NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY
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VHB Research & Consulting Inc.
Econometric Research Limited
Waste & Waste Management

VHB RESEARCH & CONSULTING INC.

A Methodology for Assessing the Socio-Economic Impacts of 50% Solid Waste Reduction/Diversion

Submitted to:

The National Round Table on the Environment and the Economy

Submitted by:

VHB Research & Consulting Inc.

Econometric Research Limited

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Contents

1 Introduction

1.1 Objectives

The primary goal of this study is to assist the National Round Table on the Environment and the Economy in estimating the socio-economic impacts of achieving a 50% reduction/diversion of municipal solid wastes in Canada. To this end, there are six objectives:

- to describe and explain the methodology developed by VHB and ERL and implemented for Ontario;
- to describe previous applications of the methodology;
- to enumerate the socio-economic impacts that can be predicted at reasonable costs;
- to identify information requirements;
- to demonstrate the utility of the methodology; and
- to estimate the cost and time requirements of applying the methodology to many waste streams.

The overall objective of this study is to demonstrate how the models developed for the assessment of waste reduction/diversion policy measures in Ontario may be extended to the nation as a whole.

1.1.1 Describe methodology, previous applications and demonstrate the utility of the methodology

A description of previous applications of the methodology developed by VHB and ERL serves as a demonstration and explanation of the methodology. The simple output of the model demonstrates the utility of this process for comparing the efficiency of alternative policy measures.

This study builds on VHB's experience in the socio-economic assessment of waste reduction/diversion. Of particular relevance is a study entitled *A socio-economic assessment of Ontario waste management initiatives* undertaken for the Ontario Ministry of the Environment, in which VHB, in collaboration with Econometrics Research Limited, assessed the socio-economic impacts in Ontario of a 50% waste diversion target. For this purpose, two models were developed:

- a waste management policy simulation model (which simulates the effects of up to 18 policy measures on reduction, reuse, recycling and disposal by waste type and source);

- an enhanced input-output model (which simulates the economic impact of waste diversion on consumption, investment, government expenditure and income, output, employment, labour income etc.)

The enhanced input-output model explicitly includes a waste management sector that recycles materials, alternative pulp and paper production technologies, five types of paper products that can be manufactured from different combinations of virgin and recycled materials and up to 20 other categories of waste materials.

Together these two models provide an extremely powerful and versatile tool for assessing the socio-economic impacts of waste reduction/diversion.

Using these two models, the implications of four policy scenarios were assessed:

1. Regulatory (all measures directly regulate behaviour);

2. Economic (all measures induce behaviour through financial incentives);

3. Combined (made up of economic and regulatory measures); and

4. The Ontario Waste Reduction Action Plan (The Ontario Ministry of the Environments plan for waste reduction, February 1991).

The Waste Management Policy Model's output yields the percentage of waste diverted and the increase in the total cost of waste management necessary to achieve that diversion. This output makes comparison of alternate policy scenarios easy.

The results from this model, in terms of diverted and reduced waste flows the flows of recycled materials are input to the second model of economic impacts.

1.1.2 Estimate the socio-economic impacts

As part of VHB and ERL's previous work for the Ontario Ministry of Environment, policy scenarios were modelled to assess their socio-economic impacts. This information is extremely valuable for a comprehensive evaluation and assessment of alternative waste reduction/diversion policies and for overall assessment of achieving reduction/diversion targets.

The list of impacts analysed includes changes in:

- gross domestic product;
- value added by sector and region;
- sales by sector, commodity and region;
- employment by sector and region;
- tax revenues by type of tax, level of government and region; and
- imports and exports by region and commodity.

A novel contribution of the economic impact model developed by VHB and ERL lies in its accounting treatment of national income. Conventional national income accounting treats pollution and waste generation in such a way that an increase in pollution causes an increase in the gross domestic product of the economy. This follows because pollution abatement and waste management costs appear as part of the final demand for goods and services of the economy. However, common sense suggests that society should not be considered richer or better off if it produces more waste, simply because it spends more to clean it up.

In *A socio-economic assessment of Ontario waste management initiatives*, a reformulation of the accounting framework is suggested that treats waste management and pollution abatement as a cost of business, rather than final demand. Even such services to households may be considered a cost of output to the extent that part of household activity may be incorporated within the business sector. In this way, waste management costs appear as a cost to society and not as final output.

This new accounting framework is supported by the theoretical framework of the input-output economic impact model. The theoretical framework allows different industries to produce the same output and identifies different commodities (technologies) as inputs in the production of the same output. Paper, for example, can be made from virgin pulp or from recycled paper.

The two inputs are distinct from one another as different technologies are used to produce them, but both technologies produce an almost indistinguishable product.

This new accounting and theoretical framework makes it possible to deal with environmental and waste management issues that are difficult or impossible to deal with within other frameworks, and to examine the socio-economic consequences of alternative strategies to reduce, reuse and recycle products and materials. Impacts are assessed using a large set of indicators which include income measures that capture the value-added generated or lost due to recycling or reduction, sales measures that capture turn-over and gross revenues of business, employment in person-years and taxes by type of tax and level of government collecting the tax. Equally important, it is possible to assess the impact in geographical terms as well as in aggregate terms. Shifting demand for paper produced from virgin pulp to that produced from recycled pulp will ultimately shift production from mills located close to trees to mills located close to consumers of paper.

1.1.3 Describe the utility of the approach

The utility of this approach is derived from several factors: accuracy of analysis, comprehensiveness, ease of use, and simplicity of output.

The combination of the Waste Management Policy Model and the enhanced input-output Economic Impact Model represents the most advanced available, in terms of level of detail and comprehensiveness of analysis. These tools make it possible to model the implications and socio-economic impacts of waste management policy measures with a reasonable degree of accuracy. At the same time, the number of policy measures, waste components, and waste management and recycling sectors covered by these models makes the output comprehensive in scope, covering all major recyclables and sectors of the economy affected by the 3Rs, and covering a wide range of policy measures, either proposed or currently in place.

Clear and simple, the output of the models is directly relevant to public policy on waste management.

Detailed results of the two models have been produced and will shortly be submitted to the Ontario Ministry of Environment for review. Examples drawn from these results will be included in the final report of this project.

1.1.4 Identify information requirements

It will be necessary to obtain equivalent data on waste generation and composition, reduction, reuse, recycling and disposal, and waste management costs for each province as exists for Ontario. Where such data are unavailable it will be necessary to extrapolate from the data that exist for Ontario and for other jurisdictions across Canada and in the United States.

Although the terms of reference for this project suggested merely identifying information requirements to conduct an assessment of the implications of a 50% reduction/diversion target, it was thought prudent to collect and examine the information that was available in order to ensure that it was sufficient for the purpose.

After contacting waste managers at provincial and municipal levels across the country a significant amount of data was obtained related to waste generation, composition, reduction/diversion and cost. While not exhaustive, sufficient data were obtained to estimate waste generation, composition and reduction/diversion for those jurisdictions for which no data are available with a reasonable degree of confidence. Data on unit costs of waste management and implementation costs for policy measures are less readily available in jurisdictions other than Ontario, but may still be estimated with confidence using data from Ontario.

It was found that enough data exist to extrapolate from available data with a reasonable degree of confidence for those provinces for which no data exist.

1.2 Methodology

Since the design of the models is guided by the availability of data required for implementation, the first stage of the study involved identifying what data are available and what is necessary to estimate data where they are not available.

The second stage of the study involved extending the Waste Management Policy Model from the assessment of waste diversion policy measures in Ontario to Canada as a whole.

The third stage of the study involved extending the input-output Economic Impact Model from the assessment of the economic impact of waste diversion in Ontario to Canada as a whole.

2 Waste management policy model[1]

2.1 Purpose of the model

The *Waste Policy Management Model* (WMPM) was developed by VHB Research and Consulting Inc. for the Ontario Ministry of the Environment to analyse the economic and physical impact of combinations of waste diversion measures based on:

- reduction, re-use, and recycling;
- incineration; and
- landfill.

The model currently incorporates 22 categories of waste (others can be added) and permits the user to:

- define measures for the diversion of waste by waste type from landfill and incineration;
- analyse the effects of combining different measures; and
- determine the waste quantities diverted by combining measures.

[1] This section is adapted from VHB Research and Consulting Inc. and Econometrics Research Ltd. 1991. *A socio-economic assessment of Ontario waste management initiatives*. Prepared for the Ontario Ministry of the Environment, Toronto.

The model is based on a current trend of waste generation and diversion for the years 1987, 1989, 1992 and 2000, assuming no new policy initiatives after 31 December 1990. The current trend for Ontario was developed by RIS (1991).

The following is a description of the structure, use, inputs and outputs of the model. A more detailed description of the operation of the model and output tables are found in the appendix.

2.2 Description and structure of the model

The WMPM is a menu driven program which prompts the user to enter data, analyze scenarios and the results of different waste diversion scenarios. The user defines the structure of the model and adjusts the model's parameters. The model was designed to operate using *Lotus 1-2-3 Version 2.2*.

The basic framework of the WMPM is presented in Figure 1.

The model divides waste management into six sectors:

- residential;
- industrial/commercial/institutional;
- collection for solid waste management;
- recycling;
- incineration;
- and landfill.

Solid waste from the residential sector is diverted through reduction, reuse and recycling with the balance collected for disposal at landfills or by incineration. The ICI sector is identical to the residential sector, with the addition of the potential diversion to private incineration. Waste management options for the recycling and solid waste management sectors are identical - wastes are either recycled, incinerated or landfilled. Incineration and landfill are assumed to be *inactive* sectors where the waste flow ends.[2]

The model is designed as a *once-through* system. All waste produced by the residential and ICI sectors will flow through the system until it is landfilled. Any indirect effects that may occur through reusable containers or recycled items is accounted for through the diversion

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2 The model does account for the waste that is generated from incineration (i.e. ash) or recycling activities (waste residuals) which go to landfill and residual waste generated from recycling activities which are assumed to go to landfill.

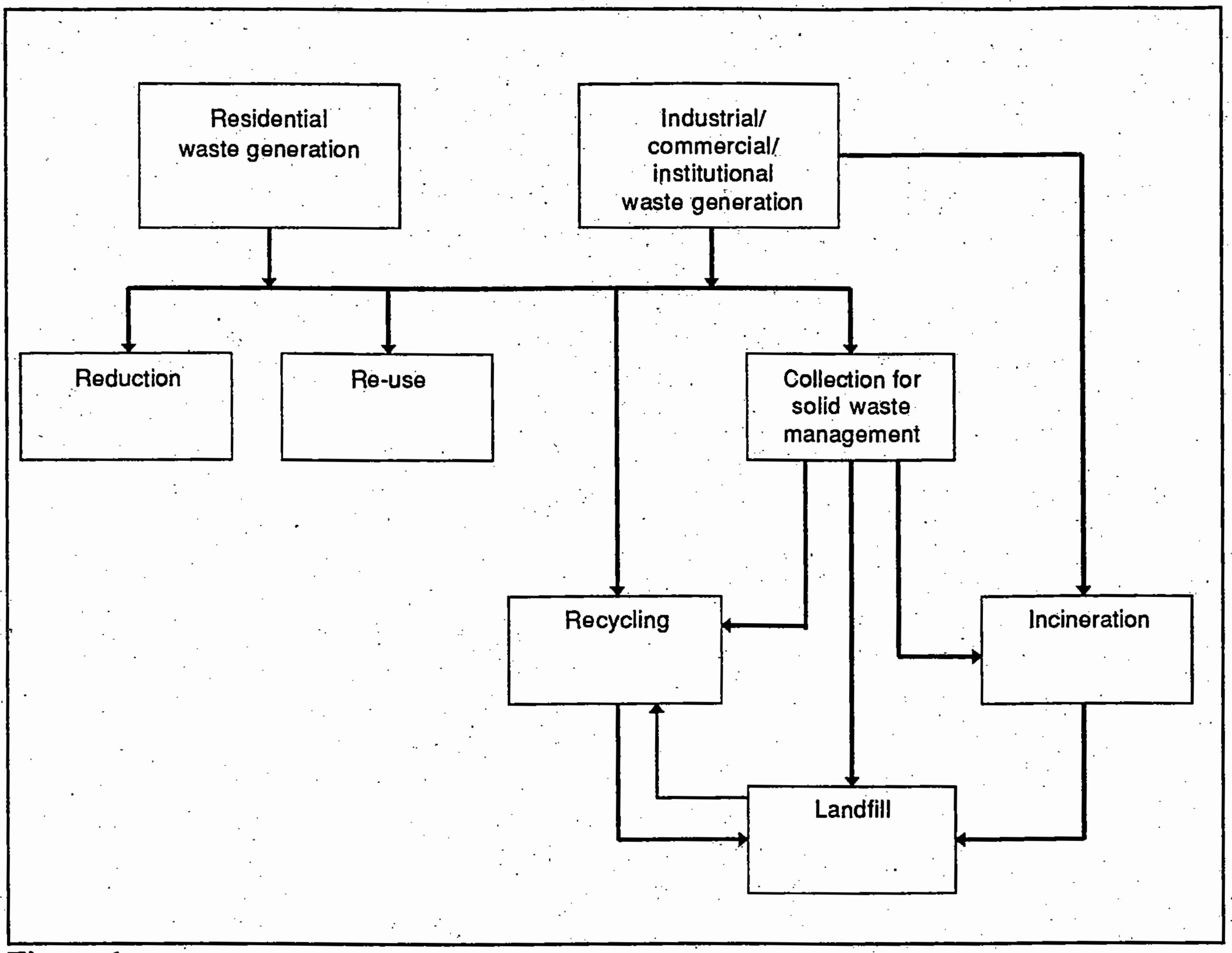

Figure 1
Schematic representation of waste management policy model

parameters which show what proportion of the waste components is reduced, reused and recycled. The model permits changes in the waste components and adjustment of the diversion parameters.

