the structure of any soil it is applied to. As the planning process restricts urban developments to lower quality farmlands, and causes loss of topsoil from subdivisions and general disturbance of the soil structure by heavy machinery, many soils in built-up areas are of poor fertility. Adding compost will assist vegetation growth and help to equalise the effect from soil disturbance and tarseal cover for roading, and increase the carrying capacity of the urban environment helping to maintain air and water quality [Shewell-Cooper, 1972; Mollison, 1988; Morrow, 1993].

Most backyard composters utilise the Indore process. This builds a squarish heap up to 1.5 m tall which can be added to at the top as materials become available. The heap is first turned 8 - 10 days after it is made, and then again after 30 - 40 days. If it is not turned at all the process will take a year. The heap must be covered by a thin layer of soil or sacking as it often deteriorates into anaerobic conditions and can become odorous. This process takes little effort but it takes time. The product can be acid and with less nutrients than could be expected from the raw materials entering the heap. The more scientific approach is that of

the Berkeley process , named after the research done at the University of California, Berkeley in the 1950s. This uses an optimum Carbon:Nitrogen ratio of 25:30, calculated for combinations of different materials from tables available [CSIRO, 1978]. The size of the heap is climate and temperature dependent. In New Zealand it would be approximately 1.5 m^3 to start with. The heap is made in one go, turned after 2-4 days and then every 2-3 days until finished after 14 days. A variation on this theme is the use of the compost tumbler, which requires a relatively large capital investment for the average household, but which seemingly has the least physical input for the fastest return of all the processes. A simple anaerobic method involves putting the material into a black plastic bag and tying the neck. The bag is then left in the sun and turned periodically. By the time the fourth bag is full, the first bag is ready to use, producing an acceptable compost by anaerobic means is a very short time [Minnich and Hunt, 1979]. A number of householders in the Palmerston North and Levin survey compost their household organics by digging them in. Variations on this system has been described in various organic gardening and farming books as ways to enhance soil fertility [Minnich and Hunt, 1979]. The utilisation of worms is part of many aerobic compost systems, but vermiculture itself is an efficient method for processing organics in the backyard. This may prove particularly useful for households on small sections or households with children [Blakeley,J., 1993]. Vermiculture also appears to circumvent the problems generally associated with backyard composting [Warmer(d), 1995; Mackay, 1995].

The problems associated with backyard composters seemingly occur most frequently in closely built-up areas where mismanaged piles are most likely to be

noticed. These problems tend to be aesthetic, rather than environmental and relate to unsightly piles and odour problems. These problems can be overcome by choosing suitable bins and locations, as must be done for other activities on urban sections [Minnich and Hunt, 1979]. Environmental problems related to vermin very rarely occur , except in the most mismanaged of situations, and yet this is most often the reason cited against backyard composters [Hlavka, 1993]. Oldfashioned by-laws in parts of America initially made home composting a hazardous business during which the composting householder could be cited as a health risk and a public nuisance and be faced with expensive fines to deter such antisocial behaviour [Minnich and Hunt, 1979][102]. Composting is now becoming socially acceptable and environmentally fashionable [Steuteville(c), 1994].

7.11 Composting as Part of the Waste Management Strategy

Local bodies aiming at making home composting part of their waste management program need to consider the role this component would play in the overall management packet:

- If the quantity of greenwaste justifies the establishment of a central composting unit, the capacity of the unit must be filled before it becomes economically justifiable to encourage greenwaste composting at home[103].
- The absence of household organics from the landfill may be advantageous, in terms of saved space and build-up of methane, which must be weighted against the potential losses mentioned above.[104]

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[102] These by-laws in most cases now no longer exist.

[103] 'Living Earth' has a philosophy that differs from this. See later report this chapter.

- If the quantities of greenwaste from a particular area is so low as to either not justify transporting it to a central cite, or making investments in heavy equipment, or the capacity of the present system has been reached, then investments in backyard composting may provide an economically sound alternative for the municipality.

