IISE Industrial Initiatives for a Sustainable Environment

Working with Industry to Protect The Environment

PN-ACQ-212

USAID/PHILIPPINES
DEVELOPMENT INFORMATION CENTER

Initial Environmental Review (IER) Pollution Prevention (P2) / Cleaner Production (CP) Training Component

Technical Report No. 99/3

July 1999

Submitted by:

Chemonics International, Inc.

Under Contract No. 492-C-00-98-00029-00
Associated Number 492-0444
United States Agency for International Development

November, 1999

Ms. Priscilla P. Rubio
Cognizant Technical Officer
Office of Environmental Management
U.S. Agency for International Development
Ramon Magsaysay Building
1680 Roxas Boulevard, Malate, 1004
Manila, Philippines

Subject: **Report on the IISE Cleaner Production/Pollution Prevention Initial Environmental Review Training**

Project: **Industrial Initiatives for a Sustainable Environment (IISE)**
Contract No. 492-C-00-98-00029-00

Dear Ms. Rubio:

In accordance with the requirements of the subject contract, we are pleased to submit a report entitled "IISE Cleaner Production/Pollution Prevention Initial Environmental Review Training. The P2/CP IER training program was conducted in Cebu on July 12-16, 1999 and in Davao City on October 25 – 29 1999, by the IISE consultant, Mr. Dale Rice, and the IISE Training Director and Deputy Chief of Party, Mr. David D. Nelson.

This report is in two parts: *Part A* consists of the main body of the report with the complete training module as an Appendix, and *Part B* is the *Risk Reduction Measurement Model.*

If you have any questions regarding this report, please do not hesitate to contact me.

Sincerely,

John A. Dorr, Ph.D.
Chief of Party

Enclosures

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IISE is an initiative of the Republic of the Philippines, funded by the U. S. Agency for International Development (USAID) and managed by Chemonics International, Inc.

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A IER P2/CP Training Curriculum

EXECUTIVE SUMMARY

Chemonics was awarded the Municipal Coastal Environmental Initiative (MCEI) contract by the United States Agency for International Development on 24 July 1998. This contract, subsequently renamed IISE (Industrial Initiatives for a Sustainable Environment), will operate in the Visayas and Mindanao regions of the Philippines, with national policy and institutional strengthening to be supported by Manila-based operations. To accomplish the objectives of the project, the IISE team will work closely with partners to create a self-sustaining, multi-stakeholder program that will encourage adoption of environmental management systems and application of pollution prevention / cleaner production (P2/CP) technologies.

A fundamental task of the P2/CP process is to conduct in-plant assessments. An early step in this process is the conduct of an Initial Environmental Review (IER). This review follows a set protocol and records information on a standard form, which has been developed and tested by the IISE team. The IER's fundamental output is the prioritization of project resources with regard to client assistance.

MSE provided the following assistance to IISE that is documented herein:

1. The P2/CP portion of the IER Training Program was developed in the form of a one week (five day) training program.
2. The P2/CP IER training program was delivered 12 - 16 July 1999 in Cebu. The program included a written curriculum, supervised in-field instruction, and testing.
3. An evaluation of the P2/CP IER training program was conducted using feedback survey forms.

At total of 36 participants attended the course. All but one completed the course exam. The results of the exam are as follows:

- 86% Pass (Grade ≥ 40)
- 14% Fail (Grade < 40)
- Average score was 45.3 (Std Dev. ±4.4)

The following feedback was gleaned from the feedback survey:

1. Most participants affirmed the value of the course for the IISE project and their personal participation in the project. The comments overall were very favorable.
2. The participants did not feel they were given sufficient advance information on

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the P2/CP IER course (i.e., the purpose, what would be covered, the need to have field clothes for the IER visits, what to study before arriving, etc.) prior to attendance.

3. The IER visits (on Days 3 and 4) should be limited to a maximum of six persons each to be more manageable. With a training group of 25, this would mean lining up four IERs per day.
4. Several participants commented on the need for safety training due to some of the chemicals hazards (e.g., in painting areas) that were present in the IER visit.

The training course given 12-16 July 1999 was the inaugural event for the P2/CP IER training. The course will be given again (two to three times) to form a sufficient pool of trained workers for this part of the IISE project. Successful completion of the P2/CP IER and the EMS IER courses should provide sufficient background to those that wish to participate in this part of the IISE program. The following conclusions are presented with respect to the P2/CP IER course:

1. The interest of Filipino organizations and individuals in becoming trained in IER (and follow-on) protocol is keen. This conclusion is supported by the very large number of inquiries that were received about the course and higher than expected turn out of participants, especially in view of the late notice that was given.
2. The availability of sufficient human resources with appropriate technical background in the Philippines is apparent.
3. The combination of classroom lectures, IER "hands on" visits, and opportunities for participation by the students appears to be an ideal forum. Moving from IER role play to instruction-led IER visits to participant-led visits helps to reinforce the required protocol for conducting IERs.
4. The course group size needs to be controlled. The ideal class size is approximately 25 with IER group visits of about six each. Appointments for IER visits need to be set up well in advance to ensure smooth logistics.
5. Assuming that the course testing materials are an accurate representation of student comprehension, the curriculum as presented was, by in large, successful in training participants.
6. Progress was made toward program sustainability as evidenced in the leadership of IISE team members with the site visits and their presentation in selected portions of the course curriculum (i.e., Ramon Abracosa with IISE policy, Jaqueline Sim-Limtin with ISO 9000, Maya Villaluz with the Filipino industry overview).

The following recommendations concerning the P2/CP IER training are offered:

1. The curriculum, as currently structured, is adequate and should be used again in future courses.

2. Better communication should be offered toward the potential participants in advance of future courses to minimize misunderstanding and to potentially screen out those that may not have adequate background for conducting IERs.
3. Successful completion of both P2/CP and EMS courses along with a minimum of two IERs following the course work should be required of all personnel wishing to participate in IER program prior to being compensated by IISE for completion of other IERs.
4. IISE should consider the preparation of a new P2/CP IER course exam. The exam given on 16 July 1999 was compromised by the lack of sufficient security. (Two or more students gained unauthorized access to the exam before it was given. Furthermore, copies of the exam may now be in circulation and potentially available to future course participants.)
5. The participation of Filipino IISE staff in course presentation should be expanded over the next course offerings. Key individuals have sufficient capability to present much of the materials and should do so, enhancing the sustainability of the IISE program. This approach can be facilitated by MSE and the IISE managers.
6. Preparation and delivery of the P2/CP assessment training course by MSE should be authorized soon so that in the next two to three months this part of the P2/CP program can be conducted.

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SECTION 1

INTRODUCTION

1.1 Background

Chemonics was awarded the Municipal Coastal Environmental Initiative (MCEI) contract by the United States Agency for International Development on 24 July 1998. This contract, subsequently renamed IISE (Industrial Initiatives for a Sustainable Environment), will operate in the Visayas and Mindanao regions of the Philippines, with national policy and institutional strengthening to be supported by Manila-based operations. The objective of IISE within four years is twofold: (1) implement environmental management systems (EMS) in 400 companies/organizations, 200 of which will be certified to ISO 14001 or another recognized international EMS (e.g., EMAS, BSI 7750, others), and (2) reduce pollution from industrial and other discharging facilities by a percentage to be agreed upon in the near future between Chemonics and the major Philippines implementing agencies: Department of Trade and Industry (DTI), Department of Environment and Natural Resources (DENR), and the Philippine Coast Guard. To accomplish these objectives, the IISE team will work closely with partners to create a self-sustaining, multi-stakeholder program that will encourage adoption of environmental management systems and application of cleaner production technologies.

A fundamental task of the Pollution Prevention/Cleaner Production (P2/CP) process is to conduct in-plant assessments. The previous visit of Millennium Science & Engineering, Inc. (MSE) initiated the development of the life-of-project plan and protocol, including sequencing and timing, to conduct these assessments. An early step in this process is the conduct of an Initial Environmental Review (IER). This review follows a set protocol and records information on a standard form, which has been developed and tested since the earlier visit of MSE. The IER's fundamental output is the prioritization of project resources with regard to client assistance.

1.2 Purpose of Report

MSE provided the following assistance to IISE that is documented herein:

1. The P2/CP portion of the IER Training Program was developed in the form of a one week (five day) training program.

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2. The P2/CP IER training program was delivered 12 - 16 July 1999 in Cebu. The program included a written curriculum, supervised in-field instruction, and testing.
3. An evaluation of the P2/CP IER training program was conducted using feedback survey forms.

SECTION 2

IER P2/CP TRAINING PROGRAM

2.1 Overview of IER

The Initial Environmental Review consists of a well-planned field visit by qualified personnel to small and mid-size enterprises (SMEs) in the study region. The IER is a part of the "entrance" strategy that has been developed by the IISE Team. The IER gives the Team a forum to introduce the overall IISE Program to the SME while at the same time enabling the capture of key information through the in-field visit. The following are the key objectives of the IER:

- Determine resource priority level of the facility for IISE;
- Develop "buy-in" of the participant; and
- Develop the required scope for the follow-on EMS/P2-CP activities.

From the perspective of the P2/CP portion of the IER, the following specific objectives are identified for the IER:

- Identify the RP 28/POPs chemicals and the relative quantities being used;
- Identify the types of processes at a facility;
- Determine the clear opportunities for P2 implementation; and
- Collect scoping information for the P2/CP process that will follow.

The highest priority participants for the IER are those industrial members that have the greatest potential to reduce their impact on the environment accompanied by a high level of interest in participation. Clearly those companies and organizations that inquire about participation in the IISE program are not likely to be turned away; likewise, those SMEs, within the project sites that are likely to have the greatest EMS and/or P2/CP needs, will be contacted. The IISE Team is currently preparing a list of priority industries that will facilitate the prioritization process.

2.2 IER Curriculum

MSE prepared a written curriculum for a one week (five day) course on P2/CP IEP training. The intent for the IER training is to include two modules: the P2/CP course and a five day IER course covering EMS. Each person wishing to conduct IERs and/or follow-on tasks (e.g., P2/CP assessments) will be required to successfully complete both modules. Each of the modules is followed by an exam.

The initial IER P2/CP curriculum that was prepared is summarized on a five day schedule (essentially 8:30 am – 5:30 pm) basis as follows:

	Morning Session	Afternoon Session
Day 1	• Introductions • Overview of IISE program	• IER Overview • Overview of Filipino Industry • Overview of Industrial Processes • Overview of RP28 and POPs Chemicals
Day 2	• Introduction to Environmental Risk Assessment • Overview of Waste Reduction (WAR) Algorithm	• IER Entrance Strategy • Overview of IER Form • Organization of Site Visit Teams
Day 3	• IER Form Completion Instructions • Role Play	• First Site Visit (Instructor-led)
Day 4	• Review of First Site Visit Results	• Second Site Visit (Participant - led)
Day 5	• Review of Second Site Visit Results	• Course Review • Course Exam

Slides used in the course are incorporated into Appendix A.

The curriculum was packaged, with the help of the IISE staff, into a 3-ring notebook that was distributed to each participant at the beginning of the course. The notebook was sectioned as follows:

Section 1 – Course Schedule/Curriculum

Section 2 – Course Materials

Section 3 – First Site Visit (IER Forms)

Section 4 – Second Site Visit (IER Forms)

Section 5 – Technical Materials

The curriculum developed includes a variety of formats designed to keep the course informal and to more fully involve the participants. The following materials were presented in addition to those shown in Appendix A:

Day 1 – Industrial processes overview incorporated a series of color slides

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illustrating several industrial processes from developing countries.

Day 2 – Risk assessment introduction incorporated a series of color slides showing exposure pathways.

Days 4 and 5 – Site visit reviews included presentation of photos taken using digital photography.

The site visits were arranged in advance for three groups of about 12 persons each on average. Some of the participants had medical backgrounds and/or interests and were assigned to a group conducting an IER of a hospital. The following facilities were visited:

Day 3	Day 4
1. Power Plant	1. Furniture Manufacturer
2. Furniture Manufacturer	2. Furniture Manufacturer
3. Hospital	3. Furniture Manufacturer

The site visits on Day 3 were led by David Nelson, technical director of IISE; Dale Rice, P2/CP Specialist; and Dioni Araze and Jaqueline Sim-Limtin. On Day 4, the teams were led by training program participants. Note that allowing Filipino team members, Dioni and Jaqueline to lead a team is a step toward building sustainability in the program.

On the mornings of Days 4 and 5, members from each of the teams presented the findings of their respective groups. Overhead slides of their IER forms were prepared and presented along with the digital photographs from the site visit.

For the afternoon of Day 5, a review of the course materials with a question and answer period was provided. Following this, a written exam that was prepared by MSE was given. The exam consisted of 30 multiple choice and true/false questions on Part I with short answer questions based on a sample site visit in Part II. A score of 40 (of a possible 55) was established as a reasonable passing grade for the exam.

2.3 IER Exam Results

At total of 35 participants completed the exam given on the afternoon of Day 5. A copy of the exam is included in Appendix B. The results of the exam are as follows:

86% Pass (Grade ≥ 40)

14% Fail (Grade < 40)

The average score was 45.3 with a standard deviation of ±4.4. The results of the exam by organization are as follows:

Group	Number of Participants	High Grade	Low Grade	Number Failed
Schema	3	49	42.5	0
Green Group	5	47.5	38	2
DENR	3	49.5	46.5	0

MEMSI	11	51.5	41.5	0
IISE Team	8	51.5	36.5	2
Individuals	5	50.5	35.5	1

A complete list of the results are included in Appendix B. Based on a review of the exams, one question (number 1. of the true/false section) was deemed to be potentially invalid as more than one half of those examined selected the incorrect answer. The question is as follows:

"The purpose of an IER is to collect as much data as possible in two hours or less."

Most participants answered "True;" but the intent here was to make the distinction that one obtaining data will not be sufficient in a successful IER. The objective of the IER is to collect the information (not just data) as specified in tne prepared format. In addition, there is no absolute two hour cut-off for the IER. Some larger facilities may actually require more than two hours as was explained during the course. Nonetheless, this question should be revised in future exams that are given to avoid being misleading.

2.4 Course Feedback

A survey of the course was distributed to all participants by the IISE team. Many of the participants chose to provide very detailed responses. The following trends were generalized from the comments received:

1. Most participants affirmed the value of the course for the IISE project and their personal participation in the project. The comments overall were very favorable.
2. The participants did not feel they were given sufficient advance information on the P2/CP IER course (i.e., the purpose, what would be covered, the need to have field clothes for the IER visits, what to study before arriving, etc.) prior to attendance.
3. The IER visits (on Days 3 and 4) should be limited to a maximum of six persons each to be more manageable. With a training group of 25, this would mean lining up four IERs per day.
4. Several participants commented on the need for safety training due to some of the chemicals hazards (e.g., in painting areas) that were present in the IER visit.

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The training course given 12-16 July 1999 was the inaugural event for the P2/CP IER training. The course will be given again (two to three times) to form a sufficient pool of trained workers for this part of the IISE project. Successful completion of the P2/CP IER and the EMS IER courses should provide sufficient background to those that wish to participate in this part of the IISE program. The following conclusions are presented with respect to the P2/CP IER course:

1. The interest of Filipino organizations and individuals in becoming trained in IER (and follow-on) protocol is keen. This conclusion is supported by the very large number of inquiries that were received about the course and higher than expected turn out of participants, especially in view of the late notice that was given.
2. The availability of sufficient human resources with appropriate technical background in the Philippines is apparent.
3. The combination of classroom lectures, IER "hands on" visits, and opportunities for participation by the students appears to be an ideal forum. Moving from IER role play to instruction-led IER visits to participant-led visits helps to reinforce the required protocol for conducting IERs.
4. The course group size needs to be controlled. The ideal class size is approximately 25 with IER group visits of about six each. Appointments for IER visits need to be set up well in advance to ensure smooth logistics.
5. Assuming that the course testing materials are an accurate representation of student comprehension, the curriculum as presented was, by in large, successful in training participants.
6. Progress was made toward program sustainability as evidenced in the leadership of IISE team members with the site visits and their presentation in selected portions of the course curriculum (i.e., Ramon Abracosa with IISE policy, Jaqueline Sim-Limtin with ISO 9000, Maya Villaluz with the Filipino industry overview).

3.2 Recommendations

The following recommendations concerning the P2/CP IER training are offered:

1. The curriculum, as currently structured, is adequate and should be used again in future courses.
2. Better communication should be offered toward the potential participants in advance of future courses to minimize misunderstanding and to potentially screen out those that may not have adequate background for conducting IERs.
3. Successful completion of both P2/CP and EMS courses along with a minimum of two IERs following the course work should be required of all personnel wishing to participate in IER program prior to being compensated by IISE for completion of other IERs.
4. IISE should consider the preparation of a new P2/CP IER course exam. The exam given on 16 July 1999 was compromised by the lack of sufficient security. (Two or more students gained unauthorized access to the exam before it was given. Furthermore, copies of the exam may now be in circulation and potentially available to future course participants.)
5. The participation of Filipino IISE staff in course presentation should be expanded over the next course offerings. Key individuals have sufficient capability to present much of the materials and should do so, enhancing the sustainability of the IISE program. This approach can be facilitated by MSE and the IISE managers.
6. Preparation and delivery of the P2/CP assessment training course by MSE should be authorized soon so that in the next two to three months this part of the P2/CP program can be conducted.

Appendix A

IISE IER P2 / CP COURSE CURRICULUM

Day	Topic	Course Instructor
1 (AM)	Introductions of Participants • Name, Organization, Background • Why Are You Taking the Course?	DN/DR
	Overview of Curriculum and Schedule • P2/CP Team Member Experience Forms	DR
	Overview of IISE • Purpose • Specific Objectives • 9000/EMS Component • P2/CP Component • "Pollution Prevention" Vs Prevention of Pollution": ISO 14000 Issues	DN/DR
1 (PM)	IER Overview • Purpose • Intended Participants • Data Objectives	DN/DR
	Overview of Industry • Description of Key Filipino Industries • Industrial "Mindset" • Major Industrial Processes • Key Chemicals (RP 28 and "POPS") • Waste Issues • Slide Show – Industrial Processes	MV/DR
2 (AM)	Introduction to Environmental Risk Assessment • What is "Risk"? • Introduction to "WAR" Algorithm Risk Factors • P2/CP Task Goal: Risk Reduction	DN/DR
	Setting Up IER Visits • Potential Participants – Who Do We Target? • "Entrance Strategies"	DN/DR
2 (PM)	Overview of IER Process/Forms • Overall Approach • General Facility Information • EMS (Quality Management) Related Questions • Occupational health and Safety Questions • Environment (P2/CP) Related Questions • Facility Walk Through • Project Incentives • IISE Resource Allocation Strategy	DN/DR
	IER Completion Protocol • Prior Call for Appointment • Team Formation • Work Order Completion • Confidentiality Issues • Proper Dress/Supplies/OSH Considerations • Initial Facility Meeting* • General Facility Information* • Quality Management Questions • Occupational Health and Safety Questions*	DN/DR

3 (AM)	IER Completion Protocol (cont.) • Environment (P2/CP) related Questions* • Facility Walk Through (Example-Slides) • Closing Meeting* • Project Incentives* • IISE Resource Allocation Strategy* • Reporting/Filing Protocol • "Next Step" – After IERs * With Role Pay	DR/DN
3 (PM)	Facility I IER Completion • Field IER Practice (Led By IER Trainers)	DR/DN
4 (AM)	Discussion of IER Results – Facility 1 • Presentation of Data • Assessment/Discussion of Data • P2/CP Data Assessment • EMS Assessment • Lessons Learned • Suggestions for Improvement • Discussion of Follow-up for Facility I	DR/DN
4 (PM)	Facility II IER Completion • Field IER Practice (Led By IER participants)	DR/DN
5 (AM)	Discussion of IER results – Facility II • Presentation of Data • Assessment/Discussion of Data • P2/CP Data Assessment • EMS Assessment • Lessons learned • Suggestions for Improvement • Discussion of Follow-up for Facility II	DR/DN
5 (PM)	Review • ISO 9001/14001 • EMS • P2/CP • Risk Reduction • IER Forms/Protocol • Q&A	DN/DR
	Exam • Written	DN/DR
	Certification • IISE IER P2/CP Certification	DN/JD/DR

CP/P2 Team Member Experience Form

Name: _____ Title: _____

Company: _____ Years of Relevant Experience: _____

Location: _____

College Degree: __ BS __ MS __ Ph.D. __ Other School: _____

Experience with Sector (Score 1-4):

__ Mining & Metal Refining __ Chemicals __ Petrochemicals

__ Electronics __ Electroplating __ Food Processing

__ Iron & Steel __ Hospitals __ Coastal Resorts

__ Steam & Power Plants __ Pulp & Paper __ Timber Milling & Treatment

__ Cement Manufacturing __ Piggeries & Slaughterhouses __ Ports & Harbors

__ Ship Building __ Ship Breaking __ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: _____

Summary of Past Relevant Experience: _____

Areas of Training Needed for Assignment: _____

Completed by: _____ *Date:* _____

ExpForm.doc

Industrial Initiatives for a Sustainable Environment
Republic of the Philippines

TRAINING CLASS

INITIAL ENVIRONMENTAL REVIEW

POLLUTION PREVENTION (P2) / CLEANER PRODUCTION (CP) COMPONENT

Davao, Philippines
25-29 October, 1999

Introductions

- Name
- Organization
- Technical Background
- Reason(s) for Taking the Course

Curriculum Overview - Day 1

- Monday AM
  - Introductions
  - Overview
- Monday PM
  - IER Overview
  - Industry Overview

Curriculum Overview - Day 2

- Tuesday AM
  - Introduction to Risk Assessment
  - Setting Up IER Visits
- Tuesday PM
  - IER Forms Instruction

Curriculum Overview - Day 3

- Wednesday AM
  - IER Forms Instruction
- Wednesday PM
  - Facility Field Visit I

Curriculum Overview - Day 4

- Thursday AM
  - Facility I Review
- Thursday PM
  - Facility Field Visit II

Curriculum Overview - Day 5

- Friday AM
  - Facility II Review
- Friday PM
  - Course Review
  - Exam

Overview of The Industrial Initiatives for a Sustainable Environment

David Nelson
Technical Director/IISE

IISE Project Goal

- To establish a national program to help industries of all types manage their operations in an environmentally sustainable manner
- Help 400 companies implement an environmental management system (EMS)
- Help 200 become certified to a recognized EMS standard such as ISO 14001
- Help industries with Pollution Prevention and Cleaner Production techniques
  - Reduce pollution in project areas by 20%

Major Features

- First and only project of its kind in the world
- 4-year project (July 1998 - July 2002)
- Initiative of the Republic of the Philippines
- Funded by the U.S. Agency for International Development

Major Features (cont.)

- Implemented by the Department of Environmental and Natural Resources
- In cooperation with the Department of Trade and Industry and the Philippine Coast Guard
- Managed by Chemonics International, Inc.

Project Implementation

- Project offices:
  - Head office in Lapu-Lapu City
  - Support office in Makati City
  - Regional office in Davao
  - Staff (32)
    - 30 Filipino; 2 expatriate
    - 22 professionals; 10 support

Project Implementation (cont.)

- Implementation sites:
  - Focus in the Visayas and Mindanao
  - Eight sites - four approved (Cebu, Tagbilaran, Davao and General Santos); four additional to be selected
- Industrial sectors
  - To be determined
  - Selections based on level of risk to environment and human health

Project "Leveraging"

- Industrial Conglomerates
- Trade Associations
- Multinational Corporations
- Industrial Sectors
- Municipalities (LGUs)
- Agencies
- Professional Associations
- Other Donor Projects

Overview of IISE Policy Program

Ramon Abracosa, Ph.D.
Policy Director
IISE

IISE Policy Program

- Tier 1: support immediate information needs of technical program to achieve IISE's targeted results 400,200,20%
- Tier 2: achieve long term results and impacts that will sustain IISE's objectives

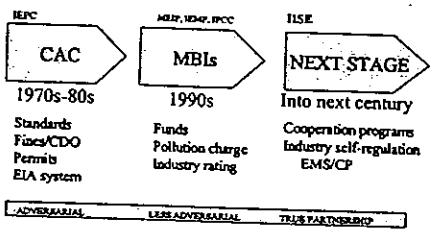
Tier 1 Activities

- **Support to technical program**
  - Inventory of incentives for industry, e.g., financial
  - Environmental audit policies
  - Basis for EMS other than ISO 14000
  - Industry survey
- **Support to government-industry-community partnership**
  - Policy working groups
  - Flexibility mechanisms, e.g., regulatory relief
  - Integrated incentives package
  - Protection of confidential information

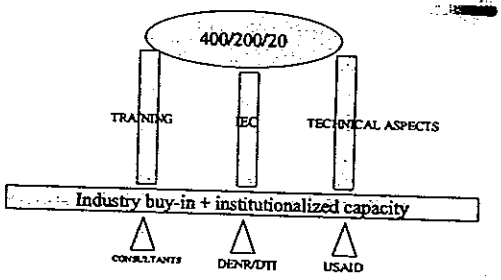
Tier 2-Tentative

- Adapt EMS for local governments
- Pollutant emissions register for public use
- Support adding EMS/CP incentives in environmental laws/ordinances
- Support EMS/CP policies for industrial estates
- Include EMS/CP in DENR's Ecowatch

IISE is Leading a Paradigm Shift



Need to Build Capacity



Overview of Initial Environmental Review (IER)

Dale Rice, P.E.
Vice President
Millennium Science & Engineering, Inc.

IISE P2/CP Program Consultant

IER Overview

- IER = Initial Environmental Review
- Purpose
- Intended Participants
- Information Objectives

IER - Purpose

- Determine Resource Priority Level of Facility for IISE
- Develop "Buy-In" of Participants
- Develop Scope for Follow-On EMS/P2-CP Activities

IER - Intended Participants

Highest Priority Participants:

- Those industrial members that have the greatest potential to reduce their impact on the environment accompanied by a high level of interest in participation

Pollution Prevention vs. "Prevention of Pollution"

- Background on ISO standards development process
- U.S. Delegation position with regard to P2
- Importance of the difference to IISE

IER - P2/CP Objectives

- RP 28/POPs Chemicals-General Quantities Used
- Types of Processes
- Opportunity to Implement P2
- Priority Level for Participation in IISE
- Scoping Information for P2/CP Process

Overview of Filipino Industries

Maya Villaluz, Ph.D.
Senior Environmental Engineer
IISE

Key Filipino Industrial Sectors

- Mining / Quarrying
- Food / Beverage Manufacturing
- Textiles
- Agriculture*
- Leather Tanning / Manufacture
- Wood / Furniture Products
- Pulp and Paper*

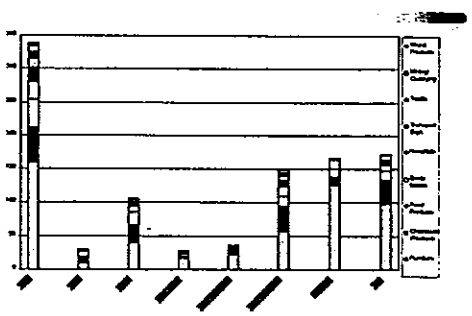
(* Not Significant in IISE Selected Sites)

Key Filipino Industrial Sectors (Cont.)

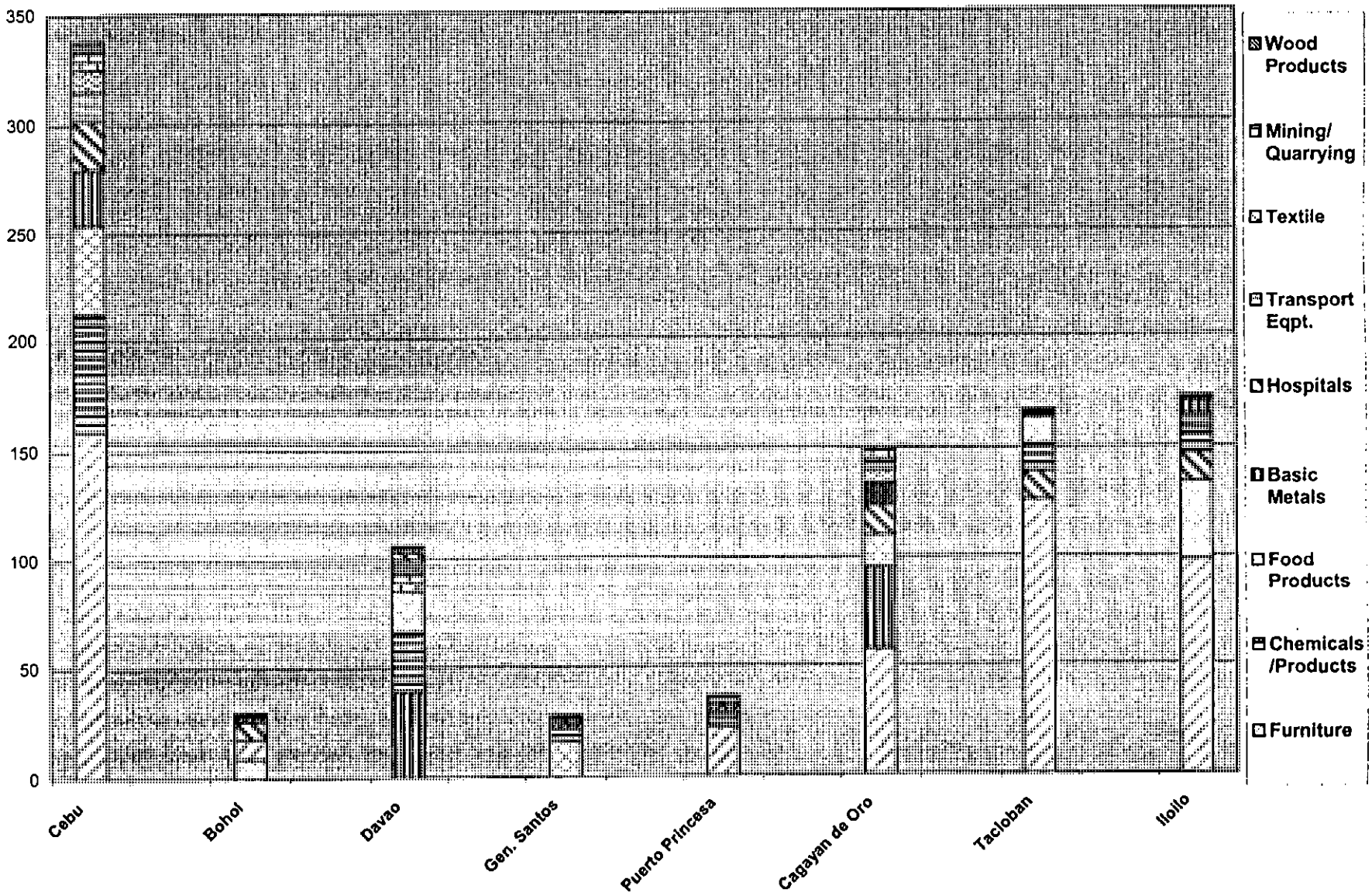
- Electroplating
- Power Generation
- Industrial Chemicals
- Petrochemicals*
- Petroleum, Products*
- Rubber Products
- Iron / Steel

(* Not Significant in IISE Selected Sites)

Major Industry Sectors in Selected Sites



Major Industry Sectors in Selected Sites



The Industrial "Mindset"

- Environmental protection still seen as a "cost" rather than a benefit
- Industry-Government tension still exists worldwide
- Industry often has better and more resources than governments.

Selected Industrial Processes

- Anodizing
- Annealing
- Assembly
- Bleaching
- Bottling
- Canning
- Cement Production
- Chemical Distillation
- Chemical Synthesis
- Conversion Coating
- Cracking
- Degreasing
- Dyeing
- Electroplating
- Extruding
- Farming
- Fermentation
- Food Processing
- Forging
- Fuel Storage
- Galvanizing
- Grinding
- Injection Molding
- Metal Casting
- Metal Refining
- Mining
- Packaging
- Painting
- Pharmaceuticals
- Photo Processing
- Pickling
- Powder Coating
- Pressing / Stamping
- Printing
- Pulping
- Refining
- Semiconductor Mfg
- Ship Building
- Ship Recycling
- Ship Repair
- Smelting
- Steel Fabrication
- Stripping
- Tanning
- Wood Preserving

Industrial Overview and IISE Priority Chemicals

Dale Rice, P.E.
Vice President
Millennium Science & Engineering, Inc.

IISE P2/CP Program Consultant

RP 28 Chemicals

Non-Organics

- Asbestos
- Selenium
- Tributyltin
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Cyanide
- Lead
- Mercury

RP 28 Chemicals

Organics

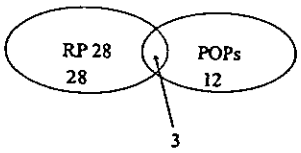
- Benzene
- Carbon Tetrachloride
- Chlorofluorocarbons
- Chloroform
- Chlorinated Ethers
- Ethylene Dibromide
- Ethylene Oxide
- Halons
- Hexachlorobenzene
- Hexachloroethane
- Mirex
- Polychlorinated Biphenyls
- Phosgene
- Pentachlorophenol
- Polybrominated biphenyls
- Vinyl Chloride
- 1,1,1-Trichloroethane
- 1,2-Diphenylhydrazine

"POPs" Chemicals

- DDT
- Aldrin
- Dieldrin
- Endrin
- Chlordane
- Heptachlor
- Hexachlorobenzene
- Mirex
- Toxaphene
- PCBs
- Dioxins
- Furans

RP 28 / POPs Chemicals

TOTAL NUMBER OF
"IISE CHEMICALS" = 37



RP 28 / POPs Chemicals

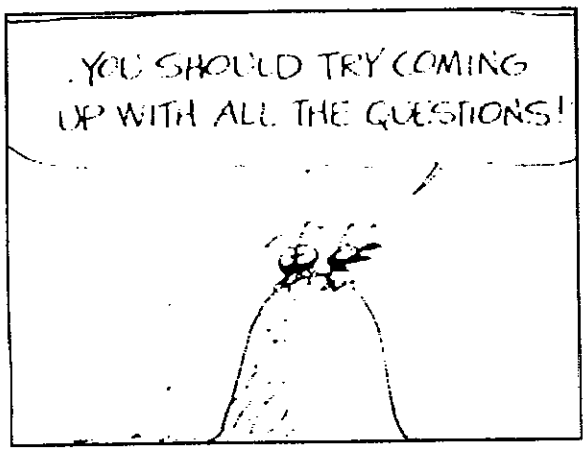
- Hexachlorobenzene
- Mirex
- PCBs

RP Waste Issues

- Lack of TSDFs
- Mixing of Waste Types
- Stockpiling of Wastes On-Site
- Poor Identification/Monitoring of Waste Sources/Streams
- Lack of Infrastructure
- Lack of Understanding of Environmental Risk
- Missed Opportunities for Recycling, Reuse
- Weak Enforcement of Environmental Legislation

Introduction to Environmental Risk Assessment

Dr. David Nelson
Technical Director/IISE



Quantitative Risk Assessment Process

- *Risk*: the mathematical probability of the occurrence of an event.
  - Example: the probability of falling into a hole in the sidewalk.
- *Risk Analysis*:
  1. hazard identification
  2. risk assessment
  3. determination of significance
  4. communication of risk information

Quantitative Risk Assessment Process

- *Risk Assessment*: a numerically quantitative component of risk analysis, the goal of which is to estimate or calculate the severity and likelihood of harm to human health or the health of the environment occurring from exposure to a risk agent (e.g. toxic chemical).

Quantitative Risk Assessment Process

- *Risk Characterization*: integrates the results of previous steps into a risk statement that includes one or more quantitative estimates of risk
  - Example: "Children under the age of 15 exposed for 5 years to 15 ppb benzene in drinking water have a 50 times greater chance of developing leukemia than those children not exposed."

Populations Potentially Exposed to Hazardous Wastes and Substances

- *Neighbors* around chemically contaminated sites
  - Exposure media: air, soils, surface water, groundwater, food chain
  - Exposure pathways: ingestion, inhalation, dermal absorption
  - Children particularly vulnerable
- *Workers* at manufacturing facilities using chemicals
  - e.g. air, water supplies, improperly handled food
- Regulatory and other *inspectors* (e.g. IISE consultants)

Potential Health Outcomes at Chemically Contaminated Facilities

1. **Symptoms** (rashes, eye irritation)
2. **Signs** (rashes, paralysis, tremor, etc.)
3. **Disease**

   A. *Apparent*

      a. Abnormal reproductive outcomes

      b. Growth and developmental disorders

      c. Cancer

      d. Mortality

Potential Health Outcomes at Chemically Contaminated Facilities

3. Disease, continued

   d. Other disorders (autoimmune diseases (CAIDS), blood dyscrasias, coronary artery diseases)

   e. Behavioral or psychological disorders

      - Depression

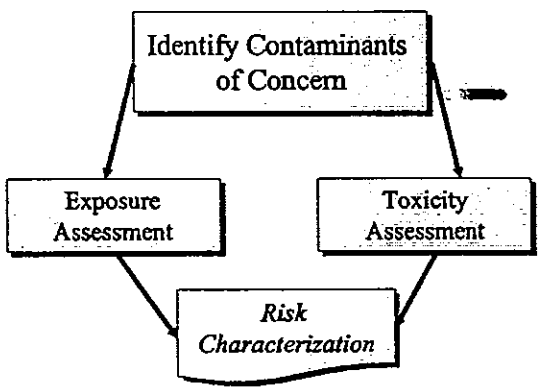
      - Violence (?)

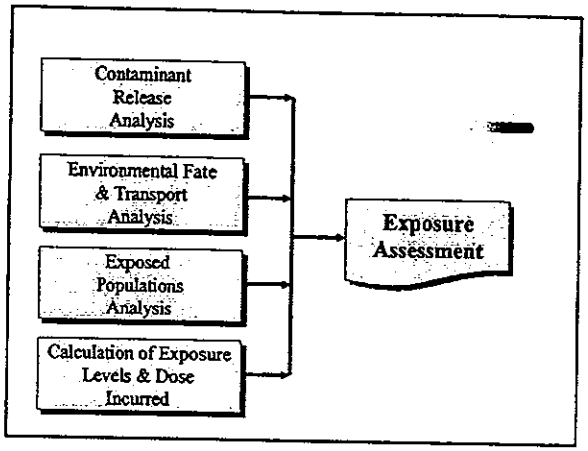
Potential Health Outcomes at Chemically Contaminated Facilities

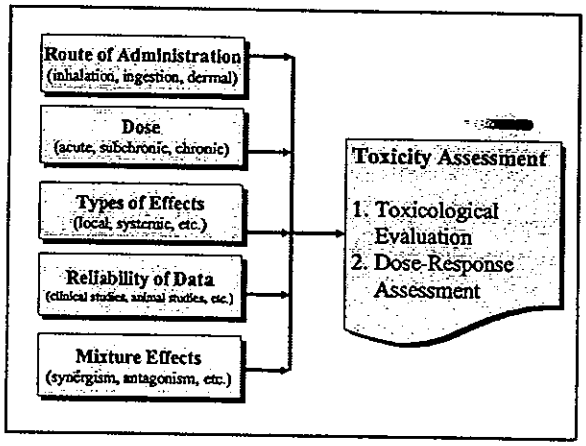
3. Disease, continued
   B. *Inapparent*
      a. Biochemical abnormalities (cholinesterase, erythrocycte protoporphyrin, liver function tests, estrogenic mimicry)
      b. Immunologic abnormalities (lymphocyte tests)
      c. Chromosomal abnormalities

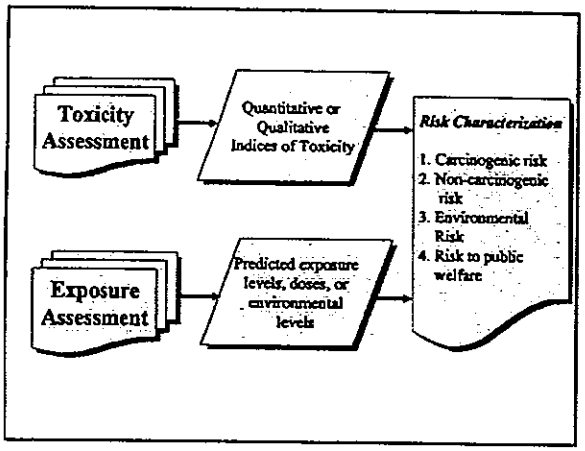
Potential Health Outcomes at Chemically Contaminated Facilities

3. Disease, continued
   d. Nerve conduction abnormalities
   e. Other test abnormalities (pulmonary function)




Contaminant Release Analysis
Environmental Fate & Transport Analysis
Exposed Populations Analysis
Calculation of Exposure Levels & Dose Incurred
Exposure Assessment


Route of Administration
(inhalation, ingestion, dermal)
Dose
(acute, subchronic, chronic)
Types of Effects
(local, systemic, etc.)
Reliability of Data
(clinical studies, animal studies, etc.)
Mixture Effects
(synergism, antagonism, etc.)
Toxicity Assessment
1. Toxicological Evaluation
2. Dose-Response Assessment


Toxicity Assessment
Quantitative or Qualitative Indices of Toxicity
Exposure Assessment
Predicted exposure levels, doses, or environmental levels
Risk Characterization
1. Carcinogenic risk
2. Non-carcinogenic risk
3. Environmental Risk
4. Risk to public welfare

Introduction to the WAR Algorithm

Dale Rice, P.E.
Vice President
Millennium Science & Engineering, Inc.

IISE P2/CP Program Consultant

"WAR" Algorithm

- WAste Reduction Algorithm
- Developed by USEPA's National Risk Management Research Laboratory
- Available to General Public - Spring 2000
- EPA Positioned to Assist the Technical Team of IISE
- Designed for Use in the Chemical Industry

"WAR" Algorithm (Cont.)

- Risk-based
- Process-oriented
- Key Assumption: Industrial Streams Entering and Leaving a Process Have Potential Environmental Impact (PEI)
- Makes Use of Matrix of 1600 Chemicals

War Algorithm: Potential Environmental Impact Equation

$$I = \sum M_j^{(in)} \sum \chi_{jk} \sum \alpha_{jk} \Psi_{jk}$$

where:
I = *rate of input of PEI*
M_j = *mass flowrate of chemical stream*
χ_{ij} = *chemical fraction*
α_k = *weighting factor*
Ψ_{jk} = *PEI of chemical component*

WAR'S Health / Environmental Impact Categories

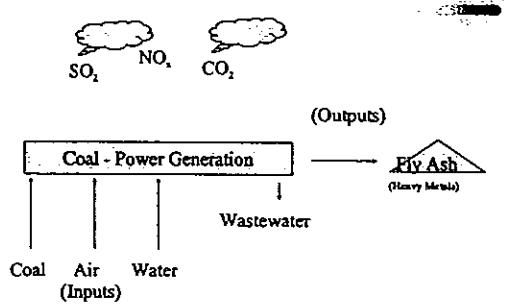
- Ozone-Depletion Potential
- Global-Warming Potential
- Acid-Rain Potential
- Photo-chemical-Oxidation Potential

WAR'S Health / Environmental Impact Categories (Cont.)

- Human-Toxicity Potential (Ingestion)
- Human-Toxicity Potential (Inhalation / Dermal Exposure)
- Aquatic-Toxicity Potential
- Terrestrial-Toxicity Potential

"WAR" Algorithm (Cont.)

PEI Illustration



Application of WAR Algorithm to IISE Project

- WAR Algorithm Can Be Modified to Use Limited Chemical Matrix
- User-friendly IISE Version, Risk Reduction Measurement Model (R2M2) Under Construction
- EPA Consulted 10/99
- R2M2 to Be Tested, Further Developed Before Widespread Use

R2M2 Modified PEI Equation

$$I = \sum M_j^{(out)} \sum \chi_{jk} \sum \alpha_{jk} \beta_{jk} \Psi_{jk}$$

where:

I = rate of output of PEI

M_j = mass flowrate of chemical wastestream

χ_{ij} = chemical fraction

α_k = weighting factor

β_{jk} = probability factor

Ψ_{jk} = PEI of chemical component

Overview of IER Process

Dr. David Nelson
Dale Rice, P.E.
Jacqui Limtin
IISE

IER Entrance Strategies

- Individual Facilities
  - Industry Databases (DTI, Statistics Office & SEC)
  - Telephone Calls
  - Letters
  - Inquiries/Referrals
- Industry Associations
  - Attending Meetings
  - Present Papers
  - Participants in Exhibitions (Booth, Brochures)

Overview of IER Process / Forms

- Overall Approach
- General Facility Information
- EMS (Quality Management) Related Questions
- Occupational Health and Safety Questions
- Environment (P2/CP) Related Questions
- Facility Walk Through
- Project Incentives
- IISE resource Allocation Strategy

IER - Pre-visit Preparation

- Pre-arranged Appointment
- Team Formation (Usually Two Persons)
- Team Leader Designation
- Work Order Completion
- IER Forms
- Appropriate Dress
  - Comfortable, Professional
  - Safety Oriented

Project No _____ File No _____ Task Code _____ Site _____

Industrial Initiatives for a Sustainable Environment (IISE)

INITIAL ENVIRONMENTAL REVIEW (IER) QUESTIONNAIRE

Note: This questionnaire is confidential and the responses will not be released to any party outside IISE.

Date: _____ IER Team Leader: _____ Site: _____
Time: _____ IER Team Members: _____

Contact Information:

Name: _____
Title: _____
Name of Organization: _____
Address: _____
Telephone No: _____
Fax: _____
Email: _____

General Organizational Information:

Owner: _____
Parent Organization: _____
☐ MNC ☐ Domestically Owned ☐ JVC JV Partner (s)_____
Year Established: _____
Industry/Government Sector: _____
PSIC: _____
Products: _____
☐ Production Capacity/Output: _____
Countries Products Exported To: _____
_____
Number of Employees: _____ Shifts: _____
Enterprise Size: ☐ Small (<50) ☐ Medium (50-300) ☐ Large (>300)
Facility Process Areas (M²): _____

General Geographic (i.e. urban vs: rural, etc.) / Geologic/Hydrogeologic Description (i.e. on-site well)
(Note: fill to the extent possible based on your knowledge, experience and readily available information)

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

G1. Does your organization have written statements related to quality, occupational health and safety and the environment?

☐ Quality ☐ Environmental ☐ Occupational Health & Safety

G2. Does your company have an organizational chart? (if so, attach to IER)

☐ Yes ☐ No ☐ Don't Know ☐ Copy attached

G3. Does your organization have a:

☐ Quality Manager ☐ Environmental Department ☐ PCO ☐ Environmental Officer ☐ Occupational Health and Safety Dept. ☐ Safety Engineer ☐ HSE Manager ☐ Don't know

G4. Is the organization certified to any of the following standards by a recognized third party provider?

☐ ISO 9001/2 ☐ ISO 14001 ☐ OHSA 18000 ☐ SA 8000 ☐ Other ☐ Don't know

Quality Management Systems Information

Q1. What methods do you use to ensure the quality of the product you produce or the service you provide?

- ☐ Inspection, during production or before dispatch of individual products or the services provided
- ☐ Quality control including product/service inspection, statistical sampling and/or other methods, etc.
- ☐ Recognized quality assurance system implemented to the ISO 9001/2/3 series standards
- ☐ Beyond ISO 9001/2/3 incorporating QMS principles contained in ISO 9004
- ☐ Don't know

Q2. Does your quality management system (QMS) apply to:

☐ Whole organization ☐ Production function only ☐ Facilities function ☐ Other ☐ Don't Know

Q3. Do you measure and monitor the quality of the products and services you provide to your customers?

☐ Yes ☐ No ☐ Don't know

Q4. Do you maintain records to demonstrate compliance with your quality performance?

☐ Yes ☐ No ☐ Don't know

Q5. Do you conduct quality audits to determine the effectiveness of the system you have in place?

☐ Yes ☐ No ☐ Don't know

Q6. If so, does your organization perform quality audits:

☐ In-house ☐ Outside auditors ☐ Both ☐ Not applicable

Occupational Health and Safety (OSH) Information

O1. Has the organization identified the OSH hazards to personnel associated with its activities, products and services?

☐ Yes ☐ No ☐ Don't know

O2. Has the organization assessed the risks to human health from physical, chemical and biological hazards and natural phenomena?

☐ Yes ☐ No ☐ Don't know

O3. Has all legislation relevant to your organization's health and safety risks been identified?

☐ Wholly ☐ Partially ☐ None ☐ Don't know

04. What methods does the organization use to control the management of its occupational health and safety risks?

- ☐ Elimination _____
- ☐ Substitution _____
- ☐ Engineering controls _____
- ☐ Administrative controls _____
- ☐ Personal Protective Equipment _____
- ☐ Occupational Health and Safety Management Systems (OHSMS) _____
- ☐ Training _____
- ☐ Others (please describe) _____

05. Does the organization have a personnel health monitoring program in place appropriate to the risks to human health?

☐ Yes ☐ No ☐ Don't know

06. Does your organization set any objectives and targets aimed at reducing the risk to human health from the workplace activities?