2.2.1 Measure analysis

A total of 18 waste diversion measures have been developed for analysis in the model. Others can be added to suit a user's needs. The measures and their expected action are presented in Table 1. Measures may be edited or combined. In addition, the efficiency of measures and other analytical parameters contained in the model can be changed.

For each measure, diversion parameters are assigned to each waste component in each of the active sectors (residential, ICI, recycling and landfill or incineration). Waste diversion parameters are assigned for specific measures by waste component. They express in quantitative terms the extent to which a given policy measure is expected to divert waste from

Table 2.1
Waste diversion measures and actions

Economic measures	Expected action
Deposit systems	Reuse and recycling
Increase municipal funding for 3Rs	Reuse and recycling
Landfill tipping fees	Reduction, reuse and recycling
Packaging taxes	Reduction and recycling
Subsides to producers	Reduction, reuse and recycling
Subsidised home composters	Reduction
User charges	Recycling and reduction
Virgin materials taxes	Recycling

Regulatory measures	Expected action
Changing product specifications	Reduction
Education programs	Reduction, reuse and recycling
Expanded "blue box" system	Recycling
Industrial waste audit	Reduction and recycling
Landfill bans	Reduction and recycling
Mandatory processing of solid waste	Reduction and recycling
Mandatory source separation	Recycling
Product bans	Reduction
Recycled content regulation	Recycling
Yard and organic waste collection	Reduction

landfill through each of the 3Rs. The measures are ranked by the user according to their importance. Measures can be substitutes, i.e., the one with the largest diversion parameter for any waste type dominates, or complements, i.e., a combined diversion parameter is calculated based on the degree of complementarity of the measures. Based on these designations of substitutes and complements for the measures, the model calculates a diversion parameter resulting from a combination of measures used in scenario analysis for each waste component and diversion category.

2.2.2 Federal, provincial and municipal measures

In addition to the discussion of substitution and complementarity above, modelling the impact of waste reduction measures for Canada as a whole will encompass measures implemented or proposed at different levels of government. Several provinces, and many municipalities, already have or are proposing waste reduction programs. It will be necessary to define measures to be implemented at the federal level with consideration for programs at provincial and municipal levels of jurisdiction.

Conceptually, this approach is no different from the one discussed above, where measures and scenarios of measures are assigned waste diversion parameters according to whether measures are substitutes, complement other measures, or obstruct the effectiveness of other measures. The information required to implement the Waste Management Policy Model for the country as a whole would be assembled in order to develop baseline waste stream and forecast inventories. This information could readily be incorporated into the analysis of measures to be implemented at the federal level and the subsequent development of waste diversion parameters.

2.2.3 Waste management costs

The model also calculates the costs of waste management for any policy scenario. These costs include the costs of landfill, incineration, reuse and the costs and revenues of recycling. They also include program implementation costs.

2.2.4 Waste components

The waste components analyzed by the model are defined by a list of key materials targeted for diversion from landfill and incineration. Table 2 lists the waste components used in the model.

2.3 Data requirements for the model

There are four types of data required for operation of the model:

- waste generation quantities for each waste component and for each sector;
- diversion parameters for each measure for each waste component for each sector;
- unit costs of diversion, incineration and landfill for each waste component; and

Table 2.2
Waste components included in the WMPM

- Old newspaper (ONP)
- Fine paper
- Boxboard
- Old corrugated cardboard (OCC)
- Mixed paper
- Magazines
- Telephone books
- Glass containers
- Plastics
- Composite packaging
- Aluminum
- Tinplate and steel
- White goods
- Used tires
- Yard waste
- Food waste
- Wood waste
- Construction/demolition waste
- Disposable diapers
- Foundry sands
- Asphalt
- Other waste

- implementation costs of the measures.

2.3.1 Waste generation quantities

It is necessary to estimate waste generation for the residential and the industrial/commercial/institutional sector for each waste type for each province.

2.3.2 Diversion parameters

For each of the residential, ICI, landfill, incineration and recycling sectors, diversion parameters are assigned to each waste type under the current system and for each measure. For the residential and ICI sectors, the diversion parameters define what proportion of the waste stream is reduced[3], reused or recycled; the remaining waste is assumed to be collected for landfill or incineration.

2.3.3 Total waste management costs

Unit costs

Unit costs of waste diversion and disposal are included in the model. The cost of incineration and landfill equals the sum of:

- collection cost;
- transportation cost; and
- landfill cost.

It is assumed that the costs for diversion through waste reduction are zero since these costs are typically associated with changes in production process or social behaviour. The costs of reuse are also assumed to be zero except for glass containers, where data are available regarding the cost of reuse (non-zero costs for reusing other materials can be incorporated if desired).

There is both a cost and revenue stream per tonne for recycled materials. Costs for recycled materials equals the sum of:

- collection cost;
- transportation cost;
- processing and handling cost; and
- administration cost.

Revenues are the prices secondary material re-processors offer for recyclable materials collected and sorted.

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[3] For example, through weight reduction, reduced packaging or changing product specifications.

2.3.4 Measure implementation costs

The costs of implementing various measures are calculated outside the model but included in the output. The implementation costs include the operating and, where necessary, capital costs of the measure beyond current and planned expenditures. Capital costs are annualized at a discount rate currently set at 6 per cent (VHB 1991).

Normal government costs and expenditures for administration and monitoring measures or programs undertaken by current staff are excluded from the estimation of implementation costs. The cost of implementing the measures are estimated based on the diversion potential in tonnes of each measure as calculated by the WMPM and expected measure costs provided from the literature (except for education programs and subsidized home composters whose costs are based on the number of households affected).

Seven measures require additional implementation costs:

- education;
- expanded blue box programs;
- increased funding to municipalities for reduction and recycling programs;
- subsidies to producers;
- mandatory processing of solid waste collected;
- subsidized home composters; and
- organic waste collection.

The remaining 11 measures are assumed not to require any new costs for their implementation. The cost of implementing a combination of measures is assumed to be the addition of each measure's implementation costs.

2.4 Limitations of the model

There are several limitations to the model:

- The information on which waste quantities, diversion parameters and costs and revenues are based is far from perfect. Where possible the results of empirical studies are utilized. In some instances professional judgement is required, especially with respect to some diversion parameters and measure costs.

- The model is non-optimizing. It does not estimate the most effective or efficient scenario for achieving a waste diversion objective. It may be worthwhile to incorporate an optimizing procedure into the model as an aid to optimal policy development.

- The handling of some waste types are not easily incorporated into the model. For example, scrap tires are typically stored in piles and not incinerated, landfilled or diverted.

- The operation of the model requires extensive input by the user of current trend data and the waste diversion potential of measures.

- The model provides scenario output for only two years (1992 and 2000). Results for other years must be interpolated.

- All cost data used in the model must be annualized by the user prior to use in the model.

3 Overview of available information for the Waste Management Policy Model

3.1 Waste generation data

A number of waste generation studies have been done or are under way across the country. Those most useful to this study have been completed or are under way in British Columbia, Alberta, Ontario, Quebec, New Brunswick and the Northwest Territories. Several provinces have not measured waste generation nor studied its composition. For these provinces it will be necessary to infer waste quantities and character from the best representative available data; data from other provinces, nation-wide Canadian surveys and American waste surveys. A review of these data sources follows[4]. A summary of available data by province is provided in Table 3.1 and a summary of data sources is provided in Table 3.2.

Enough data exists that it will be possible to extrapolate waste generation data for those provinces for which no data exist with a reasonable degree of confidence.

One difficulty in comparing data accumulated in different studies is that each study tends to use a different set of waste types according to each study's interest in particular waste stream components. Some studies also report waste quantities after recycling (eg. by sampling at disposal transfer stations) while some report quantities before (eg. by household sampling).

[4] Many of these reports have been obtained by VHB. Other sources can be obtained as required.

3.1.1 British Columbia

Under the terms of existing waste management legislation, British Columbia regional districts are responsible for submitting waste management plans to the BC Ministry of Environment. Only the Greater Vancouver Regional District (GVRD) has an existing waste management plan. The remaining 31 regional districts have plans underway.

On the basis of these plans, and a waste audit conducted at three landfills in BC, the Ministry of Environment is developing a province-wide database of waste generation, by sector, i.e., ICI, residential, and by management process, i.e., landfill, incineration, recovery and recycling (BC Environment 1991). This study will be completed by December 1991.

There are concerns that the landfills chosen (Maple Ridge, Fort Nelson, and a site in the Okanagan Valley) represent rural and northern communities and are not representative of urban waste in Vancouver and Victoria (Allas 1991). Waste studies conducted in Seattle (City of Seattle 1990), Kings County and Portland, Oregon (City of Portland 1989) are thought to be more representative of BC lower mainland urban waste in part because these areas have a long growing season and generate organic yard waste year-round.

3.1.2 Alberta

Although no province-wide waste generation or composition studies have been undertaken in Alberta, several studies have been done of urban waste in Alberta (Alberta Environment 1987; Environment Council of Alberta 1985; Monenco Consultants 1991; and Stanley Associates 1988).

Rural waste in Alberta may be estimated based on the recent BC audits of rural landfill sites (BC Environment 1991) and estimates of rural waste in Ontario (CH2M Hill 1991).

3.1.3 Saskatchewan

No waste generation data exists for Saskatchewan. Waste management planners in Saskatchewan rely on Canadian data (Bird and Hale 1979) and data from the United States (Franklin Associates 1988).

A better estimation based on more recent data may be made of waste quantities and composition using urban data from Alberta or Manitoba and rural data from northern British Columbia or Ontario.

3.1.4 Manitoba

No province-wide data exists for Manitoba. The City of Winnipeg has been weighing municipal solid waste at its landfills on a monthly basis for several years (Dowhanik 1991). These data are reported by sector, i.e., residential, commercial, institutional, and by some categories of waste (eg. yard waste, construction and demolition waste, trees and shrubs, concrete with and without re-bar, scrap metal, etc.). For more detailed waste composition figures, the City of Winnipeg relies upon Canadian data (Bird and Hale 1979). For this study, waste composition for Winnipeg may be estimated using more recent data from Edmonton (Alberta Environment 1987; Environment Council of Alberta 1985; Stanley Associates 1988).

Estimates of rural Manitoban waste generation and composition may be made from data for northern Ontario.

3.1.5 Ontario

There have been several recent studies of waste generation and composition in Ontario (CH2M Hill 1991; Gore and Storrie 1991; R. Cave and Associates 1989; RIS 1991; VHB Research and Consulting 1991). Consequently, data from Ontario can serve as a base for the rest of the country, where better data are not available.

3.1.6 Québec

Québec provincial regulations delegate waste management to Municipal Regional Councils and require that each disposal/collection site manager provide annual reports on the quantity and type of waste collected each year. These reports are issued to the provincial directorate for each Municipal Regional Council.

