Pollution Prevention in Corporate Strategy
NATIONAL POLLUTION PREVENTION CENTER FOR HIGHER EDUCATION

3M: Waste Minimization

William Lanen, Associate Professor of Accounting
School of Business Administration, University of Michigan

The company wants us to be environmentally responsible and we've got a lot of really good support from people. When you design a product, you've got to bring in the environmental issues as early as possible - in manufacturing, reducing the environmental impact is going to cost you a lot more money so think about it as early as you can. What we want is for the environment to be a part of everybody's job. Everybody has to do pollution prevention.
Tom Zosel, Manager
Pollution Prevention Programs
Environmental Technology and Services (ET&S)

Organization

3M produces over 60,000 products in countries around the globe. The company has three sectors in addition to its international operations: Industrial and Consumer Sector; Information, Imaging and Electronic Sector; and Life Sciences Sector. See **Exhibit 1** for an organization chart of the Corporation. The Industrial and Consumer Sector is composed of three groups: the Automotive Systems Group; the Abrasive, Chemical and Film Products Group; and the Tape Group. See **Exhibit 2** for an organization chart of the Industrial and Consumer Sector. The Tape Manufacturing Division is part of the Tape Group and is responsible for the manufacturing activities of that Group. Plants in the Tape Manufacturing Division produce products for all divisions in the Tape Group, as well as some products for certain Divisions in other groups, and in some case, other sectors.

Environmental Programs At 3M

The late 1960's and early 1970's was a period of increasing environmental regulation and legislation. Looking into the future, managers at 3M were concerned that these laws and regulations would affect the Corporation's competitiveness. As a result, 3M managers, in 1975, developed their first comprehensive environmental policy. This policy, which remains unchanged as of 1994, directs 3M employees to:

- Solve our own environmental and conservation problems;
- Prevent pollution at the source whenever possible;
- Develop products that have a minimal effect on the environment;
- Conserve natural resources through reclamation and other methods;
- Assure that our facilities and products meet and sustain the regulations of all federal, state, and local environmental agencies;
- Assist government agencies and other official organizations engaged in environmental activities.

Also in 1975, 3M initiated a company-wide pollution prevention program. This program, designated "3P" ("Pollution Prevention Pays"), directs 3M employees to take actions to prevent pollution and solve the corporation's environmental and conservation problems. The goal is to change thinking at 3M from "end-of-the-pipe" controls and treatment of pollution to reduction of pollution at the source. The 3P program is a voluntary program that relies on submittals by employees that identify areas for both environmental benefits and cost savings. Environmental benefits and savings are calculated for the first year of a successful 3P program only and the cost savings include both costs avoided and the

value of sales retained as a result of efforts for customers. Examples of 3P projects include the reformulation of adhesives to improve product yield and implementation of improved inventory procedures to reduce spoilage. The success of the 3P program can be measured by the 600,000 tons of pollution prevented and the cost savings of $700 million achieved since the program was introduced [**Exhibit 3**].

One effect of the 3P program is that pollution prevention has become part of the corporate culture at 3M. As a result, the company has shifted toward a more comprehensive program to minimize the environmental impact of its products, facilities, and operations. The 3P Plus program was developed to provide a structure and goals for the voluntary pollution reduction programs at 3M. The 3P Plus program includes many individual programs.

One of these programs is part of a corporate manufacturing performance improvement program. The corporate program, termed *Challenge '95*, establishes goals for improved cycle times and reduced unit costs at 3M plants. In addition to these traditional objectives, *Challenge '95* includes, as a part of the overall environmental program, both a waste minimization component and an energy reduction component. *Challenge '95* is based on goals to be met by 1995 for each of the performance areas. For example, the five year goal for waste minimization is a 35% reduction in waste generated compared to 1990 levels. This goal is based, in part, on the experience from the 3P program. As Tom Zosel explained:

> It was somewhat arbitrary — how we originally set goals. We set the year 2000 goals first and what we did there was we figured through the 3P program that we had reduced waste about 50% in the first 15 years of the program. From 1975 to 1990 waste was down about 50%. We figured if we could do 50% reduction on a voluntary program in 15 years, we could put a little pressure behind it and set goals that we should be able to meet; that in ten years we could reduce waste another 50%.

Based on existing projects and the experience from the 3P program, a reduction goal was set of 35% over five years.

Planning for *Challenge '95* began in 1990. As explained by Ernie McFadden, Manufacturing Services Administrator, Corporate Quality and Manufacturing Services (CQ&MS),

> A Corporate Operations Committee came up with several considerations for the program. Ultimately, these were weeded down to four [cycle time, unit cost, energy and waste].

As with all performance measurement programs, a major issue is the development of the measure itself. McFadden went on to note that:

> With waste, we initially considered input vs. output with the difference being waste but it was too difficult to measure inputs. Further, the measurement had to be reasonably accurate; what is important is knowing what, and how much, is going where to understand what to reduce next.

Waste Minimization Under *Challenge '95*

Although waste minimization is only one part of *Challenge '95*, it is clearly an important component of the environmental policy of 3M. However, the various goals of *Challenge '95* cannot be viewed as independent. In fact, 3M views the goal of waste minimization as consistent with the goal of cost reduction. This follows from projections of disposal costs and increased governmental regulations. Two key components of the program are the measurement of waste and reporting.