☐ Yes ☐ No ☐ Don't know

07. Do you monitor and measure your occupational health and safety performance?

☐ Wholly ☐ Partially ☐ Not at all ☐ Don't Know

08. Do you maintain records to enable the demonstration of your occupational health and safety performance?

☐ Yes ☐ No ☐ Don't Know

09. Do you conduct occupational health and safety audits to determine the effectiveness of the controls and programs you have in place?

☐ Yes ☐ No ☐ Don't Know

010. If so, does your organization perform occupational health and safety audits:

☐ In-house ☐ Outside auditors ☐ Both ☐ Not applicable

011. How often are you inspected by Department of Labor (DOLE)?

_____

Environment Information

E1. Do you know if the products, services and/or activities performed by your organization have any impact on the environment?

☐ Yes ☐ No ☐ Don't know

E2. Has your company identified any environmental impact from past activities?

☐ Yes ☐ No ☐ Don't know

E3. Have you identified the natural resources (water, electricity, gas etc.) needed to operate your facility?

☐ Yes ☐ No ☐ Don't Know

E4. What methods do you use to manage these activities, products or services to eliminate/reduce their impact, including resource use, on the environment? (Check all that apply; add comments as appropriate.)

- ☐ Pollution Prevention program
- ☐ Cleaner production technology _____
- ☐ Waste minimization _____
- ☐ Waste treatment _____
- ☐ Waste storage _____
- ☐ Disposal (☐ Off-site ☐ On-site) _____
  - ☐ Incineration
  - ☐ Landfill _____
- ☐ Recycling/Reuse _____
- ☐ Environmental Management Systems (EMS) _____
- ☐ Use no methods _____
- ☐ Others (please describe) _____

E5. Have you identified the legislation relevant to your organizations environmental impacts?

☐ Wholly ☐ Partially ☐ None ☐ Don't know

E6. In what areas, if any, have you experienced environmental compliance challenges?

☐ RA 6969 (HW) ☐ PD 984 (Air / Water) ☐ PD 1586 (ECC) ☐ None ☐ Don't know

E7. Does your organization set any objectives and targets related to environmental performance?

☐ Yes ☐ Some ☐ None ☐ Don't know

E8. What industrial processes are operated at the facility?

☐ Anodizing	☐ Fermentation	☐ Powder Coating	☐ Power Generation
☐ Assembly	☐ Food Processing	☐ Pressing / Stamping	☐ Sandblasting
☐ Bleaching	☐ Forging	☐ Printing	☐
☐ Bottling	☐ Fuel Storage	☐ Pulping	☐
☐ Canning	☐ Galvanizing	☐ Refining	☐
☐ Cement Production	☐ Grinding	☐ Semiconductor Mfg	☐
☐ Chemical Distillation	☐ Injection Molding	☐ Ship Building	☐
☐ Chemical Synthesis	☐ Metal Casting	☐ Ship Recycling	☐
☐ Conversion Coating	☐ Metal Refining	☐ Ship Repair	☐
☐ Cracking	☐ Mining	☐ Smelting	☐
☐ Degreasing	☐ Packaging	☐ Steel Fabrication	☐
☐ Dyeing	☐ Painting	☐ Stripping	☐
☐ Electroplating	☐ Pharmaceutical Synth.	☐ Tanning	☐
☐ Extruding	☐ Photo Processing	☐ Welding	☐
☐ Farming	☐ Pickling	☐ Wood Preserving	☐

E9. Which of the Philippines Priority Chemicals are used or manufactured at the site?
(Indicate Annual usage as follows:
(1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

☐ 1,1,1- Trichloroethane	☐ Chlorinated Ethers	☐ Mirex
☐ 1,2 Diphenylhydrazine	☐ Chromium Compounds	☐ PCBs
☐ Arsenic Compounds	☐ Cyanide Compounds	☐ Phosgene
☐ Asbestos	☐ Ethylene Dibromide	☐ Pentachlorophenol
☐ Benzene	☐ Ethylene Oxide	☐ Polybrominated Biphenyls
☐ Beryllium Compounds	☐ Halons	☐ Selenium
☐ Cadmium Compounds	☐ Hexachlorobenzene	☐ Tributyltin
☐ Carbon Tetrachloride	☐ Hexachloroethane	☐ Vinyl Chloride
☐ CFCs	☐ Lead Compounds	
☐ Chloroform	☐ Mercury Compounds	

E10. List other hazardous chemicals (e.g., "POPs" chemicals) used at facility:
(Indicate annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

- DDT
- Aldrin
- Dieldrin
- Endrin
- Chlordane
- Furans
- Heptachlor
- Toxaphene
- Dioxins

E11. How do you track the quantities of hazardous chemicals used at your facility?

☐ Inventory records ☐ Purchase records ☐ Shop floor estimates ☐ Don't track

E12. What are the major hazardous waste generated at the facility?

- ☐ Heavy metal residues, sludges
- ☐ Plating sludges
- ☐ Acid wastes
- ☐ Alkali wastes
- ☐ Inorganic chemical wastes
- ☐ Paints, dyes, latex, resins, inks
- ☐ Halogenated waste solvents
- ☐ Non-halogenated waste solvents
- ☐ Oils (including PCBs, PBBs)
- ☐ Organic chemical waste

E13. Do you have emergency management procedures in place?

☐ Yes ☐ No ☐ Don't know

E14. Are these procedures practiced on a regular basis?

☐ Yes ☐ No

E15. Do you use suppliers and/or subcontractors to supply raw materials, products or services (facility maintenance, repairs, wastewater facility management etc.)?

☐ Yes ☐ No ☐ Don't know

E16. Do you monitor and measure your environmental performance, including regulatory compliance?

☐ Wholly ☐ Partially ☐ Not at all ☐ Don't know

E17. Do you maintain records to enable the demonstration of your environmental performance?

☐ Yes ☐ No ☐ Don't know

E18. Do you conduct environmental audits to determine the effectiveness of the controls you have in place?

☐ Yes ☐ No ☐ Don't know

E19. Does your organization perform environmental audits:

☐ In-house ☐ Outside auditors ☐ Both ☐ Not applicable

E20. How often are you inspected by DENR?

_____

E21. Have you ever been issued a notice of violation by DENR?

☐ Yes ☐ No

E22. Have you encountered any community pressure or public relations problems related to the environmental operations of your company?

☐ Yes ☐ No

E23. Do you have a mechanism in place to respond to environmental complaints from the community?

☐ Yes ☐ No

Project Incentives

I1. Are you aware of the incentives that the project has to offer?

☐ Yes ☐ No

I1. Would the following be of interest to you regarding the IISE project?

☐ Customer requirement ☐ Potential cost savings ☐ Regulatory compliance
☐ Corporate requirement ☐ Public image ☐ No interest in participating
☐ Others

Walk through Inspection

W1. Do we have your permission to take photos in your facility?
☐ Yes ☐ No

W2. Walk through [redacted]

Observation **Comments**

- Product or service quality deficiencies
- General housekeeping problems
- Evidence of chemical releases
- Inadequate or incorrect product or hazardous chemical labeling
- Improper segregation or storage of hazardous material and/or waste
- Leaking valves, lines and containers
- Inadequate or incorrect PPE
- Inadequate machine guarding
- Uncovered chemical / waste containers
- Inadequate or incorrect emergency equipment
- Improper lighting / ventilation
- Absence of MSDS information
- Inadequate or ineffective maintenance
- Presence of uncontrolled physical, chemical and biological hazards and natural phenomena
- Other observations

IISE Resource Allocation Strategy

[redacted]

R1. Is the organization primarily a service provider?

☐ Yes ☐ No

R2. Are the organization's environmental impacts readily identifiable?

☐ Yes ☐ No

R3. Does the organization already have a quality, environmental or OSHMS in place?

☐ Quality ☐ Environmental ☐ OSH

[redacted]

R4. Is there "supply chain leverage" with this facility? If so, describe: _____

R5. In your opinion, does the organization have the managerial commitment to enter the IISE program?

☐ Yes ☐ No

R6. In your opinion, does the organization have the resources to enter the IISE program?

☐ Yes ☐ No

R7. What is the most appropriate assistance that IISE can provide for this organization?

☐ EMS only ☐ P2/CP only ☐ EMS/P2/CP ☐ QMS first ☐ OSHMS

R8. What are the prospects for certification within the time frame of IISE assistance?

☐ Small ☐ Medium ☐ Large

R9. What are the prospects for measurable pollution reduction that will help IISE document progress to 20% reduction pollution target?

☐ Small ☐ Medium ☐ Large

R10. Recommended strategy/next steps _____

IER Team Leader Certification Number

Organization Address

Telephone Fax e-mail

ISE Resource Allocation Strategy

R1. Is the organization primarily a service provider?

O Yes O No

R2. Are the organization's environmental impacts readily identifiable?

O Yes O No

R3. Does the organization already have a quality, environmental or OSHMS in place?

O Quality O Environmental O OSH

R4. Is there "supply chain leverage" with this facility? If so, describe: _____

R4. In your opinion, does the organization have the managerial commitment to enter the ISE program?

O Yes O No

R5. In your opinion, does the organization have the resources to enter the ISE program?

O Yes O No

R6. What is the most appropriate assistance that ISE can provide for this organization?

O EMS only O P2/CP only O EMS/P2/CP O QMS first O OSHMS

R7. What are the prospects for certification within the timeframe of ISE assistance?

O Small O Medium O Great

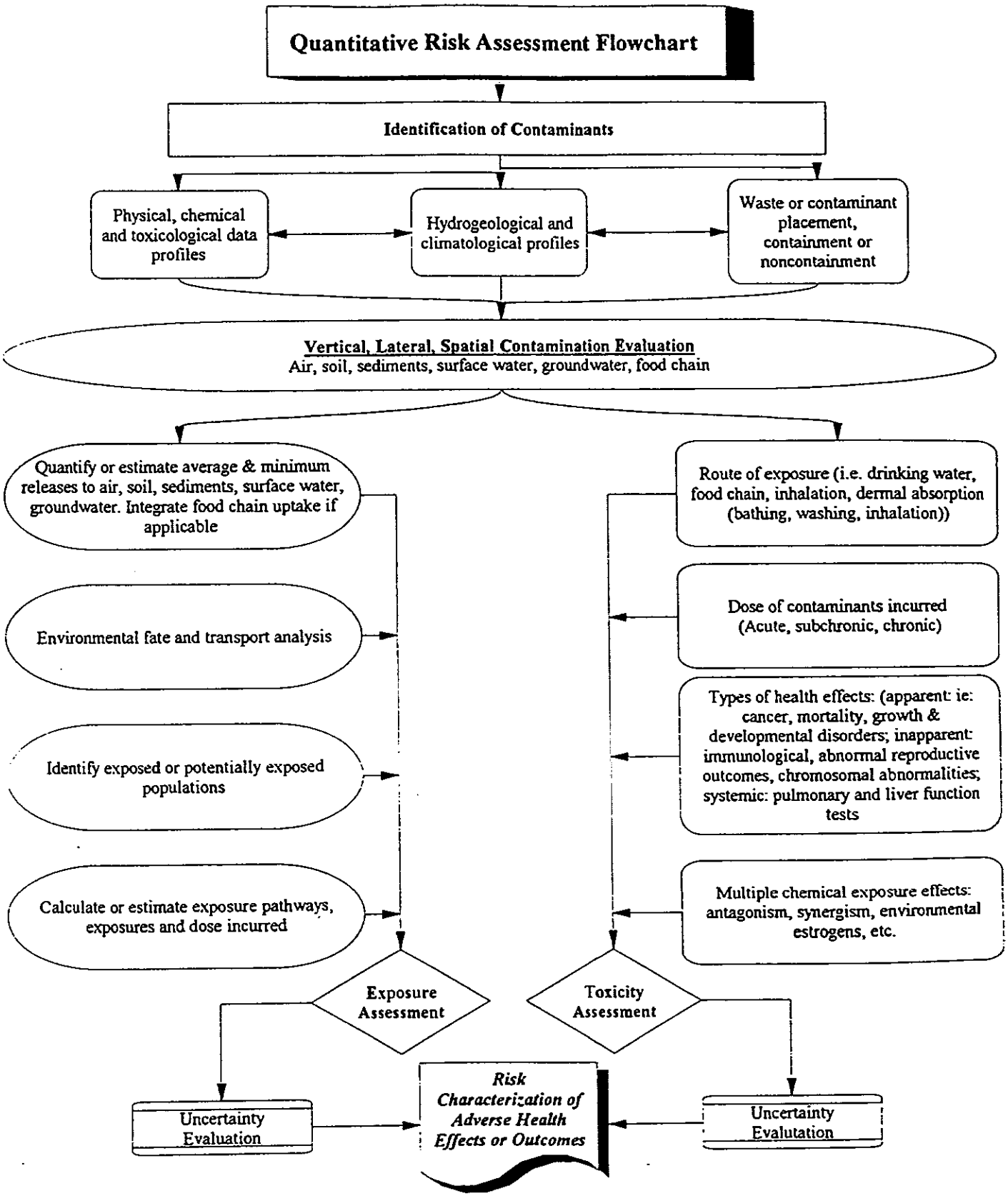
R8. What are the prospects for measurable pollution reduction that will help ISE document progress to 20% reduction pollution target?

O Small O Medium O Great

R9. Recommended strategy/next steps _____

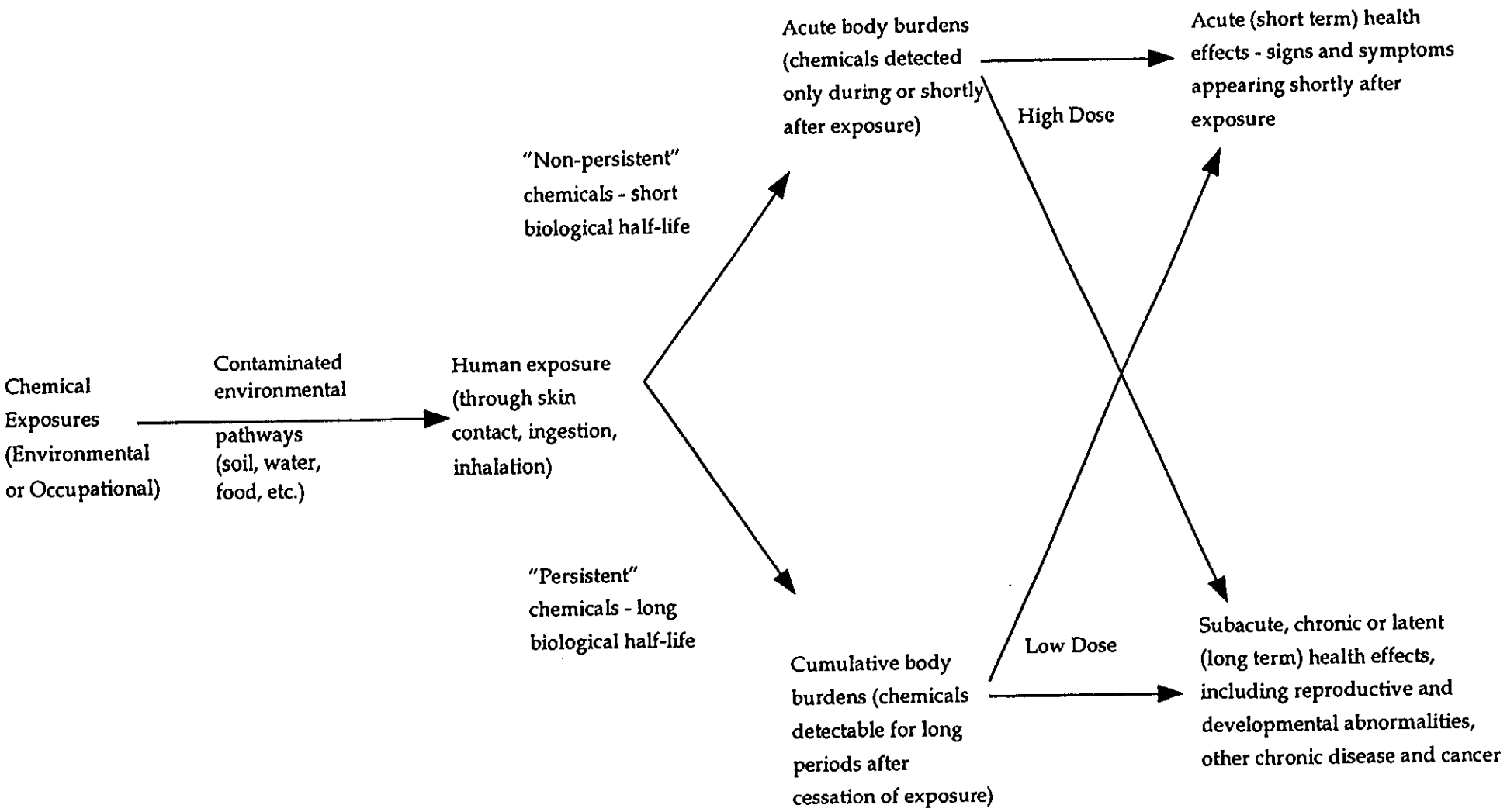
IER Team Leader _____

ENVIRONMENTAL RISK ASSESSMENT INFORMATION



USEPA Guide to Risk Assessment, 1993; Andelman, Health Effects From Hazardous Waste Sites, Underhill 1988; Van Lynden, 1997; Guidelines for the Assessment of Soil Degradation in Central and Eastern Europe; Swartjes and Van den Berg, Remediation of Contaminated Soil & Groundwater, Workshop on Contaminated Soils, 1993; Hazardous Waste Risk Assessment Techniques, D. Nelson 1993

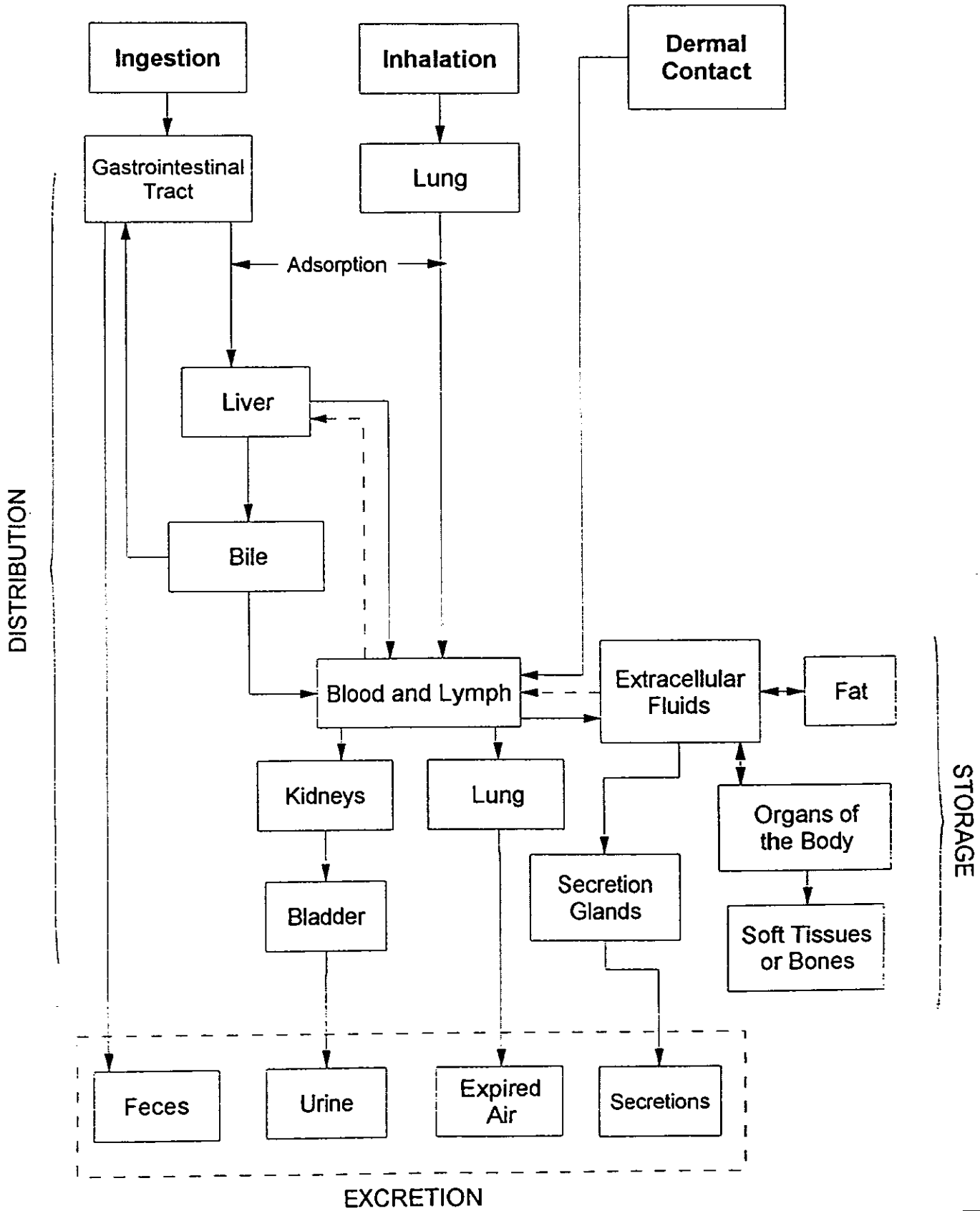
Model of Potential Health Effects Related to Chemical Exposures



After Andelman & Underhill, 1988. *Management of Hazardous & Non-Hazardous Industrial Solid Waste;* Indian Institute of Technology, New Delhi, India, October 6-7, 1998; Dr. David D. Nelson, President, EnviroSearch International; Assistant Professor, Family and Preventive Medicine, College of Medicine, Salt Lake City, Utah, USA, dnelson@xmission.com

Key Routes of Chemical Absorption, Distribution, and Excretion

Some chemcials undergo change (metabolism) within the cells of the body before excretion.
Toxicity may be produced by the chemical as introduced, or by one or more metabolites.



Generic Equation for Calculating Chemical Intakes

$$I = C \times CR \times EFC/BW \times 1/AT$$

Where:

I = intake; the amount of chemical at the exchange boundary (mg/kg body weight/day)

Chemical-related variable

C = chemical concentration; the average concentration contacted over the exposure period (e.g., mg/liter water)

Variables that describe the exposed population

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g. liters/day)

EFD = exposure frequency and duration; describes how long and how often exposure occurs. Often calculated using two terms (EF and ED):

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight; the average body weight over the exposure period (kg)

Assessment-determined variable

AT = averaging time; period over which exposure is averaged (days)

Management of Hazardous & Non-Hazardous Industrial Solid Waste: Indian Institute of Technology, New Delhi, May 6-7, 1998; D. Nelson, EnviroSearch International; Assistant Professor, College of Medicine, Salt Lake City, Utah, USA, dnelson@xmission.com

DATA AND ASSUMPTIONS NECESSARY TO ESTIMATE HUMAN DOSE OF A WATER CONTAMINANT FROM KNOWLEDGE OF ITS CONCENTRATION

Total Dose is Equal to the Sum of Doses from Five Routes

1. Direct Ingestion Through Drinking

   - Amount of water consumed each day (generally assumed to be 2 liters for adults and 1 liter for a 10 kg child).
   - Fraction of contaminant absorbed through wall of gastrointestinal tract.
   - Average human body weight.

2. Inhalation of Contaminants

   - Air concentrations resulting from showering, bathing and other uses of water.
   - Variation in air concentration over time.
   - Amount of contaminated air breathed during those activities that may lead to volatilization.
   - Fraction of inhaled contaminant absorbed through lungs.
   - Average human body weight.

3. Skin Absorption from Water

   - Period of time spent washing and bathing.
   - Fraction of contaminant absorbed through the skin during washing and bathing.
   - Average human body weight.

4. Ingestion of Contaminated Food

   - Concentration of contaminant in edible portions of various plants and animals.
   - Amount of contaminated food ingested each day.
   - Fraction of contaminant absorbed through wall of gastrointestinal tract.
   - Average human body weight.

5. Skin Absorption for Contaminated Soil

   - Concentrations of contaminant in soil exposed to contaminated groundwater or surface water.
   - Amount of daily skin contact with soil.
   - Amount of soil ingested per day (typically children).
   - Absorption rates.
   - Average human body weight.

Matrix of Potential Hazardous Waste or Chemical Route Exposures

Exposure Medium/Exposure Route	Residential Population	Commercial or Industrial Population	Recreational Population
Groundwater			
Ingestion	L	A	--
Dermal Contact	L	A	--
Surface Water			
Ingestion	L	A	L, C
Dermal Contact	L	A	L, C
Sediment			
Incidental Ingestion	C	A	C
Dermal Contact	C	A	L,C
Air			
Inhalation of Vapor			
Phase Chemicals			
Indoors	L	A	--
Outdoors	L	A	L
Inhalation of Particulates			
Indoors	L	A	--
Outdoors	L	A	L
Soil/Dust			
Incidental Ingestion	L,C	A	L,C
Dermal Contact	L,C	A	L,C
Food			
Fish and Shellfish	L		L
Meat (including organs, if consumed)	L		L
Dairy	L,C		L
Eggs	L		L
Vegetables and Fruits	L		L
Grains			L

L = lifetime exposures; **C** = exposure in children may be significantly greater than in adults; **A** = exposure to adults (occupational exposures are likely the highest); -- = exposure via this route is unlikely

Management of Hazardous & Non-Hazardous Industrial Solid Waste; Indian Institute of Technology, October 6-7, 1998; David Nelson, EnviroSearch International; Assistant Professor, University of Utah College of Medicine, Salt Lake City, Utah, USA, dnelson@xmission.com

EXAMPLE OF TABLE FORMAT FOR SUMMARIZING COMPLETE EXPOSURE PATHWAYS AT A MUNICIPAL WASTE DISPOSAL SITE IN WEST BENGAL USED FOR GROWING CERTAIN VEGETABLES*

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Exposure Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Farmers *working* on-site (including children)	Ingestion of groundwater from local wells	YES	Groundwater from shallow wells are used for irrigation of crops. Possibility of workers directly ingesting water.
Farmers *working* on-site (including children)	Ingestion of surface water from nearby sources	YES	Surface water is used for irrigation of crops. Possibility of workers directly ingesting water.
Farmers *working* on-site (including children)	Dermal exposure to chemicals	YES	Workers may be exposed to chemicals dumped at landfill via skin exposures to soil
Farmers *working* on-site (including children)	Inhalation of chemicals	YES	Workers may be exposed to volatile chemicals dumped at landfill via inhalation
Farmers *working* on-site (including children)	Consumption of contaminated food	YES	Workers may be exposed to chemicals in or on food, including fish from nearby ponds
Farmers *living* on-site (including children)	Ingestion of groundwater from local wells	YES	Groundwater from shallow wells are used for irrigation of crops. Possibility of residents directly ingesting water.
Farmers *living* on-site (including children)	Ingestion of surface water from nearby sources	YES	Surface water is used for irrigation of crops. Possibility of residents directly ingesting water.

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Exposure Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Farmers *living* on-site (including children)	Dermal exposure to chemicals	YES	Residents may be exposed to chemicals dumped at landfill via skin exposures to soil
Farmers *living* on-site (including children)	Inhalation of chemicals	YES	Residents may be exposed to volatile chemicals dumped at landfill via inhalation
Farmers *working* on-site (including children)	Consumption of contaminated food	YES	Residents may be exposed to chemicals in or on food, including fish from nearby ponds
Residents living near dumping site	Ingestion of groundwater from local wells	YES	Groundwater from shallow wells may be contaminated from landfill leachate. Possibility of residents directly ingesting water.
Residents living near dumping site	Ingestion of surface water	YES	Surface water may be contaminated from landfill leachate. Possibility of residents directly ingesting water.
Residents living near dumping site	Dermal exposure to chemicals in soils	NO	Unless working at site, it is unlikely that residents will be directly exposed to chemicals in the soil
Residents living near dumping site	Inhalation of chemicals	YES	Residents may be exposed to volatile chemicals dumped at landfill via inhalation
Residents living near dumping site	Consumption of contaminated food	YES	Residents may be exposed to chemicals in or on food, including fish from nearby ponds

Potentially Exposed Population	Exposure Route, Medium and Exposure Point	Exposure Pathway Selected for Evaluation?	Reason for Selection or Exclusion
Consumers buying food from city markets	Consumption of contaminated food (vegetables; fish)	YES	Vegetables and fish sold on open market in city
Consumers buying food from city markets	Dermal Exposures	NO	Unlikely consumers would be exposed to levels of concern
Consumers buying food from city markets	Inhalation of chemicals	NO	Unlikely consumers would be exposed to levels of concern
Consumers importing food from city markets	Consumption of contaminated food (vegetables; fish)	NO	Vegetables and fish are not exported from the area

***Note: Certain vegetables, particularly leafy vegetables, have been shown to contain heavy metal levels which exceed World Health Organization standards. No root crops are grown (radishes, carrots, beets or potatoes).**

Management of Hazardous & Non-Hazardous Industrial Solid Waste; Indian Institute of Technology, New Delhi, India, May 6-7, 1998; David D. Nelson, President, EnviroSearch International; Assistant Professor, Family and Preventive Medicine, College of Medicine, Salt Lake City, Utah, USA, dnelson@xmission.com

Project No._____ File No._____ Task Code_____ Site_____

Industrial Initiatives for a Sustainable Environment (IISE)

INITIAL ENVIRONMENTAL REVIEW (IER) QUESTIONNNAIRE

Note: This questionnaire is confidential and the responses will not be released to any party outside IISE.

Date: _____ IER Team Leader: _____
Time: _____ IER Team Members: _____

Contact Information:

Name: _____
Title: _____
Name of Organization: _____
Address: _____
Telephone No: _____
Fax: _____
Email: _____

General Organizational Information:

Owner: _____
Parent Organization: _____
❑ MNC ❑ Domestically Owned ❑ JVC JV Partner (s) _____
Year Established: _____
Industry/Government Sector: _____
PSIC: _____
Products: _____
❑ Production Capacity/Output: _____
Countries Products Exported To: _____
_____
Number of Employees: _____ Shifts: _____
Enterprise Size: ❑ Small (<50) ❑ Medium (50-300) ❑ Large (>300)
Facility Process Areas (M^2): _____

General Geographic (i.e: urban vs: rural, etc.) /Geologic/Hydrogeologic Description (i.e. on-site well) (Note: fill in to the extent possible based on your knowledge, experience and readily available information)

_____
_____
_____
_____
_____
_____
_____

G1. Does your organization have written statements related to quality, occupational health and safety, and the environment?

❑ Quality	❑ Environmental	❑ Occupational Health & Safety	❑ None

G2. Does your company have an organizational chart? (if so, attach to IER)

❑ Yes	❑ No	❑ Don't Know	❑ Copy attached

G3. Does your organization have a:

❑ Quality Manager	❑ Environmental Department	❑ PCO ❑ Environmental Officer	❑ Occupational Health and Safety Dept. ❑ Safety Engineer	❑ HSE Manager	❑ Other	❑ Don't know

G4. Is the organization certified to any of the following standards by a recognized third party provider?

❑ ISO 9001/2	❑ ISO 14001	❑ OSHMS 18000	❑ SA 8000	❑ Other	❑ Don't know

Quality Management Systems Information

Q1. What methods do you use to ensure the quality of the product you produce or the service you provide? (mark those used)

❑ Inspection, during production or before dispatch of individual products or the services provided	❑ Quality control including product / service inspection, statistical sampling and / or other methods	❑ Recognized quality assurance system implemented to the ISO 9001/2/3	❑ Beyond ISO 9001/2/3 incorporating QMS principles contained in ISO 9004	❑ Don't know

Q2. Does your quality management system (QMS) apply to:

❑Whole organization	❑ Production function only	❑ Facilities function	❑ Other	❑ Don't know

Q3. Do you measure and monitor the quality of the products and services you provide to your customers?

❑ Yes	❑ No	❑ Don't know

Q4. Do you maintain records to enable the demonstration of your quality performance?

❑ Yes	❑ No	❑ Don't know

Q5. Do you conduct quality audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't know

Q6. If so, does your organization perform quality audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

Occupational Health and Safety (OSH) Information

O1. Has the organization identified the OSH hazards to personnel associated with its activities, products and services?

❑ Yes	❑ No	❑ Don't know

O2. Has the organization assessed the risks to human health from physical, chemical and biological hazards and natural phenomena?

❑ Yes	❑ No	❑ Partially	❑ Don't know

O3. Has legislation relevant to your organization's health and safety risks been identified?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

O4. What methods does the organization use to manage its occupational health and safety risks?

- ❑ Elimination _____
- ❑ Substitution _____
- ❑ Engineering controls _____
- ❑ Administrative controls _____
- ❑ Personal Protective Equipment _____
- ❑ Occupational Health and Safety Management Systems (OHSMS) _____
- ❑ Training _____
- ❑ Others (please describe) _____

_____

O5. Does the organization have a personnel health monitoring program in place appropriate to the risks to human health?

❑ Yes	❑ No	❑ Don't know

O6. Does your organization set any objectives and targets aimed at reducing the risk to human health from the workplace activities?

❑ Yes	❑ No	❑ Don't know

O7. Do you monitor and measure your occupational health and safety performance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't Know

O8. Do you maintain records to enable the demonstration of your occupational health and safety performance?

❑ Yes	❑ No	❑ Don't Know

O9. Do you conduct occupational health and safety audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't Know

O10. If so, does your organization perform occupational health and safety audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

O11. How often are you inspected by the Department of Labor (DOLE)?

_____

Environment Information

E1. Do you know if the products, services and/or activities performed by your organization have any impact on the environment?

❑ Yes	❑ No	❑ Don't know

E2. Has your company identified any environmental impact from past activities?

❑ Yes	❑ No	❑ Don't know

E3. Have you identified the natural resources (water, electricity, gas etc.,) needed to operate your facility?

❑ Yes	❑ No	❑ Don't Know

E4. What methods do you use to manage these activities, products or services to eliminate/reduce their impact, including resource use, on the environment? (Check all that apply; add comments as appropriate.)

- ❑ Pollution Prevention program
- ❑ Cleaner production technology _____
- ❑ Waste minimization _____
- ❑ Waste treatment _____
- ❑ Waste storage _____
- ❑ Disposal (❑ Off-site ❑ On-site) _____
  - ❑ Incineration _____
  - ❑ Landfill _____
- ❑ Recycling/Reuse _____
- ❑ Environmental Management Systems (EMS) _____
- ❑ Use no methods _____
- ❑ Others (please describe) _____

E5. Have you identified the legislation relevant to your organizations environmental impacts?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

E6. In what areas, if any, have you experienced environmental compliance cballenges?

❑ RA 6969 (HW)	❑ PD 984 (Air / Water)	❑ PD 1586 (ECC)	❑ None	❑ Don't know

E7. Does your organization set any objectives and targets related to environmental performance?

❑ Yes	❑ Some	❑ None	❑ Don't know

E8. What industrial processes are operated at the facility?

❑ Anodizing	❑ Fermentation	❑ Powder Coating	❑ Power Generation
❑ Assembly	❑ Food Processing	❑ Pressing / Stamping	❑ Sandblasting
❑ Bleaching	❑ Forging	❑ Printing	❑
❑ Bottling	❑ Fuel Storage	❑ Pulping	❑
❑ Canning	❑ Galvanizing	❑ Refining	❑
❑ Cement Production	❑ Grinding	❑ Semiconductor Mfg	❑
❑ Chemical Distillation	❑ Injection Molding	❑ Ship Building	❑
❑ Chemical Synthesis	❑ Metal Casting	❑ Ship Recycling	❑
❑ Conversion Coating	❑ Metal Refining	❑ Ship Repair	❑
❑ Cracking	❑ Mining	❑ Smelting	❑
❑ Degreasing	❑ Packaging	❑ Steel Fabrication	❑
❑ Dyeing	❑ Painting	❑ Stripping	❑
❑ Electroplating	❑ Pharmaceutical Synth.	❑ Tanning	❑
❑ Extruding	❑ Photo Processing	❑ Welding	❑
❑ Farming	❑ Pickling	❑ Wood Preserving	❑

E9. Which of the Philippines Priority Chemicals are used or manufactured at the site?
(Indicate Annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

❑	1,1,1- Trichloroethane	❑	Chlorinated Ethers	❑	Mirex
❑	1,2 Diphenylhydrazine	❑	Chromium Compounds	❑	PCBs
❑	Arsenic Compounds	❑	Cyanide Compounds	❑	Phosgene
❑	Asbestos	❑	Ethylene Dibromide	❑	Pentachlorophenol
❑	Benzene	❑	Ethylene Oxide	❑	Polybrominated Biphenyls
❑	Beryllium Compounds	❑	Halons	❑	Selenium
❑	Cadmium Compounds	❑	Hexachlorobenzene	❑	Tributyltin
❑	Carbon Tetrachloride	❑	Hexachloroethane	❑	Vinyl Chloride
❑	CFCs	❑	Lead Compounds	❑	
❑	Chloroform	❑	Mercury Compounds	❑	

E10. List other hazardous chemicals (e.g., "POPs" chemicals) used at facility:
(Indicate annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

DDT		Toxaphene	
Aldrin		Dioxins	
Dieldrin		Other:	
Endrin		Other:	
Chlordane		Other:	
Furans		Other:	
Heptachlor		Other:	

E11. How do you track the quantities of hazardous chemicals used at your facility?

❑ Inventory records	❑ Purchase records	❑ Shop floor estimates	❑ Don't track

E12. What are the major hazardous wastes generated at the facility?

❑ Heavy metal residues, sludges	❑ Organic chemical wastes
❑ Plating sludge	❑ Other:
❑ Acid wastes	❑ Other:
❑ Alkali wastes	❑ Other:
❑ Inorganic chemical wastes	❑ Other:
❑ Paints, dyes, latex, resins, inks	❑ Other:
❑ Halogenated waste solvents	❑ Other:
❑ Non-halogenated waste solvents	❑ Other:
❑ Oils (including PCBs, PBBs)	❑ Other:

E13. Do you have emergency response procedures in place?

❑ Yes	❑ No	❑ Don't know

E14. Are these procedures practiced on a regular basis?

❑ Yes	❑ No

E15. Do you use suppliers and/or subcontractors to supply raw materials, products or services (facility maintenance, repairs, wastewater facility management etc.)?

❑ Yes	❑ No	❑ Don't know

E16. Do you monitor and measure your environmental performance, including regulatory compliance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't know

E17. Do you maintain records to demonstrate your environmental performance?

❑ Yes	❑ No	❑ Don't know

E18. Do you conduct environmental audits to determine the effectiveness of the controls you have in place?

❑ Yes	❑ No	❑ Don't know

E19. Does your organization perform environmental audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

E20. How often are you inspected by DENR?

_____

E21. Have you ever been served a notice of violation or cease and desist order by DENR?

❑ Yes	❑ No

E22. Have you encountered any community pressure or public relations problems related to the environmental operations of your company?

❑ Yes	❑ No

E23. Do you have a mechanism in place to respond to environmental complaints from the community?

❑ Yes	❑ No

Project Incentives

I1. Are you aware of the incentives that the project has to offer?

❑ Yes	❑ No

I2. Would the following be of interest to you regarding the IISE project?

❑ Customer requirement	❑ Potential cost savings	❑ Regulatory compliance	❑ Public image	❑ No interest in participating
❑ Corporate requirement	❑ Other			

Walk Through Inspection

W1. Do we have your permission to take photos in your facility?

❑ Yes	❑ No

W2. Walk through

Observation	Comments
❑ Product or service quality deficiencies	
❑ General housekeeping problems	
❑ Evidence of chemical releases	
❑ Inadequate or incorrect product or hazardous chemical labelling	
❑ Lack of safety warning signs	
❑ Improper segregation or storage of hazardous material and/or waste	
❑ Leaking valves, lines and containers	
❑ Inadequate or incorrect PPE	
❑ Inadequate machine guarding	
❑ Uncovered chemical / waste containers	
❑ Inadequate or incorrect emergency equipment and/or ineffective management	
❑ Improper lighting / ventilation	
❑ Absence of MSDS information	
❑ Inadequate or ineffective maintenance	
❑ Presence of uncontrolled physical, chemical and biological hazards and natural phenomena	

❑ Other Observations:	

IER Team Leader IER Certification Number

Organization

Address

Telephone email

Number of Hours On-Site

IISE Resource Allocation Strategy

R1. Is the organization primarily a service provider?

❑ Yes	❑ No

R2. Are the organization's environmental impacts readily identifiable?

❑ Yes	❑ No

R3. Does the organization already have a quality, environmental or OSH management system in place?

❑ Quality	❑ Environmental	❑ OSH

R4. Is there "supply chain leverage" with this facility? If so, describe: _____

_____

R5. In your opinion, does the organization have the managerial commitment to enter the IISE program?

❑ Yes	❑ No

R6. In your opinion, does the organization have the resources to enter the IISE program?

❑ Yes	❑ No

R7. What is the most appropriate assistance that IISE can provide for this organization?

❑EMS only	❑ P2/CP only	❑EMS/P2/CP	❑QMS first	❑OSHMS

R8. What are the prospects for certification within the timeframe of IISE assistance?

❑ Small	❑ Medium	❑ Large

R9. What are the prospects for measurable pollution reduction that will help IISE document progress to 20% reduction pollution target?

❑ Small	❑ Medium	❑ Large

R10. Recommended strategy/next steps _____

_____

_____

_____

IER Team Leader IER Certification Number

_____

Organization Address

_____

Telephone Fax Email

Project No._____ File No._____ Task Code_____ Site_____

Industrial Initiatives for a Sustainable Environment (IISE)

INITIAL ENVIRONMENTAL REVIEW (IER) QUESTIONNNAIRE

Note: This questionnaire is confidential and the responses will not be released to any party outside IISE.

Date: _____ IER Team Leader: _____
Time: _____ IER Team Members: _____

Contact Information:

Name: _____
Title: _____
Name of Organization: _____
Address: _____
Telephone No: _____
Fax: _____
Email: _____

General Organizational Information:

Owner: _____
Parent Organization: _____
❑ MNC ❑ Domestically Owned ❑ JVC JV Partner (s) _____
Year Established: _____
Industry/Government Sector: _____
PSIC: _____
Products: _____
❑ Production Capacity/Output: _____
Countries Products Exported To: _____
_____
Number of Employees: _____ Shifts: _____
Enterprise Size: ❑ Small (<50) ❑ Medium (50-300) ❑ Large (>300)
Facility Process Areas (M^2): _____

General Geographic (i.e: urban vs: rural, etc.) /Geologic/Hydrogeologic Description (i.e. on-site well) (Note: fill in to the extent possible based on your knowledge, experience and readily available information)

_____
_____
_____
_____
_____
_____
_____

G1. Does your organization have written statements related to quality, occupational health and safety, and the environment?

❑ Quality	❑ Environmental	❑ Occupational Health & Safety	❑ None

G2. Does your company have an organizational chart? (if so, attach to IER)

❑ Yes	❑ No	❑ Don't Know	❑ Copy attached

G3. Does your organization have a:

❑ Quality Manager	❑ Environmental Department	❑ PCO ❑ Environmental Officer	❑ Occupational Health and Safety Dept. ❑ Safety Engineer	❑ HSE Manager	❑ Other	❑ Don't know

G4. Is the organization certified to any of the following standards by a recognized third party provider?

❑ ISO 9001/2	❑ ISO 14001	❑ OSHMS 18000	❑ SA 8000	❑ Other	❑ Don't know

Quality Management Systems Information

Q1. What methods do you use to ensure the quality of the product you produce or the service you provide? (mark those used)

❑ Inspection, during production or before dispatch of individual products or the services provided	❑ Quality control including product / service inspection, statistical sampling and / or other methods	❑ Recognized quality assurance system implemented to the ISO 9001/2/3	❑ Beyond ISO 9001/2/3 incorporating QMS principles contained in ISO 9004	❑ Don't know

Q2. Does your quality management system (QMS) apply to:

❑Whole organization	❑ Production function only	❑ Facilities function	❑ Other	❑ Don't know

Q3. Do you measure and monitor the quality of the products and services you provide to your customers?

❑ Yes	❑ No	❑ Don't know

Q4. Do you maintain records to enable the demonstration of your quality performance?

❑ Yes	❑ No	❑ Don't know

Q5. Do you conduct quality audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't know

Q6. If so, does your organization perform quality audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

Occupational Health and Safety (OSH) Information

O1. Has the organization identified the OSH hazards to personnel associated with its activities, products and services?

❑ Yes	❑ No	❑ Don't know

O2. Has the organization assessed the risks to human health from physical, chemical and biological hazards and natural phenomena?

❑ Yes	❑ No	❑ Partially	❑ Don't know

O3. Has legislation relevant to your organization's health and safety risks been identified?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

O4. What methods does the organization use to manage its occupational health and safety risks?

- ❑ Elimination _____
- ❑ Substitution _____
- ❑ Engineering controls _____
- ❑ Administrative controls _____
- ❑ Personal Protective Equipment _____
- ❑ Occupational Health and Safety Management Systems (OHSMS) _____
- ❑ Training _____
- ❑ Others (please describe) _____

_____

O5. Does the organization have a personnel health monitoring program in place appropriate to the risks to human health?

❑ Yes	❑ No	❑ Don't know

O6. Does your organization set any objectives and targets aimed at reducing the risk to human health from the workplace activities?

❑ Yes	❑ No	❑ Don't know

O7. Do you monitor and measure your occupational health and safety performance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't Know

O8. Do you maintain records to enable the demonstration of your occupational health and safety performance?

❑ Yes	❑ No	❑ Don't Know

O9. Do you conduct occupational health and safety audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't Know

O10. If so, does your organization perform occupational health and safety audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

O11. How often are you inspected by the Department of Labor (DOLE)?

_____

Environment Information

E1. Do you know if the products, services and/or activities performed by your organization have any impact on the environment?

❑ Yes	❑ No	❑ Don't know

E2. Has your company identified any environmental impact from past activities?

❑ Yes	❑ No	❑ Don't know

E3. Have you identified the natural resources (water, electricity, gas etc.,) needed to operate your facility?

❑ Yes	❑ No	❑ Don't Know

E4. What methods do you use to manage these activities, products or services to eliminate/reduce their impact, including resource use, on the environment? (Check all that apply; add comments as appropriate.)

- ❑ Pollution Prevention program
- ❑ Cleaner production technology _____
- ❑ Waste minimization _____
- ❑ Waste treatment _____
- ❑ Waste storage _____
- ❑ Disposal (❑ Off-site ❑ On-site) _____
  - ❑ Incineration _____
  - ❑ Landfill _____
- ❑ Recycling/Reuse _____
- ❑ Environmental Management Systems (EMS) _____
- ❑ Use no methods _____
- ❑ Others (please describe) _____

_____

E5. Have you identified the legislation relevant to your organizations environmental impacts?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

E6. In what areas, if any, have you experienced environmental compliance challenges?

❑ RA 6969 (HW)	❑ PD 984 (Air / Water)	❑ PD 1586 (ECC)	❑ None	❑ Don't know

E7. Does your organization set any objectives and targets related to environmental performance?

❑ Yes	❑ Some	❑ None	❑ Don't know

E8. What industrial processes are operated at the facility?

❑ Anodizing	❑ Fermentation	❑ Powder Coating	❑ Power Generation
❑ Assembly	❑ Food Processing	❑ Pressing / Stamping	❑ Sandblasting
❑ Bleaching	❑ Forging	❑ Printing	❑
❑ Bottling	❑ Fuel Storage	❑ Pulping	❑
❑ Canning	❑ Galvanizing	❑ Refining	❑
❑ Cement Production	❑ Grinding	❑ Semiconductor Mfg	❑
❑ Chemical Distillation	❑ Injection Molding	❑ Ship Building	❑
❑ Chemical Synthesis	❑ Metal Casting	❑ Ship Recycling	❑
❑ Conversion Coating	❑ Metal Refining	❑ Ship Repair	❑
❑ Cracking	❑ Mining	❑ Smelting	❑
❑ Degreasing	❑ Packaging	❑ Steel Fabrication	❑
❑ Dyeing	❑ Painting	❑ Stripping	❑
❑ Electroplating	❑ Pharmaceutical Synth.	❑ Tanning	❑
❑ Extruding	❑ Photo Processing	❑ Welding	❑
❑ Farming	❑ Pickling	❑ Wood Preserving	❑

E9. Which of the Philippines Priority Chemicals are used or manufactured at the site?
(Indicate Annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

❑	1,1,1- Trichloroethane	❑	Chlorinated Ethers	❑	Mirex
❑	1,2 Diphenylhydrazine	❑	Chromium Compounds	❑	PCBs
❑	Arsenic Compounds	❑	Cyanide Compounds	❑	Phosgene
❑	Asbestos	❑	Ethylene Dibromide	❑	Pentachlorophenol
❑	Benzene	❑	Ethylene Oxide	❑	Polybrominated Biphenyls
❑	Beryllium Compounds	❑	Halons	❑	Selenium
❑	Cadmium Compounds	❑	Hexachlorobenzene	❑	Tributyltin
❑	Carbon Tetrachloride	❑	Hexachloroethane	❑	Vinyl Chloride
❑	CFCs	❑	Lead Compounds	❑	
❑	Chloroform	❑	Mercury Compounds	❑	

E10. List other hazardous chemicals (e.g., "POPs" chemicals) used at facility:
(Indicate annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

DDT		Toxaphene	
Aldrin		Dioxins	
Dieldrin		Other:	
Endrin		Other:	
Chlordane		Other:	
Furans		Other:	
Heptachlor		Other:	

E11. How do you track the quantities of hazardous chemicals used at your facility?