There have been two studies of waste generation and composition in Québec based on these data (Groupe-conseil Roche 1985; Ministère de l'Environment 1987). These studies report gross tonnages by sector (residential and ICI), by disposal (landfill, incineration and recovery) and by some waste stream components. However, the level of detail is not comparable to studies elsewhere and there is some doubt about the quality of the data (DuPont 1991).

Better estimates of waste generation and composition in Québec may be made with data from Ontario.

3.1.7 New Brunswick

Provincial regulations delegate waste management to 12 regional committees. Each region is required to audit waste flows and report quantities and composition to the New Brunswick Department of Environment. The audits identify residential and ICI waste streams. In addition, the Nepisiguit-Chaleur and Fredericton Solid Waste Management Regions operate waste disposal facilities charging tipping fees, so all waste is weighed at these sites. These data were compiled and summarized by Flander-Good Associates (1991). Composition data are available from a study of recycling in Fredericton (NB Dept. of Environment 1990).

3.1.8 Nova Scotia

No waste generation information is available for Nova Scotia. The Nova Scotia Department of Environment relies on Canadian data (Bird and Hale 1979).

Nova Scotia waste generation and composition may be estimated using data from New Brunswick and Ontario.

3.1.9 Prince Edward Island

Prince Edward Island is currently weighing municipal solid waste at four landfill sites. These data are expected to include gross tonnages by sector but no analysis of waste stream composition.

Composition data may be estimated using data from New Brunswick and Ontario.

3.1.10 Newfoundland

No waste generation information is available for Newfoundland.

Newfoundland waste generation and composition may be estimated using data from New Brunswick and Ontario.

3.1.11 Yukon Territory

The territorial government has little data on volumes of waste generated. Volumes of waste going to some territorial landfills has been counted but these landfills are frequently seasonal (eg. fishing resorts) or for very small communities (population less than 500) so this information is not likely to be representative for the territory as a whole.

The City of Whitehorse has estimated the volume of waste going to city landfills, broken down by residential and commercial sources, but apparently this information is sparse and inaccurate (Wilson 1991). No municipalities in the Yukon operate weigh scales at landfills.

Additional waste generation and composition data for the Yukon may be estimated using data from northern British Columbia and northern Ontario. Waste composition data from the Northwest Territories may also be useful for northernmost communities.

3.1.12 The Northwest Territories

The territorial government has no territory-wide data on the volume or composition of municipal solid waste. Archaeological analyses of landfills on Baffin Island and at Inuvik (Henke and Wong 1991; Henke and Wong forthcoming) may be used to estimate waste composition for northernmost communities.

Additional data for the NWT may be estimated using Yukon Territory data. In addition, waste generation and composition data for northern British Columbia and northern Ontario may be used to estimate waste data for more southerly communities.

3.2 Waste diversion rates from existing and committed programs

Although difficult to estimate in most provinces, waste diversion rates range from a high of more than 5% for residential waste in Ontario to a low of 0% in the Northwest Territories. Recycling programs are well established in BC, Alberta, Saskatchewan, Québec and New Brunswick.

Some recyclables are recovered relatively uniformly across the country (eg. used automotive batteries, used gypsum board, white goods and scrap metal). Programs for collection and recycling of aluminum and glass beverage containers, fine paper and boxboard, and more recently, old newspapers, are most common.

In most cases data for private, corporate or not-for-profit recycling programs may only be obtained by interviews with participants.

3.2.1 British Columbia

BC Environment commissioned a market development plan for recyclables in British Columbia that estimates recovery rates for 6 categories of recyclables based on interviews with recycling industry participants (Peat Marwick 1990). This study estimates total waste recovery in the order of 7% of the municipal solid waste stream. The waste management database under development will identify diversion rates in more detail (BC Environment 1991).

3.2.2 Alberta

Information on waste diversion rates for Alberta are unavailable. Since no province-wide waste audits have been conducted, it would be possible to obtain recovery rates by interviews with industry participants.

3.2.3 Saskatchewan

It is estimated that approximately 2% of Saskatchewan's waste stream is currently recovered (Saskatchewan Environment and Public Safety 1991). This study estimates recovery rates for glass containers, aluminum beverage cans, paper, plastics, and used tires. However, detailed waste diversion rates for Saskatchewan are unavailable.

3.2.4 Manitoba

Manitoba has just begun funding pilot recovery projects. Consequently, no data are available concerning recovery rates.

3.2.5 Ontario

Recovery rates have been estimated in detail for Ontario (CH2M Hill 1991; VHB and ERL 1991). It is unlikely that the level of detail available for Ontario will be matched elsewhere in Canada at the provincial level.

3.2.6 Québec

The Québec Ministry of Environment has estimated recovery rates for 7 categories of recyclables from residential, industrial and commercial sectors (Québec Environment 1987). More detailed or recent information is not available.

3.2.7 New Brunswick

The Flander-Good and Associates et al. study (1991) estimates diversion rates for New Brunswick based on experience from Fredericton's recycling program (NB Dept. of Environment 1990) and experience elsewhere. These rates, however, are based on "typical material recovery proportions" from a census of Canadian and US recycling programs and depend upon the adoption of measures recommended in the study. Information related to what extent these measures have been adopted, if at all, and actual diversion rates have been achieved in New Brunswick are unavailable except for the City of Fredericton.

3.2.8 Nova Scotia

No information on diversion rates is available for Nova Scotia, although there are several municipal and corporate waste recovery programs. Interviews with municipal and corporate waste managers may provide estimates of recovery rates. Diversion rates are expected to be low.

3.2.9 Prince Edward Island

Although there are a number of provincial and municipal recycling programs, diversion rates for PEI are unavailable. Since there are no curbside recycling programs, and recovery rates are lower for voluntary drop-off systems, PEI's recovery rates are expected to be low (Flander-Good 1991). Approximately 30% of PEI's MSW is recovered for incineration in an energy-from-waste facility in Charlottetown owned by Laidlaw Waste Systems.

3.2.10 Newfoundland

There is no waste diversion information available for Newfoundland. Only one community has curbside recycling and an industry initiative to buy back plastic and glass bottles, boxboard and white bond paper has had limited success with recovery rates less than 5% of these commodities (Strong 1991).

3.2.11 Yukon Territory

Several volunteer programs sponsor collection and recycling programs in the Yukon, collecting and composting organic yard waste for boulevard enhancement in the City of Whitehorse and fine paper, aluminum beverage containers and glass. Although recovery rates from these programs are unavailable, they are expected to be negligible relative to the total MSW stream for the territory.

3.2.12 The Northwest Territories

All MSW in the NWT is disposed of in landfills.

Table 3.1 summarizes, by province, the availability of information for the Waste Management Policy Model. Other than that for Ontario, little detailed information is available on waste diversion rates, unit costs and implementation costs.

Table 3.2 summarizes the sources to be used for estimation of waste generation and composition in each province and territory. A range of data sources is available, representing each of Canada's regions, for the estimation of generation and composition data.

Table 3.1
Available information for Waste Management Policy Model

Sources	BC			Alberta			Sask			Manitoba			Ontario			Quebec			NB			Nova Scotia			PEI			Newf			Yukon			NWT		
	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI	CI	PI	NI
Waste generation																																				
by material	*				*			*				*	*				*				*			*			*			*			*		*	
residential	*					*			*			*	*			*			*					*		*				*			*			*
ICI	*					*			*			*	*			*			*					*		*				*			*			*
Waste diversion																																				
existing programs	*					*			*	*			*			*			*					*			*			*			*			*
committed programs			*			*			*			*	*					*		*				*			*			*			*			*
Unit costs																																				
existing programs			*		*				*			*	*					*		*				*			*			*			*			*
committed programs			*		*				*			*	*					*		*				*			*			*			*			*
Implementation Costs																																				
Policy measures			*		*				*			*	*					*		*				*			*			*			*			*
Other																																				
demographic projections	*			*			*			*			*			*			*			*			*			*			*			*		
economic projections	*			*			*			*			*			*			*			*			*			*			*			*		

Note:
CI = Complete Information
PI = Partial Information (see text)
NI = No Information

Table 3.2
A summary of waste generation and composition sources for the Waste Management Policy Model

Sources	BC		Alberta		Saskatchewan		Manitoba		Ontario		Quebec		NB		Nova Scotia		PEI		Newfoundland		Yukon		NWT	
	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp	Gen	Comp
Alberta Environment 1987				*																				
BC Environment 1991	*	*	e		e																e	e	e	e
CH2M Hill 1991			e	e	e	e	e	e	*	*	e	e			e		e		e		e		e	
City of Portland 1989		e																						
City of Seattle 1990		e																						
City of Whitehorse 1991																					*	*	e	e
City of Winnipeg 1991							*	*																
Env. Ccil of Alberta 1985				*		e																		
Flander-Good Associates 1991													*		e		e		e					
Gore and Storrie 1991									*	*	e	e												
Groupe Conseil Roche 1985											*	*												
Henke and Wong 1991																					e		*	
Monenco Consultants 1991				*		e																		
NB Environment 1989a-e													*	*	e	e	e	e	e	e				
NB Environment 1990a-c													*	*	e	e	e	e	e	e				
Quebec Environment 1987											*	*												
R. Cave and Associates 1989										*														
RIS and VHB 1991										*														
Stanley Associates 1988				*																				
VHB and Econometrics 1991										*														
VHB and MacLaren 1991										*														
Yukon Public Works 1991																					*	*	e	e

Note:
* information available
e information to be extrapolated

3.3 Unit costs of diversion, incineration and landfill

Detailed estimates of unit (per tonne) costs of diversion, incineration and landfill have been developed for Ontario (VHB and ERL 1991). Cost differences between regions will largely be the result of higher transportation costs for northerly and remote communities, particularly for recycling, and variations in labour costs across the country. The cost data developed for Ontario may be used for the rest of the country provided they are adjusted to reflect these differences in costs. The prices paid for recycled materials have been documented for Ontario.

Per tonne costs for landfill, recycling, composting and incineration have also been developed for Alberta (Stanley Associates 1988).

The Rural Development Cooperative Extension Service at Oklahoma State University has developed a methodology and prepared a series of economic analyses of solid waste management alternatives for rural areas to assist local governments in establishing effective least-cost waste management programs. The information assembled in the course of these studies may prove useful in estimating the costs of waste management in rural Canada, and assessing the effect of waste management programs on the rural waste stream (Sloggett et al. 1991).

Similar information could be obtained relatively easily from other provinces through telephone interviews with industry participants.

3.4 Implementation costs for each measure

Estimates of implementation costs have been developed for Ontario and for Alberta (VHB and ERL 1991; Stanley Associates 1988). These costs, however, will vary less between regions than will unit costs, as transport and labour are smaller components of the implementation costs for several measures, and irrelevant for others. The costs developed for these two provinces may be used for the rest of the country with minimal modification.

4 The Economic Impact Model

4.1 Theoretical framework

Macroeconomic models are generally based on a particular national income accounting framework. The conventional approach treats waste and pollution generation in such a way that any increase in these activities increases directly the gross domestic product (GDP) of the economy. Thus, a society can increase its GDP by simply increasing the waste it produces. This follows from the fact that garbage collection, pollution abatement and sewage treatment activities appear as part of the final demand of the economy. Garbage collection and sewage treatment are part of the municipal government sector and this sector, like all other government activity, is treated as if it produces final output. Common sense suggests that no society should be considered richer or better off if it produces more waste. Since the conventional GDP measure does exactly this, it appears sensible to re-examine the GDP concept and the way it is measured.

In this project, waste management and pollution abatement are treated as services to business whose costs should be charged against business revenues. Even such services to households may be considered as costs of output to the extent that part of household activity may be incorporated within the business sector. In this way they appear as a cost to society and not as final output.

A new theoretical framework developed in conjunction with the study of waste reduction in Ontario (VHB and ERL 1991) will be expanded to correspond to the new reformulated accounting framework. Within this new framework it is possible to identify clearly and carefully the recycling activity and the operations of waste generation and management within the general operations of the economy. Furthermore, the framework can be used to outline the socioeconomic consequences and impacts that are likely to emerge from adopting alternative waste reduction/diversion strategies.

The rectangular input-output framework is particularly suited for this treatment as it allows different industries to produce the same output, and identifies different commodities as inputs in the production of the same output. In this way, paper can be made from virgin pulp or from recycled paper. Two industries may use different technologies but produce the same output. Several new commodities are also introduced into the system. These include recyclable (waste) and recycled (substitutes for virgin products) commodities. What was waste and disposed of in the past is now a new input into the production of commodities.

