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Pollution Prevention and Business Management: Curricula for Schools of Business and Public Health, Volume 2: Instructor's Manual

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Pollution Prevention and Business Management: Curricula for Schools of Business & Public Health Volume II

Instructor's Manual

by

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INTRODUCTION TO INSTRUCTOR'S MANUAL

This Instructor's Manual contains two sections. In the first section, answers and guidance are provided to the "Problems and Activities" presented in each Module. In the second section, overhead masters are provided for all figures in each of the Modules.

INTRODUCTION TO THE MODULES

These instructional modules are based on the premise that sustained economic development is dependent upon sustained protection of the environment. They also reflect the fact that preventing waste is far more cost effective than managing the waste once it is generated. Pollution prevention not only offers businesses a competitive opportunity, it is a natural extension of sound management practices. Incorporating pollution prevention into business management and government regulation will enhance longterm economic prosperity.

Pollution Prevention and Business Management is composed of three academic modules intended to supplement course material in schools of business and management, schools of public health with an emphasis in management and the environment, and schools of environmental studies with an emphasis in management. The modules are designed to be flexible. They may be used together, or independently. Though designed to meet the needs of graduate students, portions of the modules are appropriate for undergraduate instruction as well. Though intended to be read outside of class, and discussed in class, the modules offer many opportunities for outside and in-class activities, additional reading and research, and supplemental lecture. Most importantly, the modules are intended for participative learning. The problems and case studies which accompany each module are an integral part of the learning process, particularly if discussed in groups or by the class as a whole.

Module 1, Pollution Prevention and Business Competitiveness, is an introduction to pollution prevention and its value as a standard component of business management. It also clarifies how pollution prevention is a natural extension of sound management practice. Module 2, Pollution Prevention and Process Improvement, illustrates how waste generation is simply another form of process inefficiency, and presents methods for identifying and reducing such inefficiencies. Module 3, Pollution Prevention and the Business Manager, explores the multitude of ways in which the business manager is critical to the success of pollution prevention efforts, and how pollution prevention can be integrated into management strategy. Finally, the Supplemental Readings Booklet provides readings which complement material in the modules, as well as readings and case studies which form the basis for problems and activities at the end of each module.

The authors hope that these modules provide an interesting educational approach to pollution prevention. We would like to know about your experiences, impressions, and questions. Please feel free to contact us at 309/438-8329.

USING THE MODULES IN THE CLASSROOM: "*PROBLEMS AND ACTIVITIES*"

Each Module ends with a set of *Problems and Activities.* These are intended to integrate the material presented in the Modules and to develop the skills students will need to implement pollution prevention on the job. The *Problems and Activities*, along with the associated *Supplemental Readings Booklet* are an essential part of the learning experience.

Section 1 of this Instructor's Manual provides the objectives for each of the *Problems and Activities* as well as suggestions and answers, where appropriate. Many of the *Problems and Activities* have no single, correct answers. Teachers are encouraged to promote discussion about differences of opinion and to examine reasoning more than results.

SECTION 1

PROBLEMS AND ACTIVITIES

ANSWERS AND GUIDANCE

PROBLEMS AND ACTIVITIES FOR MODULE 1

1. *At the business where you work, or with the permission of a local business, examine the contents of one or more "dumpsters" for holding general refuse prior to pick-up by a waste disposal company. Classify the contents into the following two categories of waste:*

   - *Material produced directly by the business (paper waste generated by the company, scrap product, product packaging, scrap raw materials, etc.).*

   - *Material generated indirectly from business operations (packaging from inputs or raw materials, paper received from others but related to business operations, junk mail, etc.).*

Identify the economic impact on the company for each category of waste. Consider, at least, the following economic impacts:

A. Waste hauling and disposal cost.
B. Labor cost.
C. Cost of raw materials or other inputs.
D. Cost of product.
E. Regulatory compliance cost.
F. Potential liability.

(Note: if you have the opportunity, include wastes other than general refuse, including drums or tanks of waste, emissions to the air, or discharges to waterways or the sewer.)

OBJECTIVE: To familiarize the student with the variety of wastes generated by a business and to assess their economic impact.

SUGGESTIONS: This activity has been successfully employed by the University of Tennessee Center for Industrial Services as an initial pollution prevention practice. This exercise is most beneficial when performed by small groups. Encourage students to pursue all economic impacts on the firm, including the cost of packaging in raw material prices.

2. *Place each of the following activities on the Waste Management Hierarchy (Reduce, Reuse, Recycle, or Dispose). Identify the primary costs which could be reduced by adopting options one or two steps higher on the Hierarchy, and suggest what such options might involve. Be sure to consider employee health and safety, product safety, damage to the environment , and harm to public health through environmental exposures. (You are encouraged to use references from your library about the health and safety consequences of chemicals.)(Adapted from ref. 36)*

OBJECTIVE: For the student to recognize pollution prevention strategies, and the extent to which the firm's resources continue to be wasted. Remember, as you move up the hierarchy, you retain more of the firm's resources.

SUGGESTIONS: Encourage the students to assess the tangible and intangible benefits gained by an organization from each of the factors listed.

A. *Adding water to a sodium hydroxide waste stream before releasing it to the sewer in order to meet waste water discharge concentration requirements.*

Disposal. Costs include water purchased to dilute the waste stream, sewage discharge fees, and the value of lost sodium hydroxide. The discharge probably does not represent a large employee or environmental risk. An alternative might be to reuse the sodium hydroxide waste stream in the process, perhaps after some treatment.

B. *Burning up used motor oil in the company incinerator instead of sending the oil to a waste hauler.*

Disposal. Though this saves waste hauling cost and the potential long-term liability from environmental contamination after disposal, the company still incurs the significant cost of incineration, the potential liability from incinerator emissions, and the lost value of the oil. Item "C" below represents a step up the waste management hierarchy.

C. *Burning up used motor oil in the company boilers (for space heating) instead of sending the oil to a waste hauler.*

Recycling: This would capture some of the heat content of the oil and reduce fuel costs. It would also avoid landfilling or incineration However, the value of the oil is lost, and there may be environmental liability from emissions. One alternative is to send used oil out for reprocessing and purchase reprocessed oil at a reduced price.

D. *Replacing solvent cleaning agents with detergent and water cleaning operations to avoid the use of chlorinated organic solvents such as methylene chloride.*

Reduction (reduced solvent waste): This would reduce the cost of expensive organic solvents as well as the potential harm to workers, public health, and the environment (depletion of the ozone layer). However, the company still incurs costs for material cleaning. Possible improvements include making changes to reduce the need to clean the material. This would reduce all costs associated with cleaning.

E. *Using cadmium-based paint from one paint mixing tank in the formulation of the next batch of paint.*

Reuse: This reduces the cost of disposing of the waste paint (which may be legally hazardous), as well as the environmental and public health risks associated with disposal. The value of the cadmium is also retained. However, if reuse involves more handling of the waste, employee exposure risks may increase. An alternative is switching to a non-cadmium paint. This would eliminate disposal and liability costs from cadmium, but might require other costs to maintain quality.

F. *Sending used zinc electroplating bath fluids to a local commercial recycler instead of discharging to sewer.*

Recycling: This eliminates treatment and discharge costs as well a liabilities associated with disposal, and reduces the purchase of new bath fluids. However the cost of recycling is probably significant, and there may be employee and environmental liability associated with transporting the waste. An improvement may be process changes to extent the life of the bath fluids, thus reducing the volume of fluids to be recycled.

G. *Replacing the nozzle of high pressure paint applicators to better focus the chromium pigment paint spray stream.*

Reduce: This will place more paint on the product and less in the air. This reduces the purchase of paint, the cost of capturing and removing paint from the air, disposal of this captured paint, employee exposures, and environmental liability. An improvement may be to electrostatically attract the paint to the product, thereby further reducing overspray.

H. *Reformulating an adhesive to incorporate fewer toxic chemicals into the end product.*

Reduce: This reduces environmental and consumer liability associated with use of the product. Since the process involves fewer toxins, employee exposures and treatment/disposal costs are probably reduced as well. Improvements would include further reductions in the toxicity of product components.

3. *Use the Valley Paints, Inc. case in the Supplemental Readings Booklet for this role-playing activity (adapted from ref. 36). Divide the class into pairs of groups, with each group having three to five members. One group should take the role of management and the other should take the role of the pollution prevention planning group.*

   The pollution prevention planning group at Valley Paints has called an initial meeting with management to convince them that the company must commit to an integrated pollution prevention program and begin implementation of some pollution prevention options immediately. The management group is generally concerned about the environment but they are not convinced that a pollution prevention program is the answer. They are concerned about additional environmental regulation. The are also very concerned about the economic impact of implementing a pollution prevention program during a down economy.

   The management group should discuss their concerns about implementing the options listed in the case. The pollution prevention planning group should prepare a presentation that will convince management that a pollution prevention program can be implemented immediately with limited risk. Once prepared, the pollution prevention planning group will make their presentation to the management group and respond to any of management's concerns.

OBJECTIVE: To enable to the student to analyze and present the benefits and risks associated with a pollution prevention program.

SUGGESTIONS: The pollution prevention planning group may have difficulty with the technical nature of the process and waste management alternatives. They may also desire data on financial impacts. Encourage them to use their general knowledge of business and professional judgment to fill these gaps. Though this can be a bit frustrating for some students, it enhances their learning and critical thinking processes.

4. *Apollo Plastics is a mid-size manufacturing firm producing plastic housings for electronic equipment. Though they currently hold large contracts with several major electronics firms, contracts are up for bid approximately every two years and the bidding process is highly competitive in price, quality, and delivery. Apollo is privately owned by the company president, and has a relatively shallow management structure. Labor is non-union. The company adopted most of its production technology 15 years ago when it was formed and has made few changes since then, despite the recommendation of its design engineer.*

   Product is produced by heating a mixture of plastic resins, adding coloring and conditioning agents, and then molding the plastic into the appropriate shape. The product is then finished and packaged for delivery. In the last year, Jennifer Coffee, director of manufacturing, has become concerned about not only the cost of disposing of the large quantity of solid and liquid waste generated by the plant, but also the cost of complying with the many environmental, occupational, and transportation laws to which the plant is subject. Of particular concern are the hazardous materials used as plastic additives. In addition, several industrial customers have stated that they foresee a time in the near future when they will have to take back their electronic components from consumers at the end of the product's useful life and recycle the components. They want to know how Apollo will help make this possible. They have also expressed a desire to reduce packaging waste from Apollo.