❑ Inventory records	❑ Purchase records	❑ Shop floor estimates	❑ Don't track

E12. What are the major hazardous wastes generated at the facility?

❑ Heavy metal residues, sludges	❑ Organic chemical wastes
❑ Plating sludge	❑ Other:
❑ Acid wastes	❑ Other:
❑ Alkali wastes	❑ Other:
❑ Inorganic chemical wastes	❑ Other:
❑ Paints, dyes, latex, resins, inks	❑ Other:
❑ Halogenated waste solvents	❑ Other:
❑ Non-halogenated waste solvents	❑ Other:
❑ Oils (including PCBs, PBBs)	❑ Other:

E13. Do you have emergency response procedures in place?

❑ Yes	❑ No	❑ Don't know

E14. Are these procedures practiced on a regular basis?

❑ Yes	❑ No

E15. Do you use suppliers and/or subcontractors to supply raw materials, products or services (facility maintenance, repairs, wastewater facility management etc.)?

❑ Yes	❑ No	❑ Don't know

E16. Do you monitor and measure your environmental performance, including regulatory compliance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't know

E17. Do you maintain records to demonstrate your environmental performance?

❑ Yes	❑ No	❑ Don't know

E18. Do you conduct environmental audits to determine the effectiveness of the controls you have in place?

❑ Yes	❑ No	❑ Don't know

E19. Does your organization perform environmental audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

E20. How often are you inspected by DENR?

_____

E21. Have you ever been served a notice of violation or cease and desist order by DENR?

❑ Yes	❑ No

E22. Have you encountered any community pressure or public relations problems related to the environmental operations of your company?

❑ Yes	❑ No

E23. Do you have a mechanism in place to respond to environmental complaints from the community?

❑ Yes	❑ No

Project Incentives

I1. Are you aware of the incentives that the project has to offer?

❑ Yes	❑ No

I2. Would the following be of interest to you regarding the IISE project?

❑ Customer requirement	❑ Potential cost savings	❑ Regulatory compliance	❑ Public image	❑ No interest in participating
❑ Corporate requirement	❑ Other			

Walk Through Inspection

W1. Do we have your permission to take photos in your facility?

❑ Yes	❑ No

W2. Walk through

Observation	Comments
❑ Product or service quality deficiencies	
❑ General housekeeping problems	
❑ Evidence of chemical releases	
❑ Inadequate or incorrect product or hazardous chemical labelling	
❑ Lack of safety warning signs	
❑ Improper segregation or storage of hazardous material and/or waste	
❑ Leaking valves, lines and containers	
❑ Inadequate or incorrect PPE	
❑ Inadequate machine guarding	
❑ Uncovered chemical / waste containers	
❑ Inadequate or incorrect emergency equipment and/or ineffective management	
❑ Improper lighting / ventilation	
❑ Absence of MSDS information	
❑ Inadequate or ineffective maintenance	
❑ Presence of uncontrolled physical, chemical and biological hazards and natural phenomena	

❑ Other Observations:	

IER Team Leader IER Certification Number

Organization

Address

Telephone email

Number of Hours On-Site

IISE Resource Allocation Strategy

R1. Is the organization primarily a service provider?

❑ Yes	❑ No

R2. Are the organization's environmental impacts readily identifiable?

❑ Yes	❑ No

R3. Does the organization already have a quality, environmental or OSH management system in place?

❑ Quality	❑ Environmental	❑ OSH

R4. Is there "supply chain leverage" with this facility? If so, describe: _____

_____

R5. In your opinion, does the organization have the managerial commitment to enter the IISE program?

❑ Yes	❑ No

R6. In your opinion, does the organization have the resources to enter the IISE program?

❑ Yes	❑ No

R7. What is the most appropriate assistance that IISE can provide for this organization?

❑EMS only	❑ P2/CP only	❑EMS/P2/CP	❑QMS first	❑OSHMS

R8. What are the prospects for certification within the timeframe of IISE assistance?

❑ Small	❑ Medium	❑ Large

R9. What are the prospects for measurable pollution reduction that will help IISE document progress to 20% reduction pollution target?

❑ Small	❑ Medium	❑ Large

R10. Recommended strategy/next steps _____

_____

_____

_____

IER Team Leader IER Certification Number

_____

Organization Address

_____

Telephone Fax Email

MSE Millennium Science & Engineering, Inc.

1364 Beverly Road, Suite 302
McLean, Virginia 22101
Phone: 703.734.1090
Fax: 703.734.1093
e-mail: mse@erols.com

April 19, 1999

Mr. Douglas M. Young, Ph.D.
Sustainable Technology Division
National Risk Management Research Lab
US Environmental Protection Agency
26 W. Martin Luther King Dr.
Cincinnati, OH 45268

Via Fax: 513-569-7111

Dear Dr. Young:

It has been a pleasure speaking with you about pollution prevention (P2) and the Waste Reduction (WAR) Algorithm. As we discussed, P2 is very near and dear to me; and the WAR Algorithm seems like an excellent tool for comparing P2 options including process and/or chemical changes, and we believe that the WAR Algorithm and its associated database appear to have direct application to the pollution prevention / cleaner production project on which I am working for USAID in the Philippines.

It would be a great benefit to me if you could release to me the part of the database containing information on the Republic of the Philippines Priority Chemicals. These 28 chemicals include the organic compounds: asbestos, benzene, carbon tetrachloride, chlorofluoro-carbons, chloroform, chlorinated ethers, ethylene dibromide, ethylene oxide, halons, hexachlorobenzene, hexachloroethane, mirex, polychlorinated biphenyls, phosgene, pentachlorophenol, polybrominated biphenyls, selenium, tributyltin, vinyl chloride, 1,1,1-trichloroethane, and 1,2-diphenylhydrazine. Also included are arsenic, beryllium, cadmium, chromium, cyanide, lead, and mercury. If any of these chemicals are not in your database, we would be interested to learn how to add new chemicals.

Releasing an electronic copy (Excel format) as soon as possible would be a great benefit to the project, as we are currently in the development stage of the project and would benefit greatly from knowing options available for comparing CP/P2 options.

I look forward to your further input and assistance and can easily be contacted at 703-734-1090 (phone), 703-734-1093 (fax), and mse@erols.com (e-mail). Please ask for Todd Danielson in my absence.

Best Regards,

Dale Rice

cc: T.A. Danielson

Using Simulation For Pollution Prevention

Heriberto Cabezas and Douglas Young
U.S. Environmental Protection Agency, Sustainable Technology Div.

The goal is to design or modify chemical processes to minimize their environmental impact

The ability to design or modify chemical processes in a way that minimizes the formation of unwanted byproducts is an ongoing goal for process engineers. Two simulation and design methods are discussed here: Process Integration (PI), developed by El-Halwagi and Manousiouthakis [1] at UCLA, and El-Halwagi [2] at Auburn University; and the Waste Reduction (WAR) Algorithm, developed at the U.S. Environmental Protection Agency (Cincinnati, Ohio), and made commercially available through a Cooperative Research and Development Agreement (Crada) under the Federal Technology Transfer Act of 1986.[1]

PI is concerned with improving process efficiency and keeping targeted components from leaving the system. PI is essentially the practical application of the mass-exchange networks (MEN), as detailed in [1,2], which try to remove pollutants from product streams and segregate them into concentrated waste streams.

By comparison, the WAR Algorithm is concerned with evaluating and reducing the potential environmental impact of a process [3] — a key design consideration. Consider Process A, which emits 1 ton/h of a given pollutant, and Process B, which emits 2 tons/h of a different pollutant. When these two processes are compared on the basis of pollutant mass alone, one could logically conclude that Process A is preferable. However, because some pollutants are more toxic than others, the process comparison needs to assess the human-health and environmental impacts.

[1] Process Integration methodology has been commercialized by Matrix Integration, Inc. (Leesburg, Va.). The initial version of the WAR algorithm is being incorporated into the simulator product ChemCAD IV from Chemstations, Inc. (Houston, Tex.). The authors' discussion here does not endorse either of these commercial products or companies.

Note: For more on simulation, see p. 139.

The WAR Algorithm

This methodology assumes that each stream entering and exiting a process possesses an inherent property, its potential environmental impact (PEI). WAR generates four indexes (discussed below), which can be used to compare the environmental impact of various process alternatives. For a steady-state process, one can write a balance equation for PEI:

$$O = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \quad (1)$$

where:

$\dot{I}_{in}$ = The rate of PEI input, PEI/h (the impact on the environment if all feed streams were to be released at once)

$\dot{I}_{out}$ = The rate of PEI output, PEI/h, (the impact on the environment if all output streams were to be released)

$\dot{I}_{gen}$ = The rate of PEI generation by the process, PEI/h (the difference between $\dot{I}_{out}$ and $\dot{I}_{in}$; $\dot{I}_{gen}$ can be positive or negative, because a given process can either create or consume PEI)

From Equation 1, one can generate two output indexes and two generation indexes, to compare different process alternatives. The lower the value of these indexes, the better the process's environmental performance.

The *output indexes* include the rate of PEI output, $\dot{I}_{out}$, and the amount of PEI output per kilogram of product, $\hat{I}_{out}$. These indexes allow comparison of the potential impact of various output streams on human health and the environment. $\hat{I}_{out}$ is given by:

$$\hat{I}_{out} = \dot{I}_{out} / \dot{P} \quad (2)$$

where:

$\dot{P}$ = The rate at which the process produces products, kg/h

The *generation indexes* are the rate of PEI generation, $\dot{I}_{gen}$, and the amount of PEI generated per kilogram of product, $\hat{I}_{gen}$. They allow comparison of process alternatives, in terms of the generation of net PEI. $\hat{I}_{gen}$ is given by:

$$\hat{I}_{gen} = \frac{\dot{I}_{out} - \dot{I}_{in}}{\dot{P}} \quad (3)$$

To compute the four indexes for a

NOMENCLATURE

$\dot{I}_{in}$ = The rate of input of PEI, PEI/h

$\dot{I}_{out}$ = The rate of output of PEI, PEI/h

$\dot{I}_{gen}$ = The rate of PEI generation inside the process, PEI/h (i.e., the difference between $\dot{I}_{in}$ and $\dot{I}_{out}$)

$\hat{I}_{out}$ = The amount of PEI output/kg of product

$\dot{P}$ = The rate at which the process produces product, kg/h

$\hat{I}_{gen}$ = The amount of PEI generated/kg of product

$\hat{I}_i^{in}$ = The PEI input per kg of product, for each individual input stream, i

$\dot{I}_i^{in}, \dot{I}_i^{out}$ = The PEI rate of each individual input and output stream, i, PEI/h

$\dot{M}_i^{in}, \dot{M}_i^{out}$ = Mass flowrate of each input and output for each stream, i, kg/h

x_{ij} = The mass fraction of each non-product chemical component, j, in stream i, kg/kg

Ψ_j = The overall environmental impact of chemical component, j, PEI/kg

α_k = A weighting factor that allows one to assign relative importance to each of the eight environmental-impact categories, k, used by the WAR Algorithm

Ψ_{jk}^{s} = Specific impact of chemical component, j, in impact category, k, PEI/kg

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given process, the rate of PEI of all the input and output streams, $\dot{I}_{in}$ and $\dot{I}_{out}$, respectively, must be calculated. For the input streams, this is done by calculating the PEI rate of each individual input stream, i ($\dot{I}_i^{(in)}$), and then adding the individual values to get $\dot{I}_{in}$. For the output streams, this is done by calculating the PEI rate of each individual input stream, i ($\dot{I}_i^{(out)}$), and then adding them to get $\dot{I}_{out}$. For each stream, i, the PEI rates of the individual input and output streams are calculated from the following:

- The mass flowrate of each input and output, $\dot{M}_i^{(in)}$ and $\dot{M}_i^{(out)}$, respectively
- The stream composition, in terms of the mass fraction, x_{ij}, of each nonproduct chemical component (pollutant and undesired byproduct), j
- The overall environmental impact, ψ_j, of chemical component j

The overall environmental impact, ψ_j, is calculated by summing the specific impacts, ψ^s_{jk}, of chemical component j over the various impact category k (discussed below), in units of PEI/kg. This is given by,

$$\dot{I}_{in} = \sum_i \dot{I}_i^{(in)} = \sum_i \dot{M}_i^{(in)} \sum_j x_{ij}\psi_j = \sum_i \dot{M}_i^{(in)} \sum_j x_{ij} \sum_k \alpha_k \psi^s_{jk} \quad (4)$$

$$\dot{I}_{out} = \sum_i \dot{I}_i^{(out)} = \sum_i \dot{M}_i^{(out)} \sum_j x_{ij}\psi_j = \sum_i \dot{M}_i^{(out)} \sum_j x_{ij} \sum_k \alpha_k \psi^s_{jk} \quad (5)$$

where:

α_k = A weighting factor for each impact category k

GOING TO 'WAR' FOR A 'GREENER' ACRYLIC-ACID PROCESS

To illustrate the use of the WAR Algorithm, consider an acrylic-acid-production process designed to produce 50,000 m.t./yr of acrylic acid (Figure 1). The process catalytically oxidizes propylene with air to form acrylic acid, and several byproducts (acetic acid, hydrogen, water and carbon dioxide) [4]. Three alternative design scenarios were considered: a base case (Unit 300) and two alternative designs (Units 301 and 302).

In the base case (Unit 300), the reactor operates at 310°C. The effluent is quenched in an adiabatic flash drum with a substantial recycle stream (98%). The flash-drum vapor effluent is stripped with deionized water to recover any residual acrylic acid.

The vapor effluent from the stripper is delivered to an incinerator. The liquid effluent from the flash drum is mixed with liquid effluent from the stripper; 98% of this mixed stream is recycled to the flash drum for quenching. The non-recycled, liquid effluent is sent to a liquid-liquid extraction unit, where the organics are extracted with a solvent mixture of diisopropyl ether (DIPE; 87 mol%) and water.

The aqueous effluent, which contains small amounts of acetic acid, acrylic acid and DIPE, is distilled to recover pure water, which is considered a waste (since it is not deionized, it cannot be reused in the process). The acids and DIPE are recycled back to the extraction column. The organic effluent from the extraction tower is sent to solvent-recovery column and then to an acrylic-acid distillation column. The final acrylic acid product is 99.9 mol% pure.

In this design, there is no consumption of DIPE. Rather, the initial charge of DIPE is completely recovered within the process.

Acrylic acid is considered the only product in this case study. With the objective of minimizing the potential environmental impact (PEI) of the other three effluent streams and maximizing acrylic acid production, possible improvements were sought. Because the reactor waste gas contains unreacted propylene and byproduct carbon dioxide, the reactor operation was examined.

Seeking improvements

The kinetics of this process are such that lower temperatures favor acrylic acid production. Thus, in the first design alternative, Unit 301, the reactor temperature was reduced by 30°C, to 280°C. This design also incorporated a 54% increase in the reflux ratio of the acrylic acid column. Decreasing the reactor temperature resulted in an equivalent conversion of propylene. However, it produced a greater selectivity toward acrylic acid (from 1.58 to 2.31 mole of acrylic acid per mole of byproduct).

In the second design alternative, Unit 302, the reactor temperature was reduced by another 20°C, to 260°C, and the reactor volume was doubled to maintain an equivalent level of propylene conversion. The reflux ratio in the acrylic acid column was also increased; however, only a 9% increase was required to achieve the same separation as observed in Unit 301.

The four output and generation PEI indexes described above were plotted for the base case and for the the two process modifications. Figure 2 shows the output indexes, $\dot{I}_{out}$ and $\dot{I}_{out}$, and the generation indexes, $\dot{I}_{gen}$ and $\dot{I}_{gen}$. □

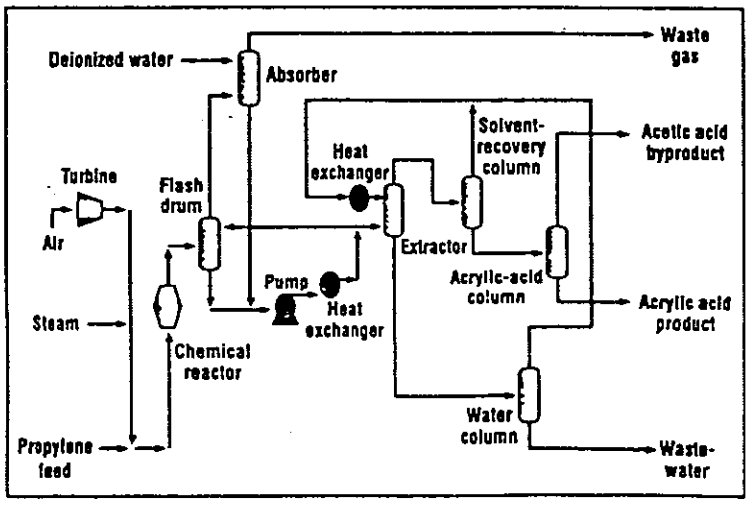

FIGURE 1. The WAR Algorithm was used to identify several waste-minimization routes for the acrylic-acid process shown above

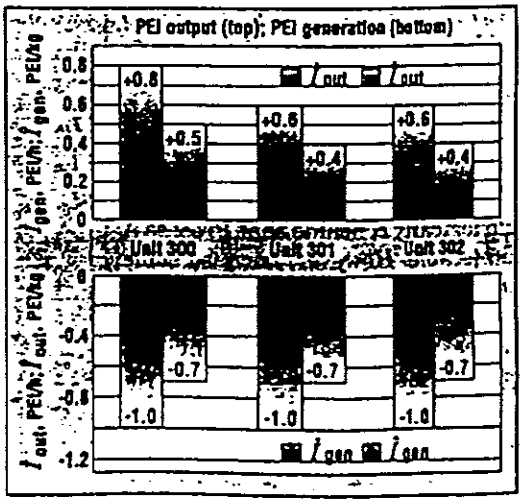

FIGURE 2. The design changes discussed above alter the output and generation PEI, as shown here

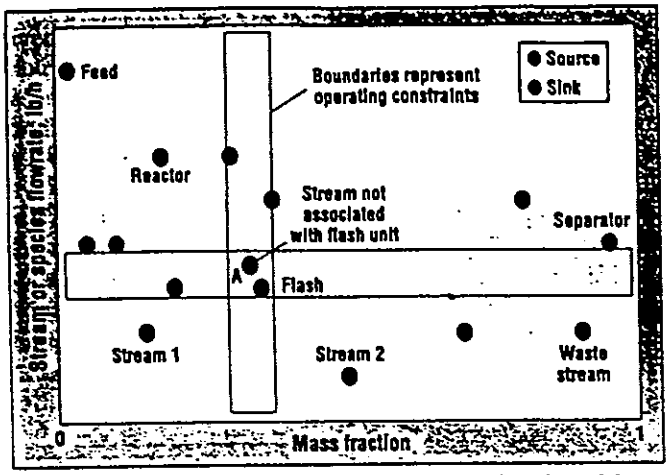

FIGURE 3. In a source-sink diagram, the mass fraction of the target species is plotted against flowrate. As shown, Stream A can be recycled directly back to the flash unit

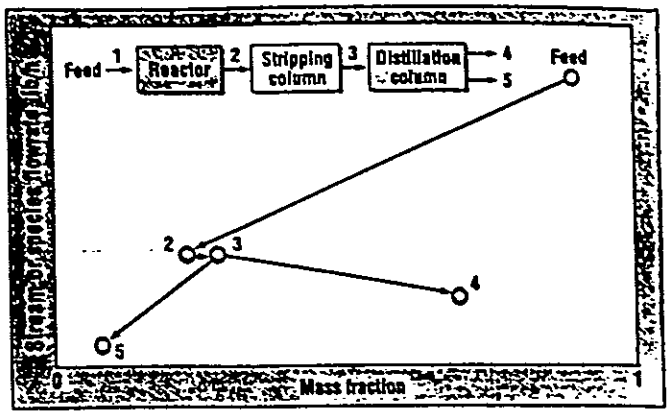

FIGURE 4. As this species-path diagram shows, streams (such as Streams 3 and 4) with a high target-species composition, a high flowrate, or both, are generally the most economical candidates for a mass-exchange operation. Stream 2 is already undergoing such an operation (stripping)

The current version of the WAR Algorithm considers eight health- and environmental-impact categories, k: ozone-depletion potential; global-warming potential; acid-rain potential; photochemical-oxidation or smog-formation potential; human-toxicity potential by ingestion; human-toxicity potential by inhalation or dermal exposure; aquatic-toxicity potential; terrestrial-toxicity potential. The weighting factor, α_k, allows us to assign relative importance to each of the eight categories. A default value of 5 for α_k can be assumed, but it can be adjusted between 0 and 10 to better represent the process and locale.

Values for ψ^s_{jk} can be obtained from a database developed by the authors, or from the database within the ChemCAD IV chemical-process simulator. The Box on p. 118 shows how the WAR Algorithm improved an acrylic-acid process.

Process Integration

The PI methodology considers the intricate relationships among flow streams, unit operations, operating parameters, and performance requirements, and then uses these relationships during process design to determine the ideal order of the unit operations and mass and energy streams; to calculate mass and energy balances for proper equipment sizing; and to optimize an existing process, increasing product flow, or reduce energy use and waste generation.

The Mass-Exchange Network (MEN), at the heart of the Process Integration simulation methodology, reduces the amount of waste generated in a process by concentrating the non-useful byproducts into waste streams, and capturing and recycling products and useful byproducts back to appropriate downstream unit operations. A MEN allows a designer to simulate any process design to determine what unit operations, if any, are needed. The analysis or optimization of a series of MENs can be performed numerically or graphically; the graphical technique is demonstrated below.

Components of MENs

In a mass-exchange network, the waste streams are referred to as *sources* and unit operations, including reactors, distillation columns and treatment units, are referred to as *sinks*. In a given process, various output streams, and any waste- or mass-separating agents, can be either emitted, recycled back to a unit operation (sink), recycled to a processing stream, or sent for post-treatment.

The mass-transfer and separation portions of a MEN typically rely on mass-exchange equipment — including absorbers, strippers, liquid-liquid extraction units, adsorbers, ion exchangers and leaching systems — which separate and concentrate the waste streams. Mass-separating agents (MSA) — including solvents used in liquid-liquid extraction or gas absorption, granulated activated carbon, ion-exchange resins, and gases used in stripping operations — are often added to enhance the recovery of the useful components.

MENs also use stream-management techniques, such as recycling to a sink, stream mixing to achieve a desired flowrate or composition, and stream segregation to avoid mixing of streams that would require further treatment downstream. Temperature, pressure and flowrate can also be adjusted to enhance performance.

Analysis of MENs

The first step in designing an MEN that will simulate a process is to define the problem to be solved — how to increase production rates, reduce pollution emission, reduce utility consumption (such as cooling water) and so on — and to list any associated constraints, such as product specifications, pollutant concentrations or flowrates, and so on. The next step is to define the target components — those chemicals that need to be identified to address the problem statement and constraints. For example, water would be a target component in a system where you are trying to reduce cooling-water consumption; hydrogen would be a target component in a dehydrogenation process where the goal is to trim gas emissions. The graphical tools used in the MEN analysis focus around these components.

The *source-sink diagram* (Figure 3) plots the composition of the target species (shown as mass fraction) against flowrate to identify recycle opportunities. The red circles represent all sources or streams, and describe the relationship between flowrate and the composition

85

of the target species in that stream.

The current operating condition of each sink (unit operation) is shown by a blue circle. The values plotted in Figure 3 represent the flowrate through the sink versus the composition of the target species inside that sink. For sinks that have variable concentrations, an average composition is shown. A source-sink diagram can be drawn for each target species.

Each sink has physical constraints that limit the compositions and flowrates within which it can operate. These are shown as box-like boundaries in Figure 3. These constraints limit the feasible operating conditions that may be considered during simulation in a "greener" design alternative. Any source that lies within this box can be recycled back to any sink within the box. While Figure 3 only highlights one sink, such a graphical analysis should be done for each sink.

A source-sink diagram can also be used to identify streams that can be combined and then recycled. For instance, in Figure 3, combining Streams 1 and 2 will increase the flowrate to an appropriate level, and adjust the composition to an acceptable level, allowing the combined stream to be recycled back to the flash unit sink shown within the box.

Similarly, if a source lies to the right of a sink but is still within its flowrate constraints, the stream can be recycled back to that sink — but only after the target-species composition has been reduced to meet the unit's constraints. The composition can be altered by using a stripper, absorber, or other mass-exchange unit.

The distance that a source lies to the right of a sink also provides information as to which units can be used to accomplish the desired degree of separation. A source that lies above a sink must reduce its flowrate before it can be recycled to that sink.

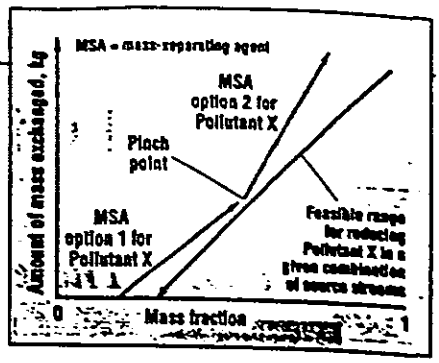

FIGURE 5. In this mass-pinch diagram, the curves on the left show the ability of two different mass-separating agents (MSA) in a given mass-exchange unit to remove Pollutant X from a given waste stream or streams. The composite curve on the right shows the range of feasibility for removing Pollutant X from a combination of streams. The pinch point (where the two curves are closest) shows the best point at which to apply the MSA options for removing Pollutant X, from an economic and thermodynamic standpoint

Another graphical tool, the *path diagram* (Figure 4), shows the flow of a specific component (i.e., a process reactant) through a process. Such a diagram is used to determine where mass exchange could be used to capture the target species and remove them from the system.

We Made A Long Story —

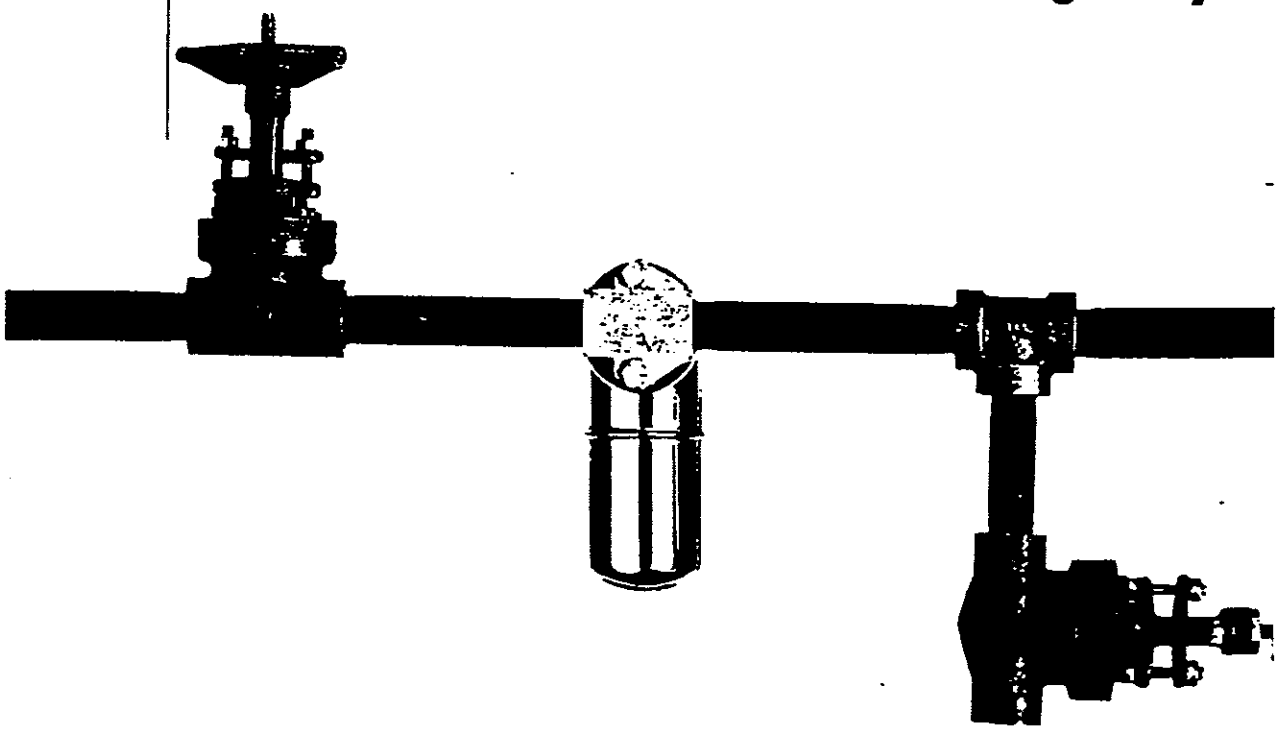

Figure 4 shows a section of a hypothetical process design, and only shows the streams that contain the target species. The arrows represent the flow. More than one arrow arising from a single source represents the separation of the stream into multiple streams, and implies that the target species is in each. Multiple arrows into a single source means several flows are feeding a mixer or reactor.

In general, streams with higher target-species compositions or higher flowrates — such as Streams 3 and 4 in Figure 4 — are the most-cost-effective candidates for mass exchange or stream-management techniques.

When the goal is to reduce the concentration of a target species (i.e., Pollutant X) from a source (waste) stream or streams using a mass-exchange system, a *mass-pinch diagram* (Figure 5) can be used to evaluate the options. While construction of such a diagram is beyond the scope of this article, a discussion of Figure 5 may be illustrative. In that figure, the curves on the left show the feasibility ranges for two different MSAs (in terms of the amount of Pollutant X each can remove). The curve on the right shows the feasible range over which Pollutant X can be reduced in a given combination of source streams. The pinch point, where the two curves are closest, is the most cost-effective, thermodynamically desirable point at which to apply mass exchange. ■

Edited by Suzanne Shelley

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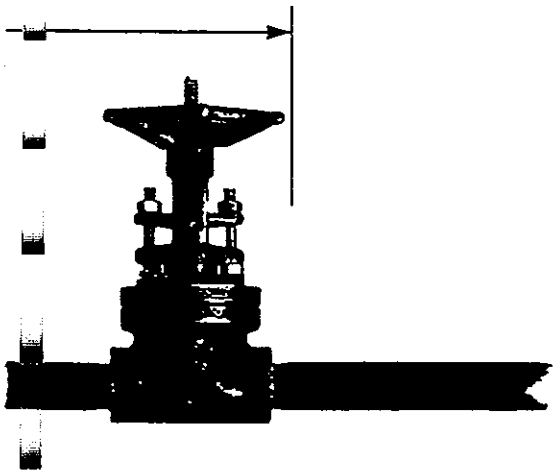

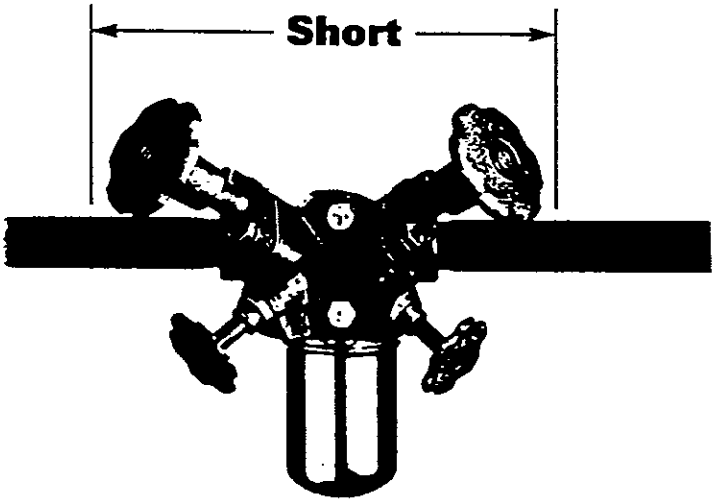

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Pollution Prevention with Chemical Process Simulators: The Generalized Waste Reduction (WAR) Algorithm-Full Version

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Abstract - A general theory for the flow and the generation of potential environmental impact through a chemical process has been developed. The theory defines six potential environmental impact indexes that characterize the generation of potential impact within a process, and the output of potential impact from a process. The indexes are used to quantify pollution reduction and to develop pollution reducing changes to process flow sheets using process simulators. The potential environmental impacts are calculated from stream mass flow rates, stream composition, and a relative potential environmental impact score for each chemical present. The chemical impact scores include a comprehensive set of nine effects ranging from ozone depletion potential to human toxicity and ecotoxicity. The resulting Waste Reduction methodology or WAR Algorithm is illustrated with two case studies using the chemical process simulator Chemcad III (Use does not imply USEPA endorsement or approval of Chemcad III).

INTRODUCTION

There is currently a great deal of interest in the development of methods that can be used to prevent or at least minimize the generation of pollution; and there are numerous efforts underway in this area (Lederman and Weber, 1991; El-Halwagi, *et al.* 1992; Fonyo, *et al.*, 1994; Rossiter, 1995; Manousiouthakis and Allen, 1995; Mallick *et al.*, 1996). This interest stems from the belief that pollution prevention is likely to lead to the creation of technologies that have a much more benign impact on human health and the environment. Because this technology is inherently less polluting, it is likely to be more robust and economical than simply adding pollution control devices to conventional designs. In chemical manufacturing, these pollution prevention methods take the form of an effort to design process plants that generate as little pollution as possible. Since chemical process simulators are widely used in the design and operation of chemical manufacturing plants, the development of a pollution prevention methodology for chemical process simulators is likely to have a significant impact on the pollution generated by the chemical industry. At the National Risk Management Research Laboratory, research efforts are underway to develop a methodology for commercial chemical process simulators. The research effort is called the WAste Reduction or WAR Algorithm after Hilaly and Sikdar (1994) who performed some of the early work in this area.

This paper presents a generalization of the WAR Algorithm, discusses the methodology for evaluating potential environmental impacts, and illustrates the use of the method in the design or modification of chemical processes with two case studies.

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ENVIRONMENTAL IMPACT THEORY

Potential environmental impact is the unrealized effect or impact that the emission of mass and energy would have on the environment on average. It is, therefore, essentially a probability function for the realization of a potential effect. Thus, the potential environmental impacts of chemical manufacturing processes are generally caused by the energy and material that the process takes from or emits to the environment. Potential environmental impact is a conceptual quantity that can not be directly measured, *i.e.*, there are no potential environmental impact meters. However, one can calculate potential environmental impact from related measurable quantities using functional relations between the two. This situation is common in science and engineering. For example, the energy of a fluid can not be directly measured, but it can be calculated from temperature and pressure by the use of heat capacities and equations of state. Exactly how to perform a calculation for potential environmental impacts will be discussed later in this paper.

Conservation Equation

Traditionally, chemical process design has been based on the creative application of mass and energy balances along with thermodynamics, chemical reaction engineering, and engineering economics. Our methodology proposes to add a conservation relation over potential environmental impact to the aforementioned two balance equations. The conservation equation for impacts is based on an accounting of the flow of potential environmental impact in and out of the processes. This flow of impact is related

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to the mass and energy flows but it is not equivalent to them. The impact conservation equation is

$$\frac{dI_{syst}}{dt} = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \qquad (1)$$

where I_{syst} is the potential environmental impact content inside a process, $\dot{I}_{in}$ is the input rate of impact, $\dot{I}_{out}$ is the output rate of impact, and $\dot{I}_{gen}$ is the rate at which impact is generated in the system by chemical reactions or other means. Note that processes can also consume potential environmental impact so that $\dot{I}_{gen}$ can, in fact, be negative. For steady state processes, the conservation equation reduces to,

$$0 = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \qquad (2)$$

which implies that no potential environmental impact accumulates in the system. Also note that Equations (1) and (2) serve as definitions of the function $\dot{I}_{gen}$.

The significance of potential environmental impacts can be better understood by considering the following definitions. If one were to dump into the environment all of the mass and energy flows entering a process, the resulting impact on the environment would equal to I_{in}; if one were to also dump into the environment all of the mass and energy flows exiting a process the resulting impact on the environment would be equal to I_{out}. However, due to chemical transformations and changes in state conditions (temperature and pressure), I_{in} is never exactly equal to I_{out}, and consequently I_{gen} is never exactly equal to zero for steady state processes.

Chemical Processes

Application of either Equation (1) or (2) to chemical manufacturing processes requires an expression that relates the conceptual potential environmental impact to measurable quantities. Potential environmental impacts are caused by energy and material inputs and outputs to or from the environment. But, as a first approach, this treatment is restricted to potential impacts due to material flows while neglecting any impacts due to energy. Effects due to energy flows can be incorporated into the analysis by extending the boundary over which the impact balance is done to include the energy generation process. Effects due to resource depletion are also neglected mainly because there is no effective methodology for measuring them. This is consistent with the focus of this work which is the chemical process plant rather than a global life-cycle type of analysis. The expression relating potential chemical environmental impacts to measurables is

$$\dot{I}_i = \sum_j \dot{I}_j^{(i)} = \sum_j \dot{M}_j^{(i)} \sum_k x_{kj}\psi_j + \cdots \qquad (3)$$

where the sum over j is taken over the streams of input i or output i, the sum over k is taken over all chemicals k, $\dot{I}_i$ is the rate of potential environmental impact either in (i=in) or out of the process (i=out), $\dot{I}_j^{(i)}$ is the rate of potential environmental impact for stream j which may be an input or an output, $\dot{M}_j^{(i)}$ is the mass flow rate of stream j which may again be either an input or an output, x_{kj} is the mass fraction of chemical k in stream j, and ψ_j is the overall potential environmental impact of chemical j.

Note that Equation (3) is a first order approximation that does not include the synergistic effects that can occur when multiple chemicals are present.

Impact Indexes

For steady state processes one can use Equation (2) to define two categories of indexes for the environmental impact of chemical manufacturing. The first category of indexes measures the generation of potential environmental impact within processes, and the second one measures the potential environmental impact emitted by processes. There are various indexes that can be defined within each category. However, only the six indexes, three from each category, that seem most useful for waste reduction will be treated here.

Following Hilaly and Sikdar (1994), all non-products are considered to be pollutants and the potential environmental impact of all products is set to zero, *i.e.*, ψ_j=0 for all products j. These assumptions are consistent with the objective of this paper which is to present a methodology for waste reduction, *i.e.*, the primary concern is reducing the impact and the amount of the non-products. The broader implications of Equation (1), including other impact indexes for which $\psi_j \neq 0$ for products j and further conjectures on the implications for sustainability, will the subject of future publications.

The first index of the first category of indexes (impact generation) is obtained by solving Equation (2) for $\dot{I}_{gen}$ and adding the superscript NP for Non-Products to give,

$$\dot{I}_{gen}^{NP} = \dot{I}_{out}^{NP} - \dot{I}_{in}^{NP} \qquad (4)$$

where $\dot{I}_{out}^{NP}$ and $\dot{I}_{in}^{NP}$ are the potential environmental impacts due to non-products, *i.e.*, pollutants in the outputs and inputs, respectively. Equation (3) is used to give explicit expressions for $\dot{I}_{out}^{NP}$ and $\dot{I}_{in}^{NP}$ where all components, products and non-products, are included in the summation, but where ψ_j=0 for all products j which effectively removes all products from the summation. The index, $\dot{I}_{gen}^{NP}$, measures the total rate at which the process generates potential environmental impact due to non-products (NP). $\dot{I}_{gen}^{NP}$ has units of potential environmental impact generated per time.

The second index, $\hat{I}_{gen}^{NP}$, of the first category is obtained by dividing Equation (4) by the rate at which the process generates products to give a specific impact generation,

$$\hat{I}_{gen}^{NP} = \frac{\dot{I}_{gen}^{NP}}{\sum_p \dot{P}_p} = \frac{\dot{I}_{out}^{NP} - \dot{I}_{in}^{NP}}{\sum_p \dot{P}_p} \qquad (5)$$

where the sum over p is taken over all the products p, and $\dot{P}_p$ is the mass flowrate of product p. $\hat{I}_{gen}^{NP}$ measures the potential impact created by all non-products in manufacturing a unit mass of all the products p. The index, $\hat{I}_{gen}^{NP}$, has units of potential environmental impact per mass of products.

The third index of the first category, $\hat{M}_{gen}^{NP}$, is obtained from Equation (5) by setting the potential environmental impact (ψ_j) of all products to zero and that of all non-products to one. This has the effect of assigning the same potential environmental impact to all non-products. The index, $\hat{M}_{gen}^{NP}$, is a measure of the mass inefficiency of the

process, *i.e.*, it gives the ratio of mass converted to an undesirable form to mass converted to a desirable form. The expression for $\hat{M}_{gen}^{NP}$ is

$$\hat{M}_{gen}^{NP} = \frac{\sum_j \dot{M}_j^{(out)} \sum_k x_{kj}^{NP} - \sum_j \dot{M}_j^{(in)} \sum_k x_{kj}^{NP}}{\sum_p \dot{P}_p} \quad (6)$$

where the summation over $\dot{M}_j^{(out)}$ is taken only over output streams, the summation over $\dot{M}_j^{(in)}$ is taken only over input streams, and the summation over x_{kj}^{NP} is taken only over all non-products k in stream j. The units of $\hat{M}_{gen}^{NP}$ are mass of non-products per mass of products.

The first index of the second category of indexes (impact emission) $\dot{I}_{out}^{NP}$ is simply the total rate of potential environmental impact output due to non-products. $\dot{I}_{out}^{NP}$ is calculated from Equation (3) subject to ψ_j=0 for all products j. The index, $\dot{I}_{out}^{NP}$, is a measure of the rate at which the process emits potential environmental impact, and it has units of potential environmental impact per time.

The second index of the second category, $\hat{I}_{out}^{NP}$, is obtained by dividing the rate of potential environmental impact output due to non-products by the output rate of products to give,

$$\hat{I}_{out}^{NP} = \dot{I}_{out}^{NP} \Big/ \sum_p \dot{P}_p \quad (7)$$

The index, $\hat{I}_{out}^{NP}$, has units of potential environmental impact per mass of products. This expression gives the pollution index Φ of Mallick *et al.* (1996) which measures the potential environmental impact emitted in manufacturing a unit mass of products.

The third index of the second category, $\hat{M}_{out}^{NP}$, is obtained from Equation (7) by setting the potential environmental impact (ψ_j) of all products to zero and that of all non-products to one. The resulting expression is,

$$\hat{M}_{out}^{NP} = \frac{\sum_j \dot{M}_j^{(out)} \sum_k x_{kj}^{NP}}{\sum_p \dot{P}_p} \quad (8)$$

which is related to the pollution index ϕ_n of Hilaly and Sikdar (1994) by,

$$\hat{M}_{out}^{NP} = \sum_n \phi_n \quad (9)$$

where the summation is taken over all products n. $\hat{M}_{out}^{NP}$ measures the amount of non-product or pollutant mass emitted in manufacturing a unit mass of products, and it has units of non-product mass per mass of products. It is also a mass inefficiency measure.

Significance of Impact Indexes

The first category of indexes, *e.g.*, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, characterize some aspects of the generation of potential environmental impact within a manufacturing process. They are most useful in addressing questions related to the internal environmental efficiency of the process plant, *i.e.*, the ability of the plant to produce desired products while creating a minimum of new, undesired potential environmental impact. It is important to note that once new potential environmental impact is created, resources such as potentially costly remediation efforts will likely be required to prevent the potential impact from being realized. Obviously, the smaller the values of $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$ the more environmentally efficient the process, and, all others factors such as economics being equal, the more desirable. $\dot{I}_{gen}^{NP}$ would be useful in comparing different designs on an absolute basis, while $\hat{I}_{gen}^{NP}$ and $\hat{M}_{gen}^{NP}$ would be useful in comparing different designs independently of manufacturing plant size.

The second category of indexes, *e.g.*, $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$ characterize some aspects of the emission of potential environmental impact from a manufacturing process. Their principal use is in addressing questions related to the external environmental efficiency of the process plant, *i.e.*, the ability of the plant to produce desired products while inflicting on the environment a minimum of undesired potential environmental impact. It is again obvious that the smaller the values of $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$ the more environmentally efficient the process, and all other factors such as economics being equal, the more desirable it is. Since $\dot{I}_{out}^{NP}$ is a total rate of impact output, it could be useful in deciding whether a given plant is compatible with a particular site. For example, it would be unwise to locate a plant with a high $\dot{I}_{out}^{NP}$ in an ecologically sensitive area. $\dot{I}_{out}^{NP}$ could also be used in matching the size of a plant to the capacity of the surrounding environment to dissipate environmental impact. $\hat{I}_{out}^{NP}$ and $\hat{M}_{out}^{NP}$ are more useful in comparing the potential environmental impact of alternative processes independently of plant size.

CHEMICAL ENVIRONMENTAL IMPACT

Application of the methodology so far developed requires that the potential environmental impacts of chemicals be estimated. Further, it is required that a relative impact number ψ_j be given for each chemical j over a wide range of different chemical environmental impacts. This is, unfortunately, not a trivial matter because chemical impacts are measured on different relative scales that can not be simply added without some form of normalization.

Chemical Impact Expression

To apply the WAR methodology to chemical processes, the following expression for ψ_j has been developed (Mallick *et al.*, 1996),

$$\psi_j = \sum_l \alpha_l \psi_{j,l}^{s} \quad (10)$$

where the sum is taken over categories of potential chemical environmental impacts, e.g., ozone depletion potential, human health, etc. listed below under *Classification of Impacts*. α_l is a relative weighting factor for impact of type l independent of chemical j, and $\psi_{j,l}^{s}$ is the specific potential environmental impact of chemical j for an impact of type l. α_l has units of potential environmental impact per mass.

The relative weighting factor α_l allows Equation (10) to be customized to specific or local conditions. The suggested procedure is to initially set all the α_l's to same value of say one, and to allow users to vary individual α_l's from 0 to 10 according to local needs and policies.

Please note that for a relative comparison, the absolute value is not critical. For example, photochemical oxidation potential would be weighted more heavily than other impacts in an area that suffers from smog. There is an effort underway in our research group to develop more sophisticated methods of determining values for the α_j's. The values for the $\psi^s_{j,l}$ were obtained from the relative rankings or scores for chemicals by normalizing according to,

$$\psi^s_{i,j} = \frac{(Score)_{i,j}}{\langle (Score)_i \rangle_j + 2\sigma_j} \qquad (11)$$

where $(Score)_{i,j}$ is the relative score of chemical i on some arbitrary scale within impact category j, $\langle (Score)_i \rangle_j$ is the arithmetic average of the scores of all chemicals i within impact category j, and σ_j is the standard deviation of all the chemical scores in impact category j. The normalizing factor $\langle (Score)_i \rangle_j + 2\sigma_j$ assures that about 75% of the normalized chemical score numbers $\psi^s_{j,l}$ will be between 0 and 1 irrespective of the statistical distribution of the initial scores as expected from Chebyshev's theorem (Lapin, 1975). If the chemical scores happen to follow a normal distribution, then the normalization range extends to approximately 95% of the scores.

Classification of Impacts

The classification of chemical environmental impacts and the values for the $(Score)_{i,j}$ were adopted from the study of Heijungs *et al.* (1992)* and normalized according to Equation (11) to obtain the $\psi^s_{j,l}$'s. In the calculation of $\langle (Score)_i \rangle_j$ and σ_j, the chemical scores for dioxin, chromium VI, and vinyl chloride were excluded. The reason is that the score numbers for these three chemicals were several orders of magnitude higher that those for all other chemicals, and including them in the normalization process would have made the normalization meaningless. Therefore, the normalized $\psi^s_{j,l}$ for these three chemicals would appear as outliers which they, in fact, are.

Table 1: Normalized Chemical Impact Scores

	H2	MEK	SBA	H2O
$\psi^s_{j,l}$	0	0.42	4.1E-4	0
	N2	Ar	CH4	NH3
$\psi^s_{j,l}$	0	0	7.4E-3	0.93

There are nine different impact categories. These can be subdivided into four environmental physical potential effects (acidification, greenhouse enhancement, ozone depletion, and photochemical oxidant formation), three human toxicity effects (air, water, and soil), and two ecotoxicity effects (aquatic and terrestrial).