- If the management plan for the landfill already includes methane, anaerobic digesters for the organics may be the answer. This would require separate collection of organics , or up-front separation of MSW. Either way maximisation of organic volume has an economic advantage. Under present rules and electricity charges, a methane extraction plant is marginally self funding given volumes of methane at or greater than 800 m^3 per hour [McKerchar, 1995]. This equation will change if penalties for carbon dioxide emission are introduced and if methane releases become a safety hazard. The reduction of organics to a landfill site that is only marginal for the economics of methane will drastically shorten the economic life of the methane to energy plant [Warmer, 1995]

The choice of approach made must depend on the resource consent rights required by each operation in a particular area. Proximity to housing, ease of traffic access, surface water and groundwater conditions all play a part in the decision making process. The access to utilities become particularly important for high-tech solutions. These considerations are similar to those faced by landfill operation considerations. It may be desirable to operate both from the same site. This has an advantage in that low quality compost does not have to be transported far to be used as landfill cover, but has the disadvantage that composting operations associated with mixed waste facilities may enhance

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[104] Biogas production per ton of waste in three different countries:

COUNTRY	ORGANIC/GREEN COMPONENT (% of waste)	GAS M^3/TON
U.K.	20.6	450
China	17.5	100
Middle East	69.0	300

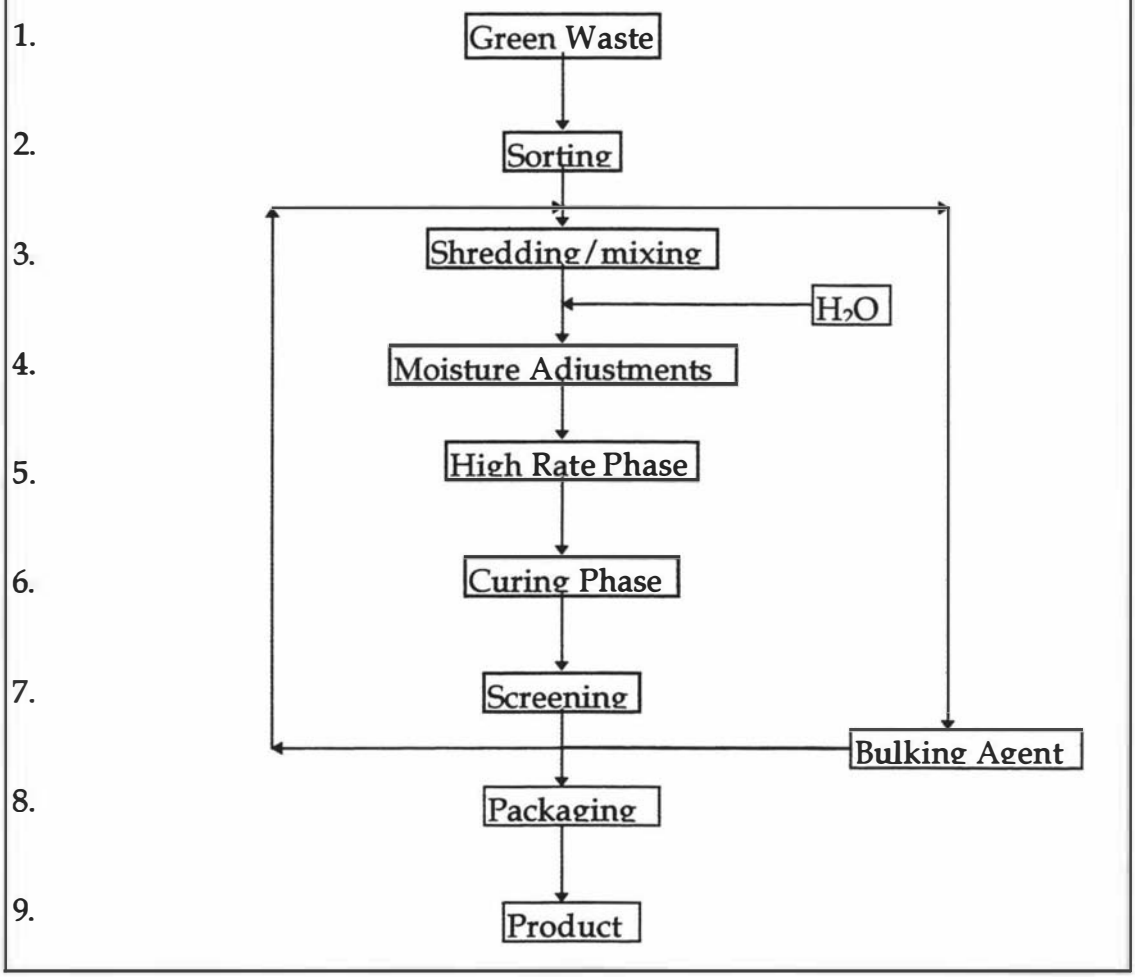
problems associated with the site such as odour and leachate, discourage proper sorting of the waste at source and associate the endproduct with landfill images, making the compost harder to market.