WASTE MEASUREMENT

The approach to waste minimization under *Challenge '95* is termed the "Total Output Approach" and is illustrated in **Exhibit 4** with the "double bubble." The program measures wastes leaving the inner bubble, the source. Thus, even though, for example, air waste (e.g., solvents) may be treated and, therefore, not result in emissions into the atmosphere, they are to be included as "waste" under the program and a target for reduction.

Two approaches were considered for the measurement of waste. The first, the "materials balance" approach is based on notions of "input-output" and treats wastes as the residuals. After a trial approach in three plants, this approach is generally used only for solvent waste because of the high costs of measuring the inputs in a consistent manner. The materials balance approach for solvents is illustrated in **Exhibit 5**.

The "total output approach," instead, measures the weight of outputs (including wastes) directly. A simple measure is then used to track waste minimization. This measure is:

$$\text{Waste Ratio (\%)} = \frac{\text{Waste (Pounds)}}{\text{Total Output (Pounds)}} \times 100$$

Total output is defined as the total weight of "Good Output" plus the total weight of "Waste." Good output consists of three components:

Finished Goods: Final products, shipped to customers, including packaging but excluding pallets and totes.

Semi-finished Goods: Products shipped to other 3M plants for further processing. (Semi-finished goods shipped to 3M plants overseas are considered Finished Goods.)

By-Product: Material that has a 'productive' secondary use. This includes material that can be resold, recycled, or reclaimed. (The use of material for fuel is not considered a by-product.)

Waste consists of five types: chemical waste, trash, organic (air and water waste), particulate air waste, and discharged water waste. Chemical wastes and trash are included at actual weights. Organic wastes weights are calculated by subtracting from volatile organics brought into the plant: liquid organics included in chemical wastes; volatile organics in final product; and net organics (consumed less created) used up in reactions. Both particulate air waste and discharged water waste can be disregarded if less than 5% (by weight) of total plant waste. To measure particulate air waste, the plant can use a materials balance approach or a baseline established by Environmental Technology & Services (ET&S) from historical data. A material balance approach can also be used for discharged water waste or the plant can use a 24 hour composite sample along with a flow rate to measure the waste. This does not include the weight of the water, only the chemicals in the water. **Exhibit 6** summarizes the computation method for each of the waste categories.

REPORTING ON WASTE MINIMIZATION

Reports for the waste minimization program are prepared at the plant level. Plants have the option of reporting monthly but, at a minimum, quarterly reports are due at the corporate office of Corporate Quality & Manufacturing Services (CQ&MS). Results on energy usage are also sent to CQ&MS while reports on cost and cycle time are sent to the Controller. In addition, reports are published annually by the plant and the division. **Exhibit 7** illustrates the basic flow of information. Two steps in the process are shown there. First, at the plant level, the individual plant information systems (e.g., PMCS, MM3000, and MDCS) are used along with information about shipments (for material that is not controlled by the plant materials control system) to develop the plant waste report. **Exhibit 8** illustrates a plant shipping log that is combined with information from the information systems in the plant to create the plant waste report (illustrated in **Exhibit 9**).

While reports are generated at the plant level, the waste minimization effort at 3M is monitored at the divisional level. As noted above, an individual plant may produce products for multiple divisions. The second step in the reporting process, shown in the lower half of Exhibit 7, is to break down results by division. These reports are combined at CQ&MS to provide the divisional reports. Plant reports are sent to CQ&MS by the end of the first month following the end of the quarter.

The role of CQ&MS in the process is strictly one of a clearinghouse of plant reports for the divisions. As noted by Ernie McFadden (CQ&MS):

> 3M manages the business at the division level. We only provide a report card function - projects and programs are monitored at the division level. Divisions, however, cannot change the reporting style. If they want the data more frequently, they must request it from the plants directly.

The reporting of waste, therefore, must include some allocation of the waste generated by a plant to the appropriate divisions. Several approaches to the allocation problem are possible. The preferred approach is the direct measurement of the waste at the plant. Such an approach may be feasible, for example, in a focused factory. However, most 3M factories provide multiple products to multiple divisions. In these cases, some indirect allocation approach will be needed. Among the allocation methods that have been suggested are:

Output: Allocate waste based on the division's share of output (not necessarily measured by weight).

Waste at the Product Level: There may be information on waste by product and this can be used to assign total waste to divisions.

MRP Explosion: Use the materials requirements (standard inputs) to determine, for example, the amount of solvents in various products.

Usage Reports: Base allocations on the usage of various materials (actual inputs) consumed by product using standard waste factors.

Special Studies: Periodic samples provide information for allocations.

Number of Employees: Used, for example, to allocate paper waste in certain locations.

Plants are free to select the method used and may use different methods for different materials. Whatever approach is chosen is supposed to satisfy two criteria: it should be "equitable" to all divisions involved; and it should be responsive to changes in both product mix and production technology. (As with all allocations, the method chosen may affect the reduction attributed to an individual division but does not affect the overall Corporate results.)

Challenge '95 At The Plant

The St. Paul Tape Plant is located near the site of the original 3M complex in St. Paul, Minnesota. The plant consists of several buildings, the first of which was built in 1938. The plant produces over 300 specialty tape products. These can include paper tapes, film tapes, foams, foil tapes, and a variety of other substrates. In 1990, a thermal oxidizer was built at the plant for disposing of the primary waste of the plant, which contains solvents of various types including toluene.

The basic process followed in the plant is illustrated in **Exhibit 10** (not all products go through all these processes). There are two primary steps: *solution compounding*, where the adhesive is manufactured; and *solution coating* where the adhesive is applied to a variety of backings to produce tape of various types.