The normalized chemical scores used in the two case studies presented in the next sections are given in Table 1 above where H2 is hydrogen, MEK is methyl ethyl ketone, SBA is secondary butyl alcohol, H2O is water, N2 is molecular nitrogen, Ar is argon, CH4 is methane, and NH3 is ammonia. These acronyms will be used throughout the rest of the paper.

* Use by the authors does not imply endorsement or approval by the U.S. Environmental Protection Agency.

CASE STUDY #1: MEK PRODUCTION

To illustrate the use of the generalized WAR Algorithm, a case study from the production of methyl ethyl ketone (MEK) from secondary butyl alcohol (SBA) is presented. The case study was adopted from the Chemcad III (Chemstations, Inc.) chemical process simulator, and all the material and energy balances were performed using Chemcad III. However, any commercial process simulator could have been used. This case study presents a typical chemical engineering process for the production of a commodity chemical that involves several unit processes such as reactors, separators, mixers, dividers, and heat exchangers. It is, therefore, sufficiently complex to illustrate the WAR Algorithm but still treatable within the space of this paper. Essentially, the chemical process consists of a SBA dehydrogenation reactor followed by a MEK purification train and associated equipment.

Base Flowsheet

Figure 1 shows the base process flow diagram for the production of MEK from SBA. SBA is fed to a hydrogen scrubber where the feed SBA scrubs residual MEK from the hydrogen stream. The SBA feed is then pumped up to reaction pressure and heated to reaction temperature with a heat exchanger and a heater. The heated SBA is fed to the reactor where the chemical transformation occurs. The

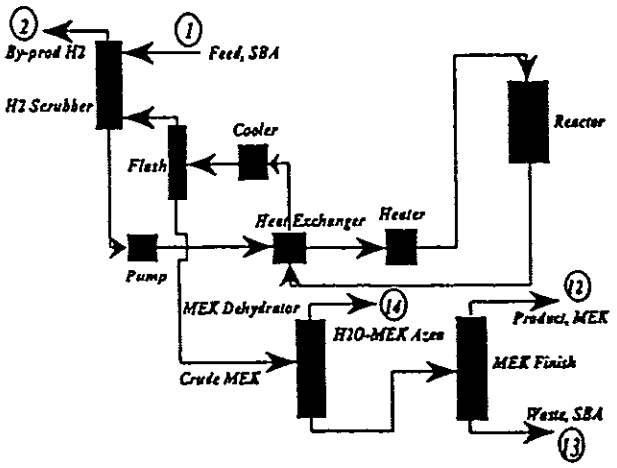

Figure 1. Base process flow diagram for the production of methyl ethyl ketone from secondary butyl alcohol.

Table 2: MEK Production Flow Summary (kg/hr)
Input & Output: Base Process

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 13 (L)	# 14 (G)
SBA	3362	19	3	2670	1
MEK	0	0	567	13	71
H2O	8	0	0	0	8
H2	0	18	0	0	0

reactor output stream is sent to a heat exchanger where it is partially condensed. The mixture of MEK, hydrogen, and unconverted SBA is cooled further and sent to a separator where the hydrogen is flashed off. The hydrogen is then scrubbed and the liquid phase fed to a MEK purification system. The mass flow rates and the state of the various input and output streams as calculated by Chemcad III are listed in Table 2 above.

Modified Flowsheet

Examination of the base process indicates that waste stream 13 contains large amounts of unreacted SBA and small amounts of MEK. It is, therefore, logical to try to recover the SBA and MEK as the first step in a waste reduction strategy. Consequently, the process flow diagram was modified by the addition of a recycle from

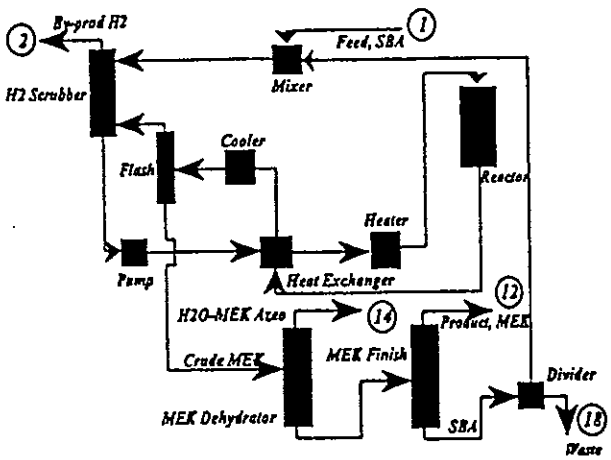

Figure 2. Modified process flow diagram for the production of methyl ethyl ketone from secondary butyl alcohol.

stream 13 to the feed, stream 1. Two cases were studied with this modification, recycling 50% and 100% of stream 13. Recycling 100% of stream 13, *i.e.*, closing off stream 18, is appropriate for this illustration. But, it is clearly not practical because stream 18 is the only liquid waste stream in the modified process and the only means of purging the system of liquid impurities. Without this purge, impurities would build up inside the process causing it to eventually cease to function. Figure 2 above shows the flow diagram for the modified process. The mass flow rates and the state of the various input and output streams for the modified process with 50% recycle are listed in Table 3

Table 3: MEK Production Flow Summary (kg/hr)
Input & Output: Modified Process (50% Recycle)

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 14 (G)	# 18 (L)
SBA	3362	168	5	1	2124
MEK	0	1	980	64	10
H2O	8	2	0	6	0
H2	0	29	0	0	0

The process modification increased the amount of product by approximately 73% while reducing the amount of waste SBA in stream 18 by about 20%.

It is important to note that an examination of Tables 2, 3, and 4 will indicate that waste was generally reduced, and that environmental impact was probably also reduced. However, the information so far considered is not sufficient to allow a quantitative comparison of the overall waste and environmental impact reduction associated with each of the three cases studied here. For this comparison one must calculate the impact indexes already described. For the modified process with 100% recycle, the mass flow rates and the state of the various input and output streams are listed in Table 4 below. Note that increasing the recycle increased the amount of product by 269% while simultaneously reducing the amount of waste SBA in stream 13 to zero.

Table 4: MEK Production Flow Summary (kg/hr)
Input & Output: Modified Process (100% Recycle)

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 14 (G)
SBA	3362	1117	11	1
MEK	0	11	2094	59
H2O	8	3	0	5
H2	0	60	0	0

Impact Index Calculations

Six different impact indexes were calculated for the base case and the two modified processes each. The indexes were obtained using Equations (3) to (8), the flow rates from Tables 2, 3, and 4, Equation (10), and the normalized chemical impact scores of Table 1. The relative weighting factors, α_i, were all set to one for these calculations.

The first category indexes, *i.e.*, the impact generation indexes, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, are shown on Figure 3 below. It should be noted that $\hat{M}_{gen}^{NP}$ is a negative number since some of the input mass is always converted to product, and the products are not included in the summation of the outputs. The specific indexes, $\hat{I}_{gen}^{NP}$ and $\hat{M}_{gen}^{NP}$, were multiplied by a factor of 100 so that they could be shown on the same scale as the rate index $\dot{I}_{gen}^{NP}$.

The second category indexes, *i.e.*, the impact output indexes $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$, are shown in Figure 4. The specific index $\hat{I}_{out}^{NP}$ was multiplied by a factor of 1000, and the specific index $\hat{M}_{out}^{NP}$ was multiplied by a factor of 10 so that they could both be shown on the same scale as $\dot{I}_{out}^{NP}$.

The largest source of uncertainty in the calculation of the impact indexes is the environmental impact scores. These measurements are probably accurate to no more than one significant figure or an order of magnitude. It is, therefore, prudent to assume that impact index calculations are also accurate to no more than one significant figure. Two significant figures are used in Figures 3 and 4 in order to help the readers to reproduce the calculations, if necessary.

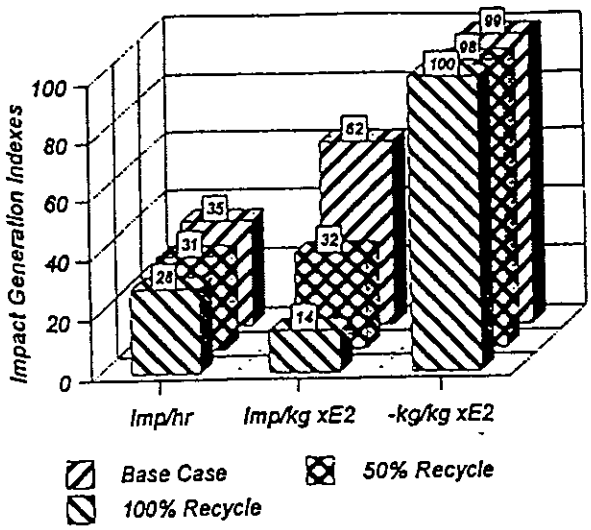

Figure 3. Impact generation indexes for the production of methyl ethyl ketone from secondary butyl alcohol: $\dot{I}_{gen}^{NP}$ in impact units per hour, $\hat{I}_{gen}^{NP}$ in impact units per kilogram of product, and $-\hat{M}_{gen}^{NP}$ in kilograms of pollutants per kilogram of product.

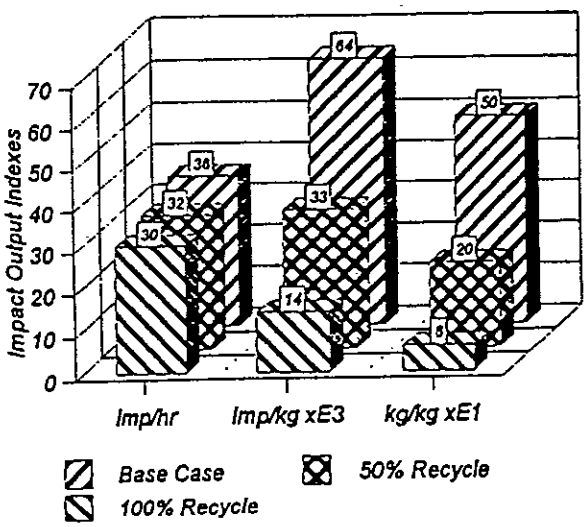

Figure 4. Impact output indexes for the production of methyl ethyl ketone from secondary butyl alcohol: $\dot{I}_{out}^{NP}$ in impact units of pollutants per hour, $\hat{I}_{out}^{NP}$ in impact units of pollutants per kilogram of products, and $\hat{M}_{out}^{NP}$ in kilograms of pollutants per kilogram of products.

DISCUSSION OF CASE STUDY #1

The impact generation indexes of Figure 3 show that: (1) the rate of impact generation by non-products decreases by 13% for 50% recycle and by 20% for 100% recycle, (2) the impact generated by non-products per kilogram of product decreases by 48% for 50% recycle and by 77% for 100% recycle, and (3) the kilograms of non-products generated per kilogram of product remains nearly constant at -100. The most significant index in this case is the impact generated per kilogram of product. The decrease of this index reflects the increase in the productivity of the plant, *i.e.*, the increase in product flow rate.

The impact output indexes of Figure 4 show that: (1) the rate of impact output from non-products decreases by 11% for 50% recycle and by 17% for 100% recycle, (2) the impact output from non-products per kilogram of product decreases by 48% for 50% recycle and by 78% for 100% recycle, and (3) the output of kilograms of non-product per kilogram of product decreases by 60% for 50% recycle and by 88% for 100% recycle. It is worth noting that the output of impact and waste decreased as measured by all the indexes. The most significant index in this case is the impact output per kilogram of product. The decrease in this index is consistent with the decrease in the impact generation per mass of product index discussed in the paragraph above. This decrease is also a reflection of the increased productivity of the plant.

The decreases in the indexes are sufficiently large such that they represent significant reductions in pollution. The consistent decrease in the impact generation per mass of product (48% to 77%) and the impact output per mass of product (48% to 78%), simply means that the modified plant can meet the needs of a much larger market without increasing its generation or its output of potential environmental impact. It also means that a modified plant that is 48% to 77% smaller than the base case can meet the needs of the same market that the base plant was designed for.

CASE STUDY#2: AMMONIA PRODUCTION

To further illustrate the use of the generalized WAR Algorithm, a second case study from the production of ammonia from synthesis gas is presented. The case study was also adopted from the Chemcad III (Chemstations, Inc.) chemical process simulator, and all the material and energy balances were performed using Chemcad III. However, any commercial process simulator could again have been used. Just as Case Study #1, this case study also presents a typical chemical engineering process that involves several unit processes such as reactors, separators, mixers, dividers, and heat exchangers. It is also sufficiently complex to illustrate the WAR algorithm but still treatable within the space of this paper.

Base Flowsheet

Figure 5 shows the base process flow diagram for the process. Essentially, the overall process is based on the reaction of nitrogen and hydrogen to produce ammonia. The mixture of hydrogen and nitrogen is compressed and

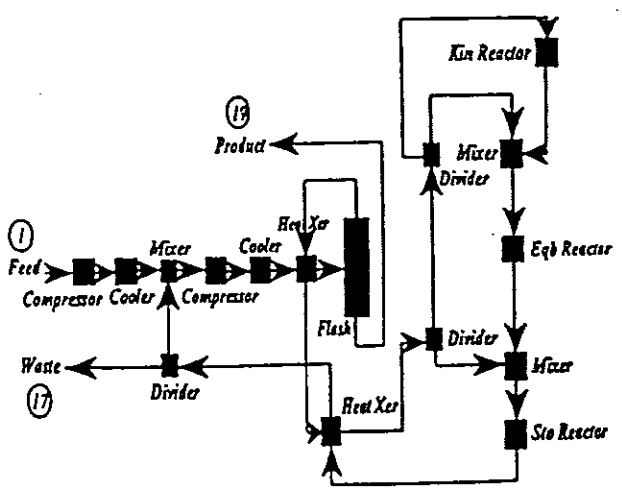

Figure 5. Base process flow diagram for the production of ammonia from synthesis gas.

cooled and feed to a series of three reactors through a flash drum. Several reactors are normally used the to maximize the conversion of feed to products which for this process is difficult to do. This flash drum also serves to separate the ammonia product from the unreacted gases which are feed back into the system. The ammonia is recovered as an anhydrous liquid under modest pressure. The mass flow rates and the state of the input and output streams as calculated by Chemcad III are all listed in Table 5.

Table 5: Ammonia Production Flow Summary (kg/hr)
Input & Output: Base Process (Purge Ratio = 0.1)

Stream (State)	# 1 (G)	#17 (G)	# 19 (L)
N2	33,334	5060	187
Ar	603	428	176
H2	7196	1120	13
CH4	805	700	112
NH3	0	3696	30453

Modified Flowsheet

Examination of the base process indicates that waste stream 17 contains ammonia and some unreacted feed. It is, therefore, logical to try to recover the ammonia and the unreacted feed as an obvious first step in a waste reduction strategy. Consequently, the process flow diagram was modified in two ways. First, the purge ratio was reduced five fold from 0.1 to 0.02, *i.e.*, the flow of stream 17 was reduced five fold. Second, in addition to reducing the purge, a flash drum was added with stream 17 as the feed to recover some of the ammonia.

Table 6: Ammonia Production Flow Summary (kg/hr)
Input & Output: Modified Process (Purge Ratio = 0.02)

Stream (State)	# 1 (G)	#17 (G)	# 19 (L)
N2	33,334	1162	217
Ar	603	199	404
H2	7196	281	16
CH4	805	446	351
NH3	0	856	38001

Figure 5 shows the configuration of the flow diagram for the reduced purge modified process which is identical to that of the base process. The mass flow rates and the state of the input and output streams for the reduced purge modified process are listed in Table 6. The process modification increased the amount of product by approximately 25% while reducing the amount of waste ammonia in stream 17 by about 77%. It is worth noting, however, that there was an small increase in the impurities present in the product stream. This changed from about 2% impurities in the base case to 3% for the reduced purge modified case.

Figure 6 shows the flow diagram for the modified process with reduced purge and addition of a flash drum with stream 17 as the feed. Under this configuration, stream 25 is used to purge impurities from the system. Without this purge, impurities would again build up inside the process, and it would eventually cease to function. Stream 24 which consists of essentially pure ammonia is mixed with stream 19 to form a new product stream, stream 26.

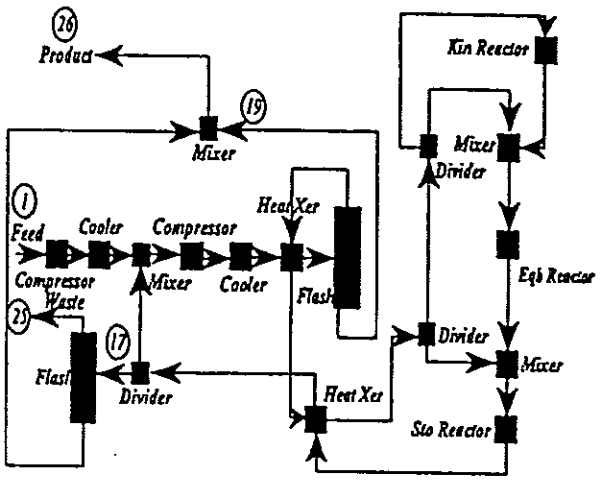

Figure 6. Modified process flow diagram for the production of ammonia from synthesis gas with reduced purge ratio and added flash drum.

The mass flow rates and the state of the various input and output streams are listed in Table 7. Note that adding the flash drum in addition to reducing the purge five fold increased the amount of product by 26% as compared to the base case. This is very close to the 25% increase in product that was obtained by simply reducing the purge. However, the amount of waste ammonia in stream 25 was reduced by 91%, and the amount of total waste in stream 25 was reduced by 78%, both compared to the base case. As compared to the reduced purge process, the addition of the flash drum increased the amount of product by a meager 1%, but it reduced the amount of waste ammonia by 61% and total amount of waste by 18%, both in stream 25. Therefore, the principal effect of adding the flash drum was the reduction of waste.

Table 7: Ammonia Production Flow Summary (kg/hr)
Input & Output: Modified Process
(Purge Ratio = 0.02 & Flash Drum)

Stream (State)	# 1 (G)	#25 (G)	# 26 (L)
N2	33,334	1162	217
Ar	603	199	404
H2	7196	281	16
CH4	805	447	351
NH3	0	335	38,521

An examination of Tables 5, 6, and 7 will again show that waste was generally reduced, that the amount of product made was increased, and that environmental impact of the process was probably also reduced. However, one finds that it is not sufficient to allow a quantitative comparison of the overall waste and environmental impact associated with each of the three cases. In a simple example such this one the task is confusing, but for complex chemical process it can become impossible. For this comparison one must calculate the impact indexes.

Impact Index Calculations

Again, six different impact indexes were calculated for the base and the two modified processes. The indexes were also obtained using Equations (3) to (8), the flow rates from Tables 5, 6, and 7, Equation (10), and the normalized chemical impact scores of Table 1. The relative weighting factors α_i were all set to one for these calculations.

The first category indexes, *i.e.*, the impact generation indexes, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, are shown on Figure 7. It should be noted that $\hat{M}_{gen}^{NP}$ is a negative number since some of the input mass is always converted to product, and the products are not included in the summation of the outputs. The specific index, $\hat{I}_{gen}^{NP}$, was multiplied by a factor of 10,000, and the index, $\hat{M}_{gen}^{NP}$, was multiplied by a factor of 1,000 so that they could both be shown on the same scale as the rate index $\dot{I}_{gen}^{NP}$.

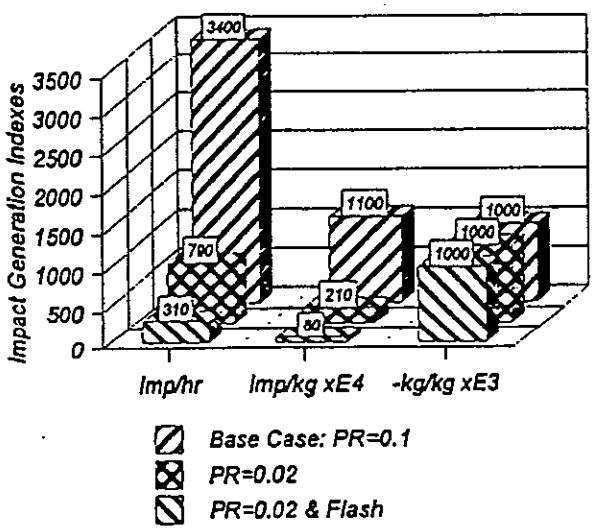

Figure 7. Impact generation indexes for the production of ammonia from synthesis gas: $\dot{I}_{gen}^{NP}$ in impact units per hour, $\hat{I}_{gen}^{NP}$ in impact units per kilogram of product, and $-\hat{M}_{gen}^{NP}$ in kilograms of pollutants per kilogram of product. PR is the purge ratio.

The second category indexes, *i.e.*, the impact output indexes, $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$, are shown in Figure 8. The specific index $\hat{I}_{out}^{NP}$ and the specific index $\hat{M}_{out}^{NP}$ were both multiplied by a factor of 10,000 so that they could be shown on the same scale as $\dot{I}_{out}^{NP}$.

The largest source of uncertainty in the calculation of the impact indexes are again the environmental impact scores. These measurements are probably accurate to no more than one significant figure or an order of magnitude, and it is, therefore, prudent to assume that impact index calculations are also accurate to no more than one significant figure. Two significant figures are presented in Figures 7 and 8 in order to allow readers to reproduce the calculations if necessary.

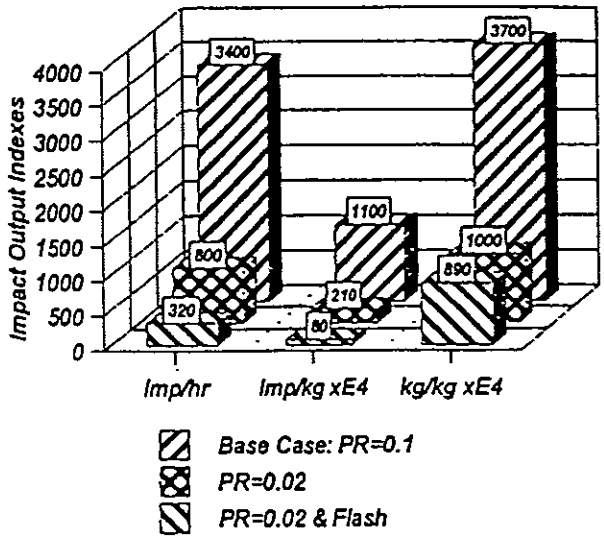

Figure 8. Impact output indexes for the production of ammonia from synthesis gas: $\dot{I}_{out}^{NP}$ in impact units of pollutants per hour, $\hat{I}_{out}^{NP}$ in impact units of pollutants per kilogram of products, and $\hat{M}_{out}^{NP}$ in kilograms of pollutants per kilogram of products. PR is the purge ratio.

DISCUSSION OF CASE STUDY #2

The impact generation indexes of Figure 7 show that: (1) the rate of impact generation by non-products decreases by 77% when the purge ratio is decreased from 0.1 to 0.02 and by 91% when the purge ratio is decreased as above and a flash drum is added to recover waste ammonia, (2) the impact generated by non-products per kilogram of product decreases by 81% when the purge ratio is reduced from 0.1 to 0.05 and by 93% when the purge ratio is decreased as above and a flash drum is added, and (3) the kilograms of non-products generated per kilogram of product remained nearly constant at -1 for all cases. The most significant index in this case is the impact generated per kilogram of product. The decrease of this index reflects primarily the recovery of the waste product and to a smaller extent the increase in the productivity of the plant, *i.e.*, the increase in product flow rate.

The impact output indexes of Figure 8 show that: (1) the rate of impact output from non-products decreases by 76% when the purge ratio is decreased from 0.1 to 0.02 and by 91% when the purge ratio is decreased as above and a flash drum is added to recover waste ammonia, (2) the impact output from non-products per kilogram of product decreases by 81% when the purge ratio is reduced from 0.1 to 0.05 and by 93% when the purge ratio is decreased as above and a flash drum is added, and (3) the output of kilograms of non-product per kilogram of product decreases by 73% when the purge ratio is reduced from 0.1 to 0.05 and by 76% when the purge ratio is decreased as above and a flash drum is added. It is again worth noting that the output of impact and waste decreased as measured by all the indexes. The most significant index

in this case is the impact output per kilogram of product. The decrease in this index was the same as that for the equivalent generation index. This is a reflection of the change in the index being primarily driven by the recovery of waste product rather than increased productivity.

The decreases in the indexes are again sufficiently large that they represent significant reductions in pollution. The consistent decrease in the impact generation per mass of product and impact output per mass of product (81% to 93%) implies that the modified plant can meet the needs of a moderately larger market with much less impact on the environment. The decrease in the rate of impact generation and impact output (76% to 91%) means that the modified process has an environmental impact that is roughly one tenth that of the base plant. Lastly, the decrease in the output of waste mass per mass of product indicates that the modified plant will lose less valuable material in its operation.

FUTURE WORK

In addition to the topics already mentioned, there are two other issues that need to be further mentioned in relation to the WAR Algorithm: Engineering Economics and Computer Aided Process Design. However, both of these are beyond the scope of this paper which is to present the basic generalized waste reduction or WAR Algorithm and to illustrate its use. Engineering Economics and Computer Aided Process Design are the subject of present and future research, and they are included here only for completeness and to aid interested readers applying the method and furthering the work.

Engineering Economics

Whenever a process is modified to reduce waste, there is a consequent change in the economics associated with it. Economic changes are generally due to: (1) the addition or removal of capital equipment, (2) an increase or decrease in energy consumption, (3) a change in the rate of consumption of feed material, and (4) a change in the rate of product generation. When a process is modified, all of the above are frequently affected. There are well established methods for estimating the economics of chemical processes either manually (Peters and Timmerhous, 1968; Richardson Engineering Services, 1997) or with the aid of a computer (ICARUS, 1997; Aspen Technology, 1997).

Modification of a chemical process using the WAR Algorithm needs to be done along with an evaluation of the economic consequences of any proposed process modifications, *i.e.*, one needs to simultaneously compare both the potential environmental impact and the cost of alternate process flowsheets. The reason is that the ultimate objective is always that of developing cost effective reductions in pollution. Unfortunately, there are no consensus criteria for cost effective waste reduction. Although one possibility, consistent with traditional process design procedures, is to require that the sum of the capital and operating costs should not increase with proposed process modifications from the base configuration. This can be expressed as,

$$\left[C_o + C_c\right]_{Base} \geq \left[C_o + C_c\right]_{Modified} \qquad (12)$$

where C_o is the operating cost and C_c is the capital cost that can be estimated by one of the aforementioned methods or some another proprietary method. Equation (12) can then be used jointly with Equations (4) to (8) to evaluate alternative process flowsheets.

Computer Aided Process Design

While it is often possible to devise pollution reducing modifications from an inspection of the process flowsheet, there are many situations where a more systematic approach such as computer aided process design and optimization may be required. This is particularly important with very complex processes that are difficult to analyze by inspection. The WAR Algorithm can be used in computer aided process design and optimization. This can be done by employing the indexes of Equations (4) to (8) as objective functions in a mathematical optimization subject to a cost constraint such as Equation (12). For example, one could minimize the output of potential environmental impact per mass of product given by Equation (7) subject to keeping the total cost from increasing. This can be expressed as,

$$Minimize\ \hat{I}_{out}^{NP} = \hat{I}_{out}^{NP}(\dot{\underline{M}}^{(out)}, \underline{x}_1^{NP}, \underline{x}_2^{NP}, \ldots, \underline{x}_n^{NP}, \dot{\underline{P}}) \quad (13)$$

subject to Equation (12) where $\dot{\underline{M}}^{out}$ is the vector of mass flowrates for all the output streams, $\underline{x}_i^{NP}$ is the vector of mass fractions for non-product component i in all output streams, and $\dot{\underline{P}}$ is the vector of mass flowrates for all products. The optimization could involve the variation of operating variables and modification of the flowsheet configuration both. In this way one can systematically reduce the pollution indexes even in very complex processes. There are several robust algorithms such as simulated annealing (Kirkpatrick *et al.*, 1983; van Laarhoven and Aarts, 1987) that can be successfully used along with mixed integer programing (Grossmann, 1985; Grossmann, 1990) here.

CONCLUSIONS

A general theory and a methodology for incorporating pollution reduction into chemical process design has been presented. The work is still at an early stage of development particularly with respect to its application. However, the fundamental bases along which future work will proceed have been established.

When used in conjunction with chemical process simulators, the WAR Algorithm offers a powerful methodology for evaluating the potential environmental impact of alternative process flow sheets. Although, the WAR Algorithm is intended for use as part of a good faith effort to reduce the environmental foot print of process plants, and it does not obviate the need to make judicious engineering and environmental decisions. For example, there is no completely unambiguous way of setting values for the impact weighting factors or α_i's. The reason is that the α_i's represent the value that society places on particular types of environmental impacts, and this will vary across locations, cultures, and even time. One should point out, however, that engineering design practice has always used human judgement in determining any number of design parameters like safety factors., and,

therefore, this dilemma is not new.

Never the less, there is a need to further improve the methodology for estimating potential environmental impacts and the weighting factors, there is a need to incorporate economics into the analysis, and there is a need to include computer aided process design and optimization. Future work will address these issues. The case studies, however, do illustrate that even in its present state the methodology is a useful process design tool.

ACKNOWLEDGMENTS

The authors wish to acknowledge the support of Chemstations, Inc., Houston, Texas under a Cooperative Research and Development Agreement with the U.S. Environmental Protection Agency. The authors also thank Dr. Douglas Young at the U.S. Environmental Protection Agency for critiquing the manuscript.

LIST OF SYMBOLS

C_c Capital costs associated with a chemical process, monetary

C_o Operating costs associated with a chemical process, monetary

I_{syst} Potential environmental impact content of system, impact

$\dot{I}_{in}$ Potential environmental impact input rate, impact/hour

$\dot{I}_{out}$ Potential environmental impact output rate, impact/hour

$\dot{I}_{gen}$ Potential environmental impact generation rate, impact/hour

$\dot{I}_{in}^{(i)}$ Potential environmental impact flow of stream j input (i=*in*) or output (i=*out*), impact/hour

$\dot{I}_{gen}^{NP}$ Potential environmental impact generation rate by non-products, impact/hour

$\dot{I}_{out}^{NP}$ Potential environmental impact output rate due to non-products, impact/hour

$\dot{I}_{in}^{NP}$ Potential environmental impact input rate due to non-products, impact/hour

$\hat{I}_{gen}^{NP}$ Specific potential environmental impact generation from non-products, impact/ kilogram

$\hat{I}_{out}^{NP}$ Specific output of potential environmental impact due to non-products, impact/kilogram

$\dot{M}_j^{(i)}$ Mass flow rate of stream j, input (i=*in*) or output (i=*out*), kilograms/hour

$\underline{\dot{M}}^{out}$ Vector of mass flowrates for all output streams, kilograms/r hour

$\hat{M}_{gen}^{NP}$ Specific generation of non-product mass, kilograms/kilogram

$\hat{M}_{out}^{NP}$ Specific output of non-product mass, kilograms/kilogram

$\dot{P}_p$ Mass output rate of product p, kilograms/hour

$\underline{\dot{P}}$ Vector of mass flowrates for all products, kilograms/hour

x_{kj} Mass fraction of chemical k in stream j

x_{kj}^{NP} Mass fraction of non-product k in stream j

$\underline{x}_i^{NP}$ Vector of mass fractions for non-product component i in all output streams, kilograms/kilograms

α_l Chemical independent relative weighting factor for impact of type l, impact/kilogram

Φ_n Pollution index, kilograms/kilogram

σ_j Standard deviation of all chemical scores in impact category j, no units

ψ_j Overall potential environmental impact of chemical j, impact/kilogram

$\psi_{j,l}^s$ Specific (s) potential environmental impact of chemical j for impact of type l, impact/kilogram

$(Score)_{ij}$ Relative potential impact score of chemical i for impact of type j, no unit

$\langle (Score)_{ij} \rangle_i$ Arithmetic average of the scores for all chemicals i in impact category j, no units

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Section B

IISE

Cleaner Production/Pollution Prevention Risk Reduction Measurement Model Development

Dale 1136

MSE Millennium Science & Engineering, Inc.

1364 Beverly Road, Suite 302
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July 1, 1999

Mr. David Gibson
Practice Area Director, Environmental and Natural Resources
CHEMONICS INTERNATIONAL
1133 20th Street NW, Suite 600
Washington, DC 20036

Re: Final Report Entitled *IISE (Philippines) Cleaner Production / Pollution Prevention Strategy Development*

Dear David:

Millennium Science & Engineering, Inc. (MSE) is pleased to provide the enclosed final report entitled *IISE (Philippines) Cleaner Production / Pollution Prevention Strategy Development*. This report has been prepared as the final requirement of the Fixed Price Contract for Chemonics International Inc. (Chemonics) under the United States Agency for International Development (USAID) Contract No. 492-C-00-98-00029-00.

MSE has incorporated comments received from Chemonics at our meeting in Phoenix on April 28, 1999 and from subsequent conversations.

We have enjoyed working with Chemonics on this challenging project. Please call us at (703) 734-1090 with any comments or questions concerning our report.

Sincerely,

Dale A. Rice, P.E.
Vice President

Enclosure

cc: J. Dorr w/enclosure
D. Nelson w/ enclosure

EXECUTIVE SUMMARY

The Industrial Initiatives for a Sustainable Environment (IISE) project (a USAID-funded initative) includes a Cleaner Production / Pollution Prevention (P2/CP) component. The overall objective of P2/CP in this program is to help in reducing pollution from industrial and other discharging facilities by twenty percent within a group of at least 400 industries selected, based on risk to human health and the environment from several industrial sectors. Measurement and analysis of "pollution reduction" will be made utilizing a risk-reduction component yet to be fully developed. A fundamental task of the P2/CP process is to conduct in-plant assessments. This report documents the development of the life-of-project plan and protocol, including sequence and timing, to conduct in-plant assessments within the Visayas-Mindanao project area.

The following are the major activities that were identified for accomplishing the goals of the P2/CP part of the IISE project:

1. Establish Baseline / Measurement Criteria
2. Develop Strategy for and Gain Access to Participating Firms
3. Conduct P2/CP Assessments
4. Follow-Up / Measure Progress
5. Input Data
6. Publicize Selective Results

While in Manila and Cebu, MSE interviewed and evaluated the current IISE team for in-house P2/CP assessment capabilities. This task was accomplished primarily through personal interviews as well as the solicitation of individual background information of team members. For this purpose, a personnel form was developed to collect this information. MSE met with staff members and Filipino subcontractors in Manila and Cebu to develop an understanding of the current capabilities of the IISE technical team and to identify additional training and personnel needs that are needed for the project. Results of the evaluation indicate that each member of the P2/CP assessment team will require additional training. Several members of the team have had IEMP (a preview USAID project) pollution prevention assessment experience, but the methodology for the P2/CP protocol of the IISE project varies significantly from IEMP.

MSE reviewed relevant DENR regulations that have direct or potential implications on the P2/CP initiative. Six regulations were identified that have significant relevance to the P2/CP initiative. The regulation that has the greatest relevance to P2/CP in the Philippines is RA 6969, which covers hazardous waste management.

During the field visit, MSE worked with the IISE field team to develop an approach that would gain immediate access into key Filipino industrial sectors. This strategy is currently being more fully developed by the IISE Technical Team in Cebu. In order to

prioritize IISE resources, a process was initiated by IISE whereby an alternative to full Environmental Management Systems (EMS) and P2/CP assessments was proposed. To help accomplish this objective, an Initial Environmental Review (IER) was designed and tested in several facilities. The IER process involves a brief facility review of EMS and P2/CP practices with subsequent recommendations for IISE technical assistance.

MSE also met with IISE team members regarding the planned approach for disseminating information to the public, other stakeholders, and project partners on the Internet and through other means. This input supported the communications and information component of the project. Such information may include the analysis of current and potential engineering controls by sector, estimated pollutant (risk-based) releases by sector, cleaner production initiatives, pollution prevention auditing results, etc. Since auditing results are to be proprietary to IISE internal staff, the P2/CP protocol will include a provision to discern what data should be made public.

A framework approach that is intended as a guide for the cleaner production and pollution prevention aspects of the project was developed and presented to the IISE P2/CP technical team. The proposed P2/CP strategy allows for feedback at several key points in the process. Thus, method testing with feedback of the initial site access, IER-component assessment, and facility reporting protocols should permit continued improvement of the process leading to development of final life-of-project protocols.

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SECTION 1

INTRODUCTION

The overall objective of the Cleaner Production / Pollution Prevention (P2/CP) component of the Industrial Initiatives for a Sustainable Environment (IISE) is to, as an adjunct to environmental management systems (EMS) support, reduce pollution from industrial and other discharging facilities by twenty percent over the life of the project. Final recommendations for estimating and measuring pollution reduction will be made using a risk-based method currently being developed. The project will work with at least 400 industries within a range of industrial sectors, all of which likely need P2/CP assessments. The Philippine implementing agency for this project is the Department of Environment and Natural Resources (DENR), in cooperation with the Department of Trade and Industry (DTI) and the Philippine Coast Guard (PCG). The IISE contract (formerly known as the Municipal Coastal Environmental Initiative or MCEI) was signed in July of 1998 with full project implementation initiated in late 1998.

To expedite the work planned for 1999, Chemonics International Inc. (Chemonics) contracted Millennium Science & Engineering, Inc. (MSE) to support the P2/CP project in the initial project development. The objective of this assignment was to:

- Develop the life-of-project pollution prevention/cleaner production (P2/CP) plan and protocol, including sequence and timing, in support of IER and full in-plant assessments within the project area.

The work is to include: (1) the planning framework for conducting the P2/CP component of the project which will guide the technical activities of the in-plant assessments and (2) the concept for establishing the pollution baseline from which the project will measure part of its success. A framework approach and template is to be developed which will be replicable throughout the plants.

SECTION 2

OVERVIEW OF P2/CP STRATEGY

The key to developing the P2/CP strategy is to identify, develop, and sequence all the required elements (activities) that must be conducted. The following are the major activities that were identified for accomplishing the goals of the P2/CP part of the IISE project:

1. Establish Baseline / Measurement Criteria
2. Develop Strategy to Gain Access to Participating Firms
3. Conduct P2/CP Assessments
4. Follow-up / Measure Progress
5. Input Data
6. Publicize Selective Results

The initial strategy development focused on approaches for baseline / progress measurement, identifying, accessing and supporting participating companies and other organizations, and development of consistent, implementable, streamlined assessment protocol. A key issue remains the development of the baseline database against which future pollution reduction will be measured. A discussion of this issue and a more complete flow chart for the P2/CP assessment process are presented in Section 4.

SECTION 3

ASSESSMENT OF P2/CP RELATED RESOURCES AND FACTORS

This section addresses topics that are relevant to the P2/CP assessment process. The issues and their importance are summarized below:

Issue / Factor	Importance to Successful P2/CP Implementation
IISE Team Capability Benchmarking	Need to understand capabilities and training needs of current staff, including subcontractors and determine additional resources for conducting P2/CP assessments.
Regulatory Requirements	Regulatory and other factors provide incentives as well as disincentives for industry to participate.
Existing Pollution Control / Prevention Measures	Knowing the typical approaches that industrial sectors have adopted with respect to pollution control / prevention can help identify potential opportunities for implementation of priorities
Industrial Sector Ranking	To realize maximum results in the P2/CP portion of the project, participating sectors should be risk-ranked as to those having the greatest impact to human health and the environment.
Data Presentation and Access	The data collected in the P2/CP program will be compiled into a useful, interactive format. Access to these data by project shareholders will be made available on a password basis.
CP / P2 Protocol	A standardized, easy to use procedure will be developed to ensure consistency and collection of the appropriate data.

3.1 IISE Team Benchmarking

In order to determine the capabilities to conduct P2/CP assessments and audits, MSE interviewed and evaluated the current IISE team for in-house P2/CP assessment capabilities. This task was accomplished primarily through the solicitation of individual background information of team members. For this purpose, a form (Appendix A) was developed to collect this information. MSE met with staff members and Filipino subcontractors in Manila and Cebu to develop an understanding of the current capabilities of the IISE technical team and to identify additional training and personnel needs that are needed for the project. Individuals from the following organizations were contacted:

- IISE's in-house technical team;
- The Green Group;
- Development Academy of the Philippines (DAP);
- SCHEMA Konsult, Inc.; and
- Resource Management International, Inc. (RMI).

Completed forms are included in Appendix A. A summary of the capabilities of these individuals is included in Table 3.1. (Note: to date, not all requested forms have been received although significant efforts have been made by both IISE and MSE. No forms were received from the Green Group, DAP, or RMI.)

Based on the information received via interviews and completed forms, the IISE in-house team and Schema Konsult possess the highest potential for fielding qualified personnel for the P2/CP assessments. The availability of Green Group and RMI personnel is questionable based on recent discussions with their respective managers. RMI could best serve this part of the project by offering personnel with energy sector expertise for assessment teams evaluating power plants and other utilities, cogeneration facilities, etc., however, they have recently indicated their disinterest in fielding such teams. DAP personnel are more oriented toward training than technical work such as process assessments.

For the number of members with expertise in specific sectors (Table 3.1), team members with ratings of 3 (environmental assessment experience) and 4 (working knowledge of the process) were totaled. As shown in Table 3.1, most of the assumed sectors have fairly good coverage with the exception of the shipbuilding / ship breaking industry. However, the number of enterprises in this industry is not expected to be excessive and could most likely be covered by current team members.

Each member of the P2/CP assessment team will require training. Several of the team have had IEMP P2 assessment experience, but the methodology for the IISE project varies significantly from the current project. A detailed description for the proposed training is described in Section 4.

3.2 Review of Appropriate Regulatory Requirements

MSE reviewed relevant DENR regulations that have direct or potential implications on the P2/CP initiative. These regulations include strict requirements for compliance and should be a potential incentive for industries to participate in the IISE P2/CP and EMS program. The benefits of P2/CP and EMS include increasing the likelihood of compliance when applied satisfactorily. Of particular interest are regulatory issues that deal with tracking chemical usage for or wastes coming from industrial facilities. Table 3.2 presents key regulatory drivers that are pertinent to the project, and Table 3.3 describes briefly how these regulations affect the P2/CP initiative.

Six regulations were identified that have significant relevance to the P2/CP initiative. The regulation that has perhaps the greatest relevance to P2/CP in the Philippines is RA 6969, which covers hazardous waste management. Of particular interest is that no person / facility shall store, import, use, transport, process, sell, or distribute any chemical not on the DENR inventory list of chemicals allowed in the Philippines. Note, that a person / facility can request a new chemical be placed on the list, but this can be a lengthy process. Another particularly relevant regulation is the Revised Air Quality Standards of 1992 (DENR AO No. 14), which state that all process changes must meet New Source Performance (Emission) Standards. Note that variances may be granted for certain durations, if meeting the limits involves great measures or large costs. Also, during certain levels of unhealthful air quality, the regulation requires curtailment of process activities contributing to air pollution. Finally, DENR AO No. 17 was instituted for the previous AID-funded project (IEMP) and provided incentives for participation in facility assessments and implementation of recommendations. Similar AOs may be beneficial for this project.

3.3 Initial Benchmarking of Existing Pollution Control / Prevention Measures

During the field visit, MSE worked with the IISE technical team to develop an approach that would gain immediate access into key Filipino industrial sectors. In order to prioritize and administer resources for the project, a process had to be developed in order to provide the team with the mechanism to respond to industrial "clients" in a predictable fashion. To accomplish this objective, an Initial Environmental Review (IER) was designed and tested in several facilities. (The P2/CP component of the IER process is an adjunct to the overall IER which incorporates EMS.) An IER is a brief survey aimed at quickly assessing the key environmental, quality, occupational safety and health and other management issues at a specific facility. The IER for the IISE project is in the process of being finalized the by the field office.

The initial IER format was tested at two industrial facilities in Cebu. The team called representatives at the facilities and discussed the IISE program and the IER process. The team also requested that IERs be conducted at the facilities. Access was granted at both facilities: an electroplating company and a carragenan packaging plant. The completed

IER form for the plating facility (Halsangz Plating Corporation) is included in Appendix B. This facility appeared to have excellent potential (and willingness) for participation in the IISE project. The carragenan plant is probably not a candidate for the P2/CP portion because no chemicals are introduced to the process.

Following the completion of the IERs, an interview was conducted with Ronald Gamban, President of the Cebu Electroplaters Association. This interview, coupled with the IER at the Halsangz facility, enabled an initial assessment of the electroplating sector in the Cebu area. Halsangz is reportedly one of the three largest platers (in terms of production) in Cebu. The facility has an on-site wastewater treatment plant to treat heavy metals, cyanides, and acids. The resulting solids (sludges) are dewatered but stored in bags on site. Several potential pollution prevention opportunities were observed during the facility walk through. Other electroplating facilities in Cebu do not have any wastewater treatment capabilities.

A central waste facility is being planned by the Cebu Electroplaters Association that will be equipped to treat liquid wastes and receive treated metal hydroxide sludges from the electroplating sector in Cebu. This facility will ship treated sludges to a disposal facility in Manila.

The IISE team needs to conduct perhaps 500 more IERs across the key sectors. The larger number (as opposed to 400 facilities designated in the USAID contract) is to account for an inevitable dropout of initially-participating facilities. This activity will result in the benchmarking of existing pollution control / prevention measures as well as P2 opportunities in these sectors.

Table 3.1
P2/CP Team Member Experience Summary

Total Number of Team Members Surveyed =	19
Number of Members Surveyed from IISE =	1
Number of Members Surveyed from RMI =	
Number of Members Surveyed from DAP =	
Number of Members Surveyed from Green Group =	
Number of Members Surveyed from Schema Konsult =	14
Number of Members Surveyed from MSE =	4

Number of Members with a Bachelor's Degree =	4
Number of Members with a Master's Degree =	12
Number of Members with a Doctorate =	3
Number of Members with Another Degree =	

Number of Members with Experience in Each of the Following Sectors:

8	Mining & Metal Refining	13	Chemicals	11	Petrochemicals
7	Electronics	11	Electroplating	13	Food Processing
8	Iron & Steel	5	Hospitals	7	Coastal Resorts
8	Steam & Power Plants	11	Pulp & Paper	4	Timber Milling & Treatment
7	Cement Manufacturing	11	Piggeries & Slaughterhouses	4	Ports & Harbors
2	Ship Building	1	Ship Breaking	5	Other (Ink Manuf., Feed Mills, Textiles, Retail, Media, Painting, Veh. Maint.)

Table 3.2
DENR Regulations Pertinent to IISE P2/CP Program

Regulation	Description
DENR Administrative Order No. 14	**Revised Air Quality Standards of 1992, Revising and Amending the Air Quality Standards of 1978.** The regulation presents emission standards for stationary sources at different levels inside and outside of Metro Manila and provides ambient air quality guidelines for both short- and long-terms. The regulation also presents air quality indices and recommendations for actions that should/must be taken at each level.
DENR Administrative Order No. 17	**Guidelines Governing Voluntary Participation in Pollution Management Appraisals (PMAs) of the Environmental Management Project.** The order encourages industries to participate in the past USAID project that performed PMAs. In exchange for serious efforts to implement PMA recommendations, the order provides a moratorium on compliance, coordination with funding sources, and a promise of confidentiality concerning information gathered during the PMA.
DENR Administrative Order No. 26	**Amending Memorandum Circular No. 2, Series of 1981: Appointment/Designation of Pollution Control Officers.** The regulation presents the minimum qualifications and responsibilities of a pollution control officer. The industries requiring a pollution control officer are presented, as well as regulations requiring full-time pollution control officers for facilities of a given size or larger. The quarterly monitoring report that must be completed by a pollution control officer for a given facility is also presented.
DENR Administrative Order No. 29	**Implementing the Rules and Regulations of Republic Act 6969.** Covers the importation, manufacture, processing, handling, storage, transportation, sale, distribution, use, and disposal of all unregulated chemical substances and mixtures in the Philippines including entry, even in transit, as well as the keeping or storage and disposal of hazardous and nuclear wastes into the country for whatever purpose. Chapter VII presents hazardous waste, policy concerning it, listed hazardous wastes, and waste treatment options.
DENR Administrative Order No. 34	**Revised Water Usage and Classification / Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of the 1978 NPCC Rules and Regulations.** Provides classification system for waters according to their beneficial uses and states that waters shall maintain the minimum conditions necessary to remain designated at their current classifications. The regulation presents water quality criteria for each class of water.
DENR Administrative Order No. 35	**Revised Effluent Regulations of 1990, Revising and Amending the Effluent Regulations of 1982.** Provides wastewater discharge limits for each class of water presented in DENR AO No. 35.