7.12 Commercial Green Waste Operations in New Zealand.

In New Zealand most green waste operations are windrow systems operate at the landfill sites. Windrow systems require odour and leachate controls. The composting team must turn the pile to keep it aerobic and constantly reform the pile to keep it to a size that conserves the heat that maintains the process. With frequent turning of the pile odour has not appeared to be a problem in New Zealand. To decrease leachate from the site, water can be collected and either led into the sewerage system or other treatment tanks, or it can be reused for watering the pile, thus reducing the requirement for a source of fresh water [Figure 7.1]. With source separation and collection, this flowchart also describes the process for composting household organics.

Figure 7.1

The Composting Sequence



Overseas experience shows that biodegradeable bags do not degrade as quickly as the green waste, detract from the appearance of the finished product and requires screening and return to the composting process. Debagging at the start can add considerably to the expense of the process. The desired quality of the final product determines the collection and composting method.

Of the steps 1-9 in the flow-chart [Figure 7.1], step 8 is not necessary for a high quality product sold at the gate, but may become relevant in marketing, if the plant deals in large volumes [Albrecht, 1989]. Steps 1-6 are all that are necessary for a low quality landfill cover or land recovery product. Even if only household organics are composted, the low grade product may reach the standard set by New York State class 1 compost, that is useable for foodcrops [Higgins, 1994]. Considering the emphasis on sustainability in the RMA 1991, and the high levels of heavy metals accepted in American standards [Table 7.3], this may not be an acceptable standard for the New Zealand situation [Mathews, 1994]. Experiments have shown that soil improving compost can be made from the compostable fraction of residential and commercial waste in approximately 3 months [BioCycle(d), 1993].

7.13 Composting at Work.

7.13.1 Masterton District Council.

Masterton District Council invested $200,000 on developing a site for composting. A contractor has been given a 'lease to buy' loan of $250,000 to cover the capital expenditure on equipment. This loan and interest will be paid back over 5 years at $4,788 per month. The council pays the contractor $26,300+Goods and Services Tax per month for recycling and composting. The rough estimate of green waste entering the landfill at the start of the composting scheme was 4,000 ton per year. At the Masterton District Council estimated cost per ton of

landfilled waste of $30.00 per ton[105], the avoided cost for the 4,000 ton green waste is $120,000 per year, saving the council $177,594/year. Since landfill charges, recycling and composting started the waste volumes arriving at the landfill has dropped 43% [MDC, 1995].