Solution Compounding includes the following steps:

Milling: Rubber, which has been stored in a heated room to remove any moisture and also to prevent moisture contamination, is pressed and cut into sheets. In some cases, dyes are added for coloring.

Grinding: The rubber sheets are broken up into small "nuggets."

Dilution: The rubber is mixed in a large vessel with solvent and other additives until the rubber is dissolved.

In the Solution Coating process, the adhesive is applied to various backing materials depending on the particular type of tape.

The major waste point is in drying the solvent off the adhesive. In this case, the waste is delivered to the thermal oxidizer for disposal. Note that this is included in the waste computation since it occurs between the first and second "bubble" of Exhibit 4 although there are no discharges into the air or water. Compounding waste sometimes occurs if a batch is defective for some reason, for example, an incorrect mix of rubber and solvent. This would be put into drums and sent to the Cottage Grove Corporate Incinerator for disposal.

Challenge '95 represents the first formal program at the plant requiring regular reporting on waste reduction, but it is not the first time plant personnel have been concerned about waste. Plant personnel have participated in the 3P program and, as a part of that program, *eliminated* landfill from one of the plant buildings through a combination of recycling and using waste in power generation. In fact, as noted by Tom Kretovics, plant engineer and *Challenge '95* Coordinator at the plant,

> By doing the job and making improvements, the goals will be achieved. Projects are usually not done specifically for *Challenge '95*.

Corporate support for *Challenge '95* is viewed as helping the program. For example, Bil Lund, Environmental Engineering Specialist at the plant, says,

> Corporate goals have made *Challenge '95* more successful while making it less competitive. Also, a capital spending project marked *Challenge '95* will get closer evaluation—again, management interest is a source of encouragement.

At the same time, as noted by A. J. Cook, Plant Manager,

> The plant is focused on six critical areas, and only two of those issues are measured under *Challenge '95*. Corporate must allow the plant or business to be more flexible in identifying areas to improve.

Results

Some results of the waste minimization leg of *Challenge '95* are shown in **Exhibit 11**. There the improvement in the waste measure is reported for both the St. Paul

Tape Plant and all plants in the program. The results in Exhibit 11 suggest that substantial progress has been made in reducing the waste to output ratio at both the tape plant and across all plants. It is, however, too early to tell from these data whether the corporate goal of a 35% reduction in the waste ratio will be attained by 1995. Ernie McFadden notes that there may be a lag between the implementation of the program and its benefits,

> Some divisions use it to push for managing the business; improvements are paid for by divisions. We're just now starting to see major benefits because there is a three year lag time.

With respect to the *Challenge '95* goals, Bill Lund believes that,

> We may not reach the *Challenge '95* goals, but we will reduce cost and do what is right for the business.

The Future

Challenge '95 ends in 1995. At that time, 3M will face the problem of replacing it with a new five year performance program. Whether waste minimization continues to be a part of a formal program or not remains to be seen. Among the questions Tom Zosel and other managers at 3M face if there is a waste component in a follow-on program is the question of the definition of the waste measure and the details of its computation. Ernie McFadden points out that:

> Any waste less than 5% of the total was ignored (we wanted to figure out how to stop it, but we didn't want the plants to worry about measuring it). This needs to be looked at because there is a potential of 10% of waste being ignored.

Whatever decision is made about waste in the next program, 3M managers believe that waste will continue to be part of the decision making process, formally or not. Don Brosky, Pollution Prevention Specialist at ET&S, points out that, "There's always going to be something that we are going to have to treat." In any case, the 3P program continues as a voluntary program of waste reduction efforts. There is a difference in the two programs as noted by Dave Greener of the Tape Manufacturing Division:

> 3P doesn't have preset goals that need to be achieved; Challenge '95 forces plants to look ahead and plan.

As for future programs, he believes that,

> Because 3M is environmentally conscious, waste will be a factor in future programs. Our main goal should be to eliminate waste, not just reduce it.