   Jennifer is considering the value of a pollution prevention program at Apollo, but she has a number of questions. (A) What kinds of environment-related costs might Apollo be experiencing due to its current product design and operating practices? (B) What kinds of pollution prevention opportunities would most likely benefit Apollo? (C) In what ways would such opportunities enhance the competitive position of Apollo? (D) What barriers to adoption of pollution prevention measures is Apollo most likely to experience? Jennifer has asked for your advice in answering these questions. What would you tell her?

OBJECTIVE: To enable students to identify and explain the costs of waste generation, options for reducing waste, the competitive effects of these options, and the barriers to adopting these options.

SUGGESTIONS:

A. Cost examples:

- **Waste disposal, particularly for hazardous additives.**
- **Compliance costs, particularly paperwork.**
- **Lost value of materials in wastes**
- **Employee exposures and resulting liability and lost productivity**
- **Environmental liability from waste disposal.**

- **Potential lost sales from plastics which are not easily recyclable and from excess packaging waste.**

B. Examples of possible pollution prevention options:

- **Using less hazardous plastic additives or reformulating plastic to reduce need for additives.**
- **Improve process efficiency to reduce waste.**
- **Use of an alternative plastic formulation process to reduce waste.**
- **Reformulate plastics to improve recyclability.**
- **Redesign packaging to reduce waste.**

C. Examples of improved competitiveness:

- **Cost savings may be used to reduce price or improve the product and service.**
- **Higher recyclability may increase sales.**
- **Reduced packaging waste may increase sales.**
- **Enhanced environmental image may increase goodwill with customers, employees and community.**

D. Examples of barriers:

- **Owner resists technology improvements.**
- **Lack of qualified personnel to implement new technologies.**
- **Pressure on price, quality, and delivery increases the risks from process changes.**
- **Capital limitations in small businesses inhibit significant technology investments.**

5. *Holiday Printing, Inc. prints greeting cards, and is a subsidiary of a large greeting card company. It is located along the northern Atlantic coast. Holiday Printing is under considerable pressure from its parent company to cut costs and increase quality. The relatively large managerial sector at Holiday has been reduced 20% in the last three years, primarily through elimination and restructuring of middle management positions. The plant has been in operation since the 1920's and was a private printing business until purchased by the greeting card company in 1974. Labor has been unionized since 1956.*

   Holiday uses a gravure printing process, in which multiple colored inks are applied to card stock. Toluene, a volatile organic compound (VOC), is the primary solvent used to clean presses and other equipment. It evaporates rapidly, and because it is used on equipment throughout the plant, it would be difficult and expensive to capture and control emissions.

   Andrew Larson, plant manager for Holiday recently received a memo from the health and safety supervisor at the plant stating that the state environmental ***protection*** *agency will be doubling its air pollution permit fee and will be reducing the amount of VOCs that it will allow Holiday to emit into the air. This is because of tighter state and federal laws to control ozone concentrations in cities along the Atlantic coast. In addition, the laundry that receives Holiday's clean-up rags recently indicated that it cannot meet sewage discharge limits for toluene due to the toluene content of Holiday's rags. On top of this, a letter came last week from the marketing division of the parent company indicating that 35% of its potential customers are concerned about the environmental impact of greeting cards. In particular, these customers are looking for cards printed on recycled paper and paper that has not been*

chlorine-bleached. The parent company wants Holiday to use such paper for at least 50% of its product within three years without compromising quality.

Mr. Larson thinks that these developments may provide the opportunity to initiate a pollution prevention program at Holiday, but he has a number of questions. (A) What kinds of environment-related costs might Holiday be experiencing due to its current product design and operating practices? (B) What kinds of pollution prevention opportunities would most likely benefit Holiday? (C) In what ways would such opportunities enhance the competitive position of Holiday and its parent company? (D) What barriers to adoption of pollution prevention measures is Holiday most likely to experience? Mr. Larson has asked for your advice in answering these questions. What would you tell him? (For additional information on the printing industry, see the following article in the Supplemental Readings Booklet: Pferdehirt, W.P., "Roll the presses but hold the waste: pollution prevention and the printing industry," Pollution Prevention Review, Autumn, 1993)

(Note: you may wish to visit a greeting card display in a retail store. What proportion of cards are printed on recycled or non-chlorine-bleached paper? How do they use this product attribute to their competitive advantage?)

OBJECTIVE: To enable students to use the literature as a resource to identify and justify the costs of waste generation, options for reducing waste, the competitive effects of these options, and the barriers to adopting these options.

SUGGESTIONS:

A. Cost examples:
- **Waste disposal, particularly air pollution permit fees.**
- **Compliance costs, particularly paperwork.**
- **Lost value of materials in wastes.**
- **Cost of rag laundering.**
- **Employee exposures and resulting liability and lost productivity**
- **Environmental liability from toluene emissions and other wastes.**
- **Potential lost sales from use of virgin, chlorine bleached paper.**

B. Examples of possible pollution prevention options:
- **Centrifuge rags to remove (and reclaim) toluene.**
- **Improve process efficiency to reduce waste.**
- **Adopt improved cleaning and chemical storage methods to reduce toluene emissions.**
- **Use a less volatile and less hazardous cleaning solvent.**
- **Improve the printing process to reduce the need for cleaning.**
- **Switch to a recycled, non-chlorine bleached paper.**

C. Examples of improved competitiveness:
- **Cost savings may be used to reduce price or improve the product and service.**
- **Higher sales from use of recycled, non-chlorine bleached paper.**
- **Enhanced environmental image may increase goodwill with customers, employees and community.**

D. Examples of barriers:

- **Managers, particularly at the middle level, may be discouraged by personnel reductions and may resist change.**
- **Pressure to reduce costs quickly may inhibit investment in pollution prevention activities with medium or long-term payoffs.**
- **Union restrictions may inhibit changes in cleaning methods or personnel.**

PROBLEMS AND ACTIVITIES FOR MODULE 2

1. *Almost everyone has ridden in cars as they move through automatic (brush or brushless) car washes. The car wash is a fairly simple linear and continuous process. Yet, if you attempt to develop a process flow diagram you may see that there is more to the production than hits the windshield. (Adapted from ref. 36).*

   A. *Develop a complete process flow diagram of an automatic car wash. Be sure to account for all materials input and materials output (qualitatively).*

   B. *Identify all points of chemical use, by-product generation and releases into the air, sewer, land, or reuse/recycling.*

OBJECTIVE: To develop the ability to translate processes into process flow diagrams and develop qualitative materials balances.

SUGGESTIONS: It may be difficult for students to identify all components of the liquids used in a car wash and the ultimate destination of those fluids. The owner or operator of a local car wash could be very helpful in providing "behind the scenes" information. In addition, students may have difficulty representing stationary processes (assuming the car does not move through the car wash) in the form of a process flow sheet. They should try to distinguish operations of the process by changes in inputs, outputs, or activities.

2. *The next time you prepare a salad, casserole, pie, or other dish requiring the input of several food items, create a process flow diagram for the activity. Be sure to include all points of food input, by-product generation and the fate of those by-products (garbage, sewer, inadvertent consumption, etc.), and final product. Don't forget food packaging, and any preparation, such as washing, of food inputs as well as the fate of generated by-products (including evaporation). If you have access to a food scale, try to quantify by-products as best you can, including weight loss during cooking (what by-product was generated and where did it go?). (Adapted from ref. 36).*

OBJECTIVE: To develop the ability to translate processes into process flow diagrams and develop qualitative materials balances.

SUGGESTIONS: This project may be easier than the car wash for some students since they control and can observe all inputs and outputs. Again, they may have difficulty representing stationary processes in the form of a process flow sheet. They should try to distinguish operations of the process by changes in inputs, outputs, or activities

3. *The production manager of a small auto parts manufacturer noted that the company had used 200 tons of plastic polymer last year, after adjusting for inventory. They had made 300 tons of final product during that same time period. The final product was 50% plastic*

by weight. The process involves 1) receiving and storing polymer, 2) molding, where the polymer is heated and molded into correct shape using molding machines, 3) trimming, where excess plastic is removed from the molded parts, and 4) assembly, where the plastic parts are assembled with the non-plastic components to create the finished product. What is the overall efficiency of the process with regard to turning the received polymer into product? If you were production manager, where would you suspect that you may be losing polymer from the process?

OBJECTIVE: To develop the ability to perform a facility-level materials balance and to improve judgment in estimating losses from a process.

RESPONSE: The overall process efficiency is 75% for plastic. Since 200 tons were purchased, but only 150 tons (50% of 300 tons) went into product, the remainder (50 tons, or 25% of the purchased material) must be lost. The operation contributing the most to this loss is probably trimming, depending upon the amount of excess removed. Assembly may also account for significant loss if the part defect rate is high and these parts are discarded. Receiving, storage, and molding may be significant contributors if spillage or air emissions are large.

4. *Refer to the Holiday Printing case in the Problems and Activities section of Module 1 and the article on the printing industry (Pferdehirt, W.P, "Roll the Presses but Hold the Waste: Pollution Prevention and the Printing Industry," Pollution Prevention Review, Autumn, 1993) in Supplemental Readings Booklet. In an attempt to reduce toluene emissions from clean-up operations, Andrew Larson and a team of production and maintenance personnel have identified several options:*

   A. Improve toluene use and management procedures, particularly several items listed in Table 3 of Pferdehirt's article under "Good Housekeeping" and "Cleanup".
   B. Install an automated washing system (e.g., automatic blanket washes).
   C. Use a detergent and water cleanup solution.
   D. Use a methyl alcohol cleanup solution.

   Identify the criteria that the team might use to determine the superior alternative. To the best of your ability, rate each alternative on the criteria you create (this may involve additional research on the printing industry and the hazardous nature of chemicals).

OBJECTIVE: To enhance the ability to analyze the various factors that are impacted by a pollution prevention program, and to use this knowledge to select superior alternatives.

RESPONSE: Responses can vary dramatically depending upon the assumptions made by the student. The important aspect of a student's response is that the assumptions are reasonable, and that the projected impacts are logically related to the assumptions. We have chosen to quantify projected impacts on a 5-point scale from very negative (--) to neutral (0) to very positive (++). We use a "?" to indicate impacts which are potentially very important but quite uncertain. (See attached table.)