Table 3.3
Implication of DENR Regulations on Hazardous Material Tracking, Process Modifications, and Emissions Tracking

Regulation	Implication on Material Tracking	Implication on Process Changes	Implication on Emissions Tracking
DENR Administrative Order No. 14	During different levels of unhealthy air quality, DENR suggests the use of "cleaner" fuels/ chemicals.	Requires process changes to meet New Source performance standards. Variances on meeting limits may be granted for certain timetables if meeting limits will involve great measures or large costs. Does not allow plants to operate at capacities that would exceed capabilities of control devices or install devices that would cause the exceedence of limitations or the concealment or dilution of emissions. During different levels of unhealthful air quality, DENR requires curtailment of contributing industrial processes.	Sets maximum limits on particulates, metals, acids, SO_x, and NO_x as well as opacity for smoke. At DENR's discretion, may require monitoring, record keeping, and reporting. Requires ambient air monitoring line for specific compounds at the property.
DENR Administrative Order No. 17	For IEMP, gave moratorium on Cease and Desist Orders and 12 months to implement no-cost and low-cost waste management options recommended by PMA.	For IEMP, gave moratorium on Cease and Desist Orders and ample time for substantial capital investments recommended by PMA.	Information collected during PMAs was confidential and would not directly result in DENR actions.
DENR Administrative Order No. 26	States industries (of a given size) must have a Pollution Control Officer (PCO) provide a quarterly (or more frequent) report that presents, among other things, fuel consumed for stationary fuel burning sources.	States industries (of a given size) must have a PCO monitor installation or construction of pollution source and control facilities to assure compliance with limits. PCO and head of establishment shall be held responsible for any violations.	States industries (of a given size) must have a PCO that provides quarterly (or more frequent) pollution discharge reports, which also include means of disposal.

Table 3.3
Implication of DENR Regulations on Hazardous Material Tracking, Process Modifications, and Emissions Tracking

Regulation	Implication on Material Tracking	Implication on Process Changes	Implication on Emissions Tracking
DENR Administrative Order No. 29	DENR shall keep an inventory list of chemicals stored, imported, exported, used, processed, manufactured, or transported. No person shall store, import, use, transport, process, sell, or distribute any chemical not on this list without petitioning for and being granted its use.	Reaction intermediates are exempted from the DENR list.	DENR shall keep an inventory list of chemicals stored, imported, exported, used, processed, manufactured, or transported. No person shall store, import, use, transport, process, sell, or distribute any chemical not on this list without petitioning for and being granted its use. Hazardous waste generators must provide quarterly a report indicating the quantity of hazardous waste generated accompanied with payment of a prescribed fee. Hazardous wastes may only be transported with a permit and must be treated in a prescribed facility.
DENR Administrative Order No. 34			Prohibits discharge of discharges that alone or in combination produce a nuisance; are acutely toxic, carcinogenic, etc.; and/or pose a serious danger to public health, safety, or welfare. Presents a guide to dischargers and regulators concerning the significant parameters to be monitored for selected industries.

Table 3.3
Implication of DENR Regulations on Hazardous Material Tracking, Process Modifications, and Emissions Tracking

Regulation	Implication on Material Tracking	Implication on Process Changes	Implication on Emissions Tracking
DENR Administrative Order No. 35		No equipment may be installed that will conceal and/or dilute effluent discharge. No facility may operate at capacities that produce wastes that cause the treatment facility to discharge wastes above permitted limits.	Presents effluent discharge regulations for the different classes of water bodies for old/existing and new/proposed industries. Regulates mixing zones.

3.4 - Review of Existing Industrial Sector Ranking Results

A ranking of the industrial sectors for relative environmental impact significance has already been completed in a prior AID-funded project, the Industrial Environmental Management Project (IEMP). The IEMP created a macro environmental risk analysis (ERA) checklist to rank the potential risk of pollution from a particular facility or industrial sector to human health, welfare, and the environment. The checklist was organized into five data categories: Industrial Considerations, Waste Generation and Management, Pathways, Receiving Media/Receptors, and Compliance. Each category had multiple factors/criteria that were reviewed and scored according to a weighting checklist. The points allowed for each factor/criterion are presented in Table 3.4.

Table 3.4
Ranking Criteria for Previous USAID-Funded Project (IEMP)

Criteria	Individual Points	Point Subtotals	Total Points
Waste Generation and Management			**44**
Airborne		*14*	
Description (Haz., Nonhaz. Point Source, Nonpoint Odor/Nuisance)	6		
Quantity (5 levels)	6		
On-Site Pollution Control System (PCS) (Yes/No)	2		
Liquid		*15*	
BOD Strength, Haz./Nonhaz. (6 levels)	6		
Quantity (5 levels)	6		
Type/Quality of PCS (4 levels)	3		
Solid		*15*	
Type (Haz, Animal, Nonhaz./Pollutive, Nonhaz./Low-pollutive)	6		
Quantity (3 levels)	6		
Type/Quality of PCS (4 levels)	3		
Pathways			**8**
Air		*2*	
Prevailing Wind Toward Resident. (Yes/No)	2		
Solid and Liquid		*6*	
Rainfall (3 ranges)	2		
Terrain (Flat/Sloped)	1		
Flood-Prone (Yes/No)	1		
Depth to Groundwater for Liquid or Haz. Solid Wastes (3 ranges)	3		

Receiving Media/Receptors			**25**
General Receptors		*4*	
Number of Environmentally Critical Areas (ECAs) within 2 km (3 ranges)	2		
Distance to Nearest ECA (3 ranges)	2		
Air Receptors		*6*	
Distance to Nearest Community (3 ranges)	6		
Surface Water Receptors		*8*	
Distance to Nearest Surface Water (3 ranges)	4		
Distance to Nearest User (3 ranges)	1		
Size & Use of Fresh Water or Use of Salt Water	3		
Groundwater Receptors		*7*	
Distance to Nearest Used Well (3 ranges)	4		
Groundwater Use (4 types)	3		
Noncompliance			**23**
Violations		*15*	
Number of PD 984 Air Violations	3		
Number of PD 984 Water Violations	3		
Number of PD 1586 Envtl. Compl. Viols.	3		
Number of RA 6969 Violations	3		
Severity of Recalcitrance	3		
Complaints		*8*	
Number of Valid Complaints (4 ranges)	8		
Total Points			**100**

As indicated in the table above, the checklist placed the most weight (44%) on the type of waste present, followed by decreasing weight on receiving media/receptors (25%), noncompliance (23%), and pathways (8%). Approximately 40% of the points scored in waste type were for whether the wastes were hazardous or (in the case of liquids) high in BOD. Another approximately 40% of the waste type scoring was based on quantity of waste generated. Points scored for receiving media / receptors were given primarily for proximity of receptors to pollutant source and for value / importance of maintaining the quality of the receptor. Points scored for "noncompliance" were almost entirely given based on the number of past violations of DENR regulations. Points scored for pathways were based on whether wind, rain, terrain, groundwater would promote or retard pollutant transport.

MSE compared the previous rankings with predicted results that are based on our knowledge of the various industries and the rankings by USEPA. Table 3.5 presents industry sector rankings for Region 11 (Davao, General Santos City) from the previous AID-funded project and compares them to their ranking by USEPA as industries most closely linked with environmental problems.

Table 3.5
Comparison Between the Ranking of Environmental Impact for Industrial Sectors from the Previous Aid-Funded Project (IEMP) to USEPA Rankings of the Industrial Sectors

Sector	Region 11 IEMP-Ranking	USEPA Ranking
Electroplating	NL	1
Plastics, Resins, and Elastomers	4	2
Industrial Organic Chemicals N.E.C.	9	3
Paint Industry	58	4
Automotive Manufacturing/Assembling	NL	5
Electronics/Semiconductors	44	6
Petroleum Refining	NL	7
Pesticides	NL	8
Commercial Printing, Lithographic	NL	9
Dry Cleaning Plants	NL	10
Inorganic Chemicals N.E.C.	9	11
Wood Preserving	29	12
Automotive Repair Shops	NL	13
Paper Mills	3	14
Commercial Printing	NL	15
Pulp Mills	3	16
Textile Dyes and Dyeing	NL	17
Ink Manufacture	NL	18
Pharmaceutical Preparations	49	19
Adhesives and Sealants	NL	20
Newspaper Publishing	NL	21
Coal Tar Crudes, Dyes, and Pigments	NL	22
Aircraft and Parts	NL	23
Leather Tanning and Finishing	NL	24
Engraving and Plate Printing	NL	25
Iron and Steel	6	26
Secondary Smelting and Refining of Non-Fe Metals	51	27
Rolling, Drawing, and Extruding of Non-Fe Metals	12	28
Cement Manufacturing	1	NL
Sugar Milling and Refining	2	NL
Hotels, Motels, Lodgings	5	NL
Canning, Preserving, etc. of Fish, Crustaceans, Seafood	7	NL
Gold and Other Precious Metals Refining	8	NL
Coal Mining	10	NL

Sector	Region 11 IEMP-Ranking	USEPA Ranking
Manufacture of Desiccated Coconut	11	NL
Production of Crude Coconut Oil, Incl. Cake and Meal	13	NL
Gold Ore Mining	14	NL
Hog Raising	15	NL

Note: NL – Not Listed

As apparent in Table 3.5, there are significant differences between the rankings for potential risk for pollution from the previous AID-funded IEMP project and rankings of sectors most closely linked with environmental problems as identified by USEPA. Some of these differences are a result of the sectors not being significant in the Philippines, however, an important part of this difference is due as a result of different ranking criteria as well as in definitional and operational adoption of risk assessment versus risk analysis criteria. As opposed to the IEMP project, where ranking was primarily based on the types and quantities of wastes present (weighing heavily on bulk parameters like BOD (a non-risk factor) or "hazardous waste"), the USEPA list was based on industry size, waste production in terms of toxicity and/or volume (true quantifiable risk factors), receptivity of the industry to innovation, benefits that would be achieved through waste minimization, cost benefits that would be realized from waste minimization, and the like as perceived by a panel of 25 experts from USEPA, academia, EPA contractors, and state environmental programs. Though this ranking was subjective, it was based upon a vast amount of experience with industries and was much more risk-based than the IEMP approach.

Environmental risk assessment is an important component of risk analysis, the latter of which is used to evaluate and communicate the importance of findings of quantitative risk assessments. Quantitative risk assessment relies on widely accepted methods integrated as a four-step process: 1) identification of contaminants of concern; 2) dose-response evaluation, 3) exposure assessment, 4) risk characterization.

It is used here as the four-step[1] process of the U.S.-based National Academy of Sciences (NAS) defines it:

> "The use of the factual base to define the health effects of exposure of individuals or populations to hazardous materials and situations".

This definition is separate from but very frequently confused with *risk management*:

[1] The four step risk assessment process of the NAS is 1) hazard identification, 2) dose-response evaluation, 3) exposure assessment, 4) risk characterization.

"The process of weighing policy alternatives and selecting the most appropriate regulatory action, integrating the results of risk assessment with engineering data and with social, economic, and political concerns to reach a decision."

A fundamental construct of the IISE project is the proper use of quantitative risk assessment, whenever feasible, to estimate, measure or predict environmental or human health risk posed by contaminants of concern within the industrial sectors of the project.

3.5 - Data Presentation / Access

MSE worked with IISE team members regarding the planned approach for disseminating technical information to the public, other stakeholders, and project partners on the Internet and through other means. Such data may likely include the analysis of engineering controls by sector, estimated pollutant releases by sector, cleaner production initiatives, pollution prevention auditing results, etc. Since auditing results will be proprietary, the P2/CP protocol will include a provision to discern which data can be made public.

The discussion also included the potential use of a GIS-based information management system and linkages to the project Web site. A related tool, "SeeIt", developed by Visible Decisions, was presented informally to IISE technical team members. This proprietary system allows the user to present spreadsheet data in interactive graphic format.

The potential use of SeeIt will be discussed with Chemonics Home Office personnel and the MIS and Technical groups in Cebu.

3.6 - Incentives for P2/CP Implementation

The IISE P2/CP team discussed the importance of incentives to foster participation both in the auditing component and the implementation for the P2/CP project. This concern stemmed from the previous IEMP project experience for which the degree of interest expressed by participants varied significantly. Therefore, the team concluded that it would be very helpful to identify the key factors to attract participants to the program. Based on informal polling of the team, the following were identified as top priorities to promote participation:

To Obtain Initial Participation:	To Obtain CP Implementation:
Cost Savings	Cost Savings
Offer of Training / Technology Transfer	Link to Obtaining Mayor's and Other Regulatory Permits
DTI Fiscal Incentives	Low Cost Loans

SECTION 4

IISE P2/CP STRATEGY DEVELOPMENT

4.1 P2/CP Overview

A framework approach that is intended as a framework guide for the cleaner production and pollution prevention aspects of the project was developed within this Scope of Work. The P2/CP strategy is represented as a flow diagram in Figure 4.1. The diagram identifies the key components of the project and their linkage along with the critical path to completion. This approach was presented to and approved by the IISE P2/CP technical team.

The proposed P2/CP strategy allows for feedback at several key points in the process (e.g., Blocks 16, 21, and 31). Thus, testing with feedback of the initial site or facility access, P2/CP assessment, and facility reporting protocols should permit continued improvement of the process leading to final protocols. Note that the Environmental Management System (EMS) component of the IISE project naturally folds in at blocks 5, 6, and 11.

The completion of several hundred IERs can be accomplished in relatively short order by the existing IISE team members, subcontractors and the new mechanism which will allow other Philippines-based, qualified consultants to participate. However, to ensure consistency, quality and effective coverage, training of all team members, including subcontractors, is required. As the IER process is the initial and cornerstone technical activity within participating facilities and organizations, its quality and consistency will set the stage for the remainder of IISE support through the life of the project. As such, emphasis will be placed on high-caliber training to a wide constituency of IISE team members, including subcontractors, the result of which will be not only properly setting of the stage for further work within the plant but it will also contribute to the post-project sustainability of the project.

The IER approach (Block 8) will establish the field of participants (for both P2/CP and EMS) through initial data gathering, screening, and analysis and will further benchmark the key industrial sectors. The IER will also be used as an opportunity to obtain a commitment from participating facilities to allow a complete (or partial) P2/CP assessment and/or EMS program participation, depending on the prioritization as determined by the IER. P2/CP

During the field visit, the following blocks from Figure 4.1 were discussed and/or developed. The outcome / status of each is as follows:

Block Number / Description	Status
1. Define (P2/CP) Goals	Discussed in detail during field visit; proposed in Section 5
2. Confirm Sectors / Selection Criteria	Addressed in Section 3
3. Prioritize Sectors	Discussed in detail during field visit; addressed in Section 3
4. Develop Measurement Methodology	Addressed in Section 4
5. Benchmark Industry Sectors	Commenced with initiation of IERs
6. Develop Preliminary Access Strategy	Commenced with initiation of IERs; IER training to be set up.
7. Identify Incentives for P2/CP Implementation	Discussed in detail during field visit; addressed in Section 3
8. Conduct IERs	IER protocol field-tested during visit
9. Develop Pilot Assessment Protocol	Proposed protocol included in Appendix C
13. Benchmark Team	P2/CP team member experience forms requested - Appendix A

A draft assessment protocol was developed using a series of worksheets based on prior P2/CP projects conducted by MSE. The worksheets and instructions on their use are included in Appendix C. The data should be gathered by a team of appropriately trained personnel including someone familiar with the process being evaluated and a P2 engineer, at a minimum. After gathering facility information, the P2 engineer will evaluate the data, establish the pollution baseline, and prepare an "alternatives evaluation."

A proposed method for establishing the baseline and measuring progress was conceptualized. This method is based on EPA research work (the so-called "WAR" model) as documented in the articles included in Appendix D. The basic approach is to "measure" the level of current potential risk for each chemical (focusing on the Philippines list of 28 chemicals from RA 6969) appearing in any of the facility's wastestreams. Following implementation of P2/CP alternatives, the updated potential risk would be compared to the previous level. Discussions between MSE and the EPA authors, Young and Cabezas, indicated the appropriateness of their method to the IISE project. A request has been made to the authors to obtain a limited matrix to allow development and testing of

a tailored approach (Appendix D). EPA's Sustainable Technology Division Office (Cincinnati) is also interested in collaborating on the project.

4.2 IER Training

The P2/CP part of the Initial Environmental Review (IER) training should be given to all IISE Technical Team personnel as well as project subcontractor personnel that have at least some technical background (college training in the sciences or engineering). The IER training can be conducted in approximately two weeks, including instruction in P2/CP and EMS aspects. A draft curriculum and schedule includes the following for Week 1:

Day	Topic	Course Instructor
1	Overview of IISE • Purpose • Specific Objectives • 9000/EMS Component • P2/CP Component	DN / SR [2]/JL
	IER Overview • Purpose • Intended Participants • Data Objectives	DN
	ISO 9001 / EMS Training	SR
2	ISO 9001/ EMS Training	SR
3	Overview of Industry • Description of Key Filipino Industries • Major Industrial Processes • Key Chemicals (RP 28) • Waste Issues • Slide Show – Industrial Processes	MV/ DR
	Introduction to Risk • What is "risk"? • Introduction to "WAR" Algorithm Risk Factors • P2/CP Task Goal: Risk Reduction	DN / DR

[2] Initial IER training will be conducted by David Nelson, IISE Technical Director, Stan Rodgers, EMS consultant, Jackie Limtin (IISE management consultant team member), Maya Villaluz (IISE Senior Environmental Engineer) and Dale Rice, P2/CP consultant. Subsequent IER training might be enhanced by project personnel who demonstrate the competence to do so.

Day	Topic	Course Instructor
3 (Cont.)	Setting Up IER Visits • Potential Participants – Who Do We Target? • "Entrance Strategy" discussion •	DN / JT / DR
	Overview of IER Process/Forms • Overall Approach • General Facility Information • EMS Related Questions • P2/CP Related Questions	DN/DR
	Facility Walk Through • Objectives • Checklist	DN / DR
4	Establishing Next Step • ISO 9001 • ISO 14001 • P2/CP Assessment • ISO 14001 and P2/CP Assessment • Scheduling	DN / DR
	IER Closure • Evaluation of Facility • Report "Coding" • Report Filing	DN / DR / TS
	IER Simulation • Fictitious Industry • Role Play	DR
5	Review • ISO 9001 / 14001 • EMS • P2/CP • Risk Reduction • IER Forms • Q&A	DN / SR / DR
	Exam • Written	DN / SR / DR

Week 2 would include actual IER completion. After scheduling IERs for the week, IERs would be conducted initially with supervision, and finally in teams of two., Finally, the entire training group would assemble to present and review the results of the IER effort.

This activity would allow an assessment of each person's understanding of the IER process and to cover any areas still needing further training. The entire two week training period could be culminated with an "awards" ceremony, in which team members are given a "certification" for competency in conducting IERs. The schedule for Week 2 is as follows:

Day	Topic	Course Instructor
1	Scheduling IERs	DN / SR / DR
2	Supervise IERs	DN / SR / DR
3	IERs by Team	
4	IERs by Individual	
5	IER Form Review (Group) • Presentations by Teams • Constructive Feedback • Lessons Learned IER Certification	DN / SR / DR JD / DN

4.3 P2/CP Assessment

P2/CP assessments are required in the project to help in documenting baseline pollution levels and to effect P2 activities that result in pollution reductions. An initial pilot assessment protocol (Appendix C worksheets) has been developed per Block 9 (Figure 4.1). Ideally, P2/CP assessments will be scheduled and conducted immediately (within two weeks) following the IER completion at each facility.

To help ensure effectiveness and consistency of the P2/CP assessment program, training for all P2/CP team members will be conducted. The training can be accomplished during a five day course with a draft curriculum and schedule as follows:

Day	Topic	Course Instructor
1	Overview of P2/CP • Purpose • Objectives • Relationship of IER and P2/CP • Major Philippines Industries / Processes • Qualifications for Conducting P2/CP Assessments	DN / DR

Day	Topic	Course Instructor
1 (Cont.)	P2 Concepts • Definition of P2 • Importance of P2 • Methods to Accomplish P2 • Measuring P2 "Progress" • Mass Balance • Hazardous Waste Baseline • Process Flow Diagrams Introduction to R2M2 (Risk Reduction Measurement Model) • EPA "WAR" Algorithm • Risk Factors • Chemical Domain • Technical Approach	DR DR
2	Worksheets • Instructions • Q&A	DR
3	P2/CP In-Field Training • Test Facility (Cebu) • By Teams • Evaluate Data Worksheets	DN / DAR
4	Data Evaluation • Data Reduction • Mass Balance • Inputs to R2M2 P2 Options • Worksheets 8-10 • P2 Technology Resources • Cost Analysis	DR DR

Full P2/CP assessments should only be completed for those facilities that are determined during the IER to use significant quantities of RP 28 or other hazardous chemicals.

4.4 Risk Reduction Measurement Model (R2M2)

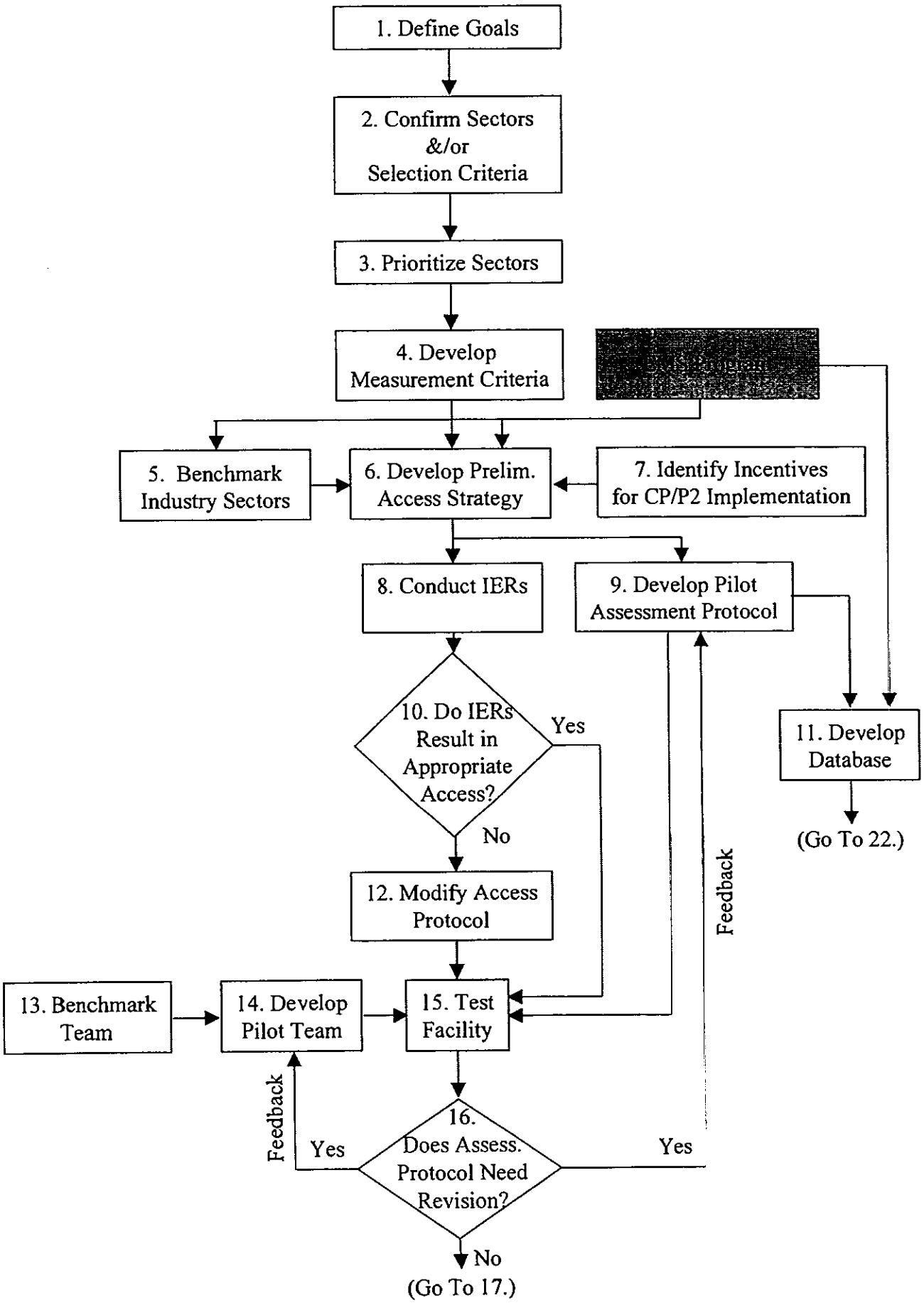
The R2M2 (Risk Reduction Measurement Model) will be constructed prior to the P2/CP training. MSE has been given tentative approval by EPA to use a subset of the "WAR" algorithm matrix. The WAR algorithm includes relative risk values (health and

environmental impact categories) for a number of chemicals, including most of the RP 28. The risk factors include:

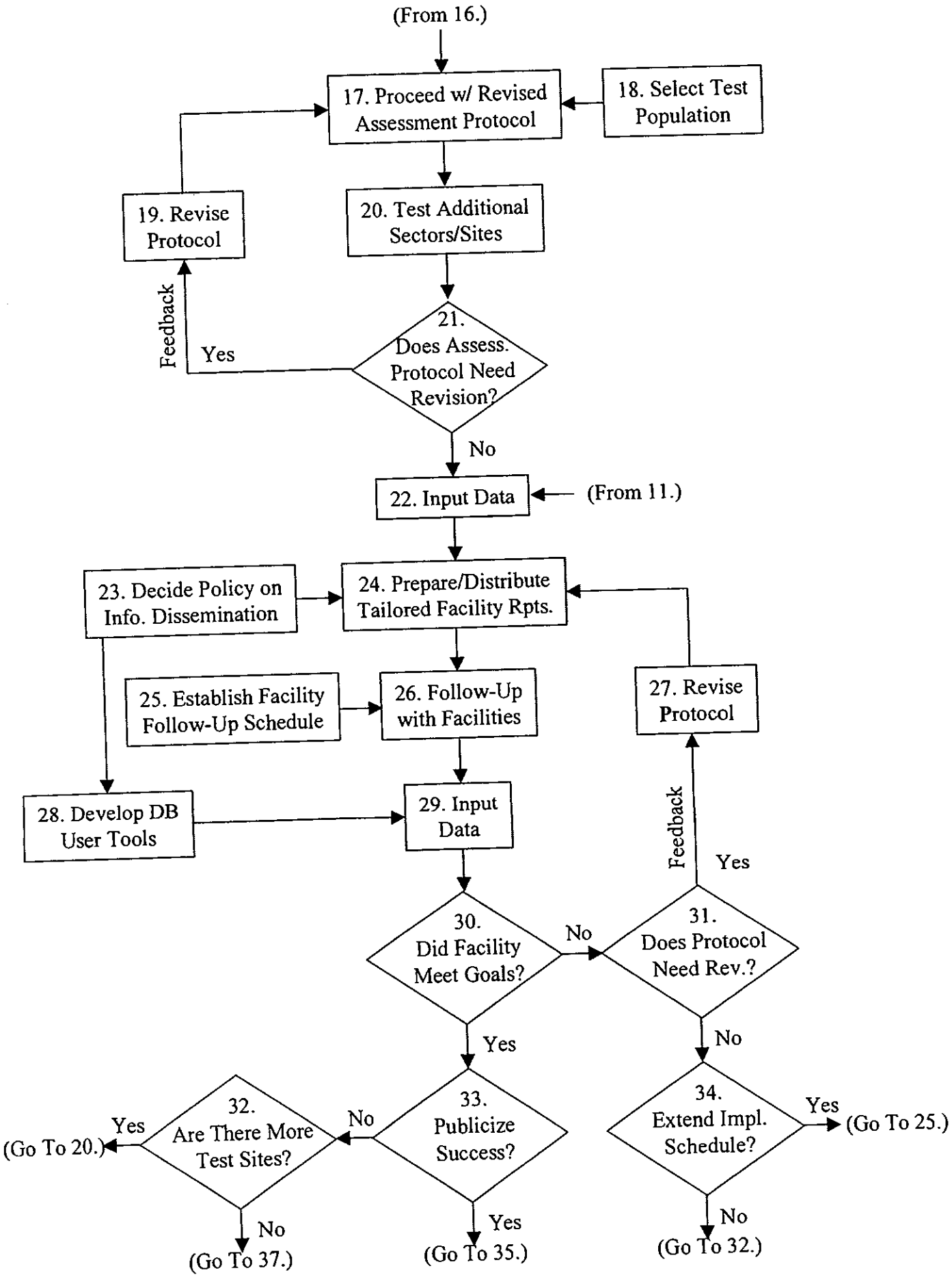
1. Ozone-depletion potential,
2. Global-warming potential,
3. Acid-rain potential,
4. Photochemical-oxidation (smog formation) potential,
5. Human-toxicity potential by ingestion,
6. Human-toxicity potential by inhalation or dermal exposure,
7. Aquatic-toxicity potential, and
8. Terrestrial-toxicity potential.

Using macros, a user-friendly platform can easily be constructed that will allow the user to input data (primarily from the worksheets). Later, as P2 alternatives are implemented, additional data will be inputted allowing for calculation of a percentage risk reduction.

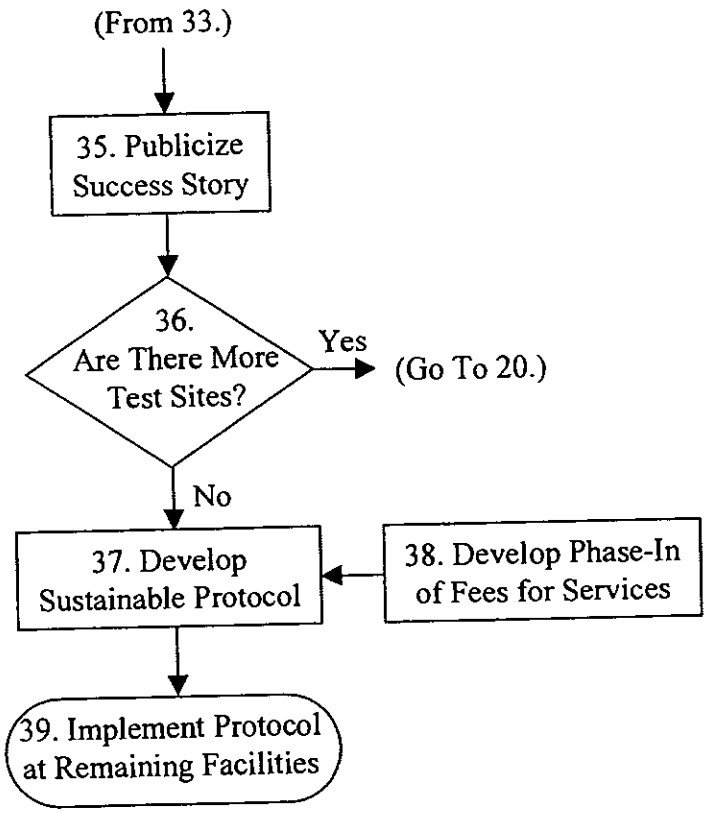
Figure 4.1
Strategy for IISE P2/CP Program Implementation



Strategy for IISE P2/CP Program Implementation - Continued



Strategy for IISE P2/CP Program Implementation - Continued



SECTION 5

RECOMMENDATIONS / PATH FORWARD

A proposed schedule and sequence of P2/CP activities are included in the attached IISE Project P2/CP Schedule. Specific details for each future activity are as follows:

1. **July 1, 1999** – MSE will meet with Chemonics staff to discuss the potential application of the WAR algorithm and incorporation of P2/CP (and risk reduction measurements) into the Geographic Information Systems (GIS) application being frameworked for the IISE project.
2. **July 5 – July 10, 1999** - The IER Training Program (which incorporates EMS and P2/CP) will be prepared by MSE and IISE in-house team members.
3. **July 12 – July 16, 1999** – The IER Training Program will be given to key in-house team members, subcontractors and potential IER trainers.
4. **July 19 – August 6, 1999** - The Risk Reduction Measurement Model (R2M2) will be developed in draft form and tested by MSE, EPA, and others prior to its use in the Philippines. EPA will also review the model to ensure appropriate use of the WAR algorithm component that they supply.
5. **July 26 – August 6, 1999** - Training in IER for additional IISE team members (in-house team members and named subcontractors) will be conducted with as many of the team that are technically qualified (per Section 4) and available. In-house IISE staff will conduct the training.
6. **Present – October 1, 1999** - The IISE Team should complete the IERs for 500 - 600 facilities within the next several months; as the IERs are conducted, a specific schedule for completing the P2/CP assessments will be established. Facilities that are selected for IERs should be those that: (1) are amongst the industries that are likely to have the most serious waste management issues, (2) can be addressed through the EMS and P2/CP assessment process, and (3) are highly receptive to participation. The list of USEPA priority sectors (Section 3) can serve as guidance in this regard.
7. **August 6 – October 1, 1999** – The R2M2 model will be field-tested in the Philippines using representative industrial facilities as test cases. Modifications to the model, including development of appropriate "tweaking factors" will be accomplished in this period. MSE will take the lead in this process and will seek guidance from EPA and others. By the end of this period, the R2M2 will be fully integrated into the P2/CP plant assessment protocol which will also be spear-headed by MSE.
8. **October 4 – October 16, 1999** - Training in P2/CP for the IISE Team (in-house team members and named subcontractors) will be conducted with as many of the team that are technically qualified (per Section 4) and available. The in-field portion of the training will be set up at a Cebu industrial facility that is willing to be a demonstration facility. MSE and IISE in-house IISE staff will conduct the training. The training will

include comprehensive instruction on R2M2.

9. **November 1, 1999 - December, 2000** - P2/CP assessments will be scheduled and conducted at facilities in the eight sites. A minimum of 400 facilities will participate in the assessment. Individuals from the named subcontractor teams and MSE have sufficient experience coverage for most of the key industries in the Philippines. The staffing of the P2/CP assessment teams would consist typically of two IISE Team members each. Generally, one of both of the team members will have a strong familiarity with the types of processes at the facility being assessed, or the team will have ready access to qualified personnel with appropriate process experience. The assessments will fully utilize R2M2.
10. **January 2000 - June 2001** - P2/CP follow-up assessments are needed to document the results of P2/CP implementation and resultant risk reduction. Follow-up assessments will be scheduled dependent on the individual facility's implementation schedule. The time elapse from initial P2/CP assessment to the follow-up assessment will likely vary from 2 - 3 months to more than a year. A minimum of 400 facilities will participate in the assessment. The staffing of the P2/CP follow-up assessment teams will consist of the initial P2/CP assessment personnel, ideally with Team members reviewing the facilities that they had a role in with the initial assessments.

SECTION 6

REFERENCES

A list of references have been compiled that may assist the P2/CP assessment teams in performing facility investigations and developing recommendations. These references follow and copies of their cover pages are included in Appendix E.

General Guides

USEPA, July 1988. *Waste Minimization Opportunity Assessment Manual.*

USEPA, January 1991. *Pollution Prevention Strategy.*

USEPA, May 1992. *Facility Pollution Prevention Guide.*

USEPA, 1993. *Creative Approaches to Pollution Prevention.*

USEPA, August 1994. *International (Non-U.S.) Industrial Pollution Prevention: A Case Study Compendium.*

USEPA, September 1994. *Pollution Prevention Directory.*

USEPA, December 1996. *Cleaner Technologies Substitutes Assessment: A Methodology & Resource Guide.*

USEPA, March 1997. *Identification of Pollution Prevention (P2) Technologies for Possible Inclusion in Enforcement Agreements Using Supplemental Environmental Projects (SEPs) and Injunctive Relief, Final Report.*

USEPA, July 1998. *Design for the Environment,* "Using Design for the Environment Concepts in Your EMS".

Chemical and Pharmaceutical Industry

USEPA, June 1998. *Final Pollution Prevention (P2) Guidance Manual for the Pesticide Formulating, Packaging, and Repackaging Industry: Implementing the P2 Alternative.*

USEPA, October 1991. *Guides to Pollution Prevention: The Pesticide Formulating Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Pharmaceutical Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Non-Agricultural Pesticide Users.*

Primary Metals / Metals Finishing

Illinois Waste Management and Research Center (Department of Natural Resources), April 1998. *Pollution Prevention in the Primary Metals Industry: A Manual for Pollution Prevention Technical Assistance Providers.*

Oregon Hazardous Waste Reduction Program (Department of Environmental Quality), July 1989. *Guidelines for Waste Reduction and Recycling: Metal Finishing, Electroplating, Printed Circuit Board Manufacturing.*

Rimer, A.E., Reinders, L.A. (Blasland, Bouck & Lee for USEPA, AIPP, and AISI), October 1992. *A Practical Guide to Pollution Prevention Planning for the Iron and Steel Industry.*

USEPA, July 1990. *Guides to Pollution Prevention: The Fabricated Metal Products Industry.*

USEPA, October 1992. *Guides to Pollution Prevention: The Metal Finishing Industry*

USEPA, July 1995. *Environmental Research Brief: Pollution Prevention Assessment for a Manufacturer of Electroplated Truck Bumpers.*

USEPA, February 1997. *Pollution Prevention for the Metal Finishing Industry: A Manual for Pollution Prevention Technical Assistance Providers.*

Pulp and Paper Industry

USEPA, June 1993. *Handbook on Pollution Prevention Opportunities for Bleached Kraft Pulp and Paper Mills.*

USEPA, August 1993. *Pollution Prevention Technologies for the Bleached Kraft Segment of the U.S. Pulp and Paper Industry.*

Other Industries

USEPA, June 1990. *Guides to Pollution Prevention: Selected Hospital Waste Streams.*

USEPA, June 1990. *Guides to Pollution Prevention: The Paint Manufacturing Industry*

USEPA, June 1990. *Guides to Pollution Prevention: The Printed Circuit Board Manufacturing Industry.*

USEPA, August 1990. *Guides to Pollution Prevention: The Commercial Printing Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Automotive Refinishing Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Marine Maintenance and Repair Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Fiberglass-Reinforced Plastic and Composite Plastics Industry.*

USEPA, October 1991. *Guides to Pollution Prevention: The Photoprocessing Industry.*

USEPA, July 1995. *Pollution Prevention at an Aging Manufacturing Facility.*

USEPA, August 1995. *Pollution Prevention Assessment for a Manufacturer of Bourbon Whiskey.*

APPENDIX A

COMPLETED P2/CP TEAM BENCHMARKING FORMS

CP/P2 Team Member Experience Form

Name: _____ Title: _____

Company: _____ Years of Relevant Experience: _____

Location: _____

College Degree: __ BS __ MS __ Ph.D. __ Other School: _____

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	__ Chemicals	__ Petrochemicals
__ Electronics	__ Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: _____

Summary of Past Relevant Experience: _____

Areas of Training Needed for Assignment: _____

Completed by: _____ *Date:* _____

ExpForm.doc

CP/P2 Team Member Experience Form

Name: Dioni Araza Title: Clean Prod. Spec.

Company: Chemonics Int'l Inc Years of Relevant Experience: 10+

Location: Cebu, Philippines

College Degree: __ BS X MS __ Ph.D. __ Other School: _____

Experience with Sector (Score 1-4):

3/4 Mining & Metal Refining	2 Chemicals	2 Petrochemicals
3/4 Electronics	3/4 Electroplating	3 Food Processing
4 Iron & Steel	4 Hospitals	4 Coastal Resorts
2 Steam & Power Plants	3 Pulp & Paper	4 Timber Milling & Treatment
3 Cement Manufacturing	3 Piggeries & Slaughterhouses	4 Ports & Harbors
4 Ship Building	2 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Conducted P2/CP audit and assessments for tannery, cement, sugar milling, coconut oil processing, pulp & paper, piggery, slaughterhouse, electroplating, metal canning, carrageenan milling, electronics and semi-con.

Summary of Past Relevant Experience: Training in environmental risk assessment, toxicity assessment, fate & transport of pollutants, health and safety in a mfg company. In-charge of EHS in a printed circuit board manufacturing company in California USA

Areas of Training Needed for Assignment:

Post-it® Fax Note 7671	Date 5/11/99	# of pages ▶ 1
To Dale Rice	From Dioni Araza	
Co./Dept. MSE	Co. IISE - Cebu	
Phone #	Phone #	
Fax # (001) 703 734 1093	Fax # (0063 32) 3408829	

Completed by: Dioni Araza *Date:* 5-1-99

CP/P2 Team Member Experience Form

Name: David Nelson Title: Technical Director

Company: Chemonics Years of Relevant Experience: 23

Location: Cebu

College Degree: __ BS ✓ MS __ Ph.D. __ Other School: _____

Experience with Sector (Score 1-4):

✓ Mining & Metal Refining	✓ Chemicals	✓ Petrochemicals
✓ Electronics	✓ Electroplating	✓ Food Processing
✓ Iron & Steel	✓ Hospitals	__ Coastal Resorts
✓ Steam & Power Plants	✓ Pulp & Paper	✓ Timber Milling & Treatment
✓ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
✓ Ship Building	✓ Ship Breaking	✓ Other (Specify) - rubber

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: audits (EMS + compliance + P2) in many industries in > 30 countries. Conducted > 800 audits.

Summary of Past Relevant Experience: Wrote a book on the subject & many P2 papers (P2 policy, planning, programmatic)

Areas of Training Needed for Assignment: More training on chem-eng. side of processing. more training needed in food industry

Completed by: David Nelson *Date:* 3/30/09

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ExpForm.doc

CP/P2 TEAM MEMBER EXPERIENCE FORM

Name Robert R. Ajaban **Title**
Company **Yr. Of Relevant Experience** (10)
Location 469-C Quezon Avenue

College Degree: Bachelor of Science in Civil Engineering
Saint Mary's University, 1988
Bachelor of Science in Sanitary Engineering
National University, 1993

Experience with Sector		(Score 1-4)			
1	Mining & Metal Refining	3	Chemicals	2	Petrochemicals
2	Electronics	2	Electroplating	4	Food Processing
1	Iron & Steel	2	Hospitals	2	Coastal Resorts
3	Steam & Power Plants	1	Pulp & Paper	1	Timber Milling & Treatment
1	Cement Manufacturing	4	Piggeries & Slaughterhouses	1	Ports & Harbors
1	Ship Building	1	Ship Breaking		Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Undertook the National Power Corporation Waste Assessment of various power plants and facilities such as:

- Hydroelectric Power Plant
- Geothermal Power Plant
- Thermal Power Plant
- Coal Fired Thermal Power Plant
- Diesel Power Plant
- Laboratory – EMD Analytical laboratory

Summary of Past Relevant Experience:

Involved in the design of various wastewater treatment plants design for the following industries, among others:

- Rublou Meat Products
- San Juan Slaughterhouse
- Candyman, Inc.
- Yakult Phils. Inc.
- Butterkrust/La Perla Inc.
- Chowking Foods, Inc.
- Colgate-Palmolive Inc.

- Colgate Palmolive Inc. -Oleo-Chemical Plant
- Valencia Hills Condominium
- Landco-PDCP Office Condomium
- La Salle Hospital
- Zilog, Phils. Inc.

Involved in the following feasibility studies:

- FS of Common Treatment Facility Project
- Environmental Baseline Survey of SBMA
- NPC Waste Assessment Project

Areas of Training Needed for Assignment:

- Needs enhancement training in ISO 14000 and EMS implementations

COMPLETED BY:
DATE: March 30, 1999

CP/P2 Team Member Experience Form

Name: Francisco A. Arellano Title: _____

Company: _____ Years of Relevant Experience: _____

Location: _____

College Degree: ✓ BS ✓ MS __ Ph.D. __ Other School: UP / AIT

Experience with Sector (Score 1-4):

3/4 Mining & Metal Refining	3/4 Chemicals	4 Petrochemicals
4 Electronics	3/4 ✓ Electroplating	3/4 ✓ Food Processing
4 Iron & Steel	4 Hospitals	3/4 ✓ Coastal Resorts
3 Steam & Power Plants	3 Pulp & Paper	2 Timber Milling & Treatment
2 ✓ Cement Manufacturing	3/4 ✓ Piggeries & Slaughterhouses	2 Ports & Harbors
Ship Building	1 Ship Breaking	__ Other (Specify) Textile Carageenan

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: • experience both as lead and associate auditor
• regular trainor for auditors
• EARA registered auditor
• design of treatment (management of waste facilities)

Summary of Past Relevant Experience: • PMA consultant for IEMP project
- design of training program, trainor and conduct of actual audit

Areas of Training Needed for Assignment: _____

CP/P2 Team Member Experience Form

Name: F. C. Ballesteros, Jr. Title: Asst. Prof.

Company: U. Phil. Diliman Years of Relevant Experience: 10

Location: Quezon City

College Degree: __ BS __ MS ✓ Ph.D. __ Other School: ____

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	4 Chemicals	4 Petrochemicals
4 Electronics	4 Electroplating	4 Food Processing
4 Iron & Steel	3 Hospitals	3 Coastal Resorts
3 Steam & Power Plants	4 Pulp & Paper	3 Timber Milling & Treatment
3 Cement Manufacturing	3 Piggeries & Slaughterhouses	2 Ports & Harbors
2 Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: PMA for JEMP/PRC/EMI

Summary of Past Relevant Experience: Rehab of failed Activated Sludge TP and prelim. design of Stabilization Basins, Design of Anaerobic Treatment Ponds and Conventional Activated Sludge Plant, Prelim. Site assessment for Solid Waste Disposal System.
Member – EIA Review Committee EMB - DENR

Areas of Training Needed for Assignment: ____

Date: 26 Mar. 99

ANNIE S. NAVARRO
SCHEMA KONSULT, INC
FAX: 634-1652

CP/P2 Team Member Experience Form

Name: ISRAEL BENTILLO Title: ASSOC PROF

Company: UNIV. OF THE PHILIPPINES Years of Relevant Experience: 16 YRS

Location: DILIMAN, QC

College Degree: ✓ BS (CIVIL ENG) ✓ MS (METEOROLOGY) ✓ Ph.D. (METEOROLOGY) ✓ Other (Dipl. in Hydrology) School: IHE (DELFT)

Experience with Sector (Score 1-4):

3 Mining & Metal Refining	2 Chemicals	3 Petrochemicals
2 Electronics	2 Electroplating	2 Food Processing
3 Iron & Steel	1 Hospitals	3 Coastal Resorts
3 Steam & Power Plants	3 Pulp & Paper	2 Timber Milling & Treatment
3, 4 Cement Manufacturing	2 Piggeries & Slaughterhouses	3 Ports & Harbors
2 Ship Building	1 Ship Breaking	___ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: CONDUCTED ACTUAL AIR QUALITY AND WATER QUALITY MONITORING OF VARIOUS INDUSTRIES/FACILITIES AND WAS INVOLVED IN TEMP PROJECT AS LECTURER IN ENVIRONMENTAL AUDIT. I WAS ALSO INVOLVED IN THE DRAFTING OF THE DENR AIR QUALITY MONITORING MANUAL.

Summary of Past Relevant Experience: PARTICIPATED AS CONSULTANT IN THREE COASTAL RESOURCE ECOLOGICAL ASSESSMENT PROJECTS OF BFAR, THREE COASTAL RESORTS EIAS, FOUR ENVIRONMENTAL MGT. PROJECTS, SIX PORT/RECLAMATION PROJECTS, FOUR MARINE WASTE DISPOSAL PROJECTS, 42 POWER PLANT EIAS, 22 CEMENT PLANT EIAS, 9 INDUSTRIAL ESTATE EIAS, 7 OIL EXPLORATION (OFFSHORE) EIAS, 9 INDUSTRIAL ESTATE EIAS AND OTHER EIA PROJECTS.

Areas of Training Needed for Assignment:

NONE

CP/P2 Team Member Experience Form

Name: Alex B. Casilla Title: Lecturer/Research Associate

Company: UP Environmental Engineering Graduate Program Years of Relevant Experience: 3

Location: Diliman, Quezon City

College Degree: x BS (on-going MS) __ Ph.D. __ Other School: UP Diliman (BS/MS)

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	3 Chemicals	2 Petrochemicals
2 Electronics	3 Electroplating	3 Food Processing
2 Iron & Steel	2 Hospitals	3 Coastal Resorts
2 Steam & Power Plants	2 Pulp & Paper	1 Timber Milling & Treatment
2 Cement Manufacturing	4 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Technical Consultant for the Industrial EcoWatch Project of the DENR. Involved in the development of rating methodology, computerized database and system. Conducted inspections/assessment of wastewater treatment facilities of companies included in the project.

Summary of Past Relevant Experience: Environmental Management Study for Roxas City and Calatagan, Batangas; Air Quality Assessment for Hermosa Economic Zone in Bataan; Environmental Assessment for PAL In-flight Center and PAL Technical Center; Environmental Assessment for RAMTOOL, a tool and dye company; Environmental Assessment for Braveheart Industries, a glass frosting company.