Exhibit 1

3M CORPORATE ORGANIZATION

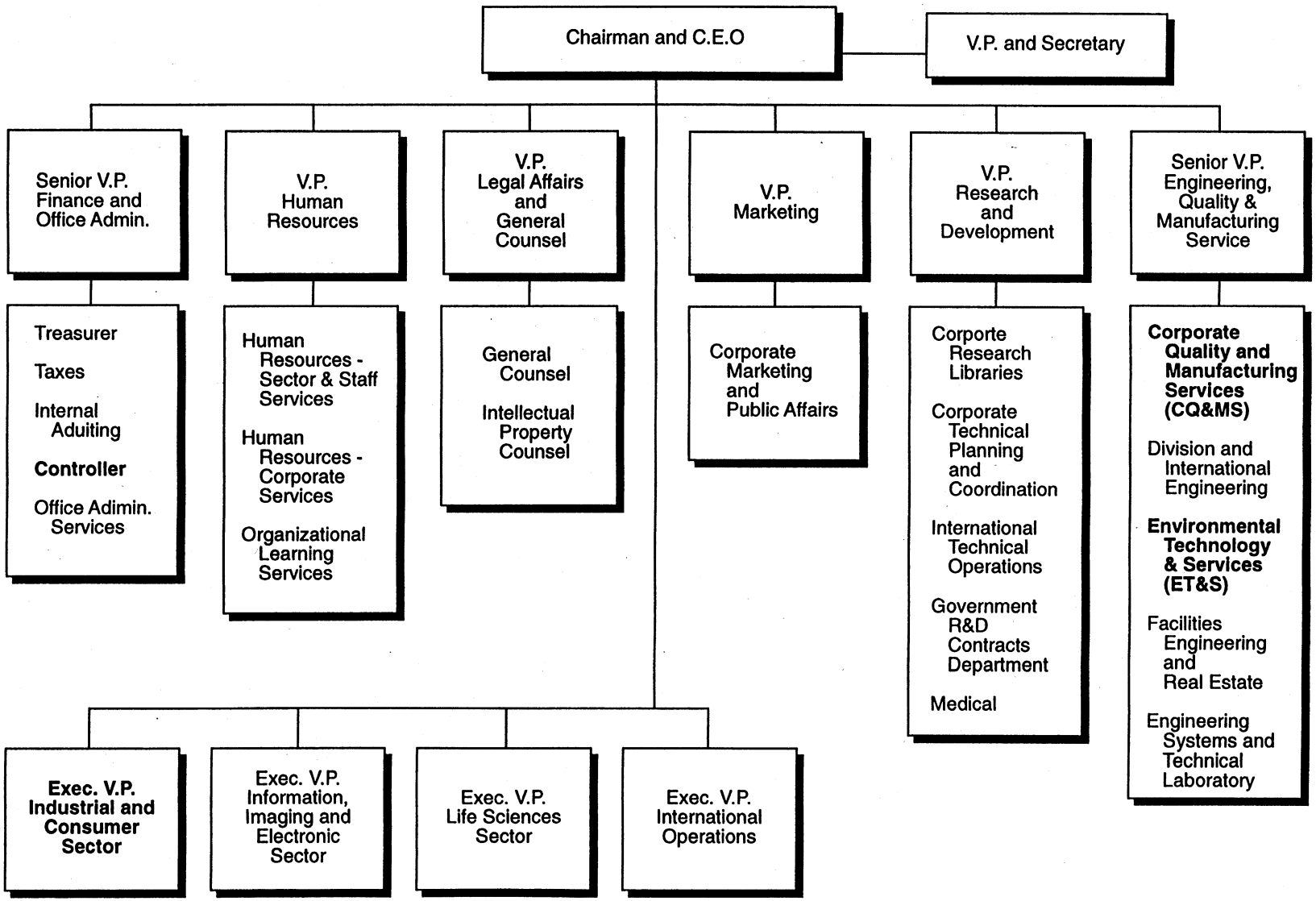


Exhibit 2

INDUSTRIAL AND CONSUMER SECTOR ORGANIZATION