7.13.2 Horowhenua District Council.

HDC allowed a private contractor to set up a pilot composting operation at the Hokio Beach landfill in September 1991 [Clarks, 1991]. At that time approximately 25,000tonnes per year of waste was disposed at the landfill [RoydsGarden, 1992]. Of this 6,000tonnes was readily separable organic waste which was mostly greens waste arriving on resident's trailers. The trial accepted green waste from 12th October 1991 to 6th February 1992, amounting to approximately 2,000m^3. The material was windrowed, watered and turned weekly for the first 2 months, monthly for the next 5 months and left to mature for 3 months. The mature compost was screened, producing a finished volume of approximately 200m^3 which was marketed and sold for $5 per 500L bag or $45 per m^3 bulk. Total revenue from the compost was between $9,000 and $12,500. The avoided cost of the product at that time was $10 per tonne This gave a total savings of $20,000. The site was unsealed giving problems with sand in the

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[105] This is an artificial value which relates to the fixed cost of operating the landfill today. When this is divided by the tonnage entering the landfill, a cost per ton of waste landfilled is obtained. This value is high for small landfills with small waste volumes where the fixed operating expenses are the same as in a larger landfill. When used to calculate 'avoided costs' the value contains a paradox in that it increases with dropping tonnages of waste. Thus when this value is used, it appears that it becomes more and more expensive to operate the landfill per ton of waste, requiring larger user-charges to recoup expenses, while seemingly making it increasingly economically desirable to keep material out of landfills. Economic decisions based on this value will be inefficient. The real value that should be used is the cost per cubic meter of landfill space saved. This value is difficult to determine for old sites as new resource regulations make new landfills expensive. How expensive depends on the location. Prices cannot easily be transferred between sites.

finished product. Equipment failure was frequent and the pilot operated without proper utilities for a long time. The sale of the product paid the part time wages of a person on site [Clarks, 1991]. In spite of the success of the trial and the product, the Council voted against setting up a composting unit as it was felt that the capital investment would take too long to recoup. The present situation has seen four local landfills close, putting another 21,300 tonnes[106] of waste into the Hokio Beach landfill. This means that another 5000 to 6000 tonnes of green waste enters this landfill. At today's cost per tonne: $20 [Hale, 1995], a composting unit would save the council $240,000/year. If The Kapiti Coast District Council proceeds with plans for a composting unit in Otaki it would make greater economical sense to purchase a transportable shredder for the Horowhenua District and send the shredded material to a proposed Otaki facility, which would then gain the advantage of greater volumes for its operation.

7.13.3 Living Earth.

The 'Living Earth' composting facility is a self-funding business, arising from the local body amalgamation of 1989. The Auckland Regional and City Councils supports the company, but gives no financial support apart from free advertising in the brochures distributed by the Councils during the year. The organisation

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[106] Quantities of waste from Horowhenua District closed landfills:

Foxton	9400tonnesper year
Foxton Beach	5900tonnesper year
Shannon	4800tonnesper year
Tokomaru	1300tonnesper year

does no collection and depends on householders and contractors to deliver the raw material to the sites. No public access is allowed at landfills, so this is the only option apart from contractors for getting garden waste off site. The firm also liaises with contractors who collect and deposit garden bags from householders requiring collection service. These contractors also sell the 'Living Earth' products, which vary from mulchgrades to fine compost. The company processes 100,000m^3 (25,000tonnes) of green waste per year from the Auckland region. During the time the company has been operating contaminants like plastic bags have steadily decreased and now make up less than 1% of the product. The company runs self-funding home composting courses. Each course runs for 3 hours a week over 6 weeks. The philosophy behind this educational service is to teach the dedicated composters to do it well, while impressing others that the effort required to produce good compost is too great for them and that the company's service does it well for a reasonable price. The 'Living Earth' operation is totally paid for by the users [Fietje, 1995].

7.14 Conclusion.

The 'Compost from Municipal Waste' debate, has suffered from the dual perspectives of the debaters. Where waste managers and engineers traditionally sought the most efficient method of collecting and disposing of all municipal waste, the RMA 1991, and Agenda 21 of the Earth Summit 1993 have added other dimensions by specifying sustainability and minimisation of resource waste. This new perspective means that other aspects of the waste cycle have taken on economic significance and must be incorporated in the cost-benefit equation when considering efficient waste disposal. Other aspects, which may

seem more intangible in the traditional economic perspective, also have to be considered under the new 'sustainability of use' criteria. This has changed the perspective on organic waste from one of waste, to one of resource, and the economic justification for landfilling is no longer as clear cut as it used to be. How this municipal waste fraction is best treated, other than by landfilling, is one that must be decided by each district and city, in view of quantity, distances and population densities within a city or a district.