Recyclables are produced primarily, but not exclusively, by households and institutions and are used by industry to produce products that are often almost indistinguishable from products made from virgin materials.

The new framework makes it possible to deal with environmental and waste management issues that are difficult or impossible to deal with within the old framework. Different scenarios of waste management policies can be run within this framework. First, commodity balances ensure a solution which entails a detailed specification of quantities and prices which may or may not be acceptable to policy makers or even economically or technologically feasible. Second, policy makers are then in a position to assess the consistency of their policies and their consequences on the economy, environment and regions. Third, it is possible to connect the Economic Impact Model to the Waste Management Policy Model to iterate for a consistent solution for waste generation and waste management strategies and impacts.

The new framework addresses the possibility of examining the feasibility and consistency of several alternative waste management strategies including reducing, reusing and recycling strategies as well as their economic and social consequences. This is achieved through a general equilibrium framework capable of specifying quantities and prices that will ensure balance in the system. Economic and social consequences are gauged using a rich set of indicators including income, output, labour income, employment, taxes collected by type of tax and the level of government, by sector and region of the country (regions could be groups of provinces, provinces or even smaller geographical-environmental areas such as counties or watersheds). Equally important is the system's ability to assess the relative efficiency of alternative policies to reuse or reduce the use of products and resources through price incentives and full cost charges. Impact indicators noted above can also be used to identify sectors, industries and regions that may be adversely affected by the waste reduction policies and regulations. Of particular interest here are the operating performance indices that can be generated by the model. These include industry specific operating surplus indices per unit of output or, if capital data are available, operating surplus per unit of invested capital as well as region-specific indicators that could tally the employment effects in terms of bench mark employment totals.

4.2 The suggested model

Recycling, reusing and waste management activities involve the use of scarce resources and the generation of outputs and services. Typically, these activities were either neglected, misallocated or subsumed within other activities of other sectors within the standard input-output accounting framework. Any attempt to focus on these activities calls for a major reformulation of the standard accounting framework. The adjustment process involves not only broadening the use (input), make (output) and final demand matrices of the interprovincial rectangular input-output framework to encompass new commodities and industries, it also calls for a redefinition of the accounting relationships governing the system.

4.2.1 The modified use matrix

The standard use matrix can be extended to explicitly include sorting station activities, recycling and waste disposal activities. These industries use resources and generate value-added. The commodity set is also expanded and disaggregated to explicitly show scrap, recyclable, recycled products and waste treatment and disposal services.

The modified use and final demand system is explained in detail in Appendix II.

The modified use matrix has a number of interesting characteristics that reveal the nature of the modifications suggested:

- a strong distinction is made between recyclable and recycled products. Recyclables are gathered, sorted and delivered either to the primary industries or to the recycling industry;

- recycled products are delivered as inputs to primary industries;

- waste disposal services are allocated to businesses and to households;

- deliveries to businesses appear as deliveries to intermediate demand.

In the standard input-output system, waste disposal services are allocated entirely to final demand. This reallocation implies reducing the value of net output of the economy. In addition, charges paid by businesses for waste disposal services reduces their operating surplus and therefore the value added assigned to them. These charges appear as revenues of the waste disposal industry and raises its value added. Thus, two changes result from this adjustment. Net output of the economy is changed by moving a part of the deliveries of this activity from final demand to intermediate demand, and also the distribution of value added between industries.

4.2.2 The modified final demand matrix

Exporting and importing recyclable, recycled products and waste are explicitly included in the framework. Maintaining balance between supply and demand for these products is likely to be difficult particularly in the initial stages of production. Imports and exports of surpluses and short falls are therefore likely to play prominent roles in sustaining the operations of these activities. These balances are specified in a way that reflects the price and behaviour structure of the system. Furthermore, final demand sectors are users as well as producers of recyclables and products made from recycled inputs. Their activities and choices will significantly influence the operations and activity levels of these sectors.

4.2.3 The modified make matrix

The extension and expansion of the use matrix imposes several modifications to the make matrix. Some of these changes include:

- Recyclables are primarily produced by all sectors including some final demand sectors.

- Paper produced from virgin inputs is indistinguishable from paper produced from recycled paper. The model is flexible enough to allow price or specific measures that influence preferences and market shares.

- Waste management services are produced solely by the waste management industries.

- Recyclables are collected, sorted at special environmental industries and transported to recycling industries that produce the recycled products.

Several features define the modifications to the structure of production:

- Recyclables are produced by all sectors other than the sorting and recycling industries.

- The paper industry produces paper from virgin materials and recycled materials.

- Households and governments are treated here as producing sectors of recyclable.

The final demand system that is left outside the production system is driven by a large macroeconometric model or could equally be driven by forecasts available from other sources. This flexibility allows the user to simulate the consequences of several alternative rates of growth and policy options.

4.2.4 The equations of the model

The model has several components. All the equations are presented in detail in Appendix II.

4.3 Current applications of the system

Although the system is still in the development stage, it has already been used in several applications. First, the model was used to estimate waste generation by county and industrial sector in Ontario. Second, it has been used to examine the 50% waste diversion target of the Ontario government. Third, it is being used to support the activities of Ontario's Waste Reduction Advisory Committee. Furthermore, for 18 months VHB and ERL have been collaborating in the design of a comprehensive model that links the economy and the environment within a framework capable of outlining economic profiles that can be considered sustainable over time. All of these initiatives have been funded by the Ontario Ministry of the Environment.

4.4 Data sources for the model

Every five years, Statistics Canada produces the *Interprovincial input-output tables*. They include the 10 provinces and the territories. The most recent tables are for 1984. The 1989 tables are expected in 1992. These tables do not explicitly include the waste management sector. It will be necessary to introduce waste management activities as well as recycling in every provincial table. As a starting point it will be possible to adapt the information for the Ontario industry. Preferably, each province should have its own activities as dictated by the technology used and by the set of prices governing the operations of the system. Some of the information described in Chapter 3 will be useful for this purpose.

Data for waste generation and diversion from each province will be used in conjunction with the employment generated by each industry in each province. The employment generated by industry will be determined by using the macroeconometric system driving the economy, assumptions about waste diversion and employment and productivity coefficients. The choice of the macroeconometric forecast will be made by considering several alternative specifications of the economy undertaken by a number of forecasters. A long list of forecasts are made for the economy at large and for each province. Among the most used forecasts are those generated by the Conference Board of Canada, Infometrica, DRI, Policy Institute of the University of Toronto and the Bank of Canada. The usual practice involves a simple average of these or a specific weighting of the alternative futures generated by these forecasts.

Employment data by industry in each province can be obtained from Statistics Canada's *Labour survey* or *Employment and earnings*. The former includes self-employed workers, whereas the second includes only wage employment. It is appropriate to use both, particularly in the non-manufacturing sectors. In the manufacturing sector the proportions of self-employed are usually small. In the non-manufacturing sectors, particularly in the retail trade sector, these proportions become very large.

Since the input-output tables are generally a few years old, the results obtained from the input-output analysis are updated by introducing current prices, wages, employment coefficients, productivity factors and taxes to adjust the input-output results. Data on all these variables are available from Statistics Canada publications or from CANSIM.

The number of sectors differ by province. To maintain consistency it may be advisable to group several provinces together. The Atlantic provinces would constitute one region, Quebec and Ontario would be considered separately, the Prairie provinces would constitute a region, British Columbia would be considered a separate region and the Territories would constitute a region.

5 Conclusions

Based on a review of the available data on waste management in each province, for Canada as a whole and from other jurisdictions from which data may be extrapolated, it has been determined that the methodology and models developed by VHB and ERL for use in Ontario can readily be adapted to other regions of Canada and used to model the impacts of a 50% waste reduction/diversion in Canada.

Ongoing research at VHB and elsewhere will contribute to the data already available and enhance the application of the methodology and models.

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Appendix I. Description of waste management policy model[1]

[1]This section is adapted from VHB Research and Consulting Inc. and Econometrics Research Ltd. 1991. *A socio-economic assessment of Ontario waste management initiatives*. Prepared for the Ontario Ministry of the Environment, Toronto.

A. Introduction

The Waste Management Policy Model (WMPM) provides:

- a means of defining measures to divert waste from incineration and landfill;
- an analysis of the effects of these measures; and
- an estimation of the waste quantities diverted by these measures.

These three processes are handled separately by three individual *Lotus 1-2-3, Version 2.2* worksheets in the WMPM. Each worksheet relies on data created by one of the others. The three processes are provided as sub-programs or options from the main menu invoked when the file **MENU.WK1** is retrieved (Table I).

Table I
MENU options for waste management policy model

```
K1: \*
MENU
Policies  Options  Results  Tutorial  Install  Quit
Call the policy editor.
       K       L       M       N       O       P       Q       R       S
1   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
2   *                                                                      *
3   *                                                                      *
4   *                --------------------------------------                *
5   *                        WASTE MANAGEMENT POLICY MODEL                 *
6   *                --------------------------------------                *
7   *                                                                      *
8   *                                                                      *
9   *                                                                      *
10  *                                                                      *
11  *                      VHB Research & Consulting Inc.                  *
12  *                                                                      *
13  *                                                                      *
14  *                                                                      *
15  *                             13 June 1991                             *
16  *                                                                      *
17  *                                                                      *
18  *                                                                      *
19  *                                                                      *
20  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
MENU.WK1                                   CMD
```

The following discusses what each of these sub-programs does, and an overview of how it does it. Where appropriate a pictorial overview is provided.

B. POLICIES sub-program

The **POLICIES** sub-program permits the creation and editing of measure parameters. "Policy parameters" means:

- waste diversion rates, in per cent, from the current trend[2]; and
- measure name and description.

Table II
POLICIES sub-program options for waste management policy model

```
AT5: \*
MENU
Edit  Save  Xtract  Import  Link  Name  Reset  Quit
Edit/view current policy data.
       AT      AU      AV      AW      AX      AY      AZ      BA      BB
5   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
6   *                                                                       *
7   *                                                                       *
8   *               ----------------------------------------                *
9   *                 POLICY DIVERSION PARAMETER EDITOR                     *
10  *               ----------------------------------------                *
11  *                                                                       *
12  *                  Companion to OPTIONS and RESULTS.                    *
13  *                                                                       *
14  *                                                                       *
15  *                   VHB Research & Consulting Inc.                      *
16  *                                                                       *
17  *                                                                       *
18  *                                                                       *
19  *                            13 June 1991                               *
20  *                                                                       *
21  *                                                                       *
22  *                                                                       *
23  *                                                                       *
24  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
POLICIES.VHB                                        CMD       CALC
```

Twenty-two waste types for four waste-producing sectors can be edited. There are two scenario "years": 1992 and 2000. Table II presents the **POLICIES** sub-program menu. In addition, the **POLICIES** sub-program permits the user to define the expected direct costs for capital outlays and operating expenses of the measure.

---

[2] Policies are said to divert waste to some waste management option (eg. reduction, reuse, or recycling). The diversion incurred from the implementation of some policy is relative to some current trend. That is, future effects are considered inherently in this model.

The following is a discussion of the menu options available under the **POLICIES** sub-program.

1. Edit

Selecting *Edit* from the main menu permits the user to create or edit *Diversions* or *Costs*. Table III presents the *Diversion Parameter* and *Costs* editing screens in the *Edit* sub-menu.

Diversions

Selecting *Diversions* drops the user into a split-screen where diversion parameters and stream sizes may be created or edited. The top half of the screen shows the measure being edited while the lower half shows the current trend scenario. The bottom half "follows" the top half: pressing any directional keys causes both screen parts to move in equal jumps. The user is therefore always shown the current trend counterpart to the parameter currently being edited. Since all parameters entered are relative to the bottom half, the method provides a convenient reference frame.

Users define diversion parameters by waste type, sector and waste handling method (3Rs, incineration or landfill). The waste diverted is a portion between 0 and minus 1 of the current amount of waste going to landfill. For example, 8 per cent of ONP is diverted from solid waste management (landfill and incineration) (Table III) from an eduction program. All of the waste diverted is due to recycling, 100 per cent. The waste diverted may result from any of the 3Rs, or incineration, however the total must equal 1. This process is repeated for each waste type, for all four sectors in the model for the years 1992 and 2000.