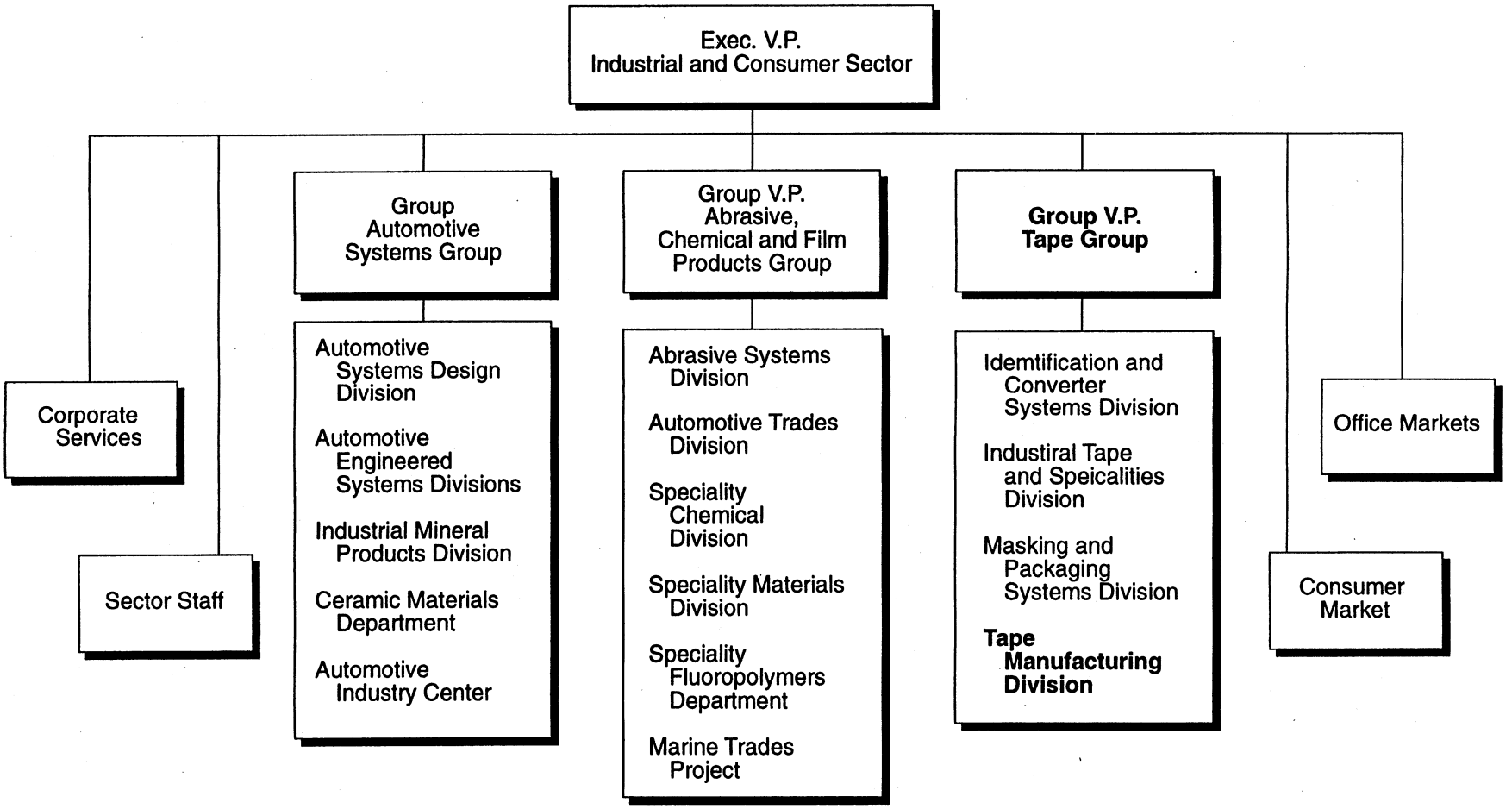


Exhibit 3

3P PROGRAM GOLBAL SAVINGS
CUMULATIVE "FIRST YEAR ONLY" SAVINGS