Areas of Training Needed for Assignment: Framework of ISO 14000 and Environmental Management Systems and Implementing Guidelines

Completed by: Alex B. Casilla *Date:* Apr 7, 1999

Attention: Ms. Victoria Adecer
Fax No.634-1652

CP/P2 Team Member Experience Form

Name: Helen B. Cruda

Title: ~~Sr. Environment Analyst~~

Company: [illegible]

Years of Relevant Experience: ~~more than 5~~ years

Location:

College Degree: __ BS / __ MS __ Ph.D. __ Other School: ~~Asian Institute of~~ Tech. Bangkok

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	3 Chemicals	__ Petrochemicals
__ Electronics	3 Electroplating	3 Food Processing
__ Iron & Steel	__ Hospitals	3 Coastal Resorts
__ Steam & Power Plants	4 Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	3 Piggeries & Slaughterhouses	3 Ports & Harbors
__ Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: I was involved in the Industrial Environmental Management Project also subcontracted by SCHEMA.

Summary of Past Relevant Experience: I have prepared several environmental assessment reports in various sectors. My current work also involves environmental review of projects in different sectors. In addition, I am working on a regional project titled the Promotion of Pollution Prevention Policies and Practices in Selected Countries in the Asia and Pacific Region.

Areas of Training Needed for Assignment: Formal training on environmental auditing and life cycle assessment.

Completed by: Helen B. Cruda *Date:* 25 March 1999

CP/I Team Member Experience Form

Name : ALVIN B. CULABA
Company: DE LA SALLE UNIVERSITY-MANILA
Location : 2401 Taft Avenue, Manila, Philippines
Degree : __ BS __ MS X Ph.D.

Title: DR.
Years of Relevant Experience: 10
School: University of Portsmouth, UK

Experience with Sector (Score 1-4):

2 Mining & Metal Refining	1 Chemicals	1 Petrochemicals
1 Electronics	1 Electroplating	3 Food Processing
4 Iron & Steel	1 Hospitals	1 Coastal Resorts
3 Steam & Power Plants	4 Pulp & Paper	1 Timber Milling & Treatment
4 Cement Manufacturing	1 Ports	1 Piggeries & Slaughterhouses
1 Ship Building	1 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Experience
4 = Working Knowledge of Process

Description of Past Auditing Experience: N/A.

Summary of Past Relevant Experience : I have over ten (10) years of energy and environmental work experience. My employment with Philippine National Oil Company (PNOC) gave me an opportunity to design energy systems for various manufacturing companies in the Philippines such as. Procter and Gamble (P&), Republic Flour Mills (RFM), San Miguel Corporation, NFA Rice Mills, National Steel Corporation, and others. With four (4) years of research and teaching stint at the University of Portsmouth, England, I have been involved in environmental audit studies of companies in the U.K. such as Johnson and Johnson, F Europe, and Jaguar. I have published and presented over twenty (20) papers related to environment in various international and local conferences. My two-year consultancy post as Corporate Environment Officer and Advisor of PHINMA Group has exposed me to different manufacturing operations including the six (6) cement plants (Hi, Davao Union, Rizal, Solid, Bacnotan in La Union and in Bulacan), a pulp and paper plant, and two (6) steel plants. Various environmental studies were done in these companies including setting up of environmental management systems (EMS), environmental protection and enhancement program as well as monitoring and control systems. Technical solutions to the many environment-related problems such as air and water pollution, coastal management, and solid waste management were addressed. Currently I am a member of the Environmental Impact Assessment (EIA) Review Committee of the Environmental Management Bureau (EMB), DENR, review member of the Philippine Environmental Technology Verification Program of the Department of Science and Technology (DOST), and the Philippine Industrial Emissions Inventory of the Intergovernmental Panel on Climate Change. I have visited many environmental projects in the countries of Europe, Asia and the US.

Areas of Training Needed for Assignment: None.

Completed by: ALVIN B. CULABA, Ph.D. Date: 3/30/99

CP/P2 Team Member Experience Form

Name: Maria Lourdes P. Dalida Title: Asst. Prof.

Years of Relevant Experience: 7

Company: UP - Diliman

Location: Quezon City

College Degree: __ BS __ MS ✓ Ph.D. Other School: _____

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	4 Chemicals	4 Petrochemicals
4 Electronics	4 Electroplating	4 Food Processing
4 Iron & Steel	2 Hospitals	2 Coastal Resorts
3 Steam & Power Plants	4 Pulp & Paper	3 Timber Milling & Treatment
4 Cement Manufacturing	3 Piggeries & Slaughterhouses	2 Ports & Harbors
2 Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Pollution Management Appraisal for IEMP/PRC/EMI
Wastewater Sources Audit for Dole Phil., Inc.
(Polomolok, South Cotabato)

Summary of Past Relevant Experience:

Areas of Training Needed for Assignment:

CP/P2 Team Member Experience Form

Name: CEZAR D. DIEZMOS Title: CIVIL / SANITARY ENGR.

Company: Consultant Years of Relevant Experience: 23

Location: Metro Manila

College Degree: ✓ BS ✓ MS __ Ph.D. __ Other School: European course Sanitary Engg. - Delft, The Netherlands

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	__ Chemicals	__ Petrochemicals
__ Electronics	__ Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity (3) = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Had been working with MWSS for 15 years relative to the preparation of feasibility studies of proposed project detailed design of MWSS expansion projects; on the private sector side - works for 4 years on the consulting firms engaged in infrastructure projects. (Pls. see my resume attached).

Summary of Past Relevant Experience: With the past 23 years of experience both in the government side and the private section working in different engineering aspects (Pls see my resume attached).

Areas of Training Needed for Assignment:

Completed by: Cezar D. Diezmos Date: April 6, 1999

IC-VIC

CP/P2 Team Member Experience Form

Name: ANDRELITA J. STO. DOMINGO Title: SENIOR ENVIRONMENTAL ENGINEER

Company: SCHEMA KONSULT INC. Years of Relevant Experience: 16 years

Location: 7F JMT BUILDING, ADB AVE, ORTIGAS, PASIG CITY

College Degree: ✓ BS Ch.E. ✓ MS Env'l Studies __ Ph.D. __ Other School: ____

Experience with Sector (Score 1-4):

1 Mining & Metal Refining	3 Chemicals	3 Petrochemicals
1 Electronics	3 Electroplating	4 Food Processing
1 Iron & Steel	2 Hospitals	4 Coastal Resorts
2 Steam & Power Plants	3 Pulp & Paper	1 Timber Milling & Treatment
2 Cement Manufacturing	4 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	4 Other (Specify) INK MANUF./FEED M.

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Conducted Pollution Management Appraisal (PM) to various companies; Conducted survey and assessment to quantify pollution reduction; involve in the conduct of Environmental Impact Assessment & Initial Environmental examination; performed Rapid Rural System Appraisal

Summary of Past Relevant Experience: Has been a Pollution Control Officer & at the same time a trainer/researcher on wastes recycling/treatment (e.g. for slaughterhouse/piggeries/meat processing plants); an Environmental Consultant in Telecommunication projects; as Consultant/researcher in the importation/processing/impacts of PVC; conducted PMAs under IEMP Project; involved in ADB projects (power plants); assessed lakes, rivers, coastal areas; e.

Areas of Training Needed for Assignment: Clean Production Strategies, ISO 14000

Completed by: ANDRELITA J. STO. DOMINGO Date: 3/24/99

CP/P2 Team Member Experience Form

Name: REYNALDO L. ESGUERRA Title: Chemical Engr.

Company: c/o SCHEMA Konsult Inc. Years of Relevant Experience: 17 yrs.

Location:

College Degree: ✓ BS ✓ MS __ Ph.D. __ Other School:

Experience with Sector (Score 1-4):

3 Mining & Metal Refining	4 Chemicals	3 Petrochemicals
3 Electronics	4 Electroplating	4 Food Processing
2 Iron & Steel	2 Hospitals	3 Coastal Resorts
3 Steam & Power Plants	2 Pulp & Paper	2 Timber Milling & Treatment
4 Cement Manufacturing	4 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	4 Other (Specify) Tannery

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: IEMP - Industrial Environmental Mgt. Project; MEIP - Metropolitan Environmental Improvement Project; USAID-ASEAN Economic Cooperation Project III; IDRC - International Devt Research Center - Electroplating; PCIERD - Phil. Council for Industry and Energy Research & Devt; Mar: Copper Mine Tailings Sludge; Boracay E-Cat; Etc. DOE - PMA of power plants

Summary of Past Relevant Experience: Resource Person - EMS/CP/GP @ Devt Academy of the Phils.; Chemical & Environmental Engineering Instructor @ Pamantasan ng Lungsod ng Maynila (PLM) & Mapua Institute of Technology (MIT); DOST Representative to RA6969 BPS-TCSE - IEMS (Integrated Envtl Mgt. for Sustainable Devt) - DOW - EMS

Areas of Training Needed for Assignment:

Completed by: REYNALDO L. ESGUERRA Date: 4/7/99

CP/P2 Team Member Experience Form

Name: RUEL B. JANOLINO Title: ENVIRONMENTAL CONSULT.

Company: SKI Years of Relevant Experience: FIVE (5)

Location: AIT (M.Eng-Env

College Degree: ✓ BS ✓ MS __ Ph.D. __ Other School: Univ. Mindanao (B.S.C.

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	3 Chemicals	4 Petrochemicals
4 Electronics	4 Electroplating	3 Food Processing
4 Iron & Steel	1 Hospitals	4 Coastal Resorts
4 Steam & Power Plants	4 Pulp & Paper	1 Timber Milling & Treatment
4 Cement Manufacturing	3 Piggeries & Slaughterhouses	4 Ports & Harbors
1 Ship Building	1 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: CONDUCTED POLLUTION MANAGEM. APPRAISALS AND PREPARED POLLUTION PREVENTION REPORTS FOR FACILITIES IN SUGAR PRODUCTION, TUNA CANNING, PIGGERIES, CHEMICAL PRODUCTION, OIL PRODUCTION.

Summary of Past Relevant Experience:

1992 – 1996 : IEMP CAUDITS OF VARIOUS FACILITIES.

1995 : MGIP CAUDITS OF CHEMICAL FACILITIES

1992 - 1996 : CONDUCTED WORKSHOPS ON COMPLIANCE AUDIT AND POLLUTION MGT. APPRAISAL

1990 – PRESENT : PREPARED VARIOUS ENVIL IMPACT ASSES.

Areas of Training Needed for Assignment: NONE

Completed by: RUEL B. JANOLINO Date: 25 MARCH '9

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CP/P2 Team Member Experience Form

Name: OSCAR M. JUSI Title: CONSULTANT

Company: SCHEMA KONSULT, INC. Years of Relevant Experience: more than 5 yea

Location: ORTIGAS CENTER, OASIG CITY

College Degree: __ BS ✓ MS __ Ph.D. __ Other School: AIT

Experience with Sector (Score 1-4):

2 Mining & Metal Refining	3 Chemicals	1 Petrochemicals
1 Electronics	2 Electroplating	4 Food Processing
1 Iron & Steel	1 Hospitals	2 Coastal Resorts
1 Steam & Power Plants	2 Pulp & Paper	2 Timber Milling & Treatment
2 Cement Manufacturing	4 Piggeries & Slaughterhouses	1 Ports & Harbors
3 Ship Building	2 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: 1) Undertaken site visits and collects data relevant in the preparation of pollution management appraisal (PMA) reports; and 2) Prepares PMA reports which are used as basis of volunteer firms for starting and maintaining waste minimization programs.

Summary of Past Relevant Experience: 1) Develops and evaluates water treatment facility needs of provincial water supply systems; and 2) Prepares environmental impact assessments in the water supply sector.

Areas of Training Needed for Assignment: Any training to further enhance my auditing experience in sectors mentioned above

CP/P2 Team Member Experience Form

Name: Jose Marie U. Lim Title: Senior Lecturer/Research Associate

Company: UP Environmental Engineering Graduate Program Years of Relevant Experience: 3

Location: Diliman, Quezon City

College Degree: x BS x MS __ Ph.D. __ Other School: UP Diliman (BS/MS)

Experience with Sector (Score 1-4):

2 Mining & Metal Refining	4 Chemicals	2 Petrochemicals
2 Electronics	3 Electroplating	3 Food Processing
2 Iron & Steel	2 Hospitals	3 Coastal Resorts
2 Steam & Power Plants	2 Pulp & Paper	1 Timber Milling & Treatment
2 Cement Manufacturing	[illegible]	1 Ports & Harbors
1 Ship Building	[illegible]	[illegible] Specify)

Note: 1 = None 2 = Some Famili[illegible] [illegible]ing Knowledge of Process

Description of Past Auditing I[illegible] Conduct of Pollution Management Appraisals of [illegible]nt factory. (pls. refer to attached CV)

Summary of Past Relevant Exp[illegible] Plan for Calatagan, Batangas and Roxas City, Capiz; Air & Noise Quality Assessment for Hermosa Economic Zone in Bataan; Environmental Assessment for PAL In-Flight Center, PAL Technical Center& RAMTOOL (a tool & dye company); Water Sampling and Quality Assessment of Philippine Inland Waters.

Areas of Training Needed for Assignment: ISO 14000 and EMS Implementing Guidelines

Completed by: Jose Marie U. Lim *Date:* Apr 7, 1999

Name: Efren E. Mariano Title:

Company: SCHEMA Years of Relevant Experience:

Location:

College Degree: ✓ BS ✓ MS ✓ completed units PhD Other School:

Experience with Sector (Score 1-4):

2 Mining & Metal Refining	2 Chemicals	2 Petrochemicals
2 Electronics	3 Electroplating	3 Food Processing
2 Iron & Steel	2 Hospitals	3 Coastal Resorts / Expressway
2 Steam & Power Plants	2 Pulp & Paper	1 Timber Milling & Treatment
2 Cement Manufacturing	4 Piggeries & Slaughterhouses	3 Ports & Harbors
1 Ship Building	Ship Breaking	3, 4 ✓ Other (Specify) Expressway / Skyways / Subdivision Development

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Norkis Electroplating Wastes
Avico Farms (Piggery); Envi Assessment Bakery (Gardenia) Prod
Toyota (Wastewater Treatment); Sewage Waste
Envi. Impact Assessment of C-5, Skyway, Coastal Roads, highway
Solid Waste transfer station various subdivision
Davao Coastal Reclamation, M. Bay Reclamation

Summary of Past Relevant Experience: • Environment Specialist for various projects for various Consultants: Schema, Filipinas Drano, TCGS; PRU-CONSULT, [illegible]
• Water Supply & Design Engineer – MWSS & NHA projects
• Project Manager / Team leader / top management posts

Areas of Training Needed for Assignment: Standardization of report format / presentation for the project. Team building / enhancement for project team members.

Completed by: Efren E. Mariano Date: March 31, 1999

CP/P2 Team Member Experience Form

Name: William Matuguina Jr. Title: Mr.

Company: Independent Consultant Years of Relevant Experience: 15

Location: Novaliches, Kalookan City

College Degree: __ BS ✓ MS Ph.D. __ Other School: UP-Diliman

Experience with Sector (Score 1-4):

3 Mining & Metal Refining	4 Chemicals	2 Petrochemicals
3 Electronics	3 Electroplating	3 Food Processing incl. sugar mills/ref
2 Iron & Steel	2 Hospitals	2 Coastal Resorts
4 Steam & Power Plants	3 Pulp & Paper	3 Timber Milling & Treatment
3 Cement Manufacturing	3 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	3 Other (Specify) Coconut Milling/Refin; 3 Hotels/Restaurants

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Conducted various env'l. audits singly (or as a team) for a number of industries, including hotels and restaurants through the following projects/programs: (1) Metro. Env. Imp. Proj. (MEIP) (2) Asean-EIP (3) US-AID IEMP (4) Cleaner Production through the HCO (5) Waste Reduction @ TAF-USAID (6) Australian AID MSIP

Summary of Past Relevant Experience: (1) Hands on practical exp. in chemicals manufacturing and power/steam generation industries. (2) Certifying reference (3) training and lectures (4) cleaner production/waste reduction assessments (5) waste treatment (6) env'l. impact assessments/risk assessments

Areas of Training Needed for Assignment: ISO Methodologies/guidelines

Completed by: William Matuguina Jr Date: April 5, 1999

CP/P2 TEAM MEMBER EXPERIENCE FORM

Name	Andrew T. Montalbo	**Title**	
Company		**Yr. Of Relevant Experience**	10
Location	14 Sorsogon St., West Triangle, Quezon City		

College Degree: M. of Engineering (Environmental), Asian Institute of Technology, Bangkok, Thailand (1989)
B. of Science in Chemical Engineering, Cebu Institute of Technology, Cebu City (1985)

Experience with Sector		(Score 1-4)			
2	Mining & Metal Refining	4	Chemicals	2	Petrochemicals
3	Electronics	2	Electroplating	4	Food Processing
2	Iron & Steel	4	Hospitals	4	Coastal Resorts
1	Steam & Power Plants	2	Pulp & Paper	2	Timber Milling & Treatment
3	Cement Manufacturing	4	Piggeries & Slaughterhouses	3	Ports & Harbors
1	Ship Building	1	Ship Breaking		Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Undertook the environmental audit/assessment of the following companies, among others:

- Sirawan Food Corporation under IEMP
- Dyzum Distillery Industries, Inc. under IEMP
- San Juan Slaughterhouse under CTF project
- Chowking Food Corporation
- Zilog Electronic Philippines, Inc.
- Foremost Farm, Inc.
- Amkor Anam (Electronics)
- Limay Slag Grinding Plant, Limay, Bataan
- Limay Pier, Limay, Bataan

Summary of Past Relevant Experience:

Undertook wastewater treatment plant design for the the following industries, among others:

- Rublou Meat Products
- MMG Hospital
- La Salle Dasmariñas Hospital
- Petrochemical Industrial Park, Limay, Bataan
- Cebu Light Industry and Science Park, Lapu Lapu City

- Filinvest Corporate City
- FEU NRMF Medical Hospital
- Kimberly Clark Manufacturing Co.
- Plastic City Industrial Estates
- Metro Regional Iligan Agro Industrial Center, Iligan City

Undertook (acted as Team Leader or Member) the following feasibility studies.

- FS of Metro Cebu Sewerage and Sanitation Project
- FS of Common Treatment Facility Project

Undertook solid waste management plan for the following projects:

- Petrochemical Industrial Park
- Tagaytay Highland

Areas of Training Needed for Assignment:

- Needs enhancement training in ISO 14000 and EMS implementations.

COMPLETED BY: Andrew J Montalla
DATE: March 30, 1999

CP/P2 Team Member Experience Form

Name: Ma. Carina M. Raval Title: Sr. Human Resources Mng. Retail Office

Company: Universal Robina Group of Cos. Years of Relevant Experience: 6 yrs. (Training + Retail experience)

Location: Libis, Quezon City

College Degree: ✓ BS ___ MS ___ Ph.D. ___ Other School: Ateneo Univ. College of Arts and Science

Experience with Sector (Score 1-4):

1 Mining & Metal Refining	1 Chemicals	1 Petrochemicals
1 Electronics	1 Electroplating	4 Food Processing
1 Iron & Steel	1 Hospitals	1 Coastal Resorts
1 Steam & Power Plants	1 Pulp & Paper	1 Timber Milling & Treatment
1 Cement Manufacturing	1 Piggeries & Slaughterhouses	1 Ports & Harbors
1 Ship Building	1 Ship Breaking	4 Other (Specify) Retail

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: With experience in auditing/evaluating the effectiveness and relevance of training methodologies/process and and worked closely with local and foreign consultants to ensure quality of program implementation.

Summary of Past Relevant Experience: I was a member of the Capacity Building component of IEMP and worked with local and foreign consultants in the coordination and implementation of various training programs of the project. I also developed and managed the implementation of training programs for a cake and food plant.

Areas of Training Needed for Assignment: Some exposure to the sector. I would have enough knowledge of the process/technicalities needed to provide/deliver quality training activities.

Completed by: Ma. Carina Mendoza-Raval Date: March 29, 1999

CP/P2 Team Member Experience Form

Name: Cynthia C. Roxas Title: Human Resource Development Manager

Company: Universal Robina Group of Cos. Years of Relevant Experience: 14 years (training program experience)

Location: Libis, Q.C.

College Degree: ✓ BS ✓ MS: __ Ph.D. __ Other School: University of Santo Tomas, University of the Philippines

Experience with Sector (Score 1-4):

1 Mining & Metal Refining	1 Chemicals	1 Petrochemicals
1 Electronics	1 Electroplating	2 Food Processing
1 Iron & Steel	1 Hospitals	1 Coastal Resources
1 Steam & Power Plants	1 Pulp & Paper	1 Timber Milling & Treatment
1 Cement Manufacturing	1 Piggeries & Slaughterhouses	1 Ports & Harbors
1 Ship Building	1 Ship Breaking	4 Other (Specify: media & communications, retail sector, beer, dairy & livestock) (Sector: C)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: My experience in auditing was in the area of auditing relevance of training programs, training processes/methods used and assuring quality of training program implementation while working with technical experts along these lines.

Summary of Past Relevant Experience: I managed the IEMP capability building component and worked with expatriate and local experts in this regard. In my previous jobs, I also managed training endeavors with technical experts in the areas of livestock, dairy product and beer manufacturing.

Areas of Training Needed for Assignment: In the array of training program development & implementation, I think I can comfortably work with experts on these. However, some exposure & familiarity with the sector and contents will be needed for me to be able to deliver quality training activities.

Completed by: Cynthia Cruz Roxas Date March 29, 1999

CP/P2 Team Member Experience Form

Name: Carlito M. Rufo Jr. Title: Environmental Engineer

Years of Relevant Experience: 1 year

Company: _____ 6 yrs. ISO Exp.
Environmental Engr. - 6 years
UP Los Baños

Location: _____

College Degree: X BS X MS __ Ph.D. __ Other School: UP Diliman

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	__ Chemicals	__ Petrochemicals
__ Electronics	3 Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	3 Coastal Resorts
3 Steam & Power Plants	2 Pulp & Paper	__ Timber Milling & Treatment
4 Cement Manufacturing	3 Piggeries & Slaughterhouses	__ Ports & Harbors
2 Ship Building	__ Ship Breaking	3 Other (Specify): Development Bank

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: • Prepared Environmental Assessment (Corporate Environmental Report) of DBP • currently assisting DBP for ISO 14000 accreditation • trained PHILCEMCOR and PULPAPEL ON ISO 14000

Summary of Past Relevant Experience: 6 EIA
• policy studies
• air dispersion modeling
• trainings/ workshops

Areas of Training Needed for Assignment: • auditor accreditation

Completed by: Carlito M. Rufo Jr. Date: 26 March 1999

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CP/P2 Team Member Experience Form

Name: Loreta S. Rufo Title: Resource Economist

Company: Years of Relevant Experience: 1994 - Present

Location: Manila

College Degree: ✓ BS ✓ MS ✓ Ph.D. candidate Other School UP Los Banos UP Diliman

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	__ Chemicals	__ Petrochemicals
__ Electronics	__ Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	x Other (Specify) Resource Valuatio

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Summary of Past Relevant Experience: • Resource Accounting, economic analysis, community-based resource mgmt

Areas of Training Needed for Assignment:

Signature: Loreta Rufo Date: April 8, 1999

CP/P2 Team Member Experience Form

Name: DAISY J. SERRANO Title: Environmental Specialist

Company: Schima Konsult Inc. Years of Relevant Experience: 8 years

Location: Metro Manila

College Degree: ✓ BS ✓ MS __ Ph.D. __ Other School: MS Chem - Ateneo University
BS Chem - U.P.

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	3 Chemicals	4 Petrochemicals
4 Electronics	4 Electroplating	3 Food Processing
3 Iron & Steel	4 Hospitals	2 Coastal Resorts
3 Steam & Power Plants	4 Pulp & Paper	2 Timber Milling & Treatment
3 Cement Manufacturing	3 Piggeries & Slaughterhouses	2 Ports & Harbors
2 Ship Building	2 Ship Breaking	3 ~~Other (Specify)~~ Vegetable (Coconut oil) processing/refining

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

3 Golf resorts 3 Industrial estates 3 Textile 3 Sugar

Description of Past Auditing Experience: Conducted EIA of industry sectors: air and water quality; waste minimization; assessment of efficiency of pollution control devices. Conducted compliance audit for steam & power plants. Prepared environmental management plans for textile & fish canning industry sectors. Conducted environmental due diligence for sugar mill.

Summary of Past Relevant Experience: Prepared manuals for solid waste management, environmental performance monitoring and due diligence. Conducted EIA of chemicals, piggeries. Conducted compliance audits. Member of EMB's EIA Review Committee.

Areas of Training Needed for Assignment: ISO 14000. Training for mining & metal refining, electronics, ship building, cement, ship breaking, electroplating, food processing, coastal resorts, timber milling, petrochemicals

CP/P2 Team Member Experience Form

Name: NAZARIO, ULYSSES Title: Principal

Company: SCHEMA Konsult Inc. Years of Relevant Experience: 1

Location: MANILA, PHILIPPINES

College Degree: ✓ BS Chem. Eng. ___ MS ___ Ph.D. ___ Other School: Adamson University / Ortanez University

Civil. Eng.

Experience with Sector (Score 1-4):

___ Mining & Metal Refining	___ Chemicals	___ Petrochemicals
___ Electronics	___ Electroplating	3 Food Processing
___ Iron & Steel	___ Hospitals	___ Coastal Resorts
2 Steam & Power Plants	___ Pulp & Paper	___ Timber Milling & Treatment
___ Cement Manufacturing	___ Piggeries & Slaughterhouses	___ Ports & Harbors
___ Ship Building	___ Ship Breaking	3/4 Other (Specify) 3 - Wood Proc 3 - Alcohol Dis 4 - Brewery

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Summary of Past Relevant Experience: - Conduct pollution management appraisals to identify opportunities for reducing pollution where minimization, reuse and recycling are main components. - Conduct training on data collection, sampl and analyses.
- Supervise beer brewing operations.

Areas of Training Needed for Assignment:

Completed by: [signature] Date: 30 Mar 99

CP/P2 Team Member Experience Form

Name: Ma. Margarita S. Uy Title: Training Consultant

Company: _____ Years of Relevant Experience: 16 yrs

Location: _____

College Degree: ✓ BS __ MS __ Ph.D. __ Other School: _____

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	__ Chemicals	__ Petrochemicals
__ Electronics	__ Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	4 Other (Specify) NGO's involved environmental profe

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: - None -

Summary of Past Relevant Experience: (Please see attached sheet)

Areas of Training Needed for Assignment: Orientation about the project, extent, coverage, Chemonics - its mission, vision, people managing the project, expectations from consultants

Ma. Margarita S. Uy
Relevant Past Experience

Worked with the U.S.A.I.D Project on Industrial Environmental Management Project as Training Officer (Senior Research Assistant) of the Capability Building Component.

Responsibilities included providing training process expertise in the conduct of the training programs that will be conducted for the primary client – the Department of Environment and Natural Resources. Was responsible for conducting trainers' meetings of expatriate and local consultants. Provided inputs on the most appropriate transfer of learning and materials, to Philippine counterparts, composed of participants from the government sectors, industries, academe and non-government organizations.

Training programs that have been conducted and manuals prepared were: Environmental Impact Assessment, Pollution Management Appraisal, Environmental Audit, Data Collection, Sampling and Sample Analysis.

Was representative of PRC-Environmental Management Inc.for the Climate Change Exhibit initiated by the Office of Sen. Heherson Alvarez and meetings with non-government organizations.

Served on the Board of Trustees, as Secretary, at the Institute for the Development of Educational and Ecological Alternatives, Inc. It is a Swiss-funded non-government organization whose main mission is ecological protection through the promotion of sustainable agriculture and ecological waste management.

Recipients are the communities of tribal Mangyans of Mindoro, upland settlers of Mindoro, farmers of Southern Palawan, farmers and urban poor in Cavite.

Before end of contract with PRC-EMI, assisted the Coastal Resources Management Program in the conduct of initial workshop for its potential trainers, community organizers, and prospective clients.

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CP/P2 Team Member Experience Form

Name: DALE A RICE Title: POLLUTION PREVENTION ENGINEER

Company: MILLENNIUM SCIENCE & ENG. Years of Relevant Experience: 20+

Location: MCLEAN, VA USA

College Degree: X BS X MS __ Ph.D. __ Other School: SYRACUSE
Chem. Env. Eng.

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	(2) X Chemicals	__ Petrochemicals
(2) X Electronics	(4) X Electroplating	(2) X Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	X Other (Specify) (4) Painting (4) Vehicle Maintenance (4) Fuel operations (4) Anodizing

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Comprehensive P2 opportunity assessments at numerous military facilities that have surfacefinishing, fueling, vehicle maintenance, depainting, etc. Extensive assessment work at surface finishing operations (plating, anodizing, painting, chromating, etc.)

Summary of Past Relevant Experience: Extensive experience in heavy metal recovery techniques, dewatering, chemical treatment, etc. in large electroplating facility. Managed multiple teams conducting P2 assessments. Published several papers on the subject of P2.

Areas of Training Needed for Assignment: Not familiar with several of the industries that may be audited.

Completed by: D. A. Rice Date: 4-23-99

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CP/P2 Team Member Experience Form

Name: M. Oppelt Title: Project Manager

Company: Millenium Science + Engineering Years of Relevant Experience: 6

Location: McLean Virginia

College Degree: __ BS ✓ MS __ Ph.D. __ Other School: University of Texas

Experience with Sector (Score 1-4):

__ Mining & Metal Refining	4 Chemicals	4 Petrochemicals
__ Electronics	__ Electroplating	__ Food Processing
__ Iron & Steel	__ Hospitals	__ Coastal Resorts
__ Steam & Power Plants	__ Pulp & Paper	__ Timber Milling & Treatment
__ Cement Manufacturing	__ Piggeries & Slaughterhouses	__ Ports & Harbors
__ Ship Building	__ Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Complete evaluation of all processes at US Army installation (Fort Bliss, El Paso, Texas). Implemented process evaluations of maintenance programs, recycling programs, waste storage and reuse, and a solid waste management plan.

Summary of Past Relevant Experience: Process evaluations of all systems at military installation; solid waste management plan.

Areas of Training Needed for Assignment:

Completed by: Michael Oppelt *Date:* 4/23/99

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CP/P2 Team Member Experience Form

Name: Michael W. Sowell Title: Senior Project Engineer

Company: MSE, Inc. Years of Relevant Experience: 17

Location: Greenville

College Degree: x BS x MS __ Ph.D. __ Other School: Ga. Tech / Clemson

Experience with Sector (Score 1-4):

4 Mining & Metal Refining	4 Chemicals	4 Petrochemicals
2 Electronics	4 Electroplating	4 Food Processing
4 Iron & Steel	2 Hospitals	2 Coastal Resorts
4 Steam & Power Plants	3 Pulp & Paper	1 Timber Milling & Treatment
1 Cement Manufacturing	4 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience: Performed environmental audit for C, E. Minerals as they considered purchasing U.S. Silica. The audit covered mines and silica processing plants in Tennessee, Georgia, South Carolina, Virginia, and Alabama.

Summary of Past Relevant Experience: Extensive process experience in the electroplating, petrochemical, chemical food processing industries. Focus has been in the areas of wastewater treatment, water reuse, and source minimization.

Areas of Training Needed for Assignment: _____

Completed by: _____ *Date:* _____

CP/P2 Team Member Experience Form

Name: Teresa M. Kabins, P.E Title: Senior Project Engineer

Company: MSE, Inc. Years of Relevant Experience: 12

Location: Greenville

College Degree: x BS __ MS __ Ph.D. __ Other School: Univ. of Illinois

Experience with Sector (Score 1-4):

3 Mining & Metal Refining	4 Chemicals	4 Petrochemicals
2 Electronics	4 Electroplating	2 Food Processing
4 Iron & Steel	2 Hospitals	2 Coastal Resorts
4 Steam & Power Plants	3 Pulp & Paper	1 Timber Milling & Treatment
1 Cement Manufacturing	4 Piggeries & Slaughterhouses	2 Ports & Harbors
1 Ship Building	1 Ship Breaking	__ Other (Specify)

Note: 1 = None 2 = Some Familiarity 3 = Environmental Assessment Exp. 4 = Working Knowledge of Process

Description of Past Auditing Experience:

Summary of Past Relevant Experience: Experienced in the areas of process engineering associated with production units and wastewater treatment system. Career includes significant design, start-up and operating experience. skilled in the areas of mechanical equipment, piping, and has working knowledge of electrical, instrumentation , and control systems.

Areas of Training Needed for Assignment:

Completed by: *Date:*

APPENDIX B

INITIAL ENVIRONMENTAL REVIEW FORMS

5/26/99 DRAFT

Industrial Initiatives for a Sustainable Environment (IISE)

INITIAL ENVIRONMENTAL REVIEW (IER) QUESTIONNNAIRE

Note: This questionnaire is confidential and the responses will not be released to any party outside IISE.

Date: _____ IER Team Leader: _____ Site: _____
Time: _____ IER Team Members: _____

Contact Information:

Name: _____
Title: _____
Name of Organization: _____
Address: _____
Telephone No: _____
Fax: _____
Email: _____

General Organisational Information:

Owner: _____
Parent Organisation: _____
❑ MNC ❑ Domestically Owned ❑ JVC JV Partner (s)_____
Year Established: _____
Industry/Government Sector: _____
PSIC: _____
❑ Production Capacity/Output: _____
Products: _____
Countries Products Exported To: _____
_____
Number of Employees: _____ Shifts: _____
Enterprise Size: ❑ Small (<50) ❑ Medium (50-300) ❑ Large (>300)
Facility Process Areas (M^2): _____

G1. Does your organisation have written policies related to quality, occupational health and safety and the environment?

❑ Quality	❑ Environmental	❑ Occupational Health & Safety	

G2. Does your company have an organizational chart? (if so, attach to IER)

❑ Yes	❑ No	❑ Don't Know	❑ Copy attached

G3. Does your organisation have a:

❑ Quality Manager	❑ Environmental Department	❑ PCO ❑ Environmental Officer	❑ Occupational Health and Safety dept.	❑ HSE Manager	❑ Don't know

G4. Is the organization certified to any of the following standards by a recognized third party provider?

❑ ISO 9001/2	❑ ISO 14001	❑ OHSA 18000	❑ SA 8000	❑ Other	❑ Don't know

Quality Management Systems Information

Q1. What methods do you use to ensure product/service quality? (mark those used)

❑ Inspection	❑ Quality control	❑ Quality assurance ISO 9001/2/3	❑ QMS ISO 9004	❑ TQM	❑ Don't know

Q2. Does your quality management system (QMS) apply to:

❑Whole organisation	❑ Production function only	❑ Facilities function	❑ Other	❑ Don't know

Q3. Do you measure and monitor the quality of the products and services you provide to your customers?

❑ Yes	❑ No	❑ Don't know

Q4. Do you maintain records to enable the demonstration of your quality performance?

❑ Yes	❑ No	❑ Don't know

Q5. Do you conduct quality audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't know

Q6. If so, does your organization perform quality audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

Occupational Health and Safety (OSH) Information

O1. Has the organisation identified the OSH hazards associated with its activities, products and services?

❑ Yes	❑ No	❑ Don't know

O2. Has the organisation assessed the risks to human health from physical, chemical and biological hazards and natural phenomena?

❑ Yes	❑ No	❑ Don't know

O3. Has all legislation relevant to your organisation's health and safety risks been identified?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

O4. What methods does the organisation use to control the management of its occupational health and safety risks?

- ❑ Elimination _____
- ❑ Substitution _____
- ❑ Engineering controls _____
- ❑ Administrative controls _____
- ❑ Personal Protective Equipment _____
- ❑ Occupational Health and Safety Management Systems (OHSMS) _____
- ❑ Training _____
- ❑ Others (please describe) _____

_____

O5. Does the organisation have a health monitoring program in place appropriate to the risks to human health?

❑ Yes	❑ No	❑ Don't know

O6. Does your organisation set any objectives and targets related to occupational health and safety performance?

❑ Yes	❑ No	❑ Don't know

O7. Do you monitor and measure your occupational health and safety performance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't Know

O8. Do you maintain records to enable the demonstration of your occupational health and safety performance?

❑ Yes	❑ No	❑ Don't Know

O9. Do you conduct occupational health and safety audits to determine the effectiveness of the controls and programs you have in place?

❑ Yes	❑ No	❑ Don't Know

O10. If so, does your organization perform occupational health and safety audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

Environment Information

E1. Do you know if the products, services and/or activities performed by your organisation have any impact on the environment?

❑ Yes	❑ No	❑ Don't know

E2. Has your company identified any environmental impact from past activities?

❑ Yes	❑ No	❑ Don't know

E3. Have you identified the natural resources (water, electricity, gas etc.,) needed to operate your facility?

❑ Yes	❑ No	❑ Don't Know

E4. What methods do you use to manage these activities, products or services to eliminate/reduce their impact, including resource use, on the environment? (Check all that apply; add comments as appropriate.)

- ❑ Pollution Prevention program
- ❑ Cleaner production technology _____
- ❑ Waste minimization _____
- ❑ Waste treatment _____
- ❑ Waste storage _____
- ❑ Disposal (❑ Off-site ❑ On-site) _____
  - ❑ Incineration
  - ❑ Landfill _____
- ❑ Recycling/Reuse _____
- ❑ Environmental Management Systems (EMS) _____
- ❑ Use no methods _____
- ❑ Others (please describe) _____

E5. Have you identified the legislation relevant to your organisations environmental impacts?

❑ Wholly	❑ Partially	❑ None	❑ Don't know

E6. In what areas, if any, have you experienced environmental compliance challenges?

❑ RA 6969 (HW)	❑ PD 984 (Air / Water)	❑ PD 1586 (ECC)	❑ None	❑ Don't know

E7. Does your organisation set any objectives and targets related to environmental performance?

❑ Yes	❑ Some	❑ None	❑ Don't know

E8. What industrial processes are operated at the facility?

❑ Anodizing	❑ Fermentation	❑ Powder Coating	❑
❑ Assembly	❑ Food Processing	❑ Pressing / Stamping	❑
❑ Bleaching	❑ Forging	❑ Printing	❑
❑ Bottling	❑ Fuel Storage	❑ Pulping	❑
❑ Canning	❑ Galvanizing	❑ Refining	❑
❑ Cement Production	❑ Grinding	❑ Semiconductor Mfg	❑
❑ Chemical Distillation	❑ Injection Molding	❑ Ship Building	❑
❑ Chemical Synthesis	❑ Metal Casting	❑ Ship Recycling	❑

❑ Conversion Coating	❑ Metal Refining	❑ Ship Repair	❑
❑ Cracking	❑ Mining	❑ Smelting	❑
❑ Degreasing	❑ Packaging	❑ Steel Fabrication	❑
❑ Dyeing	❑ Painting	❑ Stripping	❑
❑ Electroplating	❑ Pharmaceutical Synth.	❑ Tanning	❑
❑ Extruding	❑ Photo Processing	❑ Wood Preserving	❑
❑ Farming	❑ Pickling	❑	❑

E9. Which of the Philippines Priority Chemicals are used or manufactured at the site?
(Indicate Annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

❑	1,1,1- Trichloroethane	❑	Chlorinated Ethers	❑	Mirex
❑	1,2 Diphenylhydrazine	❑	Chromium Compounds	❑	PCBs
❑	Arsenic Compounds	❑	Cyanide Compounds	❑	Phosgene
❑	Asbestos	❑	Ethylene Dibromide	❑	Pentachlorophenol
❑	Benzene	❑	Ethylene Oxide	❑	Polybrominated Biphenyls
❑	Beryllium Compounds	❑	Halons	❑	Selenium
❑	Cadmium Compounds	❑	Hexachlorobenzene	❑	Tributyltin
❑	Carbon Tetrachloride	❑	Hexachloroethane	❑	Vinyl Chloride
❑	CFCs	❑	Lead Compounds	❑	
❑	Chloroform	❑	Mercury Compounds	❑	

E10. List other hazardous chemicals used at facility:
(Indicate annual usage as follows: (1) 1 – 10kg; (2) 10 – 100 kg; (3) 100 kg – 1000 kg; (4) > 1000 kg)

E11. How do you track the quantities of hazardous chemicals used at your facility?

❑ Inventory records	❑ Purchase records	❑ Shop floor estimates	❑ Don't track

E12. What are the major hazardous waste generated at the facility?

❑ Plating sludges	❑ Heavy metal residues, sludges
❑ Acid wastes	❑ Organic chemical wastes
❑ Alkali wastes	❑ Other:
❑ Inorganic chemical wastes	❑ Other:
❑ Paints, dyes, latex, resins, inks	❑ Other:
❑ Halogenated waste solvents	❑ Other:
❑ Non-halogenated waste solvents	❑ Other:
❑ Oils (including PCBs, PBBs)	❑ Other:

E13. Do you have emergency management procedures in place?

❑ Yes	❑ No	❑ Don't know

E14. Are these procedures practiced on a regular basis?

❑ Yes	❑ No

E15. Do you use suppliers and/or subcontractors to supply raw materials, products or services (facility maintenance, repairs, wastewater facility management etc.)?

❑ Yes	❑ No	❑ Don't know

E16. Do you monitor and measure your environmental performance, including regulatory compliance?

❑ Wholly	❑ Partially	❑ Not at all	❑ Don't know

E17. Do you maintain records to enable the demonstration of your environmental performance?

❑ Yes	❑ No	❑ Don't know

E18. Do you conduct environmental audits to determine the effectiveness of the controls you have in place?

❑ Yes	❑ No	❑ Don't know

E19. Does your organization perform environmental audits:

❑ In-house	❑ Outside auditors	❑ Both	❑ Not applicable

Walk through inspection

W1. Walk through

Observation	Comments
❑ Product or service quality deficiencies	
❑ General housekeeping problems	
❑ Evidence of chemical releases	
❑ Inadequate or incorrect product or hazardous chemical labelling	
❑ Improper segregation or storage of hazardous material and/or waste	
❑ Leaking valves, lines and containers	
❑ Inadequate or incorrect PPE	
❑ Inadequate machine guarding	
❑ Uncovered chemical / waste containers	
❑ Inadequate or incorrect emergency equipment and/or ineffective management	
❑ Improper lighting / ventilation	
❑ Absence of MSDS information	
❑ Inadequate or ineffective maintenance	
❑ Presence of uncontrolled physical, chemical and biological hazards and natural phenonema	
❑ Other:	

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Project Incentives

I1. Are you aware of the incentives that the project has to offer?

❑ Yes	❑ No

I2. Would the following be of interest to you regarding the EMS component of the IISE project?

❑ Customer requirement	❑ Potential cost savings	❑ Regulatory compliance	❑ Public image	❑ No interest in participating
❑ Corporate requirement	❑ Other			

IISE Resource Allocation Strategy

R1. Is the organization primarily a service provider?

❑ Yes	❑ No

R2. Are the organization's environmental impacts readily identifiable?

❑ Yes	❑ No

R3. Does the organisation already have a quality, environmental or OSHMS in place?

❑ Quality	❑ Environmental	❑ OSH

R4. Is there "supply chain leverage" with this facility? If so, describe: _____

_____

R4. In your opinion, does the organization have the managerial commitment to enter the IISE program?

❑ Yes	❑ No

R5. In your opinion, does the organization have the resources to enter the IISE program?

❑ Yes	❑ No

R6. What is the most appropriate assistance that IISE can provide for this organization?

❑EMS only	❑ P2/CP only	❑EMS/P2/CP	❑QMS first	❑OSHMS

R7. What are the prospects for certification within the timeframe of IISE assistance?

❑ Small	❑ Medium	❑ Great

R8. What are the prospects for <u>measurable</u> pollution reduction that will help IISE document progress to 20% reduction pollution target?

❑ Small	❑ Medium	❑ Great

R9. Recommended strategy/next steps _____

_____

_____

IER Team Leader _____

APPENDIX C

P2/CP ASSESSMENT FORMS

IISE P2/CP ASSESSMENT

Worksheet 1

Facility Name: _____

Location: _____ Sector: _____

Date: _____ Time: _____ Date IER Completed: _____

IER Report Attached? Yes ☐ No ☐

CP/P2 Assessment Team Members:
(Include both IISE and Facility Personnel)

1. _____
2. _____
3. _____
4. _____
5. _____

Facility Contact Information

Name: _____ Phone: _____

Address: _____ Fax: _____

_____ E-mail: _____

_____

Process Overview

Process Name	Description	Wet Process?	RP 28 Chems?
1.		Y ☐ N ☐	Y ☐ N ☐
2.		Y ☐ N ☐	Y ☐ N ☐
3.		Y ☐ N ☐	Y ☐ N ☐

Facility Name: _____

Process Name	Description	Wet Process?	RP 28 Chems?
4.		Y ☐ N ☐	Y ☐ N ☐
5.		Y ☐ N ☐	Y ☐ N ☐
6.		Y ☐ N ☐	Y ☐ N ☐
7.		Y ☐ N ☐	Y ☐ N ☐
8.		Y ☐ N ☐	Y ☐ N ☐
9.		Y ☐ N ☐	Y ☐ N ☐
10.		Y ☐ N ☐	Y ☐ N ☐
11.		Y ☐ N ☐	Y ☐ N ☐

Facility Name: _____

Input Material Information

Product Name	Annual Use (kg)	Chemical Components		RP 28 Chems. Present	Mass %	Annual RP 28 Use (kg)
1.						
2.						
3.						
4.						
5.						
6.						
7.						

IISE P2/CP ASSESSMENT

Facility Name: _____

Product Name	Annual Use (kg)	Chemical Components		RP 28 Chems. Present	Mass %	Annual RP 28 Use (kg)
8.						
9.						
10.						
11.						
12.						
13.						
14.						

Facility Name: _____

Process Wastestream Analysis

Process: _____ Operation: _____ Hrs/day _____ Days/wk

_____ Wks/yr

	Wastestream	Waste Phase	Wastestream Flowrate	Chemical Components	RP 28? Y	RP 28? N	Mass %	RP 28 Flowrate	Fate
1.					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			
2.					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			
3.					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			
					☐	☐			

Facility Name: _____

Initial Process Flow Diagram

Process: _____

IISE P2/CP ASSESSMENT

Worksheet 5

Facility Name: _____

Pollution Prevention Options

Process: _____

Note: List Options Identified During Assessment and Location for Implementation
1.
2.
3.
4.
5.

Facility Name: _____

Final Process Flow Diagram

Process: _____

IISE P2/CP ASSESSMENT

Facility Name: _____

Mass Balance Summary

Process Name: _____

	Input		Outputs							
Chemical Name	RP 28 (kg/yr)	Other HM (kg/yr)	Cons. In Proc. (kg/yr)	HW Gen. (kg/yr)	WW Gen. (kg/yr)	Air Emis. (kg/yr)	SW Gen. (kg/yr)	Recover (kg/yr)	MB? (Y/N)	Comments:

Note: Attach sheet with all back-up calculations and assumptions.

IISE P2/CP ASSESSMENT

Worksheet 8

Facility Name: _____

CP/P2 Option Description

Process: _____

Option Name	
Option Description	
Source and Contact	
Option Goal or Purpose	
Specific Estimate of Hazmat, Haz. Waste, Air Emission, and/or Wastewater Reduction by Option	
Type of CP/P2 Option	☐ Source Reduction ☐ Treatment ☐ Recycling ☐ Disposal
Nature of CP/P2 Option	☐ Personnel/Procedural ☐ Equipment ☐ Material
Specific Materials or Equipment Needed	
Qualitative Assessment for Implementation	Cost of Implementation: ☐ High Cost ☐ Low Cost ☐ No Cost Ease of Implementation: ☐ Very Difficult ☐ Moderate ☐ Easy

Facility Name: _____

CP/P2 Option Evaluation

Option Name: _____

Y	N	
☐	☐	Does the option reduce ozone depletion potential?
☐	☐	Does the option reduce global warming potential?
☐	☐	Does the option reduce acid rain potential?
☐	☐	Does the option reduce photochemical oxidation or smog-forming potential?
☐	☐	Does the option reduce human toxicity potential by ingestion?
☐	☐	Does the option reduce human toxicity potential by inhalation or dermal exposure?
☐	☐	Does the option reduce aquatic toxicity potential?
☐	☐	Does the option reduce terrestrial toxicity potential?
☐	☐	Does the option reduce the use of RP 28 chemicals?
☐	☐	Does the option reduce the use of hazardous materials?
☐	☐	Are there any anticipated problems with the option's compatibility with production? If yes, comment:
☐	☐	Is it anticipated that implementing this option would have a negative impact on compliance? If yes, comment:
☐	☐	Would there be added health and safety (industrial hygiene) concerns by implementing the option? If yes, comment:
☐	☐	Does the option require additional labor/expertise or other resources? If yes, comment:
☐	☐	Are there space or utility limitations in the buildings where the option might be implemented? If yes, comment:

IISE P2/CP ASSESSMENT

Worksheet 10

Facility Name: _____

Option Cost Identification

Process: _____

Option Name: _____

Does the option require or change the requirement for any of the following?