CRITERIA	ALTERNATIVES			
	A	*B*	*C*	*D*
Capital expenditures	++	--	++	+
Operating and maintenance expenditures.	++	-	?	0
Effects on product quality	0	?	?	0
Effects on production schedule	0	0	0	0
Hazard to workers	+	+	++	-
Environmental impacts	+	+	++	+
Disruption to personnel	-	--	-	0

In our analysis, alternatives A and C appear to be superior. However, action may be warranted to reduce uncertainty regarding the effects of alternative C on operating and maintenance expenses as well as product quality. Efforts to minimize negative impacts on personnel may also be useful.

5. Using the Standard Metal Products Company case in the Supplemental Readings Booklet, answer the following questions:

A. Develop a process flow diagram for the production of electrical switch boxes. Be sure to include all flows of raw materials, products, and by-products. (see Figure 2-2 as a guide)

See attached diagram.

B. Develop materials balance tables for each of the four materials used in the process. (see Tables 2-1 and 2-2 as guides).

Table 1: Materials Balance for Sheet Metal (Pounds in previous 12 months)		
Material In		
Sheet Metal		500,000
Material Out		
Metal in Product	400,000	
Scrap Metal to Reclaimer	100,000	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		500,000

Table 2: Materials Balance for Cutting Fluid (Gallons in previous 12 months)		
Material In		
Cutting Fluid		10,000
Material Out		
Cutting fluid by-product to wastewater	9,500	
Cutting fluid by-product to air	500	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		10,000

Table 3: Materials Balance for Degreasing Solvent (Gallons in previous 12 months		
Material In		
Degreasing Solvent		40,000
Material Out		
Degreasing solvent by-product to reclaimer	30,000	
Degreasing solvent by-product to air	10,000	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		40,000

Table 4: Materials Balance for Paint (Pounds in previous 12 months)		
Material In		
Paint		5,000
Material Out		
Paint in product	1,500	
Paint by-product to hazardous waste	1,750	
Paint by-product to air	1,750	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		5,000

C. Estimate process efficiency for the use of sheet metal and paint, and describe the composition of each by-product stream using a table similar to Table 2-4a. Standardize all units to a "per 1,000 lb. of product" basis. (For example, sheet metal input is 1,250 lb. per 1,000 lb. of product)

Table 5: Process efficiency and by-product composition for manufacture of electrical switch box housings (Estimates per 1,000 lb. of product previous 12 months).

	Metal (pounds)	Cutting fluid (gallons)	Degreasing solvent (gallons)	Paint (pounds)
Input Amount	1,250	25	100	12.5
Product Amount	1,000	----	----	3.75
Efficiency	80%	----	----	30%
By-product Amount				
scrap metal	250			
cutting fluid to wastewater		23.75		
cutting fluid to air		1.25		
degreaser to reclaimer			75	
degreaser to air			25	
paint hazardous waste				4.375
paint to air				4.375.

D. Estimate direct, tangible costs of by-products for each operation in the process. (see Tables 2-5b, 2-6b, and 2-7b as guides). Express all costs on a "per 1,000 lb. of product" basis.

Table 6: Direct costs of by-products for Cutting and Drilling Operation. ($/1,000 lb. of product previous 12 months)

	By-Products			
Cost	Scrap Metal	Cutting fluid to wastewater	Cutting fluid to air	Total
Lost Material	250[a]	190[b]	80[c]	520
Disposal	0	23.75[d]	0[e]	23.75
Total	250	213.75	80	$553.75

a - 250 lb. x $1/lb.
b - 23.75 gal. x $8/gal.
c - 10 gal. x $8/gal.
d - 23.75 gal. x $1/gal.
e - no direct tangible costs for air emissions

Table 7: Direct costs of by-products for Degreasing Operation. ($/1,000 lb. of product previous 12 months)

Cost	By-Products: Degreasing Solvent to Reclaimer	By-Products: Degreasing Solvent to Air	Total
Lost Material	750[a]	250[b]	1,000
Disposal	150[c]	0[d]	150
Total	900	250	$1,150

a - 75 gal. x $10/gal.
b - 25 gal. x $10/gal.
c - 75 gal. x $2/gal.
d - no direct tangible costs for air emissions

Table 8: Direct costs of by-products for Painting Operation. ($/1,000 lb. of product previous 12 months)

Cost	By-Products: Paint to Air	By-Products: Paint to Hazardous Waste	Total
Lost Material	4.375[a]	4.375[a]	8.75
Disposal	0[b]	8.75[c]	8.75
Total	4.375	13.125	$17.5

a - 4.375 lb. x $1/lb.
b - no direct tangible costs for air emissions
c - 4.375 lb. x $2/lb.

i. What is the total cost of by-product generation over the last 12 months?

Table 8: Total direct costs of by-products for Standard metal Products Company. (previous 12 months)

Operation	Cost of by-product ($/1,000 lb. product)
Cutting and Drilling	$553.75
Degreasing	$1,150.00
Painting	$17.50
Total	$1,721.25

Total cost is $1,721.25 /1,000 lb. product (cutting and drilling, degreasing and paint) x 400,000 lb. = $688,500

ii. Which operations and by-product streams are the greatest contributors to this loss?

Seventy percent of the losses occur at degreasing, and most of this is the cost of degreasing solvent to reclaimer. This is followed by the cost of degreasing solvent to the air, and the cost of lost scrap metal from cutting and drilling operations.

iii. Are these losses due primarily to lost materials, disposal costs, or both?

Of the above three waste streams, 89% is due to the value of lost material in the wastes.

iv. What other tangible costs might exist which were not included in this analysis and how would they likely effect the outcome?

Compliance costs could be significant. This would include the cost of pollution permits, the time involved in paperwork (particularly for the hazardous wastes), and the other costs of maintaining a compliance staff. This would increase the value of pollution prevention, particularly for the painting operation.

v. What intangible costs might exist which were not included in this analysis and how would they likely effect the outcome?

The greatest intangible costs would probably be future worker and environmental liability associated with degreasing solvent and paint. Another would be the lost employee, community, and customer goodwill from the magnitude of waste generation.

vi. What other factors would be most important to consider in selecting priority by-product streams and how would they likely effect the outcome?

In addition to considering the tangible and intangible costs discussed above, it would be useful to consider the extent to which current prevention technologies are available for the particular by-product stream, or the extent to which changes would effect workers, scheduling, or product quality.

E. Perform a present value analysis of cost for the two systems, using a 12% cost of capital estimate. Use the Sample Table, below, for guidance. Which option should Wilson select? Why?

Table 9. Present value analysis of Aquaclean and Enviroclean systems using 12% cost of capital. (Costs in $1000)

		AQUACLEAN SYSTEM			ENVIROCLEAN SYSTEM		
YEAR	PV DISCOUNT FACTOR	ANNUAL COST	PV COST	CUMULATIV. PV COST	ANNUAL COST	PV COST	CUMULATIV. PV COST
0	1	50	50.00	50.00	100	100.00	100.00
1	0.8929	38	33.93	83.93	20.4	18.22	118.21
2	0.7972	38	30.29	114.22	20.4	16.26	134.48
3	0.7118	38	27.05	141.27	20.4	14.52	140.00
4	0.6355	38	24.15	165.42	20.4	12.90	161.96
5	0.5674	38	21.56	186.98	20.4	11.57	173.54
6	0.5066	38	19.25	206.23	20.4	10.33	183.87
7	0.4523	38	17.19	223.42	20.4	9.23	193.10
8	0.4039	38	15.35	238.77	20.4	8.24	201.34
9	0.3606	38	13.70	252.47	20.4	7.36	208.70
10	0.3220	38	12.24	264.70	20.4	6.50	215.26

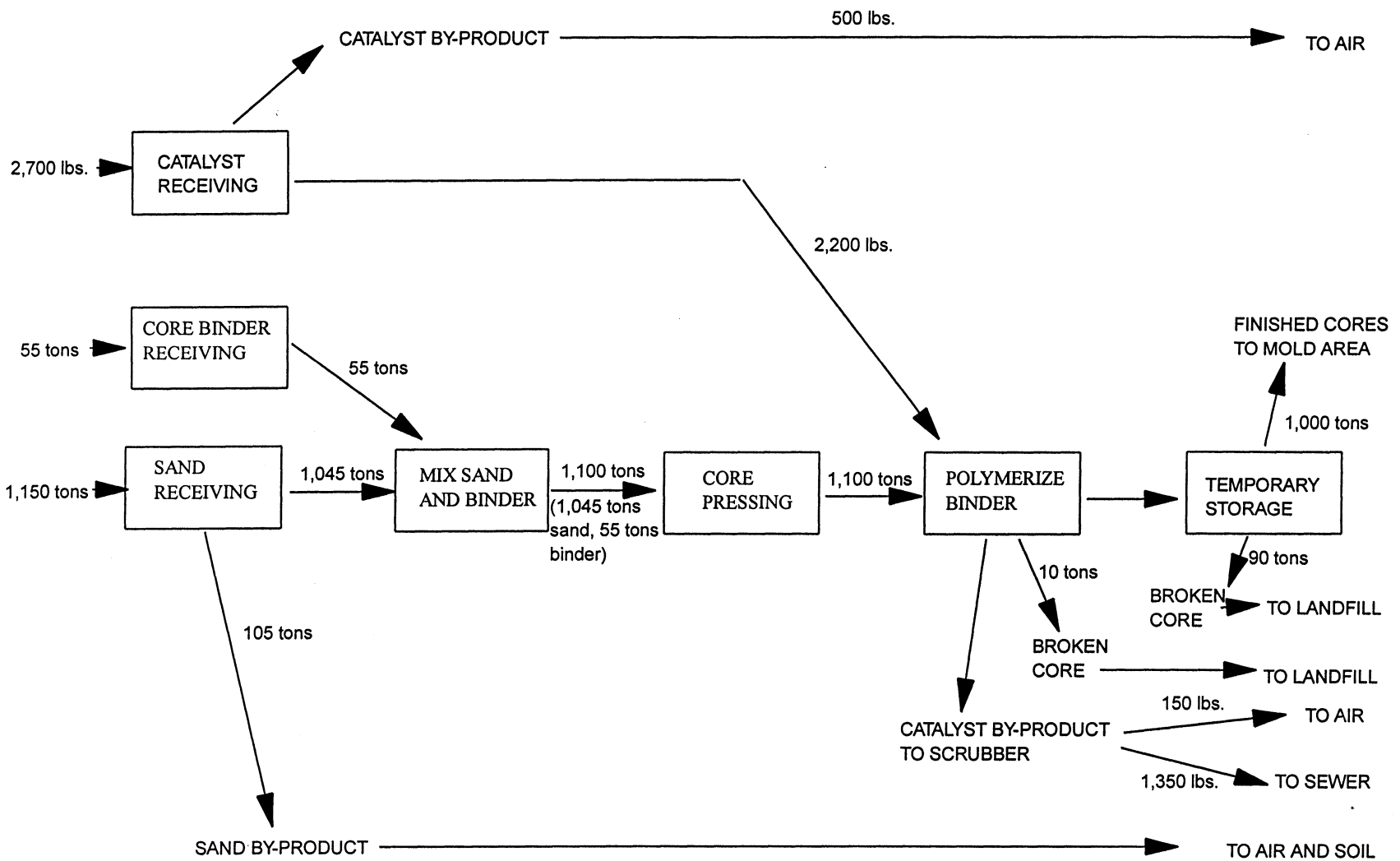
For both systems, the benefits are identical: waste TCA from the degreaser would be eliminated, at a savings of $460,000 per year. This savings quickly repays the capital and operating expenses of either alternative system. The selection of one system over another might rest on the initial capital expense for each system and the debt position of the company.