(MILLIONS OF DOLLARS)

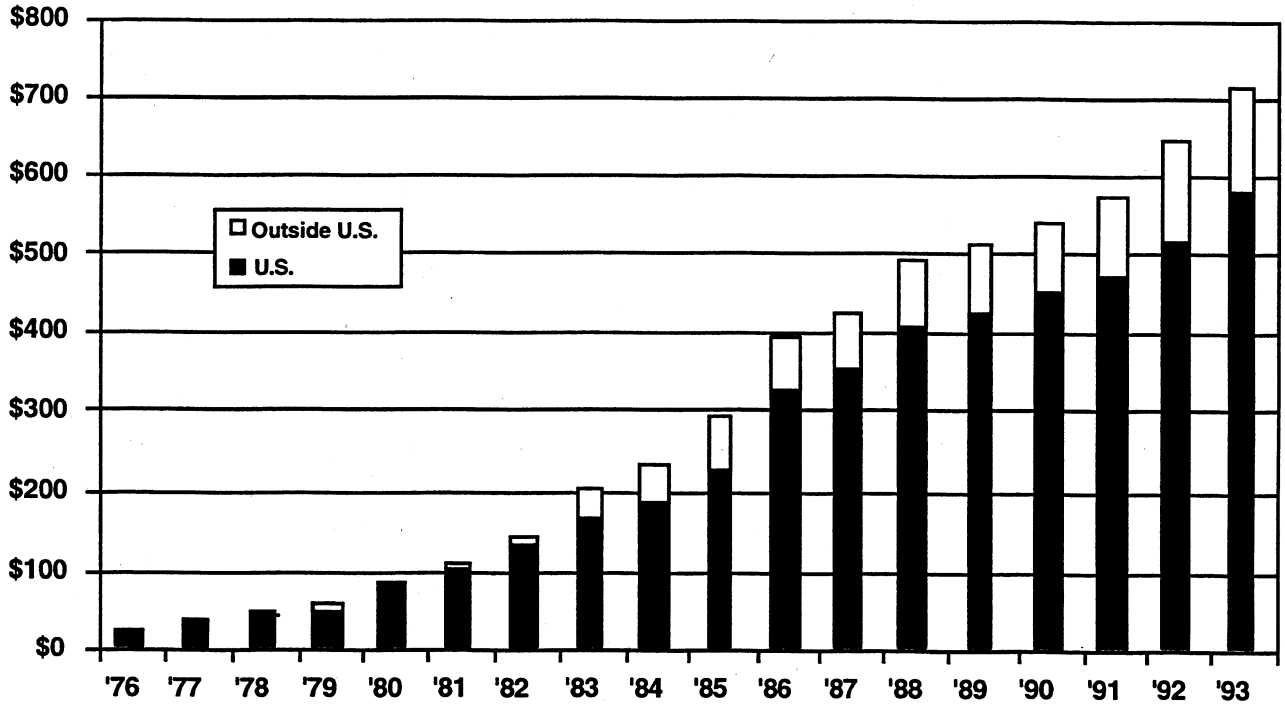
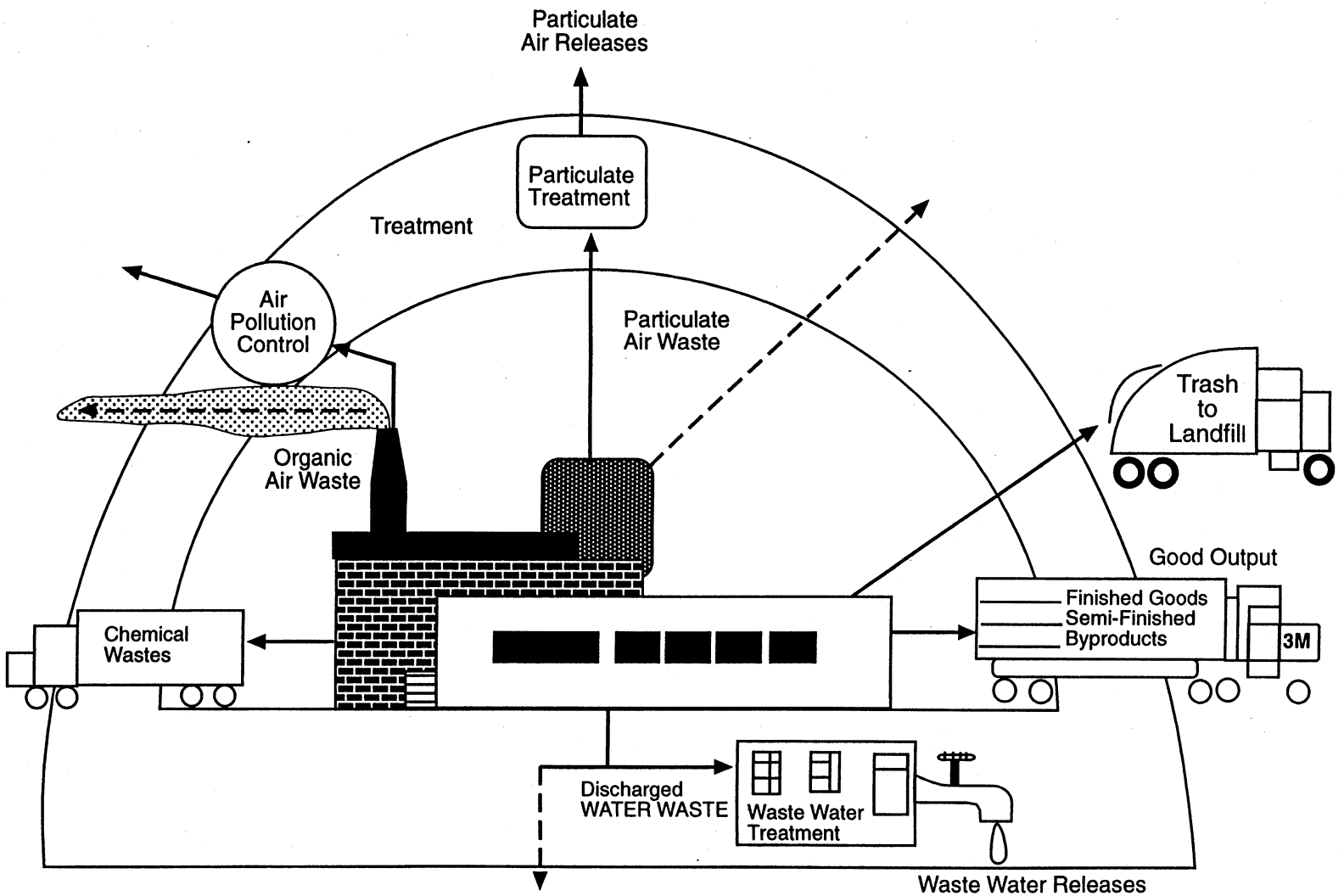