Costs

The *Costs* option permits the user to specify the 1989$ annualized cost of the measure. The user inputs the annualized: approvals/hearings; site acquisition; and equipment capital costs and the labour; maintenance; energy; and administration operating costs for the measure. The model calculates total capital and operating costs for the measure for the years 1992 and 2000.

Most *Lotus 1-2-3, Version 2.2* commands may be entered at this stage. The {END}, {WINDOW} and {GOTO} keys have been disabled. In addition, {GRAPH} (key F10) has been reassigned to exit *Edit*.

Table III
Edit option screens of waste management policy model

```
B12: PR                          Edit highlighted percentages, press <F10> to
quit

                   A                B       C       D       E       F       G
6    * Sectors and            Upper screen: diversion from "Current Trends"
7    *  Technologies          Lower Screen: "Current Trends"
8    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
9    EDUCATION PROGRAMS         ONP     Fine  Boxboard  CCC     Mixed  Magazine
10                                     Paper                   Paper
11   ----------------------------------------------------------------------------
12   RESIDENTIAL - 1992
13   Reduction                   0%       0%      0%      0%      0%      0%
14   Reuse                       0%       0%      0%      0%      0%      0%
15   Recycling                 100%     100%    100%    100%      0%    100%
16   Solid Waste Management     -8%      -5%     -3%     -5%      0%     -6%
17   ----------------------------------------------------------------------------
                   A                B       C       D       E       F       G
183 CURRENT TRENDS            -------------------------------------------------
184 RESIDENTIAL - 1992
185 Reduction                    0%       0%      0%      0%      0%      0%
186 Reuse                        0%       0%      0%      0%      0%      0%
187 Recycling                   50%       0%      0%      1%      0%      9%
188 Solid Waste Management      50%     100%    100%     99%    100%     91%
189 ----------------------------------------------------------------------------
POLICIES.VHB                                 CMD       CALC
```

```
I114: (,0) U 0                                Enter Costs, press <enter> when
done

        C       D       E       F       G       H       I       J       K
109 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
110 *       COST DATA - EDUCATION PROGRAMS                                  *
111 *       Enter annualized costs, in 000's of 1989$                       *
112 *                                                                       *
113 *       CAPITAL COSTS                                1992    2000       *
114 *          Approvals/Hearings                           0       0       *
115 *          Site Acquisition                             0       0       *
116 *          Equipment                                    0       0       *
117 *       Total Capital Costs                             0       0       *
118 *                                                                       *
119 *       OPERATING COSTS                                                 *
120 *          Labour                                   3 625   4 375       *
121 *          Maintenance                              3 635   4 375       *
122 *          Energy                                   3 625   4 375       *
123 *          Administration                           3 625   4 375       *
124 *       Total Operating Costs                      14 510  17 500       *
125 *                                                                       *
126 *       TOTAL COST                                 14 510  17 500       *
127 *                                                                       *
128 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
POLICIES.VHB                                 CMD       CALC
```

2. Save

Save stores the current file settings. This is most useful for storing unfinished work.

3. Xtract

Xtract extracts the edited parameters to a disk file for use in the **OPTIONS** sub-program of the model. Typically, measures are created or edited in **POLICIES**, extracted to disk, and then imported into **OPTIONS**. Extracted files can also be imported however, for further modification (see below).

4. Import

Import retrieves extracted disk files for further editing. Note that **POLICIES** can read files created from itself, as well as from the **OPTIONS** worksheet (see *Extract* in the **OPTIONS**). The *Import* procedure is slightly different for each sub-program. However, **POLICIES** handles all the details.

5. Link

Link returns the user to the starting **MENU** of the model. Once a measure has been edited and extracted, users may link to the **OPTIONS** sub-program to evaluate the measure effects.

The user is warned that *Link* causes the loss of newly created or modified measures that have not been e*Xtracted* or if **POLICIES** has not been *Save*d. If changes are made and *Save* is not executed, the program warns the user of the possibility of losing the measure data.

6. Name

Name attaches a measure name and description to the created or edited parameters (Table IV). This information is saved along with the diversion rates and costs when *Xtract* is invoked.

The procedure is particularly handy for creating measures with only slightly different effects. For example, suppose that two similar measures are desired. The user creates the first, changing all relevant parameters and then extracts the information to disk. He can then re*Name* the measure, change a few of the parameters, and extract again with minimum effort (ie. otherwise, both measures would have to be created from scratch).

The measure name is important. No two measures with the same name can be imported into the **OPTIONS** sub-program.

Table IV
Name sub-menu options for waste management policy model

```
AW73: U 'EDUCATION PROGRAMS            Enter Parameters, press <enter> when
done

        AT      AU      AV      AW      AX      AY      AZ      BA      BB
65  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
66  *                                                                     *
67  *                ----------------------------------------             *
68  *                       Extract File Description                      *
69  *                ----------------------------------------             *
70  *                                                                     *
71  *                                                                     *
72  *                                                                     *
73  *       Policy Name:    EDUCATION PROGRAMS                            *
74  *                                                                     *
75  *                                                                     *
76  *       Description:    INCREASED FUNDING FOR 3Rs PROGRAMS            *
77  *                                                                     *
78  *                                                                     *
79  *                                                                     *
80  *                                                                     *
81  *                                                                     *
82  *                                                                     *
83  *                                                                     *
84  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
POLICIES.VHB                                 CMD      CALC
```

7. Reset

Reset sets all diversion parameters to 0 per cent and all stream sizes to 100 per cent and all costs to zero. It also clears the current measure name and description. This provides the user with a clean slate to edit from.

8. Quit

Quit permits the user to exit the **POLICIES** sub-program.

C. OPTIONS

The **OPTIONS** sub-program (Table V) permits the analysis of the effects of indivdual measures and combined measures. The following discusses all the menu options available in **OPTIONS**.

Table V
OPTIONS sub-program — waste management policy model

```
MENU
Policies  Secondaries  Analyze  Utilities  Input-Output  Link  Quit
Select policy groups.
        AG         AH         AI         AJ         AK         AL         AM         AN         AO
81   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
82   *                                                                       *
83   *                                                                       *
84   *                                                                       *
85   *              ----------------------------------------                 *
86   *                            Policy Evaluator                           *
87   *              ----------------------------------------                 *
88   *                                                                       *
89   *          This does something wonderful, I hope you enjoy it.          *
90   *                                                                       *
91   *                                                                       *
92   *                  VHB Research & Consulting Inc.                       *
93   *                                                                       *
94   *                                                                       *
95   *                                                                       *
96   *                           24 May 1991                                 *
97   *                                                                       *
98   *                                                                       *
99   *                                                                       *
100  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
OPTIONS.VHB                                     CMD        CALC
```

1. Policies

The *Polices* option provides the user with the ability to select up to eight measures for analysis (Table VI). *Policies* creates a split-screen with two windows: the one on the right window the available measures (up to eighteen); the window on the left shows the current measures selected. Individual measures are selected by entering the number of the desired measure shown in the right-hand window. To leave a policy option as is, simply press <enter> and the cursor moves down to the next slot.

A measure can only be selected once. Choosing a measure number that has already been selected results in an error tone, and the input is not accepted.

Secondary factors (see below) are reset to default values after policies are chosen. As this may not be desired, the user is asked to confirm the measure policy selection process before actually making choices.

Table VI
Policies selection option — waste management policy model

```
Choose a number from the menu provided; 0=default; <enter>=no change; -ve=quit.
Please enter number -

        AP      AQ      AR      AS         BL  BM       BN          BO      BP
1    * * * * * * * * * * * * * * * * 4   ¿ ¿ ¿ ¿  *** POLICY OPTIONS *** ¿ ¿ ¿
¿
2    *                               5   ¿      1 DEPOSIT SYSTEMS
3    *  Choose the policies you wish 6   ¿      2 EDUCATION PROGRAMS
4    *  to invoke (TAX INCENTIVES,   7   ¿      3 EXPANDED BLUE BOX PROGRAMS
5    *  USER CHARGES, etc.).         8   ¿      4 INCREASE MUNICIPAL FUNDING
6    *  Insert the number of your    9   ¿      5 INDUSTRIAL WASTE AUDITS
7    *  choice in the space provided 10  ¿      6 LANDFILL BANS
8    *  below. You have a maximum of 11  ¿      7 LANDFILL TIPPING FEES
9    *  eight choices.               12  ¿      8 MANDATORY PROCESSING OF SOLID
WA
10   *                               13  ¿      9 MANDATORY SOURCE SEPARATION
11   *  1.   LANDFILL TIPPING FEES   14  ¿     10 PACKAGING TAXES
12   *  2.   EXPANDED BLUE BOX PROGRA15  ¿     11 PRODUCT BANS
13   *  3.   LANDFILL BANS           16  ¿     12 PRODUCT SPECIFICATIONS
14   *  4.   PRODUCT SPECIFICATIONS  17  ¿     13 RECYCLED CONTENT REGULATION
15   *  5.   VIRGIN MATERIALS TAXES  18  ¿     14 SUBSIDISED HOME COMPOSTERS
16   *  6.   INCREASE MUNICIPAL FUNDI19  ¿     15 USER CHARGES
17   *  7.   PRODUCT BANS            20  ¿     16 VIRGIN MATERIALS TAXES
18   *  8.    *** POLICY OPTIONS *** 21  ¿     17 YARD AND ORGANIC WASTE
COLLECTIO
19   *                               22  ¿     18 SUBSIDIES TO PRODUCERS
20   * * * * * * * * * * * * * * * * 23  ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿ ¿
¿
OPTIONS.VHB                              CMD       CALC
```

2. Secondaries

Secondaries allows the user to set the policies' ranks, substitute/complement factors, and measure efficiencies. These are discussed individually below and presented in Table VII.

Policy Ranks

The order of measure selection is important. Generally, the measure selected first has the most "weight". Also, the substitutional/complementarity nature (see below) of measures is relative to the first measure on the list.

After the completion of the *Policies* selection routine (Table VII), the chosen group of measures is ranked in the order of selection. This ranking may be changed through the *Secondaries/Policy Ranks/Set* menu item. Rankings may also be reset to the order of selection through *Secondaries/Policy Ranks/Initialize* item. Measure ranks are arbitrary, with higher numbers having more rank than lower numbers. The highest rank for any measure is 8. A measure can be temporarily removed from the analysis be setting its rank to zero. To restore the measure, reset measure ranks by using the *Initialize* sub-menu.

Table VII

Policies rankings and efficiencies — waste management policy model

```
AV33: U 6                                  Select Ranks, press <enter> when
done

           AP        AQ        AR        AS        AT        AU        AV        AW        AX
21    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
22    *          POLICY RANKINGS AND EFFICIENCIES                                              *
23    *                                                                                        *
24    *          Ranking is done in reverse order (i.e. assign 8 for                           *
25    *          the most important policy, then 7, 6 etc.) Set rank                           *
26    *          to 0 to ignore policy.                                                        *
27    *          Efficiencies must lie between zero (0) and one (1).                           *
28    *                                                                                        *
29    *          Policies                                Menu     Rank     Efficiency          *
30    *                                                                                        *
31    *    1.    LANDFILL TIPPING FEES                      7        8        100%            *
32    *    2.    EXPANDED BLUE BOX PROGRAMS                 3        7        100%            *
33    *    3.    LANDFILL BANS                              6        6        100%            *
34    *    4.    PRODUCT SPECIFICATIONS                    12        5        100%            *
35    *    5.    VIRGIN MATERIALS TAXES                    16        4        100%            *
36    *    6.    INCREASE MUNICIPAL FUNDING                 4        3        100%            *
37    *    7.    PRODUCT BANS                              11        2        100%            *
38    *    8.                                                                                  *
39    *                                                                                        *
40    * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
OPTIONS.VHB                                      CMD        CALC
```

Factors

Some measures complement others, while some are pure substitutes. When two measures are substitutes, the modle selects the measure with the higher diversion parameter. When two measures are compliments, the diversion parpameters are combined using one of several formulae that can be chosen by the user. The model provides the ability to change the effects of complementary measures.

After selecting a group of policies, or changing a set of *Policy Ranks*, all complementary measure factors are initialized to 100 per cent. Normally, this need not be changed. However, the *Factors* option provides the ability to change the complement/substitute relationship between measures. Choosing *Secondaries/Factors/Initialize* sets all factors to 100 per cent, while *Secondaries/Factors/Set* allows for their modification.