6. Using the Fred's Foundry case in the Supplemental Readings Booklet, answer the following questions:

A. From this information, develop a process flow diagram for the production of cores. Be sure to include all flows of raw materials, products, and by-products. (see Figure 2-2 as a guide)

See attached diagram.

B. Develop materials balance tables for each of the three materials used in the process. (see Tables 2-1 and 2-2 as guides).



Process flow sheet of core production

Table 1: Materials Balance for Sand for Core Making process (Tons in previous 12 months)		
Material In		
Sand		1,150
Material Out		
Sand in Product	950	
Sand to air and soil during transport	105	
Sand in broken core from core machine	9.5	
Sand in broken core from storage	85.5	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		1,150

Table 2: Materials Balance for Binder for Core Making process (Tons in previous 12 months)		
Material In		
Binder		55
Material Out		
Binder in Product	50	
Binder in broken core from core machine	0.5	
Binder in broken core from storage	4.5	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		55

Table 3: Materials Balance for Catalyst for Core Making process (Pounds n previous 12 months)		
Material In		
Catalyst		2,700
Material Out		
Catalyst in product	700	
Catalyst to air from piping leaks	500	
Catalyst to air after scrubber	150	
Catalyst to wastewater after scrubber	1,350	
Material Accumulated	0	
Total of Material Out Plus Material Accumulated		2,700

C. *Estimate process efficiency for the use of the three inputs , and describe the composition of each by-product stream using a table similar to Table 2-4a. Standardize all units to a "per ton. of product" basis. (For example, sand received is 1.150 tons per ton of product). You may ignore catalyst in broken core.*

Table 4: Process efficiency and by-product composition for manufacture of cores (Estimates per ton of product over last 12 months).

	Sand (tons)	Binder (pounds)	Catalyst (pounds)
Input Amount	1.15	110	2.7
Product Amount	0.95	100	0.7
Efficiency	87%	91%	26%
By-product Amount			
sand to air and soil from transport	0.105		
catalyst to air from pipe leaks			0.5
catalyst to air after scrubber			0.15
catalyst to wastewater after scrubber			1.35
broken core at core machines	0.0095	1	
broken core in storage	0.0855	9	

D. *Estimate direct, tangible costs of by-products for each operation in the process. (see Tables 2-5b, 2-6b, 2-7b as guides). Express all costs on a "per 1,000 lb. of product" basis.*

Table 5: Direct costs of by-products for Sand Receiving, Storage, and Transport. (Costs are in dollars per ton of core delivered to mold area)

	By-Products
Cost	Sand
Lost Material	15[a]
Disposal	0[b]
Total	$15

a - $100/ton x 0.15 tons/ton of core
b - no direct tangible costs for air emissions

Table 6: Direct costs of by-products for Catalyst Receiving, Storage, and Transport (piping leaks).(Costs are in dollars per ton of core delivered to mold area)

	By-Products
Cost	Catalyst
Lost Material	25[a]
Disposal	0[b]
Total	$25

a - $50/lb. x 0.5 lb./ton of core
b - no direct tangible costs for air emissions

Table 7: Direct costs of by-products for Binder Polymerization.(Costs are in dollars per ton of core delivered to mold area)

	By-Products			
Cost	Catalyst to air	Catalyst to wastewater	Broken Core	Total
Lost Material	7.5[a]	67.5[b]	1.35[c]	76.35
Labor			5[d]	5
Disposal	0[e]	13.5[f]	0.5[g]	14
Total	7.5	81	6.85	$95.35

a - $50/lb. x 0.15 lb./ton of core
b - $50/lb. x 1.35 lb./ton of core
c - $100/ton x 0.0095 tons/ton of core for sand;
$0.4/lb. x 1 lb./ton of core for binder
d - $500/ton x 0.01 ton/ton of core
e - no direct tangible costs for air emissions
f - $10/lb. x 1.35 lb./ton of core
g - $50/ton x 0.01 tons/ton of core

Table 8: Direct costs of by-products for Temporary Storage.(Costs are in dollars per ton of core delivered to mold area)

	By-Products
Cost	Broken Core
Lost Material	12.1[a]
Labor	54[b]
Disposal	4.5[c]
Total	70.6

a - $100/ton x 0.0855 tons/ton of core for sand;
$0.4/lb. x 9 lb./ton of core for binder
b - $600/ton x 0.09 ton/ton of core
c - $50/ton x 0.09 tons/ton of core

i. What is the total cost of by-product generation over the last 12 months?

By-product generation cost the company at least $205,950 last year. (see table below)

OPERATION	COST OF BY-PRODUCTS ($/ton of core)	TOTAL COST OF BY-PRODUCTS ($ in last year)
Sand receiving,/storage/transport	15	15,000
Catalyst receiving,/storage/transport	25	25,000
Binder polymerization	95.35	95,350
Temporary Core Storage	70.6	70,600
TOTAL	205.95	$205,950

ii. Which operations and by-product streams are the greatest contributors to this loss?

Based on the table above, binder polymerization (catalyst by-product stream) and temporary core storage (broken core stream) are clearly the operations in which most by-product cost is incurred.

iii. Are these losses due primarily to lost materials, disposal costs, or other costs?

In binder polymerization, most of the cost is due to the low efficiency with which catalyst reacts with binder, and the high material cost of catalyst. For temporary storage, the cost is due to the high breakage rate for cores and the high labor/energy/capital value of the cores at that point in the process.

iv. What other tangible costs might exist which were not included in this analysis and how would they likely effect the outcome?

Compliance costs, such as maintaining air and water pollution permits, public reporting requirements, employee training, and employee exposure assessments and record keeping. Maintenance costs, including clean-up of spilled sand and broken cores.

v. What intangible costs might exist which were not included in this analysis and how would they likely effect the outcome?

Potential liability, including future environmental fines of air pollution, environmental law suits for air pollution, and employee law suits for occupational exposures. Lost employee and community harmony from emissions and exposures.

E. What is the playback period for the new sand handling system selected by the pollution prevention team using only direct, tangible costs (you may also wish to perform a present value analysis)? Does this analysis alone support their recommendation? Considering other potential benefits of the system, do you believe the team made a wise decision? Why or why not?

Sand losses during receiving, transport, and storage cost $15/ton of core, or about $15,000/year. Assuming a 95% reduction in sand losses, the new system would save about $14,250/year. Ignoring

the time value of money, the $200,000 investment in the new system would be repaid in about 14 years. This is unlikely to be financially acceptable. However, significant intangible costs may result from employee exposures to the sand. Serious lung disorders, such as silicosis, may result from prolonged inhalation of sand dust. Law suits and worker's compensation claims from such diseases could cost the company millions of dollars.

F. Perform a present value analysis of the changes made to reduce core breakage in temporary storage, using a 10% cost of capital estimate. Use the Sample Table, below, for guidance.

Sample Table: Present value analysis of net savings from changes in temporary storage area using 10% cost of capital. (Costs in thousands of dollars)

YEAR	PV DISCOUNT FACTOR	ANNUAL COST	REDUCED CORE BREAKAGE	REDUCED OVERTIME	NET SAVINGS (COST)	PV SAVINGS	CUMULATIVE. PV SAVINGS
0	1	(50[a])	56.48[b]	10	16.48	16.48	16.48
1	0.9091	0	56.48[b]	10	66.48	60.44	76.92
2	0.8264	0	56.48[b]	10	66.48	55.60	132.52
3	0.7513	0	56.48[b]	10	66.48	49.95	182.47
4	0.683	0	56.48[b]	10	66.48	45.41	227.88
5	0.6209	0	56.48[b]	10	66.48	41.28	269.16
6	0.5645	0	56.48[b]	10	66.48	37.53	306.69
7	0.5132	0	56.48[b]	10	66.48	34.12	340.81
8	0.4665	0	56.48[b]	10	66.48	31.02	371.83
9	0.4241	0	56.48[b]	10	66.48	28.19	400.02
10	0.3855	0	56.48[b]	10	66.48	25.63	425.65

a - personnel time in development of storage area changes
b - 91.1% reduction in core losses of $70.6/ton of core

i. Do the changes in the storage area have a positive financial impact? Why?

Yes, the changes to reduce core breakage have a net present value in excess of $400,000 considering direct, tangible costs alone. Most of this is due to the savings in lost labor value of broken cores.

ii. What other tangible or intangible costs or benefits might exist which were not included in this analysis and how would they likely effect the outcome?

Core material is relatively non-toxic and did not pose a significant risk to workers or the community. However, the reduction in core waste probably represents a substantial decrease in the solid waste from the foundry disposed of in the landfill. Since most communities are attempting to extent landfill life, this reduction may reap community goodwill. In addition, employee moral may increase with the improved operation of the storage area.

G. The company developed solutions to sand transport spillage and core breakage during temporary storage. What by-product stream would you recommend they focus on next? Why? Do you have any suggestions for what they might do to reduce the generation of this by-product?

Catalyst by-product from binder polymerization. This is the costliest by-product stream in the process. Methods to increase the efficiency of catalyst reaction would reduce the amount of catalyst used, and the amount of by-product generated. Increased efficiency might be possible by changing the way it is injected into the core. It may be profitable to switch to another binder/catalyst combination.

PROBLEMS AND ACTIVITIES FOR MODULE 3

1. For each of the following scenarios, identify who should be involved in the investigation and change-over. (From Ref. 17)

OBJECTIVE: To familiarize the student with the variety of individuals involved in pollution prevention projects and their respective interests.