Exhibit 4

TOTAL OUTPUT APPROACH



From 3M *Chanllenge '95* Waste Minimization Guidebook (copied with permission)

Exhibit 5

AN ILLUSTRATION OF THE MATERIALS BALANCE APPROACH TO MEASURING SOLVENT WASTE†

Inputs

+ Beginning Inventory of Solvent

+ Receipts of Solvents

- Ending Inventory of Solvents

=Total Solvent Inputs

Outputs

-Solvents in Products

-Sold Solvent

- Solvent Sent to Waste Disposal (Wet Scrap)‡

= Waste

†Note that this calculation could be done for each of the many products and material inputs at each plant.
‡Treated as chemical waste.

Exhibit 6

HOW WASTE IS COMPUTED

Waste Category	Method of Computation
Trash	Included at actual weight
Chemical Waste	Included at actual weight
Particulate Air Waste	Materials balance approach or Baseline developed by ET&S
Discharged Water Waste	Materials Balance Approach or 24 hour composite sample with flow rate
Organic Wastes	Volatile Organics Brought Into plan less liquid organics included in chemical wastes less volatile organics in final products less net organics (consumed - created) used up in reactions

Exhibit 7

WASTE MINIMIZATION
OVERALL REPORTING FLOW

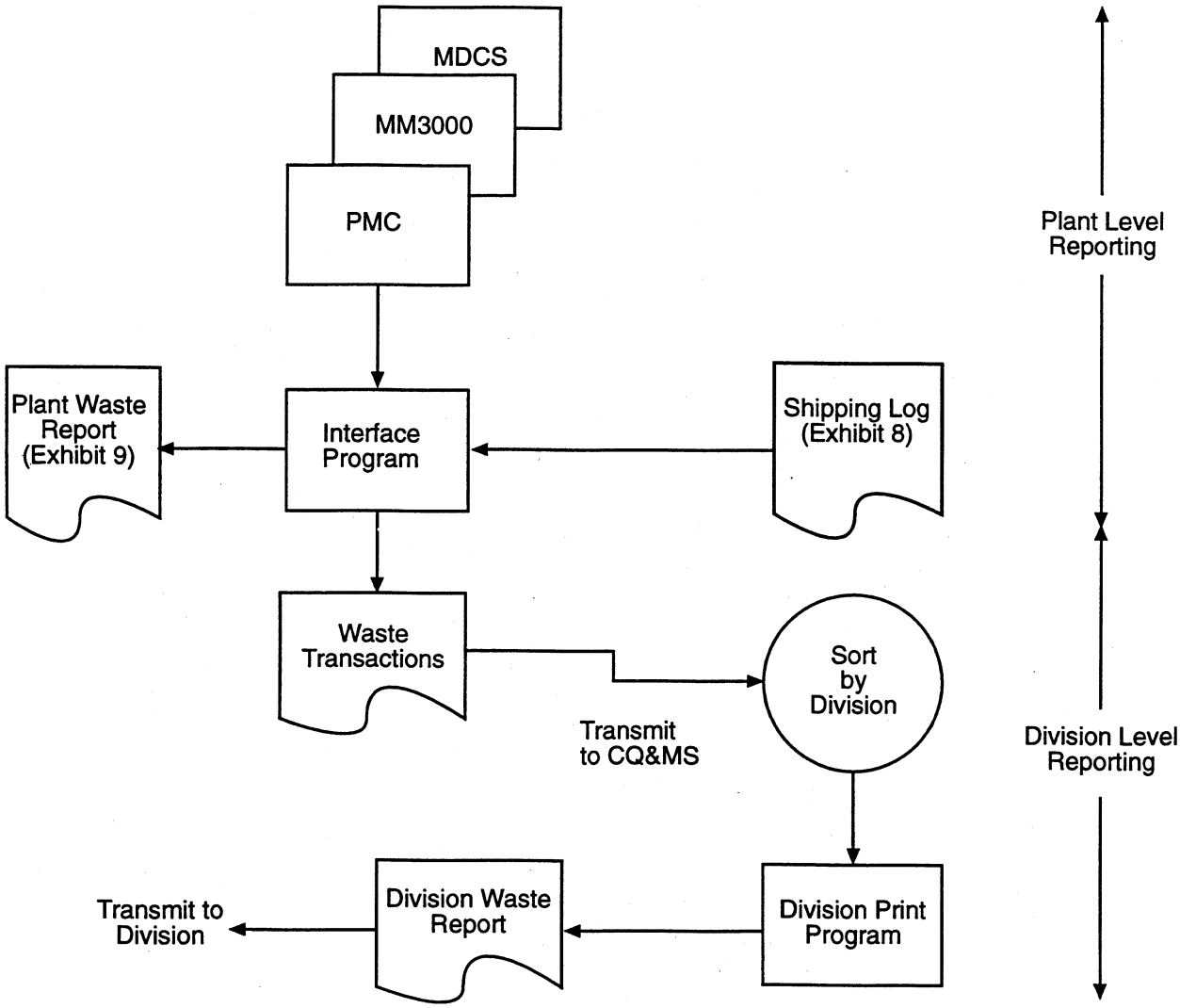


Exhibit 8

SAMPLE WASTE MINIMIZATION SHIPPING LOG

Date	Reference	Division	Material Type	Amount - Lbs	Initials
7/12/94	BL 345678	63	Semi-Finished	7,500	DML
	BL 456789	63	Finished Goods	8,900	SWA
	BL 567890	63	By-Product	2,500	DFL
	BL 678901	63	Waste (e.g., to incinerator)	1,500	TEF

(To be used when material is not controlled by any kind of plant materials control system.)

Exhibit 9

SAMPLE PLANT WASTE REPORT

Month	Plant	Division	Material	Amount - Pounds
July 1994	ABC	10	Semi-Finished	100
			Finished Goods	1,000
			By-Product	200
			Waste	300

Month	Plant	Division	Material	Amount - Pounds
July 1994	ABC	20	Semi-Finished	500
			Finished Goods	2,000
			By-Product	700
			Waste	500

Month	Plant	Division	Material	Amount - Pounds
July 1994	ABC	30	Semi-Finished	1,000
			Finished Goods	10,000
			By-Product	3,000
			Waste	6,000