Efficiencies

The effectiveness of any given measure can be globally improved or reduced by altering its efficiency. All diversion parameters for all sectors and years are multiplied by this efficiency (normally 100 per cent) before the final analysis.

The efficiency factor for each measure may be set by the user. Typically, the user would set the efficiency for each measure somewhere between 0 and 1 (0 per cent and 100 per cent efficiency). However the efficiency of a measure can be set in excess of 100 per cent or less than 0 per cent. For example, the user may wish to examine a measure's effect if the diversion for all waste types and sectors were 200 per cent, or double the diversion specified for the measure in the **POLICIES** sub-program.

Unlike *Factors*, changing measure ranks does not reset the efficiencies (they are initialized when new policies are selected). Choosing *Secondaries/Efficiencies/Initialize* does initialize the policies' efficiencies (Table VII). Selecting *Secondaries/Efficiencies/Set* allows for their modification.

3. Analyze

Once all measures are selected and ranked, complementarity factors and efficiencies set as desired, the user can finally analyze the cumulative effects of combined measures as a policy scenario.

The process results in one set of diversion parameters for all waste streams, sectors and years. This data may then be exported (see below), for quantitative analysis, *View*ing and *Print*ing.

Analyze may be interrupted by pressing the escape key (<esc>). The routine will ask if the user really wants to abort, or continue *Analyzing* where the program left off (ie. prior to the <esc> press).

4. Utilities

Several options are provided under *Utilities*.

Maintenance

The ability to delete measures from the list of eighteen measures available for analysis is provided through the *Maintenance* routine. Since a maximum of eighteen measures is allowed, users may want to substitute or replace some measures.

In order to update a given measure, it is necessary to first edit the parameters through the **POLICIES** program (and extract the file to disk), delete it from **OPTIONS** and then import it again. Importing measures is discussed below.

Formulae

There are a number of ways in which the substitutional/complementarity effects of measures may be considered. As users may have their own views about this, the ability to change the method is provided here.

Four formulae are provided: each treats complementary measures differently. The four options are presented under *Utilities/Formulae* with a short description (Table VIII). The model is provided with option number three, *Substitutes with remainder complements* as the default, as this seems the most rational. The user selects the number corresponding to the preferred evaluation formulae.

Table VIII

Evaluation formulae options — waste management policy model

```
MENU
1.  2.   3.   4.  Help  Return
Set to 'Substitutes with remainder complements.'
       AP       AQ       AR       AS       AT       AU       AV       AW       AX
81  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
82  *                                                                         *
83  *                ----------------------------------------                 *
84  *                         Evaluation Formulae.                            *
85  *                ----------------------------------------                 *
86  *                                                                         *
87  *       Available methods for evaluating policy effects:                  *
88  *                                                                         *
89  *   1.   @if(@tri  Substitutes with remainder complements: eff-           *
90  *                  ectiveness of complementary policy reduced by          *
91  *                  diversion "so far".                                    *
92  *   2.   @if(@tri  Substitutes with perfect complements: each             *
93  *                  complementary policy is additive.                      *
94  *   3.   @if(@abs  Substitutes only: policies are never additive.         *
95  *   4.   LASTEFFE  Complements only: policy effects are additive.         *
96  *                                                                         *
97  *          Note:  Complementary Policy Factors are always                 *
98  *                 applied, regardless of formula chosen.                  *
99  *                                                                         *
100 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
OPTIONS.VHB                                   CMD        CALC
```

Table

The substitutional/complementarity aspects of measures is defined in *Table*. It is a symmetric table consisting of the letters "S" and "C", implying substitutes or complements, respectively.

Selecting *Utilities/Table* puts the user in a window where half of the factors may be edited (given the table's symmetry, the other half are determined automatically) (Table IX). In the WMPM the determination of the complement/substitute relationship between two measures was determined based on the following:

1) Do the measures affect the same sectors? If No...substitutes

2) Do the measures affect any of the same waste components? If No...substitutes

If Yes, is it only one waste component?

If No, is there one principal waste component that both measures affect? If No...Go to 4).

3) Do the measures affect the same portion of the one waste component? If No...complements

If Yes, is their *combined* effect additive? If Yes...complements
If No...substitutes

4) In general, do the measures affect the same portions of the waste components? If No...complements

If Yes, is their *combined* effect additive? If Yes...complements
If No...substitutes

The user may reset the complement/substitute relationship between two measures based on other criteria.

Table IX
Complements/substitutes matrix — waste management policy model

```
CY5: U [W3] "C                                      Select S/C, press <enter> when
done

       CU         CV    CW CX CY CZ DA DB DC DD DE DF DG DH DI DJ DK DL DM DN DO
3   Substitute-Complement Table - Symmetric, but not case-sensitive.
4                        0  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18
5   DEPOSIT SYSTEMS  1  S  C  S  C  S  S  S  C  S  S  S  S  S  S  S  S  S  S
6   EDUCATION PROGR  2  C  S  C  C  C  S  C  C  C  C  S  C  C  C  C  C  C  C
7   EXPANDED BLUE B  3  S  C  S  S  S  S  S  C  S  C  S  C  S  C  S  S  S  C
8   INCREASE MUNICI  4  C  C  S  S  S  S  S  S  S  C  S  C  S  S  S  S  S  C
9   INDUSTRIAL WAST  5  S  C  S  S  S  S  S  C  S  C  C  C  C  S  S  S  S  S
10  LANDFILL BANS    6  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S
11  LANDFILL TIPPIN  7  S  C  S  S  S  S  S  S  S  C  C  S  S  S  S  S  S  S
12  MANDATORY PROCE  8  C  C  C  S  C  S  S  S  C  S  S  S  S  S  S  S  S  S
13  MANDATORY SOURC  9  S  C  S  S  S  S  S  C  S  C  C  C  C  S  S  S  S  S
14  PACKAGING TAXES10  S  C  C  C  C  S  C  S  C  S  S  S  C  S  C  S  S  C
15  PRODUCT BANS   11  S  S  S  S  C  S  C  S  C  S  S  S  C  S  C  C  S  S
16  PRODUCT SPECIFI12  S  C  C  C  C  S  S  S  C  S  S  S  S  S  S  S  S  S
17  RECYCLED CONTEN13  S  C  S  S  C  S  S  S  C  C  C  S  S  S  S  S  S  S
18  SUBSIDISED HOME14  S  C  C  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S
19  USER CHARGES   15  S  C  S  S  S  S  S  S  S  C  C  S  S  S  S  S  S  S
20  VIRGIN MATERIAL16  S  C  S  S  S  S  S  S  S  S  C  S  S  S  S  S  S  S
21  YARD AND ORGANI17  S  C  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S  S
22  SUBSIDIES TO PR18  S  C  C  C  S  S  S  S  S  C  S  S  S  S  S  S  S  S
OPTIONS.VHB                                    CMD       CALC
```

5. Input-Output

All disk operations are handled by this sub-menu. The items are discussed individually below.

Extract

The *Analyzed* effects of combined measures may be extracted for two different purposes.

By selecting *Input-Output/Extract/Model* the results may be quantitatively examined in terms of tonnes of waste diverted, results *Viewed* and *Printed*. This menu option stores the extracted file in a sub-directory that only the **RESULTS** sub-program reads.

By selecting *Input-Output/Extract/Policies* the results may be imported into **POLICIES** for further editing, or brought back into **OPTIONS** as a single measure. Thus the user has the ability to analyze the effects of an unlimited number of measures. For example, eight measures could be selected, analyzed, extracted, and then imported as one measure.

In either case, the user is prompted for a measure name and description.

Import

Edited or combined measures can be brought into **OPTIONS** by using *Import*.

If a measure with the same name already exists, the *Import* will not be allowed.

After successfully *Import*ing a measure, the user is asked to modify the substitute/complement table to specify which policies the new one is a substitute or complement for.

Current

The ability to modify current trend in **POLICIES** and to import it into **OPTIONS** through *Current* is not provided in the present version of the model.

Save

The user may *Save* the current settings of **OPTIONS** if desired. This is especially necessary if the available measure list has been modified through *Input-Output/Import* or *Utilities/Maintenance*. All other settings can be recreated.

6. Link

Link returns the user to the starting menu of the model.

The user is warned if the link would cause the loss of modified data. That is, if changes are made and *Save* is not executed, then the program warns the user.

7. Quit

Quit permits the user to exit the **OPTIONS** sub-program.

D. RESULTS

Once measure groups have been *Analyze*d and *Extract*ed through the **OPTIONS** sub-program, the quantitative effect of diverting wastes can be examined in the **RESULTS** sub-program (Table X). The individual menu options are discussed below.

Table X
RESULTS sub-program — waste management policy model

```
AP1: \*
MENU
View  Import  Save  Link  Print  Extract  Compare  Quit
View summary of results.
            AP         AQ         AR        AS        AT        AU        AV        AW        AX
 1   * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 2   *                                                                         *
 3   *                 --------------------------------------                  *
 4   *                        POLICY RESULTS EVALUATOR                         *
 5   *                 --------------------------------------                  *
 6   *                                                                         *
 7   *                                                                         *
 8   *       This spreadsheet quantifies the diversion scenario                *
 9   *       calculated in OPTIONS. The costs and revenues resulting           *
 10  *       from the scenario are also estimated. Results may be              *
 11  *       viewed on-screen or dumped to the printer.                        *
 12  *                                                                         *
 13  *                                                                         *
 14  *                                                                         *
 15  *                            23 May 1991                                  *
 16  *                                                                         *
 17  *                                                                         *
 18  *                                                                         *
 19  *                                                                         *
 20  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 RESULTS.VHB                                      CMD        CALC
```

1. View

After *Importing* **OPTIONS** results (see below), **RESULTS** calculates the quantity of waste sent to each waste management option, in each sector, for all years (in tonnes). *View* provides two options: *Summary* results for the policy(s) or a *Comparison* of the results with the current trend or other policy results imported through the *Comparison* option (see below) (Table XI).

Since there are a great number of individual results (i.e., four waste management options for twenty-two waste types, in four sectors and two years), viewing the entire set was deemed too overwhelming a task for both the programmers, and the viewers. For detailed results, the user is asked to *Print* (see below).

Table XI

View option of summary and comparison results — waste management policy model

Summary results:

AP1: * Press F10 to Exit

	AD	AE	AF	AG	AH	AI
25	SCENARIO:	CURRENT TREND				
45			1987	1989	1992	2000
46	RECYCLING					
47	Received			583 082	1 182 123	2 103 055
48	Recycled			539 804	1 082 728	1 924 150
49	Incineration					
50	Solid Waste Management			43 278	99 396	178 905
51	Total Diversion			539 804	1 082 728	1 924 150
52	Percent Diversion		0	93%	92%	91%
53	SOLID WASTE MANAGEMENT					
54	Received for Disposal		9 075 379	8 798 736	8 596 742	8 349 975
55	Incineration					
56	Landfill		9 075 379	8 798 736	8 596 742	8 349 975
57	Sent to Recycling					
58	Percent Diversion		0	0	0	0
59	SUMMARY - ALL WASTE					
60	Total Waste Generated		9 075 379	9 409 200	9 824 245	10 681 000
61	Total Waste Diverted			610 464	1 227 503	2 331 024
62	Percent of Waste Diverte		0	6%	12%	22%
63	<pgdn> for more, <pgup> to review					

Comparison results:

AP1: * Press F10 to Exit

	BT	BU	BV	BW	BX	BY
25	COMPARISON:		CURRENT TREND	vs.	CURRENT TREND	
45			1992	2000	1992	2000
46	RECYCLING					
47	Received for Recycling		1 182 123	2 103 055	1 182 123	2 103 055
48	Recycled		1 082 728	1 924 150	1 082 728	1 924 150
49	Incineration					
50	Landfill		99 396	178 905	99 396	178 905
51	Total Diversion		1 082 728	1 924 150	1 082 728	1 924 150
52	Percent Diversion		92%	91%	92%	91%
53	SOLID WASTE MANAGEMENT					
54	Received for Disposal		8 596 742	8 349 975	8 596 742	8 349 975
55	Incineration					
56	Landfill		8 596 742	8 349 975	8 596 742	8 349 975
57	Sent to Recycling					
58	Percent Diversion		0	0%	0%	0
59	SUMMARY - ALL WASTE					
60	Total Waste Generated		9 824 245	10 681 000	9 824 245	10 681 000
61	Total Waste Diversion		1 227 503	2 331 024	1 227 503	2 331 024
62	Percent of Waste Diver		12%	22%	12%	22%
63	<pgdn> for more, <pgup> to review					

2. Import

The effects of individual or combined measures, analyzed by **OPTIONS** are *Import*ed through this menu option. This data is specified in percentages. **RESULTS** calculates the actual physical quantities of waste by waste type, sector and year.