SUGGESTIONS: There is no, single correct answer for these questions. It is the student's analysis and reasoning that is important. Small, in-class group discussion can be useful to highlight differences of opinion. It is these differences that offer the greatest learning opportunities. Be sure that students consider the value of individuals from various levels and functions within the organization, including the hourly workforce which will be affected by the proposed changes.

A. *An oil-based cutting fluid is currently being used to produce metal parts on the company's CNC turning lathe. The operators are having several problems: frequent tool breakage, parts out of specification due to heat stress, oil spills and leaks on the floor and foul odors from the cutting fluid. Who would investigate the possible changeover to a more cost-effective and cleaner alternative?*

B. *A grocery store chain learns that the cost of having a trash collector to pick up their cardboard boxes is going to increase. It is suggested that the truckers pick up the boxes on the return trip to the warehouse instead of going back with an empty trailer. The boxes would then be sold to a paper recycling plant for a profit. Who should be involved in this program?*

C. *A company that paints its final product has discovered problems with its conventional air atomized spray equipment. As little as 30% of the paint sprayed actually reaches the target object and this adds to the high cost of solvent-based coatings. Several suggestions have been made to solve the problem. These include: installing electrostatic spray equipment to increase the efficiently of paint transfer (this will save the company money through reduced paint costs and disposal charges) or using water-borne paints to replace solvent-borne paints and installing a paint recovery system in the plant. Determine which individuals should participate in this investigation.*

2. For the following questions, refer to the Procter & Gamble and Colgate-Palmolive corporate policies (see Wright, D.R. "Designing a Corporate Environmental Program: The Colgate-Palmolive Approach" and Fisher, M.T., "Total Quality Environmental management: The Procter & Gamble Approach" in the Supplemental Readings Booklet.

Procter & Gamble and Colgate-Palmolive are both large consumer product organizations with corporation-wide pollution prevention policies. Each organization has taken a decidedly different approach in developing their pollution prevention policy statements.

A. Compare and contrast each organization's approach to environmental policy.

OBJECTIVE: The purpose of this question is to have the student review and analyze two different approaches to implement a corporation-wide pollution prevention policy.

RESPONSE: Proctor & Gamble developed an extensive, multi-faceted corporate pollution prevention policy. It is built around the concept of product "stewardship", which emphasizes pollution prevention as a "new consumer need". Their corporate policy is written to involve everyone in the company. The policy statements are descriptive and prescriptive to function as a guide for all employees on what to do and how to do it.

The Colgate-Palmolive Company has a very simple pollution prevention policy consisting of only three statements. This pollution prevention policy is supported by the corporate ENVIROPRIDE™ program. The ENVIROPRIDE™ program consists of a simple pollution prevention vocabulary - reduce, reuse and recycle. Much like the Colgate-Palmolive's extensive policy statement, the ENVIROPRIDE™ program was designed to provide guide for the employees to achieve pollution prevention in their daily work.

B. Which organization has the best approach? Support your answer.

OBJECTIVE: To enhance the student's understanding of the connection between corporate pollution prevention policy and the organization culture and management philosophy of a company.

SUGGESTIONS: Though there is no single, correct response to this questions, students should recognize that each policy approach has advantages and disadvantages, depending upon the management philosophy and culture of the organization. For example, the simple approach taken by Colgate-Palmolive would be consistent with an organization using a highly decentralized management style. Corporate management is expected to initiate new programs and point the company in the correct direction, but individual divisions or units are expected to develop their own means of operationalizing the policies. It will work best where great diversity of outcomes can be tolerated. The more prescriptive approach used by Procter & Gamble is consistent with more centralized guidance of policy development throughout the organization. Responses to the policy will be more uniform.

The Colgate-Palmolive approach in an organization with a tradition of highly centralized decision making would be ineffective and non-motivational. Similarly, the Procter & Gamble approach in an organization of highly autonomous divisions would produce frustration and resentment.

C. P&G has characterized the concept of "product stewardship" as a new "consumer need". What is meant by the term "product stewardship"?

"Product stewardship incorporates environmental attributes into the development of Procter & Gamble products and packages." In other words, attributes of a product and its packaging which have environmental impacts are considered along with other consumer -valued attributes in the development process.

D. In your judgment, how has Procter & Gamble's environmental policy influenced the following aspects of the organization?.

- *management philosophy*
- *organizational structure*
- *business plan*

The policy probably reflects, rather than effects, the management philosophy, assuming the new policy does not reflect a fundamental shift in management philosophy. The policy does clarify, however, how environmental impacts will be factored into managerial decisions. The organizational structure may be influenced in several ways. In general, the policy requires close integration of Environment, Health and Safety personnel into many aspects of business, including marketing/product design and manufacturing. Life cycle assessment requires the cooperation of individuals from nearly every division. Reliance on audits and customer feedback requires the integration of accounting, auditing, and marketing staffs into routine business operations in ways which may not have previously been attempted. The business plan is affected in many ways. Product stewardship has significant effects on marketing. Production planning must incorporate waste minimization and other environmental impacts of manufacturing processes. Finance must broaden its perspective of the costs of waste on company profitability.

3. Lightolier, Inc. (see Whittman, M.R. "Lightolier, Inc." in the Supplement Reading booklet).

A. Using the organizational chart, discuss the role of the following personnel in determining the success of the pollution prevention effort:

Controller
Senior industrial engineer
Senior design engineer
Senior manufacturing engineer
Plant manager
VP of Manufacturing

OBJECTIVE: To give the student an opportunity to evaluate a typical manufacturing organizational structure and weave a P2 strategy into the management structure of a typical manufacturing organization.

SUGGESTIONS: The student should be able to identify how each of these individuals can not only contribute, but play an integral role in a successful P2 strategy. It is important that the student recognize the particular expertise contributed by each individual as well as the collaboration that will be necessary between specific individuals.

B. Draft a "corporate environmental statement" for Lightolier, Inc. consistent with both the guidelines of the text and the case. Draft an environmental statement for the APC plant, consistent with both the case and the text.

OBJECTIVE: To enable the student to develop environmental policy statements appropriate to the corporate and production plant level.

SUGGESTIONS: The corporate statement should provide a general guide to the environmental policies of the production facilities. It should have sufficient flexibility to allow the diverse facilities to develop appropriate policies of their own. The facility-level policies should be more

specific to the needs and operations of that facility. All policies should address "What, Why, and Who" as discussed in the text. Encourage students to apply policy formats used by the companies for which they work, companies associated with the school, or policy formats taught in other courses.

C. Assume that you are the Plant Manager for the APC and you are in the process of modifying the business plan with Lightolier Corporate Headquarters. Michael Cahill of Manufacturing Engineering has strongly encouraged you to incorporate pollution prevention into the business plan, consistent with the Corporate Environmental Statement. Suggest ways in which you could modify the APC Business Plan in the areas of marketing, finance, operations, and personnel, in order to facilitate pollution prevention.

OBJECTIVE: To improve the student's understanding of the connection between the business plan and the implementation of pollution prevention.

RESPONSE: Though responses can vary considerably, some of the important changes would include:

- **Marketing - seeking customer input on environment or waste problems related to APC's products; communicating APC's improved environmental performance to both customers and the community.**
- **Finance - modify financial analysis systems to allocate all production-related costs to the appropriate production operation; include less tangible costs such as liability and indirect costs such as maintenance and compliance.**
- **Operations - Recognize the replacement of the degreasers and painting line, and the changeover in Hydroform oil. Plan for the eventual move to a closed-loop system with "zero emissions".**
- **Personnel - Develop personnel policies which both include production personnel in the implementation of the proposed changes and assure personnel individuals will not be eliminated due the proposed changes.**

D. Financial Analysis

OBJECTIVE: To improve the student's ability to conduct and interpret financial analyses.

i. The "Company Analysis" and TCA ("Discounted cash flow project analysis") estimates for the proposed project differed very little. Why was this? In what ways were the analyses different?

The Company Analysis demonstrated a net profit of $99,873 while the TCA analysis demonstrated a net present value of $93,504. These two estimates are similar due to two, offsetting effects in the TCA analysis. First, the recognition of the time value of money produces a significant discounting of future cash flows. However, the recognition of hidden or intangible costs, such as compliance and maintenance costs, significantly increases the value of the pollution prevention option. In this case, these two effects are roughly equal.

ii. Do you believe it was worth the time to complete the TCA in this case? Why or why not?

From one point-of-view, the TCA analysis is not beneficial because the initial analysis demonstrated such a large net benefit for the project. Since additional analyses would be unlikely to alter the final decision on the project, the TCA analysis would seem to be unwarranted. However, the TCA analysis could have produced estimates significantly different from the initial analysis, even though the TCA estimates would likely be quite positive. For a company attempting to allocate resources to projects yielding the greatest returns, this more accurate information could be very beneficial.

iii. No estimate was made of future liability resulting from the continued use of TCE (which would be avoided with the proposed project). Do you believe this omission would significantly alter the decisions to be made about pollution prevention investments? Explain.

Because the decision to adopt the new technologies was clear, inclusion of future liability would not have altered the decision. However, the potential liability associated with worker exposure to TCE is not small, given the likelihood of a major malfunction in the existing degreasing equipment. Recognition of this potential could significantly increase the benefits of the proposed project.

iv. Cahill noted that the current TCE system could fail in the near future, disrupting production. This was not directly factored into either cost assessment. What are the likely implications of such a failure and how should APC include them in their project evaluation?

It is quite difficult to quantify the financial impact of such a disruption. It would result in high-cost repairs, increased labor costs to make-up lost production, and lost sales and customer goodwill due to the disruption in supply. Even if these impacts cannot be estimated accurately, they should be featured prominently in the project proposal.

4. Williams Precision Valve Company, Inc. (see Whittman, M.R. "Williams Precision Valve Company, Inc." in the Supplement Reading booklet).

A. Draft a "corporate environmental statement" for Williams Precision consistent with both the guidelines of the text and the case. Compare and contrast this with your statement for Lightolier, Inc.

OBJECTIVE: To enable the student to develop environmental policy statements appropriate to the corporate and production plant level.

SUGGESTIONS: The corporate statement should provide a general guide to the environmental policies of the production facilities. It should have sufficient flexibility to allow the diverse facilities to develop appropriate policies of their own. The facility-level policies should be more specific to the needs and operations of that facility. All policies should address "What, Why, and Who" as discussed in the text.