Exhibit 10

SIMPLIFIED MANUFACTURING PROCESS AT THE ST. PAUL TAPE PLANT

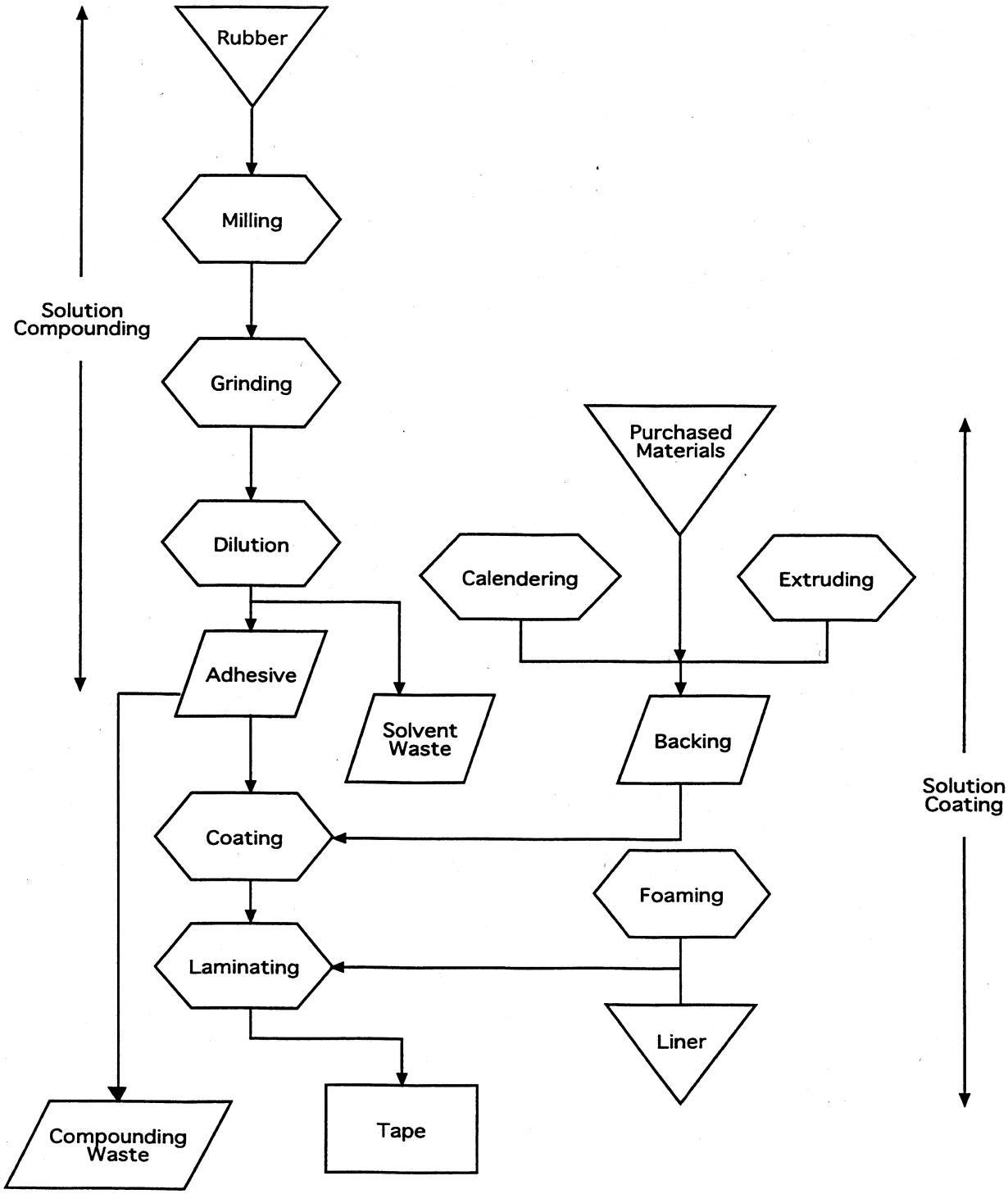
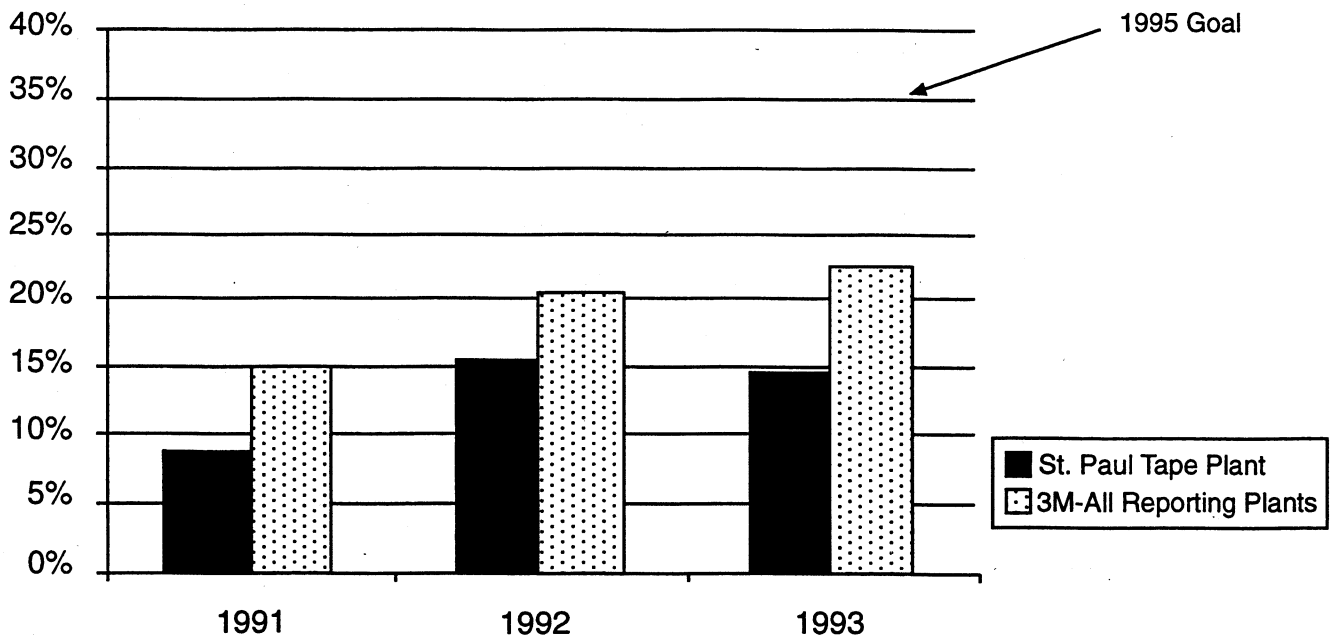


Exhibit 11

GAINS IN WASTE MINIMIZATION
(PERCENTAGE IMPROVEMENT RELATIVE TO 1990)



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The National Pollution Prevention Center for Higher Education
University of Michigan, Dana Building
430 East University Ave.
Ann Arbor, MI 48109-1115
• Phone: 313-764-1412
• Fax: 313-647-5841
• E-mail: nppc@umich.edu

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