CHAPTER 8

FINAL DISCUSSION AND CONCLUSIONS

This thesis has attempted to analyse New Zealand's perspective on municipal solid waste by investigating in detail the domestic waste behaviour in two selected areas, namely Palmerston North City and Horowhenua District Council. Municipal waste management practices and philosophies have been surveyed and compared to practices overseas. While recognising the limitations of comparing systems from different economic, cultural and climatic conditions, some general principles regarding solid waste management have emerged. These principles can be divided into two categories, economic and environmental. Efficiency, in economic terms, has been the most important aspect of waste management in the past, but the move towards sustainability and the realisation that economics do not always account for environmental externalities, has led to recognition of a need for other methods of accounting for waste and its effects.

The results of the household surveys done in the two sample areas, show that consumers tend to respond to economic signals given by the Councils. Some of these responses may be tempered by the sociological status of the consumer. An attempt to analyse differences in response according to the income of the householder was unsuccessful. The differences were easier to explain in terms of age and family size of the household. In general householders are more likely to

use systems they perceive as "free". Thus Palmerston North householders make greater use of the collection system than their Levin counterparts, who in turn use the landfill more frequently. The exception to this appears to be a 18-25 year old 'un-attached' group in the population, which appears to behave similarly with respect to recycling in both the surveyed New Zealand centres and in a survey done in the US. This group appear to respond to signals other than those discussed here.

Although clear differences in the waste generation and handling behaviour in other groups of the populations are apparent, the behaviour of the Tokomaru population group supports the conclusion that it is the economic message, such as the perceived costs of the utility they use, that determines householders waste behaviour. Thus householders in Palmerston North perceive the bags as "free", but the landfill as expensive, because the cost of the bags is hidden in the general rates, and the landfill is a user charge. In the Horowhenua the householders pay for the bags, but the cost of the landfill is hidden in the general rates. Although the population of Tokomaru has the same age group characteristics as the Palmerston North population, their waste behaviour is similar to that of the Levin population. As they receive the same economic messages pertaining to the cost of waste disposal, it seems reasonable to conclude that these are important in determining waste behaviour. Conclusions made overseas that, for alternative waste programs to be successful, they have to be mandatory, cannot be established easily in New Zealand as all the programs studied have been based on voluntary participation.

All the surveys support the theory that different population groups respond differently to waste management messages. In all the areas surveyed, the young family group and the middle family groups use the landfill more frequently than do any of the other groups. Recycling behaviour also differ between groups. Family groups are more likely to participate in recycling. This supports overseas data, which suggest that children in the age group of 5 - 15 are particularly informed and eager participants in these programs. However, these groups also tend to visit the landfills more, which suggests that the alternative waste behaviour have not resulted in true waste minimisation behaviour. Although the Tokomaru analysis of income groups did not illustrate clearly that social groups correlate with differences with regard to recycling, the Palmerston North data show a clear difference between the Hokowhitu ward and the other three wards surveyed. Takaro ward shows a particularly low level of composting and recycling compared to the other three wards. Although overseas studies suggest that this could be related to the socioeconomic status of the wards, it could also be a reflection of proximity to the recycling centres. If, however, this difference is related to some aspect of the population group, for example, educational levels, then the Council may consider that educative material aimed at other wards may have to be designed differently to have a similar effect to that observed in Hokowhitu.