The policies for Williams and Lightolier would be similar in that each represents a corporation with several diverse production facilities. However, there are several differences. Lightolier is a U.S. corporation, while Williams is a U.S. subsidiary of a European multinational corporation. The policy statement for Williams' parent company should reflect the diversity of conditions and

interests of the nations in which it operates. In addition, the policy should reflect the critical role of quality in the competitive strategy of Williams and its parent.

B. Based upon the case, characterize the management philosophy at Williams Precision, and identify the likely impact of this on the implementation of pollution prevention (be sure to consider management philosophy on employee harmony and involvement, continuous improvement, decision-making based on systematic analysis, customer harmony, and community harmony). Compare and contrast this with your answer for Lightolier, Inc.

OBJECTIVE: To enhance the student's understanding of the connection between management philosophy and pollution prevention.

SUGGESTIONS: One important difference between Williams and Lightolier's approach to pollution prevention is in the personnel involved. Williams formed a cross-disciplinary team to develop proposals, while at Lightolier, the proposal resulted from the initiative of one individual from the Manufacturing Engineering Department. This difference suggests an underlying difference in management philosophy, with Williams using greater employee participation. Further evidence of the nature of Williams' management philosophy is that organizational "structures provide a flow of information from the shop floor to the managers, a team to oversee projects, motivational opportunities, and feedback loops." This management philosophy would appear to promote greater employee harmony as well as the other important potential benefits of a management philosophy (continuous improvement, customer harmony, etc.).

C.. For Williams Precision and Lightolier, compare and contrast the role of company personnel and organizational policy in justifying funding for pollution prevention initiatives.

OBJECTIVE: To increase the students' awareness of the different approaches organizations may take to implement a pollution prevention program.

ANALYSIS: Lightolier and Williams Precision are both metal fabrication companies, but they have taken very different organizational approaches to pollution prevention. The students analyzing these cases should identify the following differences.

Williams Precision	Lightolier
• has a corporate policy - committed to environmental awareness	• has a corporate policy -
• proactive approach to P2 program - invests in potential opportunities	• reactive P2 program - evaluates P2 opportunities when appropriate (i.e. new equipment purchase)
• team approach to P2 problem definition and resolution	• individual assigned to P2 problem definition and resolution

D. To what extent is pollution prevention integrated into the business operations of each of these two companies? What mechanisms or structures exist in each organization for this purpose?

OBJECTIVE: To provide the students with insight on how an organization can integrate P2 practices into its management structure to insure that P2 is way of doing business.

ANALYSIS: Williams Precision is "committed to environmental awareness" and "invests" in potential P2 opportunities. It approaches P2 opportunities as it approaches other revenue generating production opportunities in the organization. It has successfully developed an integrated team approach to identifying and evaluating potential opportunities. Williams Precision has weaved P2 into its organizational fabric so well that it is simply a way of doing business.

Lightolier on the other hand supports P2 from an organizational policy perspective, but responsibility is assigned to a given individual to identify and evaluate potential opportunities. Lightolier pursues P2 as a criterion in the business decision process rather than a way of doing business.

5. Wrayburn Jewelry Company, Inc. (see Wittman, M.R. "Wrayburn Jewelry Company, Inc." in the Supplemental Readings Booklet).

A. In your opinion, why was the proposed purchase of the ethyl acetate recovery still "languishing" in Wrayburn's corporate headquarters? Why might the new financial analysis speed-up approval?

OBJECTIVE: The purpose of this question is to have the students evaluate the possible corporate political aspects of a pollution prevention project. The second component of this question requires the student to investigate what additional factors could be included in the proposal to make it even more financially appealing.

ANALYSIS: Wrayburn may be committed to pollution prevention, but this may not translate into action in the capital budgeting process. Another perspective may be that the proposal has to compete for limited financial resources and the justification of the project must demonstrate that the purchase of the still has broader impact not only on finances, but employee harmony (i.e. safety), community harmony (i.e. regulatory requirements) and customer harmony (i.e. low cost).

The second aspect of the questions addresses the need to convert the concepts of employee harmony, community harmony and customer harmony into quantitative cost concepts. These concepts need to be integrated into the proposal to improve its financial justification.

B. Draft a "corporate environmental statement" for Wrayburn consistent with both the guidelines of the text and the case. Compare and contrast this with your statements for Lightolier, Inc. and Williams Precision

OBJECTIVE: To enable the student to develop environmental policy statements appropriate to the corporate and production plant level.

SUGGESTIONS: The corporate statement should provide a general guide to the environmental policies of the production facilities. It should have sufficient flexibility to allow the diverse facilities to develop appropriate policies of their own. The facility-level policies should be more specific to the needs and operations of that facility. All policies should address "What, Why, and Who" as discussed in the text.

The policies for Wrayburn, Williams and Lightolier would be similar in that each requires policies for both corporate and production facility usage. However, Wrayburn has much less diversity than the other two corporations, and the Massachusetts plant appears to be the primary production facility for Wrayburn. Thus, Wrayburn's corporate and facility policies are likely to be more closely connected.

C. Based upon the case, characterize the management philosophy at Wrayburn, and identify the likely impact of this on the implementation of pollution prevention (be sure to consider management philosophy on employee harmony and involvement, continuous improvement, decision-making based on systematic analysis, customer harmony, and community harmony). Compare and contrast this with your answers for Lightolier, Inc. and Williams Precision.

OBJECTIVE: To enhance the student's understanding of the connection between management philosophy and pollution prevention.

SUGGESTIONS: Wrayburn is described as having a "maternal" management philosophy, where the well-being of the employees and community is very important, but the initiative and decision-making rests with management. Employee, customer, and community harmony are clear priorities. It is unclear, however, to what extent this philosophy promotes the other potential benefits.

D. For Wrayburn, Williams Precision and Lightolier, compare and contrast the role of company personnel and organizational policy in justifying funding for pollution prevention initiatives.

OBJECTIVE: To increase the students' awareness of the different approaches organizations may take to implement a pollution prevention program.

ANALYSIS: Wrayburn, Lightolier and Williams Precision are all metal fabrication companies, but they have taken different organizational approaches to pollution prevention. The students analyzing these cases should identify the following differences.

Wrayburn	Williams Precision	Lightolier
• corporate policy committed to employee and community harmony	• corporate policy committed to environmental awareness	• corporate policy providing very formal program approval process.
• proactive approach to P2 - exceed compliance for worker satisfaction.	• proactive approach to P2 program - invests in potential opportunities	• reactive P2 program - evaluates P2 opportunities when appropriate (i.e. new equipment purchase)
• management driven P2 initiatives.	• team approach to P2 problem definition and resolution	• individual assigned to P2 problem definition and resolution

E. To what extent is pollution prevention integrated into the business operations of each of these three companies? What mechanisms or structures exist in each organization for this purpose?

OBJECTIVE: To provide the students with insight on how an organization can integrate P2 practices into its management structure to insure that P2 is way of doing business.

ANALYSIS: Wrayburn views pollution prevention as an opportunity to maintain employee loyalty and community satisfaction, and often justifies expenditures on such a basis. However, cost analyses are also used to justify expenditures. Responsibility for initiating projects appears to reside with selected management personnel, though the expenditure approval process is relatively open and informal.

Williams Precision is "committed to environmental awareness" and "invests" in potential P2 opportunities. It approaches P2 opportunities as it approaches other revenue generating production opportunities in the organization. It has successfully developed an integrated team approach to identifying and evaluating potential opportunities. Williams Precision has weaved P2 into its organizational fabric so well that it is simply a way of doing business.

Lightolier on the other hand support P2 from an organizational policy perspective, but is assigned to a given individual to identify and evaluate potential opportunities. Lightolier pursues P2 as a criterion in the business decision process rather than a way of doing business.

6. *Coated Fine Paper Mill (see White, A.L., Becker, M., Goldstein, J. "Coated Fine Paper Mill" in the Supplement Reading booklet).*

   A. *Compare the "Company" and TCA financial results. Identify where they differ and explain the basis for this difference. Which costs are not included in the Company Analysis?*

Company and TCA differ dramatically in their results. The "unprofitable" company analysis (substantial negative net present value) becomes very profitable in the TCA analysis (NPV exceeds $1 million with payback period of 2 years). The primary difference relates to utility savings for pumping and treating fresh and wastewater, and for freshwater heating. These were not included in the company analysis.

   B. *The Coated Fine Paper Mill does not have a corporate pollution prevention policy. What type of long term problems might the company encounter if it fails to address the waste water issues in its strategic business planning?*

OBJECTIVE: The purpose of this question is to have the student review the current operations of a small manufacturing company to identify potential problems that may result from not addressing potential pollution issues

ANALYSIS: This is a manufacturing company which has no pollution prevention strategy, nor does the organization have any policies in place to promote pollution prevention projects in the company. The Coated Fine Paper Company is faced with some pending pollution issues that could impact the long term success of the organization including waste water disposal problems, relations with neighboring organization, community relations, potential expansion and product development

C. *Write an appropriate pollution prevention policy for the Coated Fine Paper Mill Company. Review the pollution prevention strategies for Williams Precision, Wrayburn and Lightolier for possible ideas.*

OBJECTIVE: The purpose of this question is to have the student develop a comprehensive pollution prevention policy for an organization that has no program and potential long-term pollution problems.

ANALYSIS: The pollution prevention policy should address the following areas:

a. Employee harmony and involvement
b. Continuous improvement
c. Decision-making based on systematic analysis
d. Customer harmony
e. Community harmony

SECTION 2

FIGURES

MASTERS FOR OVERHEAD TRANSPARENCIES

Figure 1-1. Tradeoff between decreasing pollution and increasing cost of control.