Import permits the user to *View* and *Print* all individual and combined policy scenarios E*Xtract*ed from **OPTIONS**. The user either *Get*s the updated listing of possible policy scenarios or chooses from the list of policy options previously imported and *Save*d in the **RESULTS** sub-program (the user selects *Import\Don't*).

3. Save

There really is not much reason for the user to *Save* the **RESULTS** file. Since its primary functions are *Import*, *View*, and *Print*, these can be done quickly, over and over again. However, the *Save* option is provided since the user may want to *Import* now, and *Print* or *View* later.

4. Link

Link returns the user to the starting menu of the model. The user is warned if the link would cause the loss of modified data. That is, if changes are made and *Save* is not executed, then the program warns the user.

5. Print

Four *Print* options are provided in the WMPM and are discussed below. For each option, the user is asked if output should be directed directly to the printer or to a file.

All output is formatted by the *Lotus* add-in program *Allways*. The program assumes that *Allways* has been correctly configured for the printer available.

Diversions

Detailed tables of the raw percentages calculated by **OPTIONS** are printed. This takes the place of a print function in *OPTIONS*. The output is approximately two letter-size pages long.

Results

Detailed tables of the actual quantities going to each waste management option for each waste stream, sector, and year are printed. The output is approximately ten pages long.

Summary

This output is identical to the four screens shown by the *View* menu choice. It requires two pages to print.

Comparison

This output is identical to the four screens shown by the *View* menu *Comparison* option. It requires two pages to print.

6. Extract

Extract extracts the combined policies scenario *Import*ed into **RESULTS** to a disk file for *Comparison* with other WMPM **OPTIONS** policy analysis (see below). By selecting *Extract* the results may be quantitatively examined in terms of tonnes of waste diverted with other model results. This menu option stores the extracted file in a sub-directory that only the **RESULTS** sub-program reads.

7. Compare

The effects of combined measures, analyzed by **RESULTS** and *Extract*ed are imported through *Compare* for comparison with the *Import*ed policy results. Typically this is the current trend on which all policy scenarios are applied. However, the user may choose any *Extract*ed results for comparison.

The user *Import*s the policy *Extract*ed from **RESULTS** for comparison. The user either *Get*s the updated listing of possible *Extract*ed policy results or chooses from the list of policy results previously *Extract*ed and *Save*d in the **RESULTS** sub-program (the user selects *Compare\Don't*).

8. Quit

Quit permits the user to exit the **RESULTS** sub-program.

Appendix II. Description of the Economic Impact Model[3]

[3]This section is adapted from VHB Research and Consulting Inc. and Econometrics Research Ltd. 1991. *A socio-economic assessment of Ontario waste management initiatives*. Prepared for the Ontario Ministry of the Environment, Toronto.

A. Introduction

Three basic matrices define the structure of the traditional system: a "Make" matrix "V", a "Use" matrix "U", and a final demand matrix "F". The new adjusted system starts with these typical matrices and adjustments and changes are made to each one in a manner that preserves consistency across all the component parts.

The typical element of the Make matrix, $\{v_{ij}\}$ is the value of commodity i produced by industry j. Thus each industry may, and typically does, produce more than one commodity. The Make matrix V has as many rows as there are commodities, and as many columns as there are industries. The incorporation of the environmental perspective necessitates the reformulation of the traditional Make matrix in a way that allows the production of recyclables and the management of waste. The changes that follow from this will be detailed below.

The typical element of the Use matrix, $\{u_{ij}\}$, represents the value of commodity i used in production by industry j. Additional rows of the Use matrix are organized into a primary input matrix, "Y", whose typical element $\{y_{ij}\}$, represents the value of each primary input k used in industry j. The usual categories of primary inputs include : non - competitive imports, indirect taxes, labour income including benefits, net income of unincorporated business and other operating surplus.

The environment-economy linkages perspective introduces two basic changes to the structure of the U matrix. First, many new producible inputs will be alloted new rows. These are the recyclable products, and services provided by the waste management and environmental protection (EPI). Second, the primary input matrix will be expanded and reorganized to included the use of renewable and non-renewable resources extracted directly from the environment.

The final demand matrix, F, whose typical entry $\{f_{is}\}$, defines the deliveries of commodity i to final demand category s: consumption, investment, government expenditures, exports to other provinces, and exports to the rest of the world. The primary input rows of the final demand matrix, are grouped into a matrix YF, with typical elements, $\{yf_{ks}\}$.

Several adjustments are needed here to introduce the environmental linkages. First, households, institutions and government produce waste and recyclable products. Second, business investment is allowed to create capacity for future production. The environmental perspective is typically long term and the system is made dynamical by linking business investment to output increases.

The organization of these matrices before and after incorporating the environmental - economy linkages are presented in Figures 1 and 2 respectively.

Figure 1

Traditional I/O System

	Commodities	Industries	Final Demand	Row Total
Commodities		U	F	q + m
Industries	V			g
Primary Inputs		Y	Y_F	y_T
Column Total	q'	g'	F'^T	

The row totals, q, represent the total value of domestic production of each commodity and m represents the total value of imports of each commodity; the column totals, g, the value of gross output (value of sales) of each industry ; the totals, e_c, the total value of gwch primary input ; and the total f_w, the total value of each final demand category.

Figure 2

Adjusted Make Matrix (output)

	Industries	Waste Material Processing	C/S/T/P	Final Demand	Row Total
commodities	V_{ij}				q_i
Recycled Material		RM_{kl}			RM_k
Recyclable Waste	WM_{kj}			WM_s	WM_k
Collect/Sort/ Transport			CSTP		q_{cstp}
Column Total	g_j	g_l	g_{cstp}	WM_s	

A major departure from the traditional I/O system is the inclusion of the final demand sectors into the Make matrix. Here material households and institutions as well as industries produce waste. In addition recycled material and recyclable waste are distinguished from the rest of commodities. Also important is the prominent role given to waste management services and environmental protection industries.

Similar changes are required to adjust the Use matrix (input), as shown in Figure 3.

Figure 3

Adjusted Use Matrix

	Industries	Waste Material Processing	Waste Management	Final Demand	Row Total
Commodities	U_{ij}	U_{il}	U_{icstp}	F_{is}	q_i+m_i
Recycled Material	RM_{kj}				RM_k+m_k
Recycled Waste		WM_{kl}			WM_k + mw_k
C/S/T/P Services	$CSTP_j$	$CSTP_l$		CSTPs	q_{cstp}+m_{cstp}
Charges for Non-Renewable Inputs	RN_j	RN_l	RN_{cstp}	RN_s	RN_t
Value Added	VA_j^R	VA_l^R	$VA_{cstp}R$	VA_s^R	VA_T^R
Column Total	g_j	g_l	g_{cstp}	F_s	

The changes introduced alter in a substantive way the various accounting relationships governing the system. A full representation of these accounting relationships and the hypotheses of the model are given below.

B. The accounting identities

1) $\Sigma_j V_{ij} = q_i$

Commodity i is produced by many industries.

2) $\Sigma_l \ RM_{kl} = RM_k$

Recycled material k is produced by waste material processing and is used only by industries. It may be a substitute for virgin inputs.

3) $\Sigma_j \ WM_{kj} + \Sigma_f \ WM_{kf} = WM_k$

Waste material is produced by industries, households and institutions.

4) $CSTP = q_{cstp}$

Collection, sorting, transportation and environmental protection services are defined as a single specific and unique service.

5) $\Sigma_i \ V_{ij} + \Sigma_k \ WM_{kj} = g_j$

Industries produce commodities and waste products. Usually, waste products are valued at a zero price. If a zero price is assigned to them, only commodities are counted as outputs of industries.

6) $\Sigma_k \ RM_{kl} = g_l$

Recycled materials are produced by specific waste material processing industries.

7) $CSTP = g_{cstp}$

Waste management and environmental protection products and services add to the total output of this industry.

8) $\Sigma_k \ WM_{ks} = WM_s$

Waste generated by households and institutions is added together under final demand.

9) $\Sigma_j U_{ij} + \Sigma_l U_{il} + U_{i\,cstp} + \Sigma_s F_{is} = q_i + m_i$

This equation represents the commodity balance (Supply = Demand) for commodity i. Supply is made of domestic production (q_i) and imports (m_i). Demand comprises intermediate and final demands for commodity i.

10) $\Sigma_j RM_{kj} = RM_k + m_{rk}$

Recycled materials are delivered to industries. The total industrial demand is satisfied by domestic production and imports (m_{rk}).

11) $\Sigma_l WM_{kl} = WM_k + m_{wk}$

Recyclable waste materials are delivered to waste material processing industries. The total demand by the recycling industries is equal to production of recyclables plus net imports (m_{wk})

12) $\Sigma_j CSTP_j + \Sigma_l CSTP_l + \Sigma_s CSTP_s = q_{cstp} + m_{cstp}$

Waste management services and environmental protection services' demand by regular industries, recycling industries and final demand categories must equal available domestic production of these services plus imports (m_{cstp}).

13) $\Sigma_j RN_j + \Sigma_l RN_l + RN_{cstp} + \Sigma_s RN_s = RN_T$

The use and depletion of non-renewable resources is charged as a cost against output of each of the respective industries. Non-renewable resources are treated here as if they were non-competing imports. They are in a sense imported from the environment.

14) $\Sigma_j VA_j^R + \Sigma_l VA_l^R + VA_{cstp}^R + \Sigma_s VA_s = VA_T^R$

Value added is treated as the sum of factor payments that are left after paying for intermediate inputs and the charges for non-renewable resources.

15) $\Sigma_i U_{ij} + \Sigma_k RP_{kj} + CSTP_j + RN_j + VA_j^R = g_j$

The total value of inputs used to produce output j is equal to the value of that output. This follows from treating value added as a residual item.

16) $\Sigma_i U_{il} + \Sigma_k WM_{kl} + CSTP_l + RN_l + VA_l^R = g_l$

The output of waste material processing and cstp industries fully cost out.

17) $\Sigma_i U_{icstp} + NR_{cstp} + VA_{cstp}^R = g_{cstp}$

18) $\Sigma_i F_{is} + CSTP_s + NR_s + VA_s^R = F_s$

The above 18 identities depict in algebraic form the accounting structures in Figures 5.1. 5.2 and 5.3.

C. The hypotheses of the linkages model

In order to go from the accounting framework to a model of the economy it is necessary to make a number of simplifying assumptions. Traditionally, the most restrictive ones are in the area of fixed market shares and fixed input coefficients. The ease with which a linear system works compensates for the limited flexibility that fixed coefficients lend to the system. Furthermore, in this project, by allowing for some substitution among technologies, the restrictiveness of the assumption of fixed input coefficients is less stringent than in many other applications of input-output analysis. The following description of the model starts with a very simple system that is subsequently made more complex.

There is a logical order to the hypotheses of the model. The discussion begins with the Make matrix conditions. Next will be the hypotheses of the Use matrix to be followed by the Final Demand system.

1. The market structure

19) $V_{ij} = d_{ij}\, q_i$

Where d_{ij}'s represent the fixed market share of industry j in the production of commodity i. This assumption, together with the Industry Output identity (5), implies that industry gross outputs can be calculated from commodity output assuming, for convenience, that waste products are assigned a zero price. We have :

20) $g_j = \Sigma_i\, V_{ij} = \Sigma_i\, d_{ij}\, q_i$

Thus the vector of industry gross outputs {g}, is related to the vector of commodity outputs {q}, by the following matrix equation:

21) $\{g\} = [D]\ \{q\}$

Where { } indicates a column vector and [ ] indicates a matrix of coefficients.

Equation (21) indicates that the fixed market share assumption implies that the production of the j^{th} (multi-product) industry is a weighted sum of the commodity outputs which it produces, where the weights are the coefficients d_{ij}. These weights sum to one across industries. Since $q_i = \Sigma_j V_{ij} = \Sigma_j d_{ij} q_i$, it follows that:

22) $\Sigma_j d_{ij} = 1$ for i=1,2,3,....,n.