Y	N		Description	Savings / (Cost)
☐	☐	Process Equipment		
☐	☐	Personnel Training		
☐	☐	Installation / Site Preparation		
☐	☐	Utility Connections / Systems		
☐	☐	Permitting		
☐	☐	Input Materials		
☐	☐	Disposal / Treatment		
☐	☐	O&M Labor and/or Supplies		

APPENDIX D

"WAR" ALGORITHM

MSE Millennium Science & Engineering, Inc.

1364 Beverly Road, Suite 302
McLean, Virginia 22101
Phone: 703.734.1090
Fax: 703.734.1093
e-mail: mse@erols.com

April 19, 1999

Mr. Douglas M. Young, Ph.D.
Sustainable Technology Division
National Risk Management Research Lab
US Environmental Protection Agency
26 W. Martin Luther King Dr.
Cincinnati, OH 45268

Via Fax: 513-569-7111

Dear Dr. Young:

It has been a pleasure speaking with you about pollution prevention (P2) and the Waste Reduction (WAR) Algorithm. As we discussed, P2 is very near and dear to me; and the WAR Algorithm seems like an excellent tool for comparing P2 options including process and/or chemical changes, and we believe that the WAR Algorithm and its associated database appear to have direct application to the pollution prevention / cleaner production project on which I am working for USAID in the Philippines.

It would be a great benefit to me if you could release to me the part of the database containing information on the Republic of the Philippines Priority Chemicals. These 28 chemicals include the organic compounds: asbestos, benzene, carbon tetrachloride, chlorofluoro-carbons, chloroform, chlorinated ethers, ethylene dibromide, ethylene oxide, halons, hexachlorobenzene, hexachloroethane, mirex, polychlorinated biphenyls, phosgene, pentachlorophenol, polybrominated biphenyls, selenium, tributyltin, vinyl chloride, 1,1,1-trichloroethane, and 1,2-diphenylhydrazine. Also included are arsenic, beryllium, cadmium, chromium, cyanide, lead, and mercury. If any of these chemicals are not in your database, we would be interested to learn how to add new chemicals.

Releasing an electronic copy (Excel format) as soon as possible would be a great benefit to the project, as we are currently in the development stage of the project and would benefit greatly from knowing options available for comparing CP/P2 options.

I look forward to your further input and assistance and can easily be contacted at 703-734-1090 (phone), 703-734-1093 (fax), and mse@erols.com (e-mail). Please ask for Todd Danielson in my absence.

Best Regards,

Dale Rice

cc: T.A. Danielson

Using Simulation For Pollution Prevention

Heriberto Cabezas and Douglas Young
U.S. Environmental Protection Agency, Sustainable Technology Div.

The goal is to design or modify chemical processes to minimize their environmental impact

The ability to design or modify chemical processes in a way that minimizes the formation of unwanted byproducts is an ongoing goal for process engineers. Two simulation and design methods are discussed here: Process Integration (PI), developed by El-Halwagi and Manousiouthakis [1] at UCLA, and El-Halwagi [2] at Auburn University; and the Waste Reduction (WAR) Algorithm, developed at the U.S. Environmental Protection Agency (Cincinnati, Ohio), and made commercially available through a Cooperative Research and Development Agreement (Crada) under the Federal Technology Transfer Act of 1986.[1]

PI is concerned with improving process efficiency and keeping targeted components from leaving the system. PI is essentially the practical application of the mass-exchange networks (MEN), as detailed in [1,2], which try to remove pollutants from product streams and segregate them into concentrated waste streams.

By comparison, the WAR Algorithm is concerned with evaluating and reducing the potential environmental impact of a process [3] — a key design consideration. Consider Process A, which emits 1 ton/h of a given pollutant, and Process B, which emits 2 tons/h of a different pollutant. When these two processes are compared on the basis of pollutant mass alone, one would logically conclude that Process A is preferable. However, because some pollutants are more toxic than others, the process comparison needs to assess the human-health and environmental impacts.

[1] Process Integration methodology has been commercialized by Matrix Integration, Inc. (Leesburg, Va.). The initial version of the WAR algorithm is being incorporated into the simulator product ChemCAD IV from Chemstations, Inc. (Houston, Tex.). The authors' discussion here does not endorse either of these commercial products or companies.

For more on simulation, see p. 139.

The WAR Algorithm

This methodology assumes that each stream entering and exiting a process possesses an inherent property, its potential environmental impact (PEI). WAR generates four indexes (discussed below), which can be used to compare the environmental impact of various process alternatives. For a steady-state process, one can write a balance equation for PEI:

$$O = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \quad (1)$$

where:

$\dot{I}_{in}$ = The rate of PEI input, PEI/h (the impact on the environment if all feed streams were to be released at once)

$\dot{I}_{out}$ = The rate of PEI output, PEI/h, (the impact on the environment if all output streams were to be released)

$\dot{I}_{gen}$ = The rate of PEI generation by the process, PEI/h (the difference between $\dot{I}_{out}$ and $\dot{I}_{in}$; $\dot{I}_{gen}$ can be positive or negative, because a given process can either create or consume PEI)

From Equation 1, one can generate two output indexes and two generation indexes, to compare different process alternatives. The lower the value of these indexes, the better the process's environmental performance.

The *output indexes* include the rate of PEI output, $\dot{I}_{out}$, and the amount of PEI output per kilogram of product, $\hat{I}_{out}$. These indexes allow comparison of the potential impact of various output streams on human health and the environment. $\hat{I}_{out}$ is given by:

$$\hat{I}_{out} = \dot{I}_{out} / \dot{P} \quad (2)$$

where:

$\dot{P}$ = The rate at which the process produces products, kg/h

The *generation indexes* are the rate of PEI generation, $\dot{I}_{gen}$, and the amount of PEI generated per kilogram of product, $\hat{I}_{gen}$. They allow comparison of process alternatives, in terms of the generation of net PEI. $\hat{I}_{gen}$ is given by:

$$\hat{I}_{gen} = \frac{\dot{I}_{out} - \dot{I}_{in}}{\dot{P}} \quad (3)$$

To compute the four indexes for a

NOMENCLATURE

$\dot{I}_{in}$ = The rate of input of PEI, PEI/h

$\dot{I}_{out}$ = The rate of output of PEI, PEI/h

$\dot{I}_{gen}$ = The rate of PEI generation inside the process, PEI/h (i.e., the difference between $\dot{I}_{in}$ and $\dot{I}_{out}$)

$\hat{I}_{out}$ = The amount of PEI output/kg of product

$\dot{P}$ = The rate at which the process produces product, kg/h

$\hat{I}_{gen}$ = The amount of PEI generated/kg of product

$\hat{I}_i^{in}$ = The PEI input per kg of product, for each individual input stream, i

$\dot{I}_i^{in}, \dot{I}_i^{out}$ = The PEI rate of each individual input and output stream, i, PEI/h

$\dot{M}_i^{in}, \dot{M}_i^{out}$ = Mass flowrate of each input and output for each stream, i, kg/h

x_{ij} = The mass fraction of each nonproduct chemical component, j, in stream i, kg/kg

Ψ_j = The overall environmental impact of chemical component, j, PEI/kg

α_k = A weighting factor that allows one to assign relative importance to each of the eight environmental-impact categories, k, used by the WAR Algorithm

Ψ^s_{jk} = Specific impact of chemical component, j, in impact category, k, PEI/kg

given process, the rate of PEI of all the input and output streams, $\dot{I}_{in}$ and $\dot{I}_{in}$, respectively, must be calculated. For the input streams, this is done by calculating the PEI rate of each individual input stream, i ($\dot{I}_i^{(in)}$), and then adding the individual values to get $\dot{I}_{in}$. For the output streams, this is done by calculating the PEI rate of each individual input stream, i ($\dot{I}_i^{(out)}$), and then adding them to get $\dot{I}_{out}$. For each stream, i, the PEI rates of the individual input and output streams are calculated from the following:

- The mass flowrate of each input and output, $\dot{M}_i^{(in)}$ and $\dot{M}_i^{(out)}$, respectively
- The stream composition, in terms of the mass fraction, x_{ij}, of each non-product chemical component (pollutant and undesired byproduct), j
- The overall environmental impact, ψ_j, of chemical component j

The overall environmental impact, ψ_j, is calculated by summing the specific impacts, ψ^s_{jk}, of chemical component j over the various impact category k (discussed below), in units of PEI/kg. This is given by,

$$\dot{I}_{in} = \sum_i \dot{I}_i^{(in)} = \sum_i \dot{M}_i^{(in)} \sum_j x_{ij}\psi_j = \sum_i \dot{M}_i^{(in)} \sum_j x_{ij} \sum_k \alpha_k \psi^s_{jk} \quad (4)$$

$$\dot{I}_{out} = \sum_i \dot{I}_i^{(out)} = \sum_i \dot{M}_i^{(out)} \sum_j x_{ij}\psi_j = \sum_i \dot{M}_i^{(out)} \sum_j x_{ij} \sum_k \alpha_k \psi^s_{jk} \quad (5)$$

where:

α_k = A weighting factor for each impact category k

GOING TO 'WAR' FOR A 'GREENER' ACRYLIC-ACID PROCESS

To illustrate the use of the WAR Algorithm, consider an acrylic-acid-production process designed to produce 50,000 m.t./yr of acrylic acid (Figure 1). The process catalytically oxidizes propylene with air to form acrylic acid, and several byproducts (acetic acid, hydrogen, water and carbon dioxide) [4]. Three alternative design scenarios were considered: a base case (Unit 300) and two alternative designs (Units 301 and 302).

In the base case (Unit 300), the reactor operates at 310°C. The effluent is quenched in an adiabatic flash drum with a substantial recycle stream (98%). The flash-drum vapor effluent is stripped with deionized water to recover any residual acrylic acid.

The vapor effluent from the stripper is delivered to an incinerator. The liquid effluent from the flash drum is mixed with liquid effluent from the stripper; 98% of this mixed stream is recycled to the flash drum for quenching. The non-recycled, liquid effluent is sent to a liquid-liquid extraction unit, where the organics are extracted with a solvent mixture of diisopropyl ether (DIPE; 87 mol%) and water.

The aqueous effluent, which contains small amounts of acetic acid, acrylic acid and DIPE, is distilled to recover pure water, which is considered a waste (since it is not deionized, it cannot be reused in the process). The acids and DIPE are recycled back to the extraction column. The organic effluent from the extraction tower is sent to solvent-recovery column and then to an acrylic-acid distillation column. The final acrylic acid product is 99.9 mol% pure.

In this design, there is no consumption of DIPE. Rather, the initial charge of DIPE is completely recovered within the process.

Acrylic acid is considered the only product in this case study. With the objective of minimizing the potential environmental impact (PEI) of the other three effluent streams and maximizing acrylic acid production, possible improvements were sought. Because the reactor waste gas contains unreacted propylene and byproduct carbon dioxide, the reactor operation was examined.

Seeking improvements

The kinetics of this process are such that lower temperatures favor acrylic acid production. Thus, in the first design alternative, Unit 301, the reactor temperature was reduced by 30°C, to 280°C. This design also incorporated a 54% increase in the reflux ratio of the acrylic acid column. Decreasing the reactor temperature resulted in an equivalent conversion of propylene. However, it produced a greater selectivity toward acrylic acid (from 1.58 to 2.31 mole of acrylic acid per mole of byproduct).

In the second design alternative, Unit 302, the reactor temperature was reduced by another 20°C, to 260°C, and the reactor volume was doubled to maintain an equivalent level of propylene conversion. The reflux ratio in the acrylic acid column was also increased; however, only a 9% increase was required to achieve the same separation as observed in Unit 301.

The four output and generation PEI indexes described above were plotted for the base case and for the the two process modifications. Figure 2 shows the output indexes, $\dot{I}_{out}$ and $\dot{I}_{out}$, and the generation indexes, $\dot{I}_{gen}$ and $\dot{I}_{gen}$. □

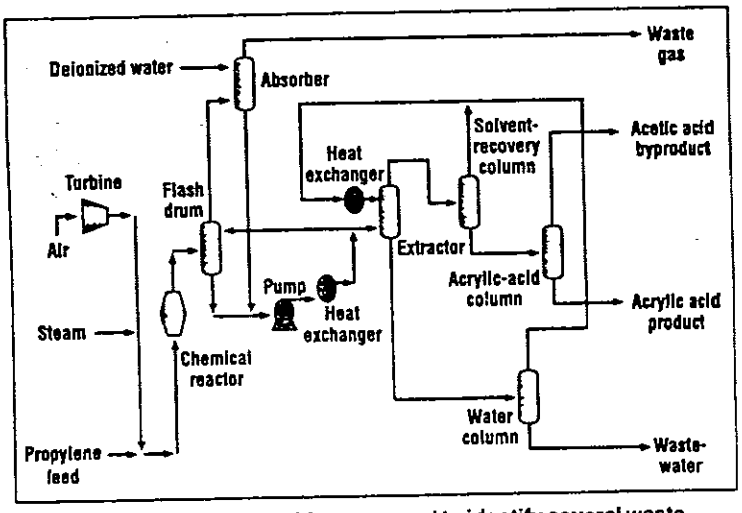

FIGURE 1. The WAR Algorithm was used to identify several waste-minimization routes for the acrylic-acid process shown above

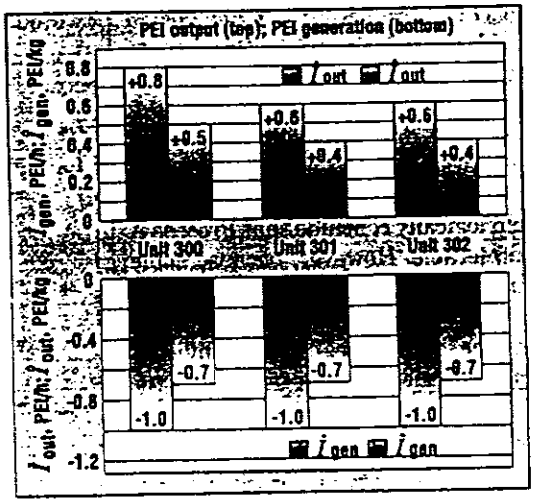

FIGURE 2. The design changes discussed above alter the output and generation PEI, as shown here

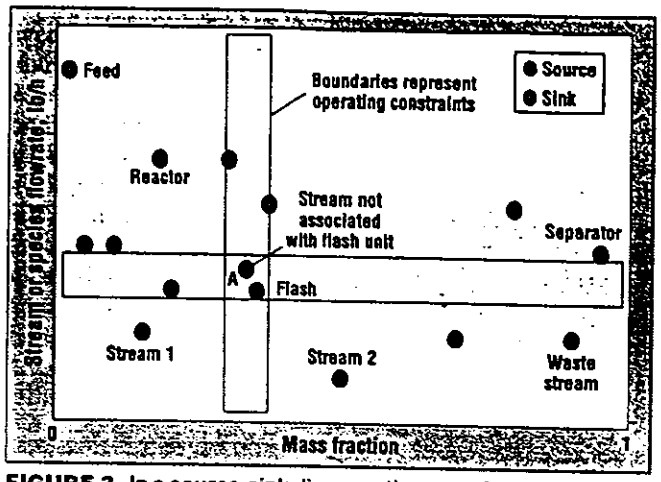

FIGURE 3. In a source-sink diagram, the mass fraction of the target species is plotted against flowrate. As shown, Stream A can be recycled directly back to the flash unit

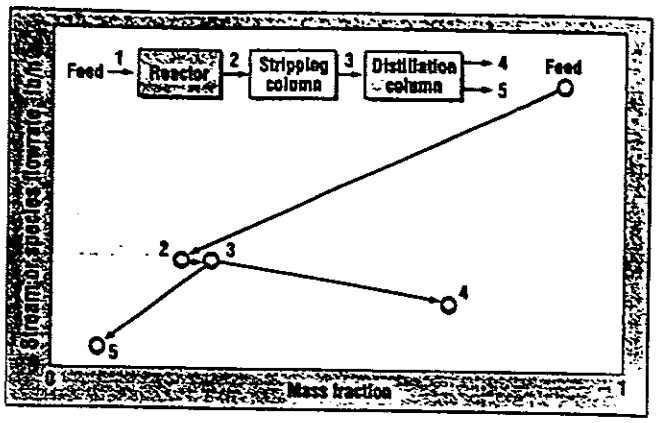

FIGURE 4. As this species-path diagram shows, streams (such as Streams 3 and 4) with a high target-species composition, a high flowrate, or both, are generally the most economical candidates for a mass-exchange operation. Stream 2 is already undergoing such an operation (stripping)

The current version of the WAR Algorithm considers eight health- and environmental-impact categories, k: ozone-depletion potential; global-warming potential; acid-rain potential; photochemical-oxidation or smog-formation potential; human-toxicity potential by ingestion; human-toxicity potential by inhalation or dermal exposure; aquatic-toxicity potential; terrestrial-toxicity potential. The weighting factor, α_k, allows us to assign relative importance to each of the eight categories. A default value of 5 for α_k can be assumed, but it can be adjusted between 0 and 10 to better represent the process and locale.

Values for ψ^s_{jk} can be obtained from a database developed by the authors, or from the database within the ChemCAD IV chemical-process simulator. The Box on p. 118 shows how the WAR Algorithm improved an acrylic-acid process.

Process Integration

The PI methodology considers the intricate relationships among flow streams, unit operations, operating parameters, and performance requirements, and then uses these relationships during process design to determine the ideal order of the unit operations and mass and energy streams; to calculate mass and energy balances for proper equipment sizing; and to optimize an existing process, increasing product flow, or reduce energy use and waste generation.

The Mass-Exchange Network (MEN), at the heart of the Process Integration simulation methodology, reduces the amount of waste generated in a process by concentrating the non-useful byproducts into waste streams, and capturing and recycling products and useful byproducts back to appropriate downstream unit operations. A MEN allows a designer to simulate any process design to determine what unit operations, if any, are needed. The analysis or optimization of a series of MENs can be performed numerically or graphically; the graphical technique is demonstrated below.

Components of MENs

In a mass-exchange network, the waste streams are referred to as *sources* and unit operations, including reactors, distillation columns and treatment units, are referred to as *sinks*. In a given process, various output streams, and any waste- or mass-separating agents, can be either emitted, recycled back to a unit operation (sink), recycled to a processing stream, or sent for post-treatment.

The mass-transfer and separation portions of a MEN typically rely on mass-exchange equipment — including absorbers, strippers, liquid-liquid extraction units, adsorbers, ion exchangers and leaching systems — which separate and concentrate the waste streams. Mass-separating agents (MSA) — including solvents used in liquid-liquid extraction or gas absorption, granulated activated carbon, ion-exchange resins, and gases used in stripping operations — are often added to enhance the recovery of the useful components.

MENs also use stream-management techniques, such as recycling to a sink, stream mixing to achieve a desired flowrate or composition, and stream segregation to avoid mixing of streams that would require further treatment downstream. Temperature, pressure and flowrate can also be adjusted to enhance performance.

Analysis of MENs

The first step in designing an MEN that will simulate a process is to define the problem to be solved — how to increase production rates, reduce pollution emission, reduce utility consumption (such as cooling water) and so on — and to list any associated constraints, such as product specifications, pollutant concentrations or flowrates, and so on. The next step is to define the target components — those chemicals that need to be identified to address the problem statement and constraints. For example, water would be a target component in a system where you are trying to reduce cooling-water consumption; hydrogen would be a target component in a dehydrogenation process where the goal is to trim gas emissions. The graphical tools used in the MEN analysis focus around these components.

The *source-sink diagram* (Figure 3) plots the composition of the target species (shown as mass fraction) against flowrate to identify recycle opportunities. The red circles represent all sources or streams, and describe the relationship between flowrate and the composition

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of the target species in that stream.

The current operating condition of each sink (unit operation) is shown by a blue circle. The values plotted in Figure 3 represent the flowrate through the sink versus the composition of the target species inside that sink. For sinks that have variable concentrations, an average composition is shown. A source-sink diagram can be drawn for each target species.

Each sink has physical constraints that limit the compositions and flowrates within which it can operate. These are shown as box-like boundaries in Figure 3. These constraints limit the feasible operating conditions that may be considered during simulation in a "greener" design alternative. Any source that lies within this box can be recycled back to any sink within the box. While Figure 3 only highlights one sink, such a graphical analysis should be done for each sink.

A source-sink diagram can also be used to identify streams that can be combined and then recycled. For instance, in Figure 3, combining Streams 1 and 2 will increase the flowrate to an appropriate level, and adjust the composition to an acceptable level, allowing the combined stream to be recycled back to the flash unit sink shown within the box.

Similarly, if a source lies to the right of a sink but is still within its flowrate constraints, the stream can be recycled back to that sink — but only after the target-species composition has been reduced to meet the unit's constraints. The composition can be altered by using a stripper, absorber, or other mass-exchange unit.

The distance that a source lies to the right of a sink also provides information as to which units can be used to accomplish the desired degree of separation. A source that lies above a sink must reduce its flowrate before it can be recycled to that sink.

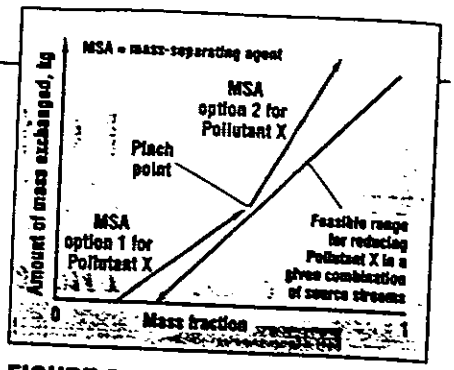

FIGURE 5. In this mass-pinch diagram, the curves on the left show the ability of two different mass-separating agents (MSA) in a given mass-exchange unit to remove Pollutant X from a given waste stream or streams. The composite curve on the right showa the range of feasibility for removing Pollutant X from a combination of streams. The pinch point (where the two curves are closest) shows the best point at which to apply the MSA options for removing Pollutant X, from an economic and thermodynamic standpoint

Another graphical tool, the *path diagram* (Figure 4), shows the flow of a specific component (i.e., a process reactant) through a process. Such a diagram is used to determine where mass exchange could be used to capture the target species and remove them from the system.

We Made A Long Story —

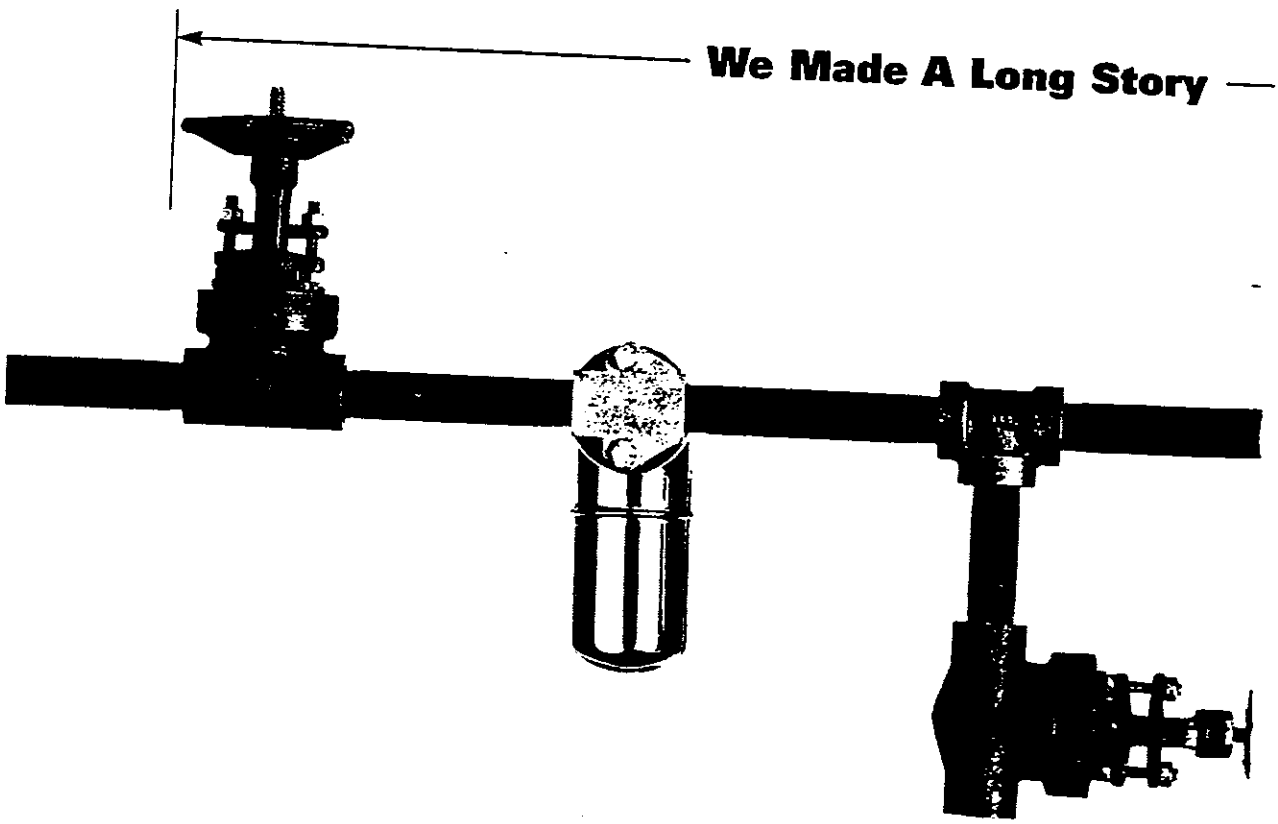

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Figure 4 shows a section of a hypothetical process design, and only shows the streams that contain the target species. The arrows represent the flow. More than one arrow arising from a single source represents the separation of the stream into multiple streams, and implies that the target species is in each. Multiple arrows into a single source means several flows are feeding a mixer or reactor.

In general, streams with higher target-species compositions or higher flowrates — such as Streams 3 and 4 in Figure 4 — are the most-cost-effective candidates for mass exchange or stream-management techniques.

When the goal is to reduce the concentration of a target species (i.e., Pollutant X) from a source (waste) stream or streams using a mass-exchange system, a *mass-pinch diagram* (Figure 5) can be used to evaluate the options. While construction of such a diagram is beyond the scope of this article, a discussion of Figure 5 may be illustrative. In that figure, the curves on the left show the feasibility ranges for two different MSAs (in terms of the amount of Pollutant X each can remove). The curve on the right shows the feasible range over which Pollutant X can be reduced in a given combination of source streams. The pinch point, where the two curves are closest, is the most cost-effective, thermodynamically desirable point at which to apply mass exchange. ■

Edited by Suzanne Shelley

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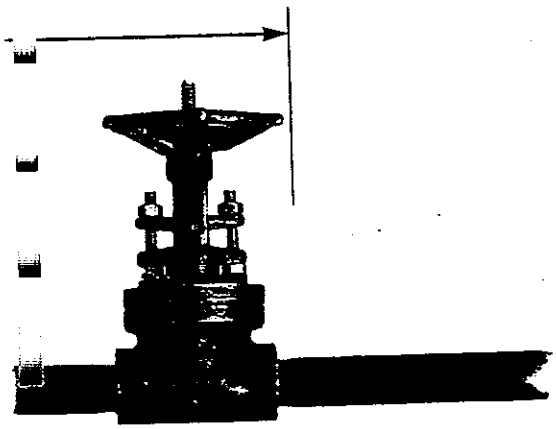

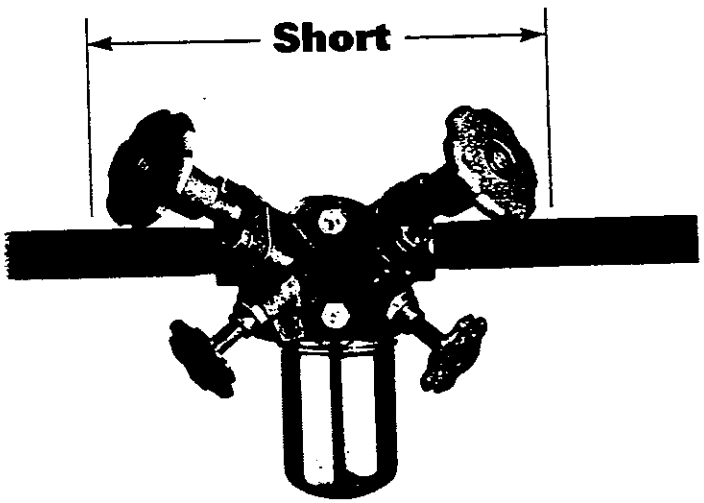

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Pollution Prevention with Chemical Process Simulators: The Generalized Waste Reduction (WAR) Algorithm-Full Version

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Abstract - A general theory for the flow and the generation of potential environmental impact through a chemical process has been developed. The theory defines six potential environmental impact indexes that characterize the generation of potential impact within a process, and the output of potential impact from a process. The indexes are used to quantify pollution reduction and to develop pollution reducing changes to process flow sheets using process simulators. The potential environmental impacts are calculated from stream mass flow rates, stream composition, and a relative potential environmental impact score for each chemical present. The chemical impact scores include a comprehensive set of nine effects ranging from ozone depletion potential to human toxicity and ecotoxicity. The resulting Waste Reduction methodology or WAR Algorithm is illustrated with two case studies using the chemical process simulator Chemcad III (Use does not imply USEPA endorsement or approval of Chemcad III).

INTRODUCTION

There is currently a great deal of interest in the development of methods that can be used to prevent or at least minimize the generation of pollution; and there are numerous efforts underway in this area (Lederman and Weber, 1991; El-Halwagi, *et al.* 1992; Fonyo, *et al.*, 1994; Rossiter, 1995; Manousiouthakis and Allen, 1995; Mallick *et al.*, 1996). This interest stems from the belief that pollution prevention is likely to lead to the creation of technologies that have a much more benign impact on human health and the environment. Because this technology is inherently less polluting, it is likely to be more robust and economical than simply adding pollution control devices to conventional designs. In chemical manufacturing, these pollution prevention methods take the form of an effort to design process plants that generate as little pollution as possible. Since chemical process simulators are widely used in the design and operation of chemical manufacturing plants, the development of a pollution prevention methodology for chemical process simulators is likely to have a significant impact on the pollution generated by the chemical industry. At the National Risk Management Research Laboratory, research efforts are underway to develop a methodology for commercial chemical process simulators. The research effort is called the WAste Reduction or WAR Algorithm after Hilaly and Sikdar (1994) who performed some of the early work in this area.

This paper presents a generalization of the WAR Algorithm, discusses the methodology for evaluating potential environmental impacts, and illustrates the use of the method in the design or modification of chemical processes with two case studies.

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ENVIRONMENTAL IMPACT THEORY

Potential environmental impact is the unrealized effect or impact that the emission of mass and energy would have on the environment on average. It is, therefore, essentially a probability function for the realization of a potential effect. Thus, the potential environmental impacts of chemical manufacturing processes are generally caused by the energy and material that the process takes from or emits to the environment. Potential environmental impact is a conceptual quantity that can not be directly measured, *i.e.*, there are no potential environmental impact meters. However, one can calculate potential environmental impact from related measurable quantities using functional relations between the two. This situation is common in science and engineering. For example, the energy of a fluid can not be directly measured, but it can be calculated from temperature and pressure by the use of heat capacities and equations of state. Exactly how to perform a calculation for potential environmental impacts will be discussed later in this paper.

Conservation Equation

Traditionally, chemical process design has been based on the creative application of mass and energy balances along with thermodynamics, chemical reaction engineering, and engineering economics. Our methodology proposes to add a conservation relation over potential environmental impact to the aforementioned two balance equations. The conservation equation for impacts is based on an accounting of the flow of potential environmental impact in and out of the processes. This flow of impact is related

to the mass and energy flows but it is not equivalent to them. The impact conservation equation is

$$\frac{dI_{syst}}{dt} = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \qquad (1)$$

where I_{syst} is the potential environmental impact content inside a process, $\dot{I}_{in}$ is the input rate of impact, $\dot{I}_{out}$ is the output rate of impact, and $\dot{I}_{gen}$ is the rate at which impact is generated in the system by chemical reactions or other means. Note that processes can also consume potential environmental impact so that $\dot{I}_{gen}$ can, in fact, be negative. For steady state processes, the conservation equation reduces to,

$$0 = \dot{I}_{in} - \dot{I}_{out} + \dot{I}_{gen} \qquad (2)$$

which implies that no potential environmental impact accumulates in the system. Also note that Equations (1) and (2) serve as definitions of the function $\dot{I}_{gen}$.

The significance of potential environmental impacts can be better understood by considering the following definitions. If one were to dump into the environment all of the mass and energy flows entering a process, the resulting impact on the environment would equal to I_{in}; if one were to also dump into the environment all of the mass and energy flows exiting a process the resulting impact on the environment would be equal to I_{out}. However, due to chemical transformations and changes in state conditions (temperature and pressure), I_{in} is never exactly equal to I_{out}, and consequently I_{gen} is never exactly equal to zero for steady state processes.

Chemical Processes

Application of either Equation (1) or (2) to chemical manufacturing processes requires an expression that relates the conceptual potential environmental impact to measurable quantities. Potential environmental impacts are caused by energy and material inputs and outputs to or from the environment. But, as a first approach, this treatment is restricted to potential impacts due to material flows while neglecting any impacts due to energy. Effects due to energy flows can be incorporated into the analysis by extending the boundary over which the impact balance is done to include the energy generation process. Effects due to resource depletion are also neglected mainly because there is no effective methodology for measuring them. This is consistent with the focus of this work which is the chemical process plant rather than a global life-cycle type of analysis. The expression relating potential chemical environmental impacts to measurables is

$$\dot{I}_i = \sum_j \dot{I}_j^{(i)} = \sum_j \dot{M}_j^{(i)} \sum_k x_{kj}\psi_j + \ldots \qquad (3)$$

where the sum over j is taken over the streams of input i or output i, the sum over k is taken over all chemicals k, $\dot{I}_i$ is the rate of potential environmental impact either in (i=in) or out of the process (i=out), $\dot{I}_j^{(i)}$ is the rate of potential environmental impact for stream j which may be an input or an output, $\dot{M}_j^{(i)}$ is the mass flow rate of stream j which may again be either an input or an output, x_{kj} is the mass fraction of chemical k in stream j, and ψ_j is the overall potential environmental impact of chemical j.

Note that Equation (3) is a first order approximation that does not include the synergistic effects that can occur when multiple chemicals are present.

Impact Indexes

For steady state processes one can use Equation (2) to define two categories of indexes for the environmental impact of chemical manufacturing. The first category of indexes measures the generation of potential environmental impact within processes, and the second one measures the potential environmental impact emitted by processes. There are various indexes that can be defined within each category. However, only the six indexes, three from each category, that seem most useful for waste reduction will be treated here.

Following Hilaly and Sikdar (1994), all non-products are considered to be pollutants and the potential environmental impact of all products is set to zero, *i.e.*, ψ_j=0 for all products j. These assumptions are consistent with the objective of this paper which is to present a methodology for waste reduction, *i.e.*, the primary concern is reducing the impact and the amount of the non-products. The broader implications of Equation (1), including other impact indexes for which $\psi_j \neq 0$ for products j and further conjectures on the implications for sustainability, will the subject of future publications.

The first index of the first category of indexes (impact generation) is obtained by solving Equation (2) for $\dot{I}_{gen}$ and adding the superscript NP for Non-Products to give,

$$\dot{I}_{gen}^{NP} = \dot{I}_{out}^{NP} - \dot{I}_{in}^{NP} \qquad (4)$$

where $\dot{I}_{out}^{NP}$ and $\dot{I}_{in}^{NP}$ are the potential environmental impacts due to non-products, *i.e.*, pollutants in the outputs and inputs, respectively. Equation (3) is used to give explicit expressions for $\dot{I}_{out}^{NP}$ and $\dot{I}_{in}^{NP}$ where all components, products and non-products, are included in the summation, but where ψ_j=0 for all products j which effectively removes all products from the summation. The index, $\dot{I}_{gen}^{NP}$, measures the total rate at which the process generates potential environmental impact due to non-products (NP). $\dot{I}_{gen}^{NP}$ has units of potential environmental impact generated per time.

The second index, $\hat{I}_{gen}^{NP}$, of the first category is obtained by dividing Equation (4) by the rate at which the process generates products to give a specific impact generation,

$$\hat{I}_{gen}^{NP} = \frac{\dot{I}_{gen}^{NP}}{\sum_p \dot{P}_p} = \frac{\dot{I}_{out}^{NP} - \dot{I}_{in}^{NP}}{\sum_p \dot{P}_p} \qquad (5)$$

where the sum over p is taken over all the products p, and $\dot{P}_p$ is the mass flowrate of product p. $\hat{I}_{gen}^{NP}$ measures the potential impact created by all non-products in manufacturing a unit mass of all the products p. The index, $\hat{I}_{gen}^{NP}$, has units of potential environmental impact per mass of products.

The third index of the first category, $\hat{M}_{gen}^{NP}$, is obtained from Equation (5) by setting the potential environmental impact (ψ_j) of all products to zero and that of all non-products to one. This has the effect of assigning the same potential environmental impact to all non-products. The index, $\hat{M}_{gen}^{NP}$, is a measure of the mass inefficiency of the

process, *i.e.*, it gives the ratio of mass converted to an undesirable form to mass converted to a desirable form. The expression for $\hat{M}_{gen}^{NP}$ is

$$\hat{M}_{gen}^{NP} = \frac{\sum_j \dot{M}_j^{(out)} \sum_k x_{kj}^{NP} - \sum_j \dot{M}_j^{(in)} \sum_k x_{kj}^{NP}}{\sum_p \dot{P}_p} \quad (6)$$

where the summation over $\dot{M}_j^{(out)}$ is taken only over output streams, the summation over $\dot{M}_j^{(in)}$ is taken only over input streams, and the summation over x_{kj}^{NP} is taken only over all non-products k in stream j. The units of $\hat{M}_{gen}^{NP}$ are mass of non-products per mass of products.

The first index of the second category of indexes (impact emission) $\dot{I}_{out}^{NP}$ is simply the total rate of potential environmental impact output due to non-products. $\dot{I}_{out}^{NP}$ is calculated from Equation (3) subject to ψ_j=0 for all products j. The index, $\dot{I}_{out}^{NP}$, is a measure of the rate at which the process emits potential environmental impact, and it has units of potential environmental impact per time.

The second index of the second category, $\hat{I}_{out}^{NP}$, is obtained by dividing the rate of potential environmental impact output due to non-products by the output rate of products to give,

$$\hat{I}_{out}^{NP} = \dot{I}_{out}^{NP} \Big/ \sum_p \dot{P}_p \quad (7)$$

The index, $\hat{I}_{out}^{NP}$, has units of potential environmental impact per mass of products. This expression gives the pollution index Φ of Mallick *et al.* (1996) which measures the potential environmental impact emitted in manufacturing a unit mass of products.

The third index of the second category, $\hat{M}_{out}^{NP}$, is obtained from Equation (7) by setting the potential environmental impact (ψ_j) of all products to zero and that of all non-products to one. The resulting expression is,

$$\hat{M}_{out}^{NP} = \frac{\sum_j \dot{M}_j^{(out)} \sum_k x_{kj}^{NP}}{\sum_p \dot{P}_p} \quad (8)$$

which is related to the pollution index ϕ_n of Hilaly and Sikdar (1994) by,

$$\hat{M}_{out}^{NP} = \sum_n \phi_n \quad (9)$$

where the summation is taken over all products n. $\hat{M}_{out}^{NP}$ measures the amount of non-product or pollutant mass emitted in manufacturing a unit mass of products, and it has units of non-product mass per mass of products. It is also a mass inefficiency measure.

Significance of Impact Indexes

The first category of indexes, *e.g.*, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, characterize some aspects of the generation of potential environmental impact within a manufacturing process. They are most useful in addressing questions related to the internal environmental efficiency of the process plant, *i.e.*, the ability of the plant to produce desired products while creating a minimum of new, undesired potential environmental impact. It is important to note that once new potential environmental impact is created, resources such as potentially costly remediation efforts will likely be required to prevent the potential impact from being realized. Obviously, the smaller the values of $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$ the more environmentally efficient the process, and, all others factors such as economics being equal, the more desirable. $\dot{I}_{gen}^{NP}$ would be useful in comparing different designs on an absolute basis, while $\hat{I}_{gen}^{NP}$ and $\hat{M}_{gen}^{NP}$ would be useful in comparing different designs independently of manufacturing plant size.

The second category of indexes, *e.g.*, $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$ characterize some aspects of the emission of potential environmental impact from a manufacturing process. Their principal use is in addressing questions related to the external environmental efficiency of the process plant, *i.e.*, the ability of the plant to produce desired products while inflicting on the environment a minimum of undesired potential environmental impact. It is again obvious that the smaller the values of $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$ the more environmentally efficient the process, and all other factors such as economics being equal, the more desirable it is. Since $\dot{I}_{out}^{NP}$ is a total rate of impact output, it could be useful in deciding whether a given plant is compatible with a particular site. For example, it would be unwise to locate a plant with a high $\dot{I}_{out}^{NP}$ in an ecologically sensitive area. $\dot{I}_{out}^{NP}$ could also be used in matching the size of a plant to the capacity of the surrounding environment to dissipate environmental impact. $\hat{I}_{out}^{NP}$ and $\hat{M}_{out}^{NP}$ are more useful in comparing the potential environmental impact of alternative processes independently of plant size.

CHEMICAL ENVIRONMENTAL IMPACT

Application of the methodology so far developed requires that the potential environmental impacts of chemicals be estimated. Further, it is required that a relative impact number ψ_j be given for each chemical j over a wide range of different chemical environmental impacts. This is, unfortunately, not a trivial matter because chemical impacts are measured on different relative scales that can not be simply added without some form of normalization.

Chemical Impact Expression

To apply the WAR methodology to chemical processes, the following expression for ψ_j has been developed (Mallick *et al.*, 1996),

$$\psi_j = \sum_l \alpha_l \psi_{j,l}^s \quad (10)$$

where the sum is taken over categories of potential chemical environmental impacts, e.g., ozone depletion potential, human health, etc. listed below under *Classification of Impacts*. α_l is a relative weighting factor for impact of type l independent of chemical j, and $\psi_{j,l}^s$ is the specific potential environmental impact of chemical j for an impact of type l. α_l has units of potential environmental impact per mass.

The relative weighting factor α_l allows Equation (10) to be customized to specific or local conditions. The suggested procedure is to initially set all the α_l's to same value of say one, and to allow users to vary individual α_l's from 0 to 10 according to local needs and policies.

Please note that for a relative comparison, the absolute value is not critical. For example, photochemical oxidation potential would be weighted more heavily than other impacts in an area that suffers from smog. There is an effort underway in our research group to develop more sophisticated methods of determining values for the α_l's. The values for the $\psi^s_{j,l}$ were obtained from the relative rankings or scores for chemicals by normalizing according to,

$$\psi^s_{i,j} = \frac{(Score)_{i,j}}{\langle (Score)_i \rangle_j + 2\sigma_j} \qquad (11)$$

where $(Score)_{i,j}$ is the relative score of chemical i on some arbitrary scale within impact category j, $\langle (Score)_i \rangle_j$ is the arithmetic average of the scores of all chemicals i within impact category j, and σ_j is the standard deviation of all the chemical scores in impact category j. The normalizing factor $\langle (Score)_i \rangle_j + 2\sigma_j$ assures that about 75% of the normalized chemical score numbers $\psi^s_{j,l}$ will be between 0 and 1 irrespective of the statistical distribution of the initial scores as expected from Chebyshev's theorem (Lapin, 1975). If the chemical scores happen to follow a normal distribution, then the normalization range extends to approximately 95% of the scores.

Classification of Impacts

The classification of chemical environmental impacts and the values for the $(Score)_{i,j}$ were adopted from the study of Heijungs *et al.* (1992)* and normalized according to Equation (11) to obtain the $\psi^s_{j,l}$'s. In the calculation of $\langle (Score)_i \rangle_j$ and σ_j, the chemical scores for dioxin, chromium VI, and vinyl chloride were excluded. The reason is that the score numbers for these three chemicals were several orders of magnitude higher that those for all other chemicals, and including them in the normalization process would have made the normalization meaningless. Therefore, the normalized $\psi^s_{j,l}$ for these three chemicals would appear as outliers which they, in fact, are.

Table 1: Normalized Chemical Impact Scores

	H2	MEK	SBA	H2O
$\psi^s_{j,l}$	0	0.42	4.1E-4	0
	N2	Ar	CH4	NH3
$\psi^s_{j,l}$	0	0	7.4E-3	0.93

There are nine different impact categories. These can be subdivided into four environmental physical potential effects (acidification, greenhouse enhancement, ozone depletion, and photochemical oxidant formation), three human toxicity effects (air, water, and soil), and two ecotoxicity effects (aquatic and terrestrial).

The normalized chemical scores used in the two case studies presented in the next sections are given in Table 1 above where H2 is hydrogen, MEK is methyl ethyl ketone, SBA is secondary butyl alcohol, H2O is water, N2 is molecular nitrogen, Ar is argon, CH4 is methane, and NH3 is ammonia. These acronyms will be used throughout the rest of the paper.

* Use by the authors does not imply endorsement or approval by the U.S. Environmental Protection Agency.

CASE STUDY #1: MEK PRODUCTION

To illustrate the use of the generalized WAR Algorithm, a case study from the production of methyl ethyl ketone (MEK) from secondary butyl alcohol (SBA) is presented. The case study was adopted from the Chemcad III (Chemstations, Inc.) chemical process simulator, and all the material and energy balances were performed using Chemcad III. However, any commercial process simulator could have been used. This case study presents a typical chemical engineering process for the production of a commodity chemical that involves several unit processes such as reactors, separators, mixers, dividers, and heat exchangers. It is, therefore, sufficiently complex to illustrate the WAR Algorithm but still treatable within the space of this paper. Essentially, the chemical process consists of a SBA dehydrogenation reactor followed by a MEK purification train and associated equipment.

Base Flowsheet

Figure 1 shows the base process flow diagram for the production of MEK from SBA. SBA is fed to a hydrogen scrubber where the feed SBA scrubs residual MEK from the hydrogen stream. The SBA feed is then pumped up to reaction pressure and heated to reaction temperature with a heat exchanger and a heater. The heated SBA is fed to the reactor where the chemical transformation occurs. The

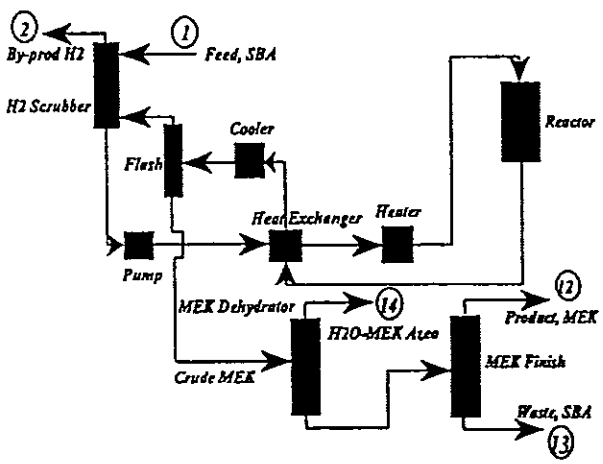

Figure 1. Base process flow diagram for the production of methyl ethyl ketone from secondary butyl alcohol.

Table 2: MEK Production Flow Summary (kg/hr)
Input & Output: Base Process

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 13 (L)	# 14 (G)
SBA	3362	19	3	2670	1
MEK	0	0	567	13	71
H2O	8	0	0	0	8
H2	0	18	0	0	0

reactor output stream is sent to a heat exchanger where it is partially condensed. The mixture of MEK, hydrogen, and unconverted SBA is cooled further and sent to a separator where the hydrogen is flashed off. The hydrogen is then scrubbed and the liquid phase fed to a MEK purification system. The mass flow rates and the state of the various input and output streams as calculated by Chemcad III are listed in Table 2 above.