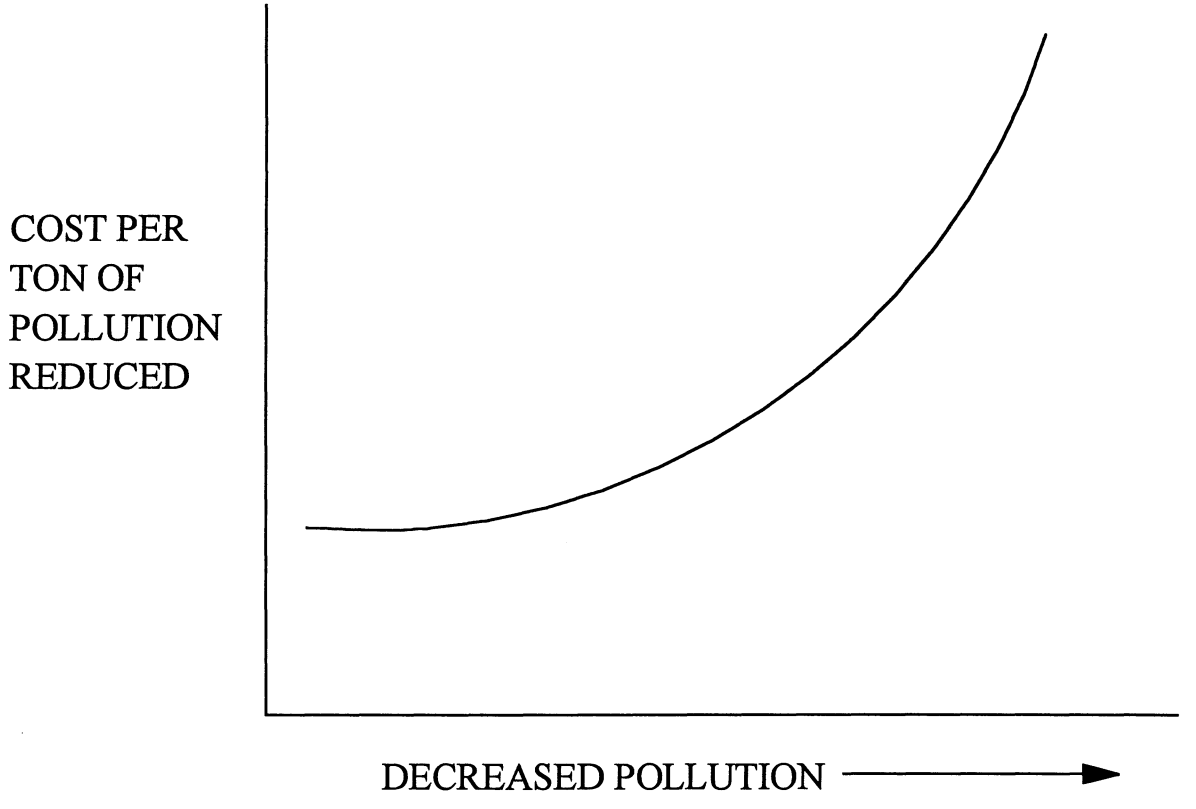


Figure 1-2. Decreasing long-run pollution control cost curve produced from innovation-driven shifts in short-run cost curves.

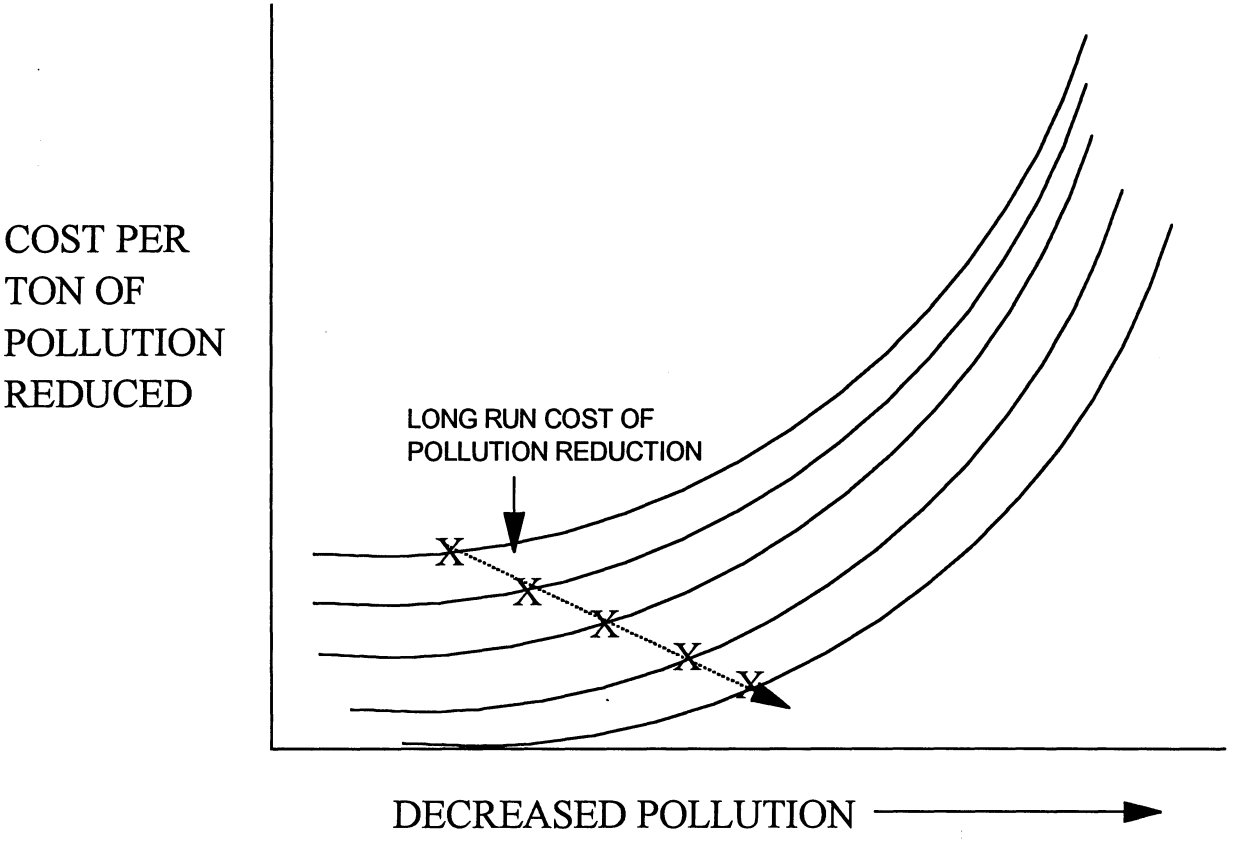


Figure 2-1: Conversion of raw materials into products and by-products.