Waste generation by type of waste or pollutant k is linked to employment in industry j. But since employment is linked by fixed employment-output coefficients, we establish a direct and fixed link to industry gross outputs g_j by equation 23 below:

23) $WM_{kj} = w_{kj} g_j$

Where w_{kj} are waste (pollutants) of type k measured by physical units per $1000 of industry j output. w_{kj} could be ONP tonnes or litres or CFCF per $1000 worth of output of industry j.

Waste and pollutants are also generated by households and the institutional sectors. This type of waste generation is related to Final Demand categories directly.

24) $WM_{ks} = w_{ks} F_s$

Finally,

25) $RM_{kl} = r_{kl} RM_k$

Equation (25) establishes a market share for recycling industry l in the production of the k^{th} recycled material.

2. The industry-production function hypotheses

The production function underlying most of the production processes of the system is assumed to be of the fixed proportion type (generally known as a Leontieff production function).

26) $g_i = \underset{i}{\text{Min}}\, [U_{ij}/b_{ij}]$ for i=1,2,...,n.
j=1,2,...,m.

Where $b_{ij} = U_{ij}/g_j$ is the amount of commodity i needed to produce one unit of output j. Thus, the use of each commodity is assumed to be a fixed proportion of industry gross output:

27) $U_{ij} = b_{ij}\, g_j$

Therefore, the following sets of equations hold:

28) $RM_{kj} = r_{kj}\, g_j$

29) $CSTP_j = cstp_j\, g_j$

30) $RN_j = rn_j\, g_j$

31) $VA_j^R = v_j\, g_j$

32) $U_{il} = b_{il}\, g_l$

33) $WM_{kl} = b_{kl}\, g_l$

34) $CSTP_l = cstp_l\, g_l$

35) $RN_l = rn_l \, g_l$

36) $VA_l = v_l \, g_l$

3. The final demand system

Final Demand categories include consumption, investment, government expenditures, exports and imports. Some are endogenously determined by being related to other components of the system, while some are purely exogenous to the system. In this model we treat consumption, investment and imports as endogenous variables.

When consumption is related to income, the household sector becomes a sort of producing sector whose output can be solved within the production system. Let

37) $F_c = \beta Y$

Where F_c is total consumption, β is the long-run Marginal Propensity to Consume, and Y is income.

Income is defined as the sum of Labour Income, W, and Net Income of Unincorporated Business, UIC. Thus, income is related to gross industry output by the vectors of primary input coefficients (components of value added) w and e.

38) $Y = \Sigma_j (w_j + e_j) \, g_j + \Sigma_l (w_l + e_l) \, g_l + (w_{cstp} + e_{cstp}) \, g_{cstp} + (w_c + e_c)F_c + W^f$

Where W_f is the sum of Labour income associated with all final demand categories except consumption and competitive imports.

The integration of consumption into the model is completed by assuming that the values of commodities and primary inputs that enter into consumption expenditures are fixed proportions of the total value of consumption.

39) $Fc_i = c_i F_c$

or, in matrix-vector notation:

$$\{F_c\} = \{c\} F_c$$

Where c_i is the proportion of consumption used to purchase commodity i and $\{c\}$ is the column vector of c_i's. Also,

40) $W_c = (w_c + e_c) F_c$

Where w_c is the proportion of the total value of consumption spent on Labour, and e_c is the proportion of the total value of consumption which generates net income of unincorporated business.

The income concept defined in (37) does not include dividends and government and private transfers and may, therefore, not accurately represent personnal income. On the other hand, the inclusion of dividends, government transfers and private transfers would require information on the distribution of dividends and transfers between Ontario, the other provinces, and abroad. This information is not available.

Investment plays a dual role in the model. On the one hand, it is part of the current demand for output. On the other hand, it builds the capital stock of the economy and, therefore, increases the capacity of the economy to produce future output.

41) $FI_t = k \Delta g + \tau K_t$

Where FI_t is total investment in year t, k is the capital-output ratio, τ is the fraction of capital that depreciates within a year and Δg is the change in the total gross output of the economy and K_t is the capital stock in year t.

Equation (41) can be rewritten as:

42) $FI_t = kg_t - kg_{t-1} + \tau K_t$

But in the input-output system there is a column vector of investment deliveries by commodity. To relate this vector of deliveries to investment by commodity to the activity of building capacity by industry, a distribution matrix [S] is required where the typical element, s_{ij}, is the deliveries of commodity i to build capacity in industry j per unit of output of industry j.

43) $FI_{it} = \Sigma_j[k_j\ s_{ij}\ g_{jt} - k_j\ s_{ij}\ g_{jt-1} + \tau_{ij}\ K_{jt}]$

In matrix-vector notation:

44) $\{FI_t\} = [\hat{k}]\ [S]\ \{\Delta g_j\} + [\tau]\ \{K_t\}$

There are two types of imports in the model, competitive and non-competitive. Competitive imports which make up the major portion, are imports for which there exists domestically produced counterparts. Non-competitive imports have no corresponding domestic production.

Competitive imports are assumed to be a constant fraction of total industry and Final Demand use (exclusive of imports) for each commodity.

45) $MC_i = m_i\ [\Sigma_j\ b_{ij}\ g_j + \Sigma_l\ b_{il}g_l + b_{icstp}\ g_{cstp} + \Sigma_j[k_j\ s_{ij}\ g_{jt} - k_j\ s_{ij}\ g_{jt-1} + \tau_{ij}\ K_{jt}] + c_i\beta y + F_{io}]$

Where m_i is the fraction of total domestic use of commodity i supplied by imports, and F_{oi} is the final demand use of commodity i exclusive of imports. In matrix-vector notation, 45 becomes:

46) $\{mc\} = [\hat{m}] \, [\, [B_J] \, \{g_J\} + [B_L]\{g_l\} + b_{cstp} g_{cstp} + [\hat{k}][S]\{\Delta g_j\} + [\Gamma]\{K\} + \{F^o\}$

Where $\hat{m}$ is a diagonal matrix of m_i values.

Non-competitive imports by industry are related to industry outputs and are added to non-competitive imports to calculate total non-competitive imports,(MNC).

47) $MNC = \langle mnc \rangle \, \{g\} + MNC_F$

Where $MNC_F = \Sigma_s \, MNC_s$.

Total imports are the sum of competitive and non-competitive imports.

D. The full model

Combining the equations above reduces the system to a small subset of equations.

From the Use and Final Demand systems and substituting the various assumptions made above in the relevant places, we have:

48) $(1-m_i)(\Sigma_j \, b_{ij} \, g_j + \Sigma_l \, b_{il} \, g_l + b_{i\,cstp} \, g_{cstp} + \Sigma_i \, c_i \, \beta Y + \Sigma_j \, (k_j \, s_{ij} \, g_{jt} - k_j \, s_{ij} \, g_{jt-1} + \tau_{ij} \, K_{jt}) + f_i^o) = q_i$

49) $\Sigma_j \, r_{kj} \, g_j = RM_k + m_{rk}$

50) $\Sigma_l\, b_{kl}\, g^l = WM_k + m_{wk}$

51) $\Sigma_j\, cstp_j\, g_j + \Sigma_l\, cstp_l\, g_l + \Sigma_s\, cstp_s\, F_s = q_{cstp} + m_{cstp}$

From the Make matrix the following are obtained:

52) $\Sigma_i\, d_{ij}\, q_i + \Sigma_k\, w_{kj}\, g_j = g_j$

53) $\Sigma_k\, r_{kl}\, RM_k = g_l$

54) $\Sigma_j\, w_{kj}\, g_j + \Sigma_s\, w_{ks}\, F_s = WM_k$

55) $q_{cstp} = g_{cstp}$

E. Solving the model's equations

Let $G_J = \{g_j\}$, $G_L = \{g^l\}$, $F_S = \{f_s\}$

$Q = \{q_i\}$, $RP = \{RP_k\}$, $WM = \{WM_k\}$

$B_J = [b_{ij}]$, $B_L = [b_{il}]$, $B_{cstp} = [b_{icstp}]$

$F = [f_{is}]$, $R_k = \{r_k\}$, $B_{KL} = [b_{kl}]$

$CSTP_J = \{cstp_j\}$, $CSTP_L = \{cstp_l\}$

$CSTP_F = \{cstp_f\}$, $W = [wk_j]$, $W_F = [w_{kf}]$

56) $[I-\hat{m}]([B_J]\{g_j\} + [B_L]\{g_l\} + [B_{CSTP}]\{g_{cstp}\} + \{c\}\beta Y + \hat{k}][S]\{\Delta g_j\} + [\tau]\{K\} + \{F^o\} = \{q\}$

57) $[R]\{g_j\} = \{RM_k\} + \{m_{rk}\}$

58) $[B_L]\{g_l\} = \{WM_l\} + \{mw_k\}$

59) $<cstp_j> \{q_j\} + <cstp_l> \{g_l\} + <cstp_f> \{f_s\} = q_{cstp} + m_{cstp} = g_{cstp} + m_{cstp}$

60) $[D]\ \{q\} + [w]'\ \{g_j\} = \{g_j\}$

61) $[R]'\ \{RM_k\} = \{g_l\}$

62) $[W]\ \{g_j\} + [W_f]\ \{f_s\} = \{WM_k\}$

From (60):

63) $[D]\{q\} = [I-[W]']\{g_j\}$

Multiplying (56) by [D]:

64) $[I-\hat{m}]([D][B_j]\{g_j\} + [D][B_L]\{g_l\} + [D][B_{cstp}]\{g_{cstp}\} + [D]\{C\}BY + [\hat{k}][D][S]\{g_{jt}-g_{jt-1}\} + [D][\Gamma]\{K\} + [D]\{F\} = [D]\{q\}) = [I-[w]']\{g_j\}$

Reorganizing (64) and collecting terms:

65) $[I-\hat{m}]([[D][B_J]\ +[\hat{k}][D][S]\ -\ [I-[W]']\ ]\{g_j\}\ +\ [D][B_L]\{g_l\}\ +\ [D][B_{CSTP}]\{g_{cstp}\}\ + [D]\{C\}BY) = -[D][F] - [D][\Gamma]\{K\} + [\hat{k}][D][S]\{g_{Jt-1}\}$

65') $[[[I-\hat{m}]\ [\ [D][B_J]\ ]\ + [\hat{k}][D][S]\ -\ [I-[w']]\ ]\{g_j\}\ +\ [D][B_L]\{g_l\}\ +\ [D][B_{CSTP}]\{g_{cstp}\}\ + [D]\{C\}BY = [\hat{k}][D]\{f_o\} - [D]\{\not{f}\} - [D][\Gamma][k]$

Representing the simultaneous system of equations above in matrix-vector notation, we have:

$$
\begin{bmatrix}
[A_1] & (I-\hat{m})[DB_L] & (I-\hat{m})[DB_{CSTP}] & 0 & 0 & (I-\hat{m})D\{C\}\beta \\
[R] & 0 & 0 & 0 & -I & 0 \\
[O] & [B_L] & 0 & 0 & -I & 0 \\
\langle cstp_j \rangle & \langle cstp_l \rangle & -I & 0 & 0 & 0 \\
[W] & 0 & 0 & 0 & -I & 0 \\
\langle w_j+e_j \rangle & \langle w_l+e_l \rangle & \langle w_{cstp}+e_{cstp} \rangle & 0 & 0 & -I
\end{bmatrix}
\begin{bmatrix}
g_j \\ g_l \\ g_{cstp} \\ RP_k \\ WM_k \\ Y
\end{bmatrix}
=
\begin{bmatrix}
\Phi_1 \\ \Phi_2 \\ \Phi_3 \\ \Phi_4 \\ \Phi_5 \\ 0
\end{bmatrix}
$$

Where:

$$[A_1] = [\ [I-\hat{m}]\ [\ [D][B_J]\ ] + [\hat{k}][D][S] - [I-[W]']\ ]$$

$$\Phi_1 = -(I-\hat{m})\ [\ [D]\{F\} - [D][\Gamma]\{K\} + [\hat{k}][D][S]\{g_{jt-1}\}\ ]$$

$$\Phi_3 = \{\mathbf{m}w_k\}$$

$$\Phi_4 = -\langle cstp_f \rangle \{\not{f}\} + \mathbf{m}_{cstp}$$

$$\Phi_5 = -[W_f]\{\not{f}\}.$$