Modified Flowsheet

Examination of the base process indicates that waste stream 13 contains large amounts of unreacted SBA and small amounts of MEK. It is, therefore, logical to try to recover the SBA and MEK as the first step in a waste reduction strategy. Consequently, the process flow diagram was modified by the addition of a recycle from

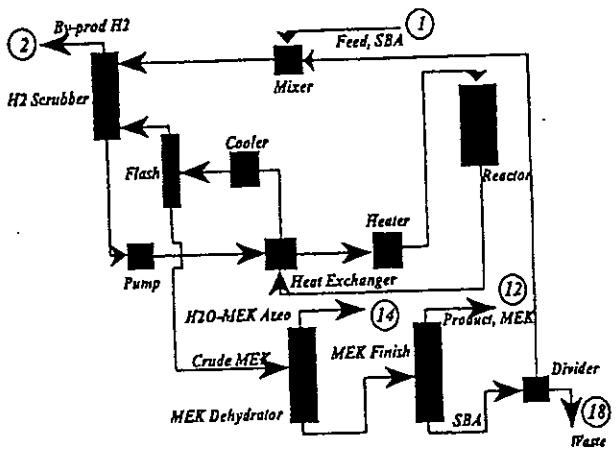

Figure 2. Modified process flow diagram for the production of methyl ethyl ketone from secondary butyl alcohol.

stream 13 to the feed, stream 1. Two cases were studied with this modification, recycling 50% and 100% of stream 13. Recycling 100% of stream 13, *i.e.*, closing off stream 18, is appropriate for this illustration. But, it is clearly not practical because stream 18 is the only liquid waste stream in the modified process and the only means of purging the system of liquid impurities. Without this purge, impurities would build up inside the process causing it to eventually cease to function. Figure 2 above shows the flow diagram for the modified process. The mass flow rates and the state of the various input and output streams for the modified process with 50% recycle are listed in Table 3

Table 3: MEK Production Flow Summary (kg/hr)
Input & Output: Modified Process (50% Recycle)

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 14 (G)	# 18 (L)
SBA	3362	168	5	1	2124
MEK	0	1	980	64	10
H2O	8	2	0	6	0
H2	0	29	0	0	0

The process modification increased the amount of product by approximately 73% while reducing the amount of waste SBA in stream 18 by about 20%.

It is important to note that an examination of Tables 2, 3, and 4 will indicate that waste was generally reduced, and that environmental impact was probably also reduced. However, the information so far considered is not sufficient to allow a quantitative comparison of the overall waste and environmental impact reduction associated with each of the three cases studied here. For this comparison one must calculate the impact indexes already described. For the modified process with 100% recycle, the mass flow rates and the state of the various input and output streams are listed in Table 4 below. Note that increasing the recycle increased the amount of product by 269% while simultaneously reducing the amount of waste SBA in stream 13 to zero.

Table 4: MEK Production Flow Summary (kg/hr)
Input & Output: Modified Process (100% Recycle)

Stream (State)	# 1 (L)	# 2 (G)	# 12 (L)	# 14 (G)
SBA	3362	1117	11	1
MEK	0	11	2094	59
H2O	8	3	0	5
H2	0	60	0	0

Impact Index Calculations

Six different impact indexes were calculated for the base case and the two modified processes each. The indexes were obtained using Equations (3) to (8), the flow rates from Tables 2, 3, and 4, Equation (10), and the normalized chemical impact scores of Table 1. The relative weighting factors, α_i, were all set to one for these calculations.

The first category indexes, *i.e.*, the impact generation indexes, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, are shown on Figure 3 below. It should be noted that $\hat{M}_{gen}^{NP}$ is a negative number since some of the input mass is always converted to product, and the products are not included in the summation of the outputs. The specific indexes, $\hat{I}_{gen}^{NP}$ and $\hat{M}_{gen}^{NP}$, were multiplied by a factor of 100 so that they could be shown on the same scale as the rate index $\dot{I}_{gen}^{NP}$.

The second category indexes, *i.e.*, the impact output indexes $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$, are shown in Figure 4. The specific index $\hat{I}_{out}^{NP}$ was multiplied by a factor of 1000, and the specific index $\hat{M}_{out}^{NP}$ was multiplied by a factor of 10 so that they could both be shown on the same scale as $\dot{I}_{out}^{NP}$.

The largest source of uncertainty in the calculation of the impact indexes is the environmental impact scores. These measurements are probably accurate to no more than one significant figure or an order of magnitude. It is, therefore, prudent to assume that impact index calculations are also accurate to no more than one significant figure. Two significant figures are used in Figures 3 and 4 in order to help the readers to reproduce the calculations, if necessary.

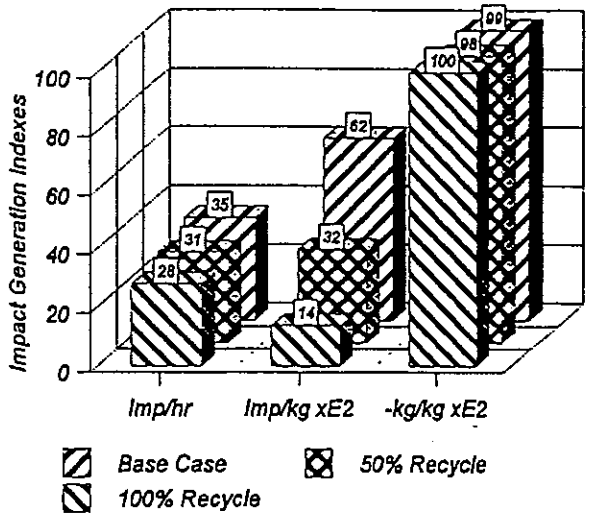

Figure 3. Impact generation indexes for the production of methyl ethyl ketone from secondary butyl alcohol: $\dot{I}^{NP}_{gen}$ in impact units per hour, $\hat{I}^{NP}_{gen}$ in impact units per kilogram of product, and $-\hat{M}^{NP}_{gen}$ in kilograms of pollutants per kilogram of product.

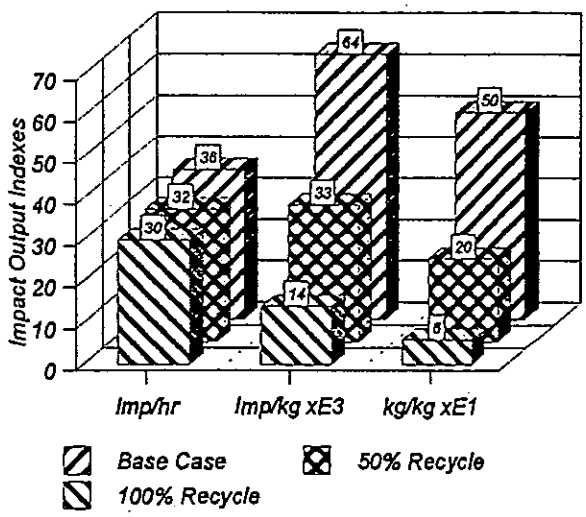

Figure 4. Impact output indexes for the production of methyl ethyl ketone from secondary butyl alcohol: $\dot{I}^{NP}_{out}$ in impact units of pollutants per hour, $\hat{I}^{NP}_{out}$ in impact units of pollutants per kilogram of products, and $\hat{M}^{NP}_{out}$ in kilograms of pollutants per kilogram of products.

DISCUSSION OF CASE STUDY #1

The impact generation indexes of Figure 3 show that: (1) the rate of impact generation by non-products decreases by 13% for 50% recycle and by 20% for 100% recycle, (2) the impact generated by non-products per kilogram of product decreases by 48% for 50% recycle and by 77% for 100% recycle, and (3) the kilograms of non-products generated per kilogram of product remains nearly constant at -100. The most significant index in this case is the impact generated per kilogram of product. The decrease of this index reflects the increase in the productivity of the plant, *i.e.*, the increase in product flow rate.

The impact output indexes of Figure 4 show that: (1) the rate of impact output from non-products decreases by 11% for 50% recycle and by 17% for 100% recycle, (2) the impact output from non-products per kilogram of product decreases by 48% for 50% recycle and by 78% for 100% recycle, and (3) the output of kilograms of non-product per kilogram of product decreases by 60% for 50% recycle and by 88% for 100% recycle. It is worth noting that the output of impact and waste decreased as measured by all the indexes. The most significant index in this case is the impact output per kilogram of product. The decrease in this index is consistent with the decrease in the impact generation per mass of product index discussed in the paragraph above. This decrease is also a reflection of the increased productivity of the plant.

The decreases in the indexes are sufficiently large such that they represent significant reductions in pollution. The consistent decrease in the impact generation per mass of product (48% to 77%) and the impact output per mass of product (48% to 78%), simply means that the modified plant can meet the needs of a much larger market without increasing its generation or its output of potential environmental impact. It also means that a modified plant that is 48% to 77% smaller than the base case can meet the needs of the same market that the base plant was designed for.

CASE STUDY#2: AMMONIA PRODUCTION

To further illustrate the use of the generalized WAR Algorithm, a second case study from the production of ammonia from synthesis gas is presented. The case study was also adopted from the Chemcad III (Chemstations, Inc.) chemical process simulator, and all the material and energy balances were performed using Chemcad III. However, any commercial process simulator could again have been used. Just as Case Study #1, this case study also presents a typical chemical engineering process that involves several unit processes such as reactors, separators, mixers, dividers, and heat exchangers. It is also sufficiently complex to illustrate the WAR algorithm but still treatable within the space of this paper.

Base Flowsheet

Figure 5 shows the base process flow diagram for the process. Essentially, the overall process is based on the reaction of nitrogen and hydrogen to produce ammonia. The mixture of hydrogen and nitrogen is compressed and

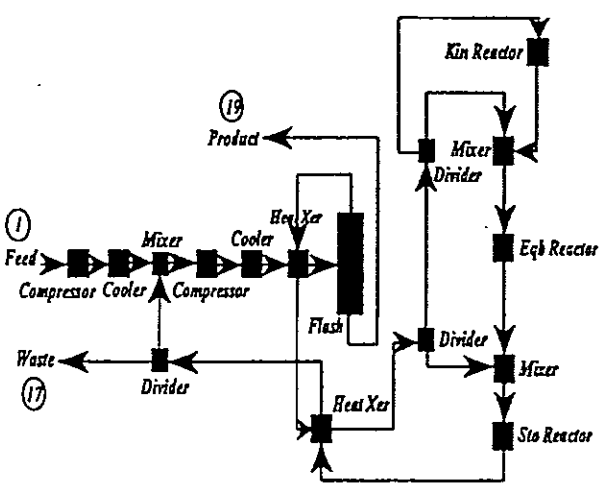

Figure 5. Base process flow diagram for the production of ammonia from synthesis gas.

cooled and feed to a series of three reactors through a flash drum. Several reactors are normally used the to maximize the conversion of feed to products which for this process is difficult to do. This flash drum also serves to separate the ammonia product from the unreacted gases which are feed back into the system. The ammonia is recovered as an anhydrous liquid under modest pressure. The mass flow rates and the state of the input and output streams as calculated by Chemcad III are all listed in Table 5.

Table 5: Ammonia Production Flow Summary (kg/hr)
Input & Output: Base Process (Purge Ratio = 0.1)

Stream (State)	# 1 (G)	#17 (G)	# 19 (L)
N2	33,334	5060	187
Ar	603	428	176
H2	7196	1120	13
CH4	805	700	112
NH3	0	3696	30453

Modified Flowsheet

Examination of the base process indicates that waste stream 17 contains ammonia and some unreacted feed. It is, therefore, logical to try to recover the ammonia and the unreacted feed as an obvious first step in a waste reduction strategy. Consequently, the process flow diagram was modified in two ways. First, the purge ratio was reduced five fold from 0.1 to 0.02, *i.e.*, the flow of stream 17 was reduced five fold. Second, in addition to reducing the purge, a flash drum was added with stream 17 as the feed to recover some of the ammonia.

Table 6: Ammonia Production Flow Summary (kg/hr)
Input & Output: Modified Process (Purge Ratio = 0.02)

Stream (State)	# 1 (G)	#17 (G)	# 19 (L)
N2	33,334	1162	217
Ar	603	199	404
H2	7196	281	16
CH4	805	446	351
NH3	0	856	38001

Figure 5 shows the configuration of the flow diagram for the reduced purge modified process which is identical to that of the base process. The mass flow rates and the state of the input and output streams for the reduced purge modified process are listed in Table 6. The process modification increased the amount of product by approximately 25% while reducing the amount of waste ammonia in stream 17 by about 77%. It is worth noting, however, that there was an small increase in the impurities present in the product stream. This changed from about 2% impurities in the base case to 3% for the reduced purge modified case.

Figure 6 shows the flow diagram for the modified process with reduced purge and addition of a flash drum with stream 17 as the feed. Under this configuration, stream 25 is used to purge impurities from the system. Without this purge, impurities would again build up inside the process, and it would eventually cease to function. Stream 24 which consists of essentially pure ammonia is mixed with stream 19 to form a new product stream, stream 26.

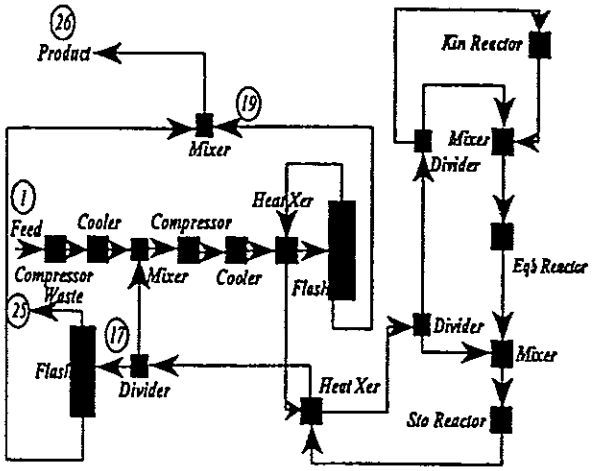

Figure 6. Modified process flow diagram for the production of ammonia from synthesis gas with reduced purge ratio and added flash drum.

The mass flow rates and the state of the various input and output streams are listed in Table 7. Note that adding the flash drum in addition to reducing the purge five fold increased the amount of product by 26% as compared to the base case. This is very close to the 25% increase in product that was obtained by simply reducing the purge. However, the amount of waste ammonia in stream 25 was reduced by 91%, and the amount of total waste in stream 25 was reduced by 78%, both compared to the base case. As compared to the reduced purge process, the addition of the flash drum increased the amount of product by a meager 1%, but it reduced the amount of waste ammonia by 61% and total amount of waste by 18%, both in stream 25. Therefore, the principal effect of adding the flash drum was the reduction of waste.

Table 7: Ammonia Production Flow Summary (kg/hr)
Input & Output: Modified Process
(Purge Ratio = 0.02 & Flash Drum)

Stream (State)	# 1 (G)	#25 (G)	# 26 (L)
N2	33,334	1162	217
Ar	603	199	404
H2	7196	281	16
CH4	805	447	351
NH3	0	335	38,521

An examination of Tables 5, 6, and 7 will again show that waste was generally reduced, that the amount of product made was increased, and that environmental impact of the process was probably also reduced. However, one finds that it is not sufficient to allow a quantitative comparison of the overall waste and environmental impact associated with each of the three cases. In a simple example such this one the task is confusing, but for complex chemical process it can become impossible. For this comparison one must calculate the impact indexes.

Impact Index Calculations

Again, six different impact indexes were calculated for the base and the two modified processes. The indexes were also obtained using Equations (3) to (8), the flow rates from Tables 5, 6, and 7, Equation (10), and the normalized chemical impact scores of Table 1. The relative weighting factors α_i were all set to one for these calculations.

The first category indexes, *i.e.*, the impact generation indexes, $\dot{I}_{gen}^{NP}$, $\hat{I}_{gen}^{NP}$, and $\hat{M}_{gen}^{NP}$, are shown on Figure 7. It should be noted that $\hat{M}_{gen}^{NP}$ is a negative number since some of the input mass is always converted to product, and the products are not included in the summation of the outputs. The specific index, $\hat{I}_{gen}^{NP}$, was multiplied by a factor of 10,000, and the index, $\hat{M}_{gen}^{NP}$, was multiplied by a factor of 1,000 so that they could both be shown on the same scale as the rate index $\dot{I}_{gen}^{NP}$.

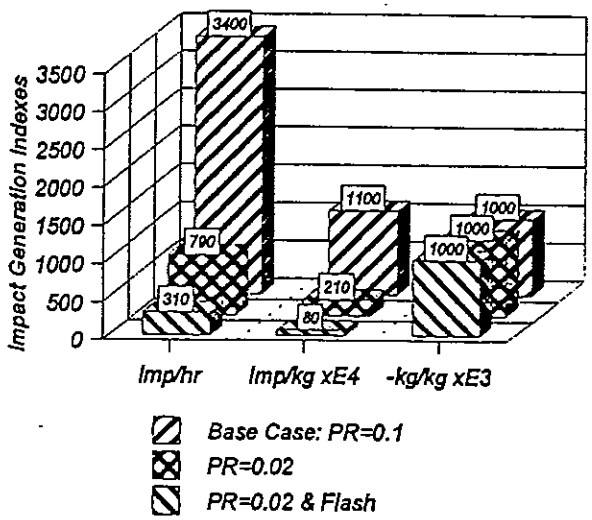

Figure 7. Impact generation indexes for the production of ammonia from synthesis gas: $\dot{I}_{gen}^{NP}$ in impact units per hour, $\hat{I}_{gen}^{NP}$ in impact units per kilogram of product, and $-\hat{M}_{gen}^{NP}$ in kilograms of pollutants per kilogram of product. PR is the purge ratio.

The second category indexes, *i.e.*, the impact output indexes, $\dot{I}_{out}^{NP}$, $\hat{I}_{out}^{NP}$, and $\hat{M}_{out}^{NP}$, are shown in Figure 8. The specific index $\hat{I}_{out}^{NP}$ and the specific index $\hat{M}_{out}^{NP}$ were both multiplied by a factor of 10,000 so that they could be shown on the same scale as $\dot{I}_{out}^{NP}$.

The largest source of uncertainty in the calculation of the impact indexes are again the environmental impact scores. These measurements are probably accurate to no more than one significant figure or an order of magnitude, and it is, therefore, prudent to assume that impact index calculations are also accurate to no more than one significant figure. Two significant figures are presented in Figures 7 and 8 in order to allow readers to reproduce the calculations if necessary.

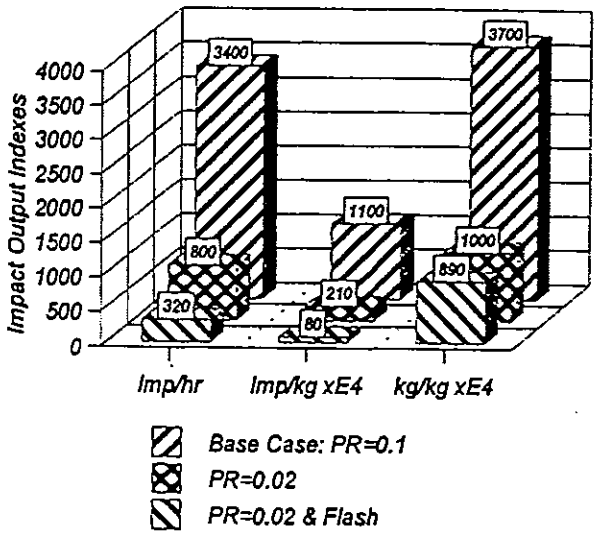

Figure 8. Impact output indexes for the production of ammonia from synthesis gas: $\dot{I}_{out}^{NP}$ in impact units of pollutants per hour, $\hat{I}_{out}^{NP}$ in impact units of pollutants per kilogram of products, and $\hat{M}_{out}^{NP}$ in kilograms of pollutants per kilogram of products. PR is the purge ratio.

DISCUSSION OF CASE STUDY #2

The impact generation indexes of Figure 7 show that: (1) the rate of impact generation by non-products decreases by 77% when the purge ratio is decreased from 0.1 to 0.02 and by 91% when the purge ratio is decreased as above and a flash drum is added to recover waste ammonia, (2) the impact generated by non-products per kilogram of product decreases by 81% when the purge ratio is reduced from 0.1 to 0.05 and by 93% when the purge ratio is decreased as above and a flash drum is added, and (3) the kilograms of non-products generated per kilogram of product remained nearly constant at -1 for all cases. The most significant index in this case is the impact generated per kilogram of product. The decrease of this index reflects primarily the recovery of the waste product and to a smaller extent the increase in the productivity of the plant, *i.e.*, the increase in product flow rate.

The impact output indexes of Figure 8 show that: (1) the rate of impact output from non-products decreases by 76% when the purge ratio is decreased from 0.1 to 0.02 and by 91% when the purge ratio is decreased as above and a flash drum is added to recover waste ammonia, (2) the impact output from non-products per kilogram of product decreases by 81% when the purge ratio is reduced from 0.1 to 0.05 and by 93% when the purge ratio is decreased as above and a flash drum is added, and (3) the output of kilograms of non-product per kilogram of product decreases by 73% when the purge ratio is reduced from 0.1 to 0.05 and by 76% when the purge ratio is decreased as above and a flash drum is added. It is again worth noting that the output of impact and waste decreased as measured by all the indexes. The most significant index

in this case is the impact output per kilogram of product. The decrease in this index was the same as that for the equivalent generation index. This is a reflection of the change in the index being primarily driven by the recovery of waste product rather than increased productivity.

The decreases in the indexes are again sufficiently large that they represent significant reductions in pollution. The consistent decrease in the impact generation per mass of product and impact output per mass of product (81% to 93%) implies that the modified plant can meet the needs of a moderately larger market with much less impact on the environment. The decrease in the rate of impact generation and impact output (76% to 91%) means that the modified process has an environmental impact that is roughly one tenth that of the base plant. Lastly, the decrease in the output of waste mass per mass of product indicates that the modified plant will lose less valuable material in its operation.

FUTURE WORK

In addition to the topics already mentioned, there are two other issues that need to be further mentioned in relation to the WAR Algorithm: Engineering Economics and Computer Aided Process Design. However, both of these are beyond the scope of this paper which is to present the basic generalized waste reduction or WAR Algorithm and to illustrate its use. Engineering Economics and Computer Aided Process Design are the subject of present and future research, and they are included here only for completeness and to aid interested readers applying the method and furthering the work.

Engineering Economics

Whenever a process is modified to reduce waste, there is a consequent change in the economics associated with it. Economic changes are generally due to: (1) the addition or removal of capital equipment, (2) an increase or decrease in energy consumption, (3) a change in the rate of consumption of feed material, and (4) a change in the rate of product generation. When a process is modified, all of the above are frequently affected. There are well established methods for estimating the economics of chemical processes either manually (Peters and Timmerhous, 1968; Richardson Engineering Services, 1997) or with the aid of a computer (ICARUS, 1997; Aspen Technology, 1997).

Modification of a chemical process using the WAR Algorithm needs to be done along with an evaluation of the economic consequences of any proposed process modifications, *i.e.*, one needs to simultaneously compare both the potential environmental impact and the cost of alternate process flowsheets. The reason is that the ultimate objective is always that of developing cost effective reductions in pollution. Unfortunately, there are no consensus criteria for cost effective waste reduction. Although one possibility, consistent with traditional process design procedures, is to require that the sum of the capital and operating costs should not increase with proposed process modifications from the base configuration. This can be expressed as,

$$\left[C_o + C_c\right]_{Base} \geq \left[C_o + C_c\right]_{Modified} \qquad (12)$$

where C_o is the operating cost and C_c is the capital cost that can be estimated by one of the aforementioned methods or some another proprietary method. Equation (12) can then be used jointly with Equations (4) to (8) to evaluate alternative process flowsheets.

Computer Aided Process Design

While it is often possible to devise pollution reducing modifications from an inspection of the process flowsheet, there are many situations where a more systematic approach such as computer aided process design and optimization may be required. This is particularly important with very complex processes that are difficult to analyze by inspection. The WAR Algorithm can be used in computer aided process design and optimization. This can be done by employing the indexes of Equations (4) to (8) as objective functions in a mathematical optimization subject to a cost constraint such as Equation (12). For example, one could minimize the output of potential environmental impact per mass of product given by Equation (7) subject to keeping the total cost from increasing. This can be expressed as,

$$Minimize\ \hat{I}_{out}^{NP} = \hat{I}_{out}^{NP}(\dot{\underline{M}}^{(out)}, \underline{x}_1^{NP}, \underline{x}_2^{NP}, \ldots, \underline{x}_n^{NP}, \dot{\underline{P}}) \quad (13)$$

subject to Equation (12) where $\dot{\underline{M}}^{out}$ is the vector of mass flowrates for all the output streams, $\underline{x}_i^{NP}$ is the vector of mass fractions for non-product component i in all output streams, and $\dot{\underline{P}}$ is the vector of mass flowrates for all products. The optimization could involve the variation of operating variables and modification of the flowsheet configuration both. In this way one can systematically reduce the pollution indexes even in very complex processes. There are several robust algorithms such as simulated annealing (Kirkpatrick *et al.*, 1983; van Laarhoven and Aarts, 1987) that can be successfully used along with mixed integer programing (Grossmann, 1985; Grossmann, 1990) here.

CONCLUSIONS

A general theory and a methodology for incorporating pollution reduction into chemical process design has been presented. The work is still at an early stage of development particularly with respect to its application. However, the fundamental bases along which future work will proceed have been established.

When used in conjunction with chemical process simulators, the WAR Algorithm offers a powerful methodology for evaluating the potential environmental impact of alternative process flow sheets. Although, the WAR Algorithm is intended for use as part of a good faith effort to reduce the environmental foot print of process plants, and it does not obviate the need to make judicious engineering and environmental decisions. For example, there is no completely unambiguous way of setting values for the impact weighting factors or α_l's. The reason is that the α_l's represent the value that society places on particular types of environmental impacts, and this will vary across locations, cultures, and even time. One should point out, however, that engineering design practice has always used human judgement in determining any number of design parameters like safety factors., and,

therefore, this dilemma is not new.

Never the less, there is a need to further improve the methodology for estimating potential environmental impacts and the weighting factors, there is a need to incorporate economics into the analysis, and there is a need to include computer aided process design and optimization. Future work will address these issues. The case studies, however, do illustrate that even in its present state the methodology is a useful process design tool.

ACKNOWLEDGMENTS

The authors wish to acknowledge the support of Chemstations, Inc., Houston, Texas under a Cooperative Research and Development Agreement with the U.S. Environmental Protection Agency. The authors also thank Dr. Douglas Young at the U.S. Environmental Protection Agency for critiquing the manuscript.

LIST OF SYMBOLS

C_c Capital costs associated with a chemical process, monetary

C_o Operating costs associated with a chemical process, monetary

I_{syst} Potential environmental impact content of system, impact

$\dot{I}_{in}$ Potential environmental impact input rate, impact/hour

$\dot{I}_{out}$ Potential environmental impact output rate, impact/hour

$\dot{I}_{gen}$ Potential environmental impact generation rate, impact/hour

$\dot{I}_{in}^{(i)}$ Potential environmental impact flow of stream j input (i=*in*) or output (i=*out*), impact/hour

$\dot{I}_{gen}^{NP}$ Potential environmental impact generation rate by non-products, impact/hour

$\dot{I}_{out}^{NP}$ Potential environmental impact output rate due to non-products, impact/hour

$\dot{I}_{in}^{NP}$ Potential environmental impact input rate due to non-products, impact/hour

$\hat{I}_{gen}^{NP}$ Specific potential environmental impact generation from non-products, impact/ kilogram

$\hat{I}_{out}^{NP}$ Specific output of potential environmental impact due to non-products, impact/kilogram

$\dot{M}_j^{(i)}$ Mass flow rate of stream j, input (i=*in*) or output (i=*out*), kilograms/hour

$\underline{\dot{M}}^{out}$ Vector of mass flowrates for all output streams, kilograms/r hour

$\hat{M}_{gen}^{NP}$ Specific generation of non-product mass, kilograms/kilogram

$\hat{M}_{out}^{NP}$ Specific output of non-product mass, kilograms/kilogram

$\dot{P}_p$ Mass output rate of product p, kilograms/hour

$\underline{\dot{P}}$ Vector of mass flowrates for all products, kilograms/hour

x_{kj} Mass fraction of chemical k in stream j

x_{kj}^{NP} Mass fraction of non-product k in stream j

$\underline{x}_i^{NP}$ Vector of mass fractions for non-product component i in all output streams, kilograms/kilograms

α_l Chemical independent relative weighting factor for impact of type l, impact/kilogram

Φ_n Pollution index, kilograms/kilogram

σ_j Standard deviation of all chemical scores in impact category j, no units

ψ_j Overall potential environmental impact of chemical j, impact/kilogram

$\psi_{j,l}^s$ Specific (s) potential environmental impact of chemical j for impact of type l, impact/kilogram

$(Score)_{ij}$ Relative potential impact score of chemical i for impact of type j, no unit

$\langle (Score)_{ij} \rangle_j$ Arithmetic average of the scores for all chemicals i in impact category j, no units

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APPENDIX E

REFERENCE DOCUMENTS COVER PAGES

United States
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EPA/625/7-90-004
February 1990

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Guides to Pollution Prevention

The Pesticide Formulating Industry

210

G-243

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Environmental programs that focus on the end of the pipe or the top of the stack, on cleaning up after the damage is done, are no longer adequate. We need new policies, technologies, and processes that prevent or minimize pollution — that stop it from being created in the first place.

— President George Bush
October, 1990

January 1991

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Creative Approaches to Pollution Prevention Training

A Compendium of Exercises and Activities

U.S. Environmental Protection Agency

1993

212

United States
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International (Non-U.S.) Industrial Pollution Prevention:

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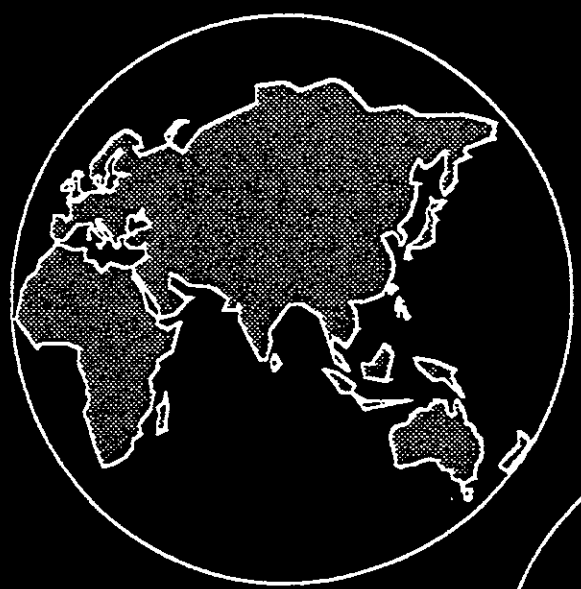

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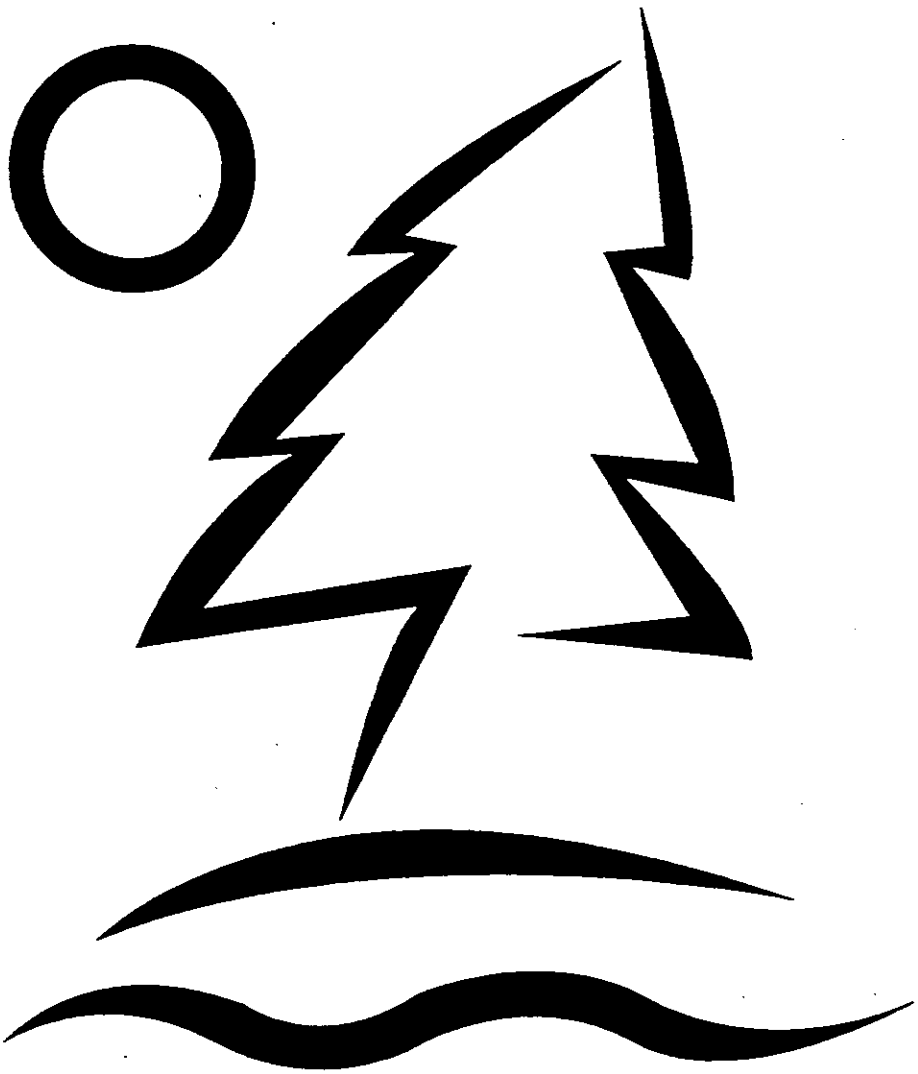

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Environmental Pollution Prevention Project

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Training Manual

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1530 Wilson Boulevard, Suite 900
Arlington, VA 22209-2406
HBI Reference No. TR-95-061

Environmental Pollution Prevention
Project Number 936-5559
Contract Number PCE-5559-Q-00-3022-00

July 1995

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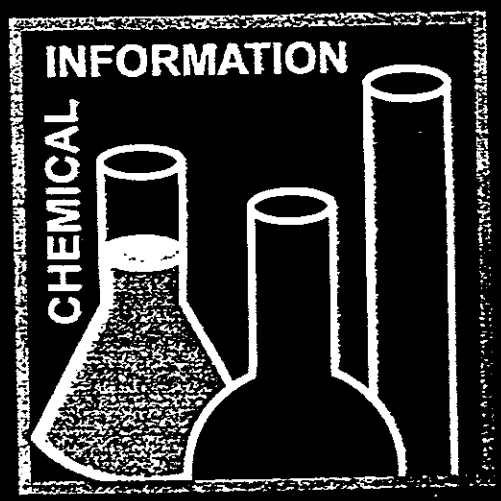

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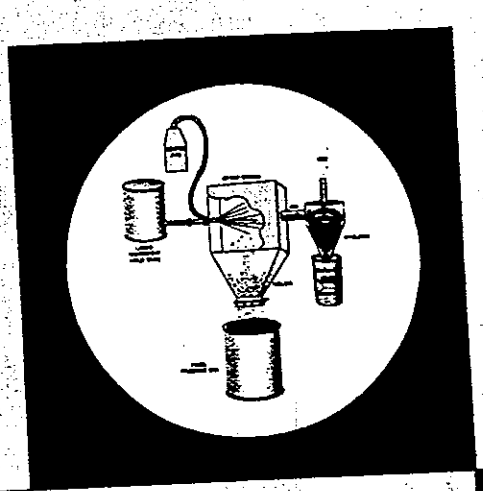

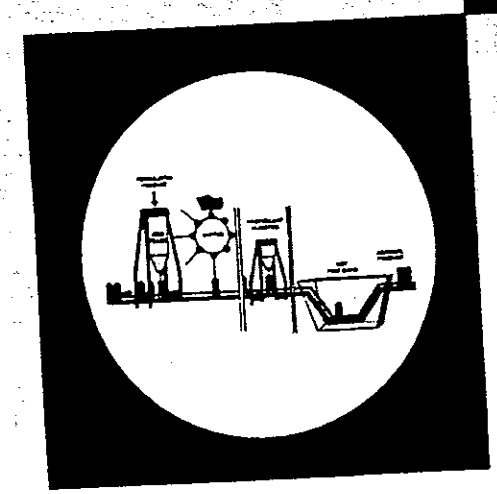

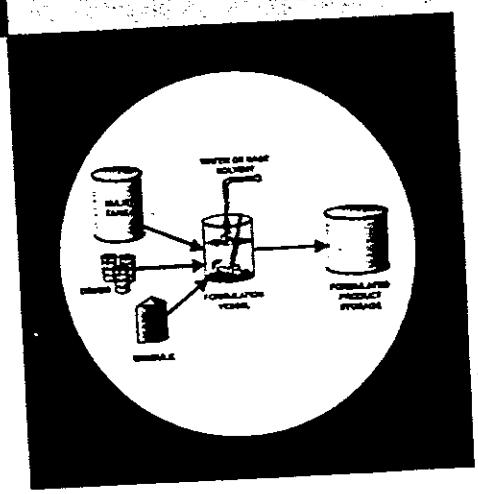

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July 1998

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design FOR THE ENVIRONMENT

Environmental Management System Bulletin 1

Design for the Environment U.S. EPA

BULLETIN HIGHLIGHTS

- Benefits of an EMS based on DfE concepts
- Real-world examples of benefits from the Acushnet Rubber Company

ALSO IN THIS BULLETIN

- What is an EMS?
- Facility profile of Acushnet

Tony Mello and Ray Lalievre of Achushnet Rubber Company discuss their facility's EMS.

Using Design for the Environment Concepts in Your EMS

An Environmental Management System (EMS) can provide a company with a systematic way to improve its operations for better environmental performance. While an EMS supplies the basic management framework, EPA's Design for the Environment (DfE) Program provides guidance and tools to help companies achieve continuous environmental improvement. The DfE approach encourages companies to consider environmental and human health risks in all business decisions. In addition, it encourages companies to evaluate cleaner processes, technologies, and workplace practices.

Why Establish a DfE-Based EMS?

A DfE-based EMS provides a company with opportunities to go "beyond compliance" and save money. The DfE approach can help a company meet the objectives of its EMS by promoting the evaluation of cleaner production alternatives. By implementing these alternatives, a company can continuously improve its environmental performance.

In addition, an EMS encourages the systematic evaluation of each area of the company's operation. An EMS can provide the following benefits:

- improved worker health and safety
- reduced costs — greater efficiency means fewer materials used and less time and energy wasted
- increased business opportunities — customers may start requiring their suppliers to have an EMS

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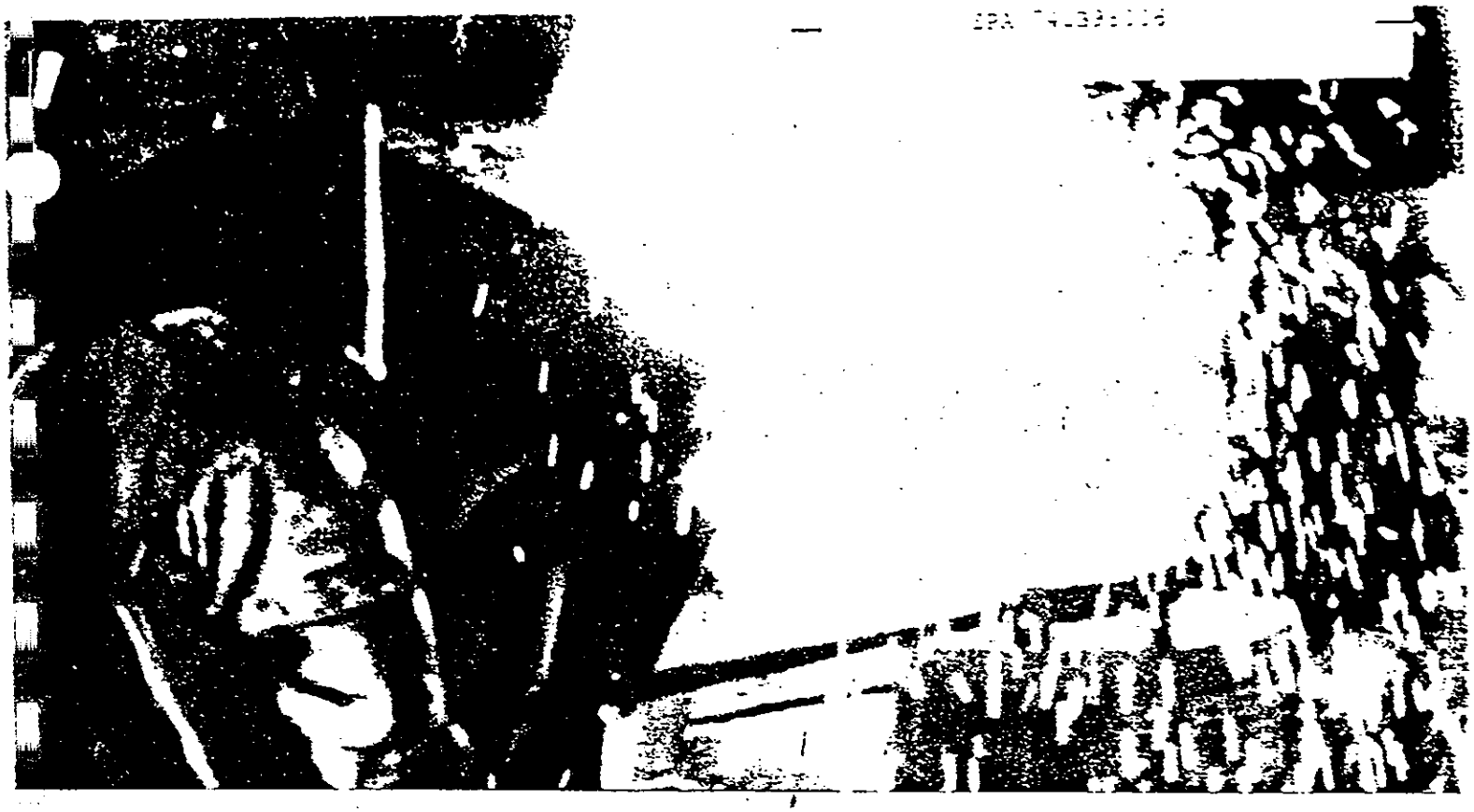

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A Manual for Pollution Prevention Technical Assistance Providers

WMRC

Hazardous Waste Reduction Program of Oregon

Guidelines for Waste Reduction and Recycling

Metal Finishing
Electroplating
Printed Circuit Board Manufacturing

a program of
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A PRACTICAL GUIDE TO POLLUTION PREVENTION PLANNING FOR THE IRON AND STEEL INDUSTRIES

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EPA/600/S-95/019 September 1995

EPA ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Electroplated Truck Bumpers

Richard J. Jendrucko*, Thomas N. Coleman*, Brian T. Hurst*, and Gwen P. Looby**

Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. In an effort to assist these manufacturers Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at the University of Tennessee performed an assessment at a plant that manufactures electroplated bumpers and miscellaneous parts for trucks. Steel and aluminum parts received from a nearby facility are cleaned, rinsed, etched, and electroplated. The team's report, detailing findings and recommendations, indicated that a considerable amount of wastewater treatment sludge is generated from the onsite treatment of wastewater, and that significant waste reduction and cost savings could be achieved by reducing drag-out from the plating tanks.

This Research Brief was developed by the principal investigators and EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center.

Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste generation is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, PA) has begun a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the in-house expertise to do so. Under agreement with EPA's National Risk Management Research Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Tennessee's (Knoxville) WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The pollution prevention opportunity assessments are done for small and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $75 million, employ no more than 500 persons, and lack in-house expertise in pollution prevention.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

Methodology of Assessments

The pollution prevention assessments require several site visits to each client served. In general, the WMACs follow the

* University of Tennessee, Department of Engineering Science and Mechanics
** University City Science Center, Philadelphia, PA

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Pollution Prevention for the Metal Finishing Industry

A Manual for Pollution Prevention Technical Assistance Providers

February 1997

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A Demonstration Project of the Industrial Pollution Prevention Project (IP3)

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EPA/600/S-95/010 August 1995

EPA ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Bourbon Whiskey

Marvin Fleischman*, Debra Cambron*,
and Gwen P. Looby**

Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at the University of Louisville performed an assessment at a plant that produces bourbon whiskey. Grains are ground, cooked, and fermented using yeast. The resulting fermented product is sent to a beer still for alcohol recovery. Overhead vapors go to a doubler from which they flash yielding a new whiskey. The new whiskey obtained is stored in charred wooden barrels for several years and, after maturation, is shipped offsite for bottling. The team's report, detailing findings and recommendations, indicated that carbon dioxide and ethanol are vented to the atmosphere in large quantities and that significant cost savings could be realized through carbon dioxide and ethanol recovery.

This Research Brief was developed by the principal investigators and EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center.

*University of Louisville, Department of Chemical Engineering.
**University City Science Center, Philadelphia, PA.

Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste generation is to reduce or eliminate the waste at its source.

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The pollution prevention opportunity assessments are done for small and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $75 million, employ no more than 500 persons, and lack in-house expertise in pollution prevention.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

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Executive Summary

The model proposed to be used for the measurement of pollution reduction in the Philippines under the Industrial Initiatives for a Sustainable Environment (IISE) project has been developed. The approach used by the model is based on the relative risk of a process in comparison to alternatives. This ensures that all the environmental pollution pathways are considered, implementing multi-media pollution reduction. The model measures Potential Environmental Impact (PEI) of the output streams of the process.

A fundamental task of the project is to conduct in-plant P2/CP assessments. To accomplish the project's pollution reduction goal, a "baseline" must be established at each facility that documents the current hazardous waste streams. These data and information will be gathered by teams of appropriately trained personnel including those familiar with the processes being evaluated and P2 engineers, at a minimum. After gathering facility information, the P2 engineer will evaluate the data, establish the pollution baseline, and prepare an "alternatives evaluation." Following implementation of P2/CP alternatives, the updated potential risk would be compared to the baseline level.

The model developed for this project is the Risk Reduction Measurement Model (R2M2). The model is based on earlier work performed by the US Environmental Protection Agency (US EPA). This earlier work, the Waste Reduction (WAR) algorithm, examines all the waste streams of a process for targeted chemicals, and quantifies the risk based on the chemicals present and mass loading of each chemical. Risk is quantified for the following categories:

1. Global warming potential,
2. Acid rain potential,
3. Photochemical oxidation potential,
4. Ozone depletion potential,
5. Aquatic toxicity potential,
6. Terrestrial toxicity potential,
7. Human toxicity potential by ingestion, and
8. Human toxicity potential by inhalation or dermal exposure.

One modification made to the WAR algorithm is the inclusion of an additional parameter, β, which introduces the probability to the calculation of potential environmental impact. The parameter β is used to account for the reduction of risk of release of chemicals to the environment. This parameter would be used, for example, where exposure to the worker is reduced by the implementation of the workers wearing PPE or better waste management practices that would lessen the probability of release to an environmental medium.

R2M2 is proposed to be used for the evaluation of processes. In instances where the resources are not available to perform a complete risk reduction approach using R2M2,

or the process does not contain targeted chemicals in any of the waste streams, a second model, the Mass Tracking Model (MTM), is proposed for used. This model would simply track reduction in waste stream loading of a gross parameter or a specific chemical.

The following conclusions are presented with respect to P2/CP measurement model development:

1. The IISE Project assumes that environmental risk is an appropriate parameter for measuring P2/CP progress.
2. Reduction of environmental risk can be quantified in a relative sense by comparing baseline risk to the risk determined following implementation of P2 alternatives. The proposed methodology for measurement is based on research conducted by the US EPA.
3. US EPA's "WAR" algorithm is suitable for use in the IISE project and can be enhanced by incorporating a probability factor. The proposed R2M2 algorithm allows the user to insert a coefficient that reduces the calculated potential environmental impact for cases in which probability of environmental impact is reduced.
4. Not all of P2/CP assessments will use the R2M2. Where IISE-targeted chemicals are not present, a waste loading model, MTM, will be used.

The following recommendations are proposed for the next steps in the P2/CP portion of the IISE project:

1. The IISE team should develop concurrence on using the R2M2/MTM approach for the P2/CP assessment task. MSE should be authorized to meet with US EPA within the next month to review MSE's approach and obtain EPA's concurrence.
2. The R2M2 conceptual model should be fully developed into a user-friendly tool that can be used by the P2/CP personnel of the IISE team. Specifically, Visual Basic or other commonly available software can be used to write the R2M2 program that walks the user through the P2/CP evaluation process. This task should be authorized by Chemonics International prior to the conduct of further P2/CP training. MSE is prepared to lead the model preparation.
3. MSE should be authorized to further expand the beta table, consulting with the IISE team in Cebu.
4. The P2/CP assessment training should be authorized to MSE. The training should incorporate general information on P2, R2M2, and MTM. The course should be "hands-on" in the nature allowing participants to walk through the evaluation process for actual IISE project participants.

SECTION 1

INTRODUCTION

1.1 Background

Chemonics was awarded the Municipal Coastal Environmental Initiative (MCEI) contract by the United States Agency for International Development on 24 July 1998. This contract, subsequently renamed IISE (Industrial