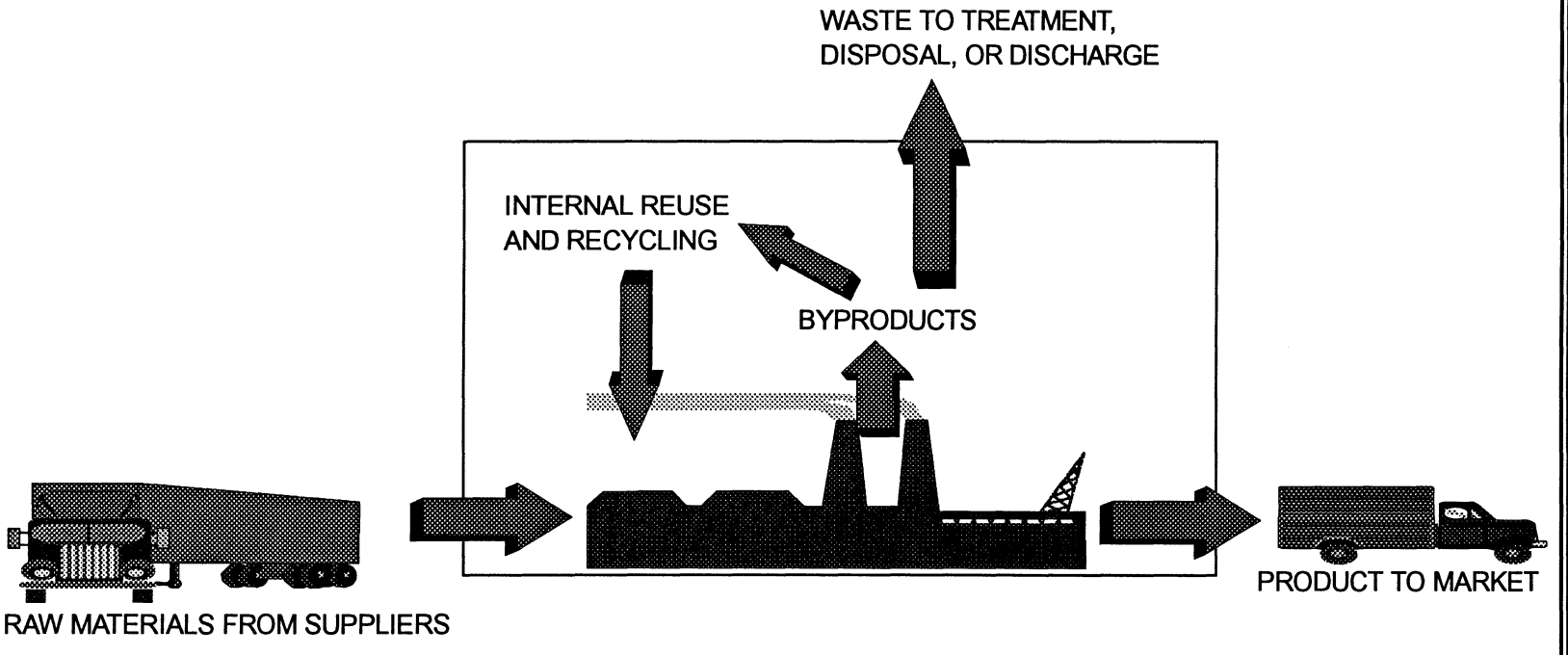
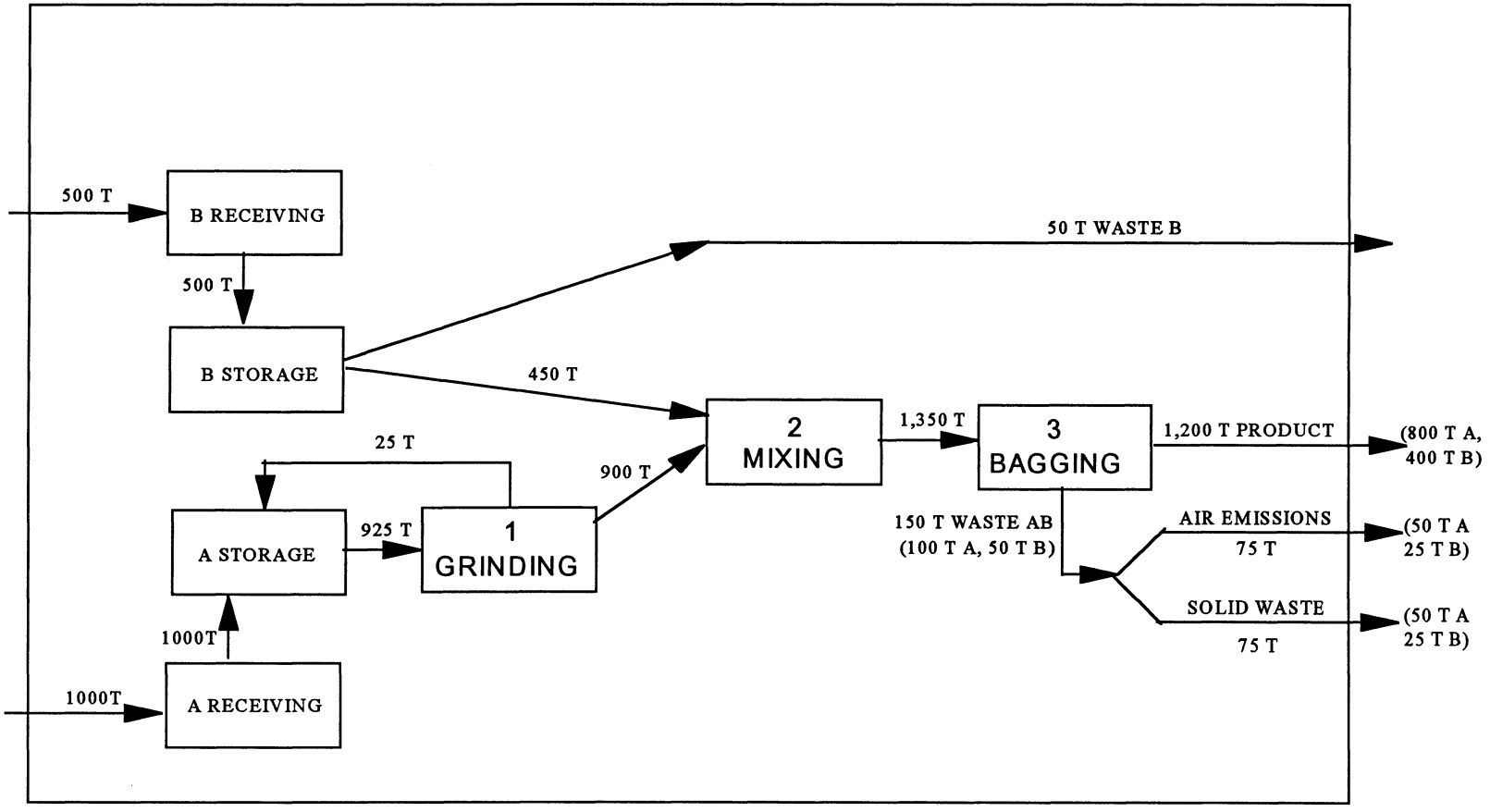
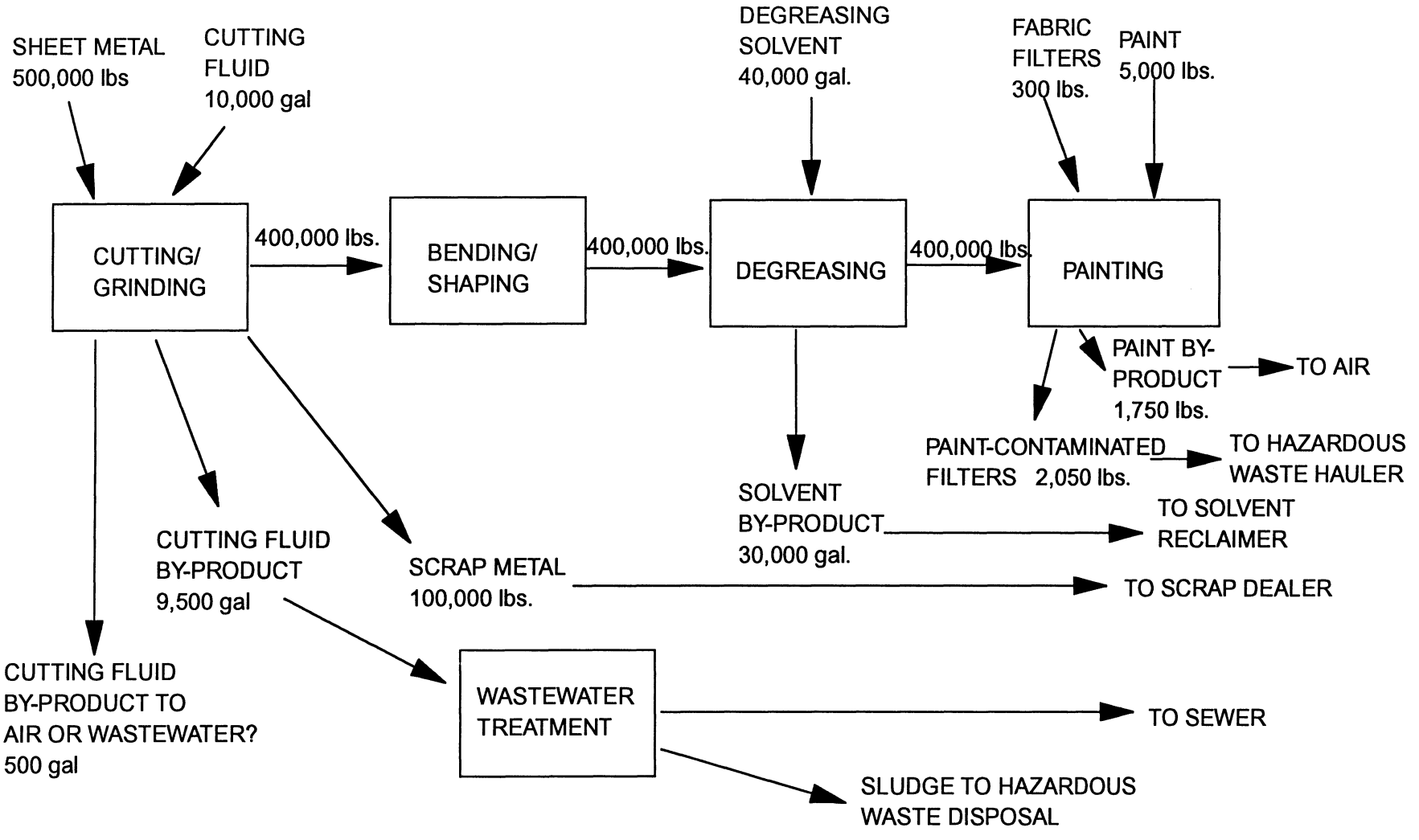
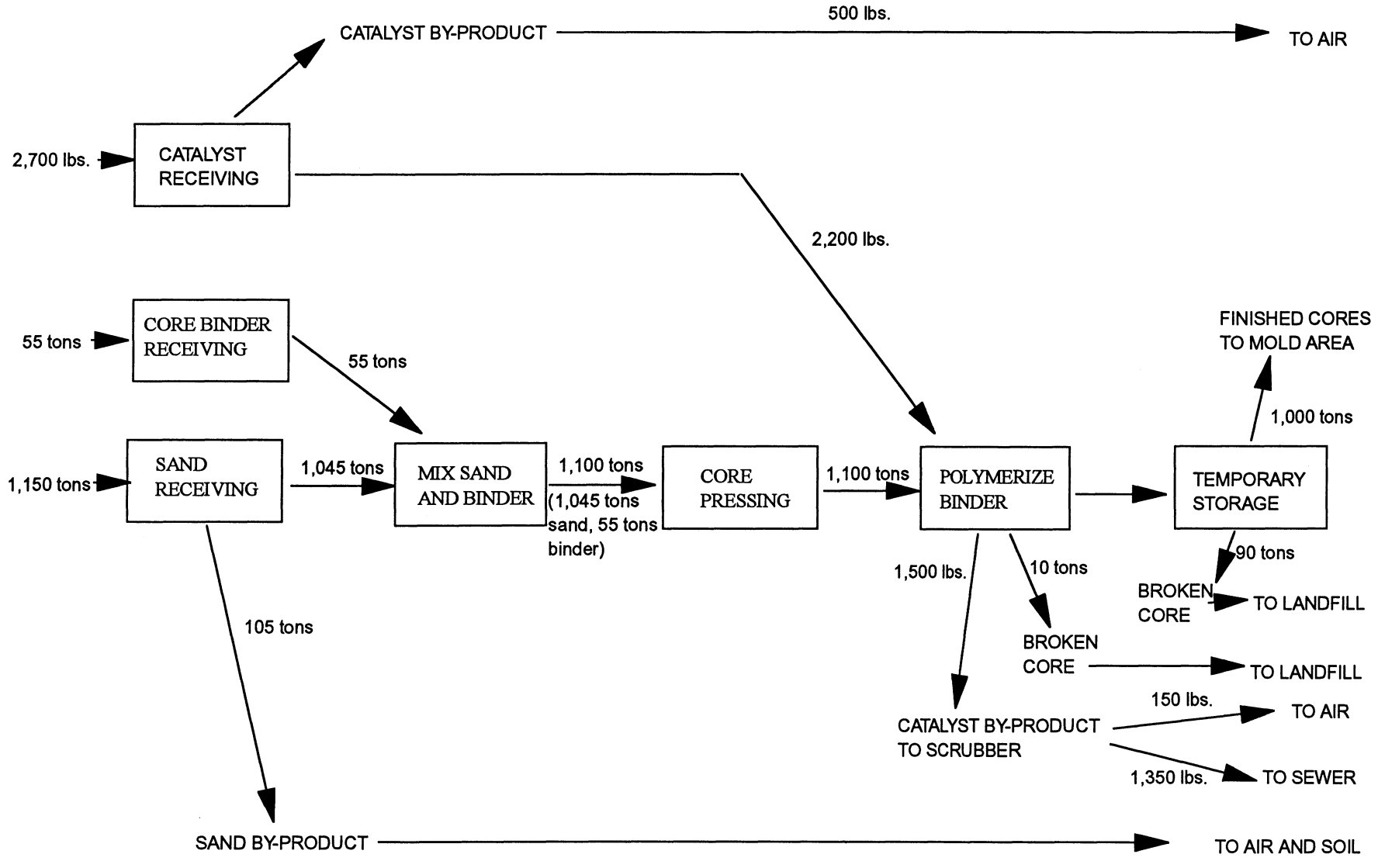


Figure 2-2: Process flow sheet for Midwest Manufacturing Company.





Process flow sheet of Standard Metal Products Company



Process flow sheet of core production at Fred's Foundry