The survey of waste arriving at the landfills in the two areas shows that organics and paper are the most predominant. This suggests that recycling programs aimed at these two alone will have a large impact on the amount of waste arriving at the landfills from the domestic source at little extra cost. This is in

direct contrast to overseas studies which often conclude that it is the combination of many different materials that ensures the success of the recycling program. Materials other than paper and organics are often falsely perceived by the householders as important polluters. These include the plastics, glass and aluminium. Aluminium carries its own economic incentive for recycling. Glass is the most consistently recycled material throughout the country. This appears to be tied into the pricing structure the industry has applied to cullet, such that the cullet travelling shorter distances subsidises that from further away. The recycling of plastics may be uneconomic in that the savings associated with recovery of the material barely covers the fuel used in its collection [Steuteville, 1995]. Thus the recycling of plastic appears to fall into the 'feel-good' category, where the act of recycling gives the consumer a feeling of satisfaction which is unrelated to the price of this material which, amongst others, lack a realistic economic reflection of its true costs, in terms of the environmental impact of its eventual disposal. This means that ratepayers at the end of its lifecycle pay the cost of its disposal.

When making recycling decisions, waste managers should be aware that some materials seem to 'drive' the recycling of others. Some of these 'drivers' appear to be glass, aluminium and clothes. The last item seems to be particularly important in rural areas. Aluminium and glass are seen as financial returners, even if this is not for personal gain. In Levin paper seems to have the same effect, as it is collected by a charity. Very few householders in either of the surveyed areas recycle only one material. The savings in landfill space from recycling of these materials can vary from 1% to 25% of the potential space used. This saving can

be calculated in 'avoided costs' which is an artificial measure, but which, in the absence of lifecycle assessments, is the only economic term that can be applied to many of these materials. Such lack of monetary values of environmental services makes it difficult to establish a realistic comparison between alternative waste management systems.

The process with the highest potential for waste reduction, composting has had varied emphasis as an alternative municipal solid waste management strategy in New Zealand. Often cost-benefit considerations of compost programs fail to consider the long-term environmental benefits of the product. None of the commercial composting processors in New Zealand take household organics. The potential for contamination by hazardous materials is thought to be too great. No councils in New Zealand give financial incentives for home composting although there is some evidence that this is an economically viable solution. Because of New Zealand's low population density and large distances, waste management programs will probably be served best by a combination of municipal and home composting.

Setting up a waste management program without clear policies is fraught with difficulties and expenses. One such example is the Horowhenua District Council's move towards a new waste management strategy. Although the desirability of the final outcome in terms of environmental checks and overall compliance with the RMA was indisputable, there was no consensus between ratepayers and management on how to implement new waste management programs. The trial program run for Tokomaru illustrates the problems when the

consulting engineers are given one brief and the elected decision makers another. Neither group knew their target population or their needs. The resulting sequence of potential solutions illustrates a lesson for all the decision makers. The final solution was based on market forces and clear economic messages. To establish whether this solution also offers the most sustainable solution, environmental indicators and intergenerational equity will have to be included as part of the assessment.

Many New Zealand municipal solid waste management programs lack a clear focus. This lack of focus has a historic reason. The Health Department's Directive on landfills, the RMA 1991, the local body amalgamation in 1989 and Agenda 21, have changed the focus on solid waste management, keeping the responsibility at the local level, but providing no central mechanisms for implementing alternative methods at solving the problems. The messages given to the consumer have been confusing and distorted. Without clear messages successful waste minimisation behaviour are not occurring. This has often led to waste-'minimisation' programs, that are expensive and environmentally costly, such as curbside recycling of plastics in thinly populated suburbs [Bentham, 1992; Dolan, 1991; Harris *et al.*, 1994; Hawthorne, 1991, Young(b), 1993; Young, 1994].

This study finishes where most of the questions begin. A further study on New Zealander's response to mandatory programs need to be done to determine whether such programs would ensure that more material stays out of landfills. The importance of education programs have been surmised but never proved, and are, in many cases applied ad hoc and sporadically.

The overall conclusion from this study is that householders do modify their waste behaviour according to the economic signals they receive. Some of these signals are not forthcoming because of central government policies and some cannot easily be incorporated into the waste management equation. These include environmental externalities which have not had a traditional monetary value. Recycling activities are to a large extent subsidised by ratepayers. This subsidisation appears set to stay as long as the pricing structure for virgin materials are distorted by lack of lifecycle reflections. Without some form of subsidy, recycled materials are unlikely to be competitive and the resource loop will remain open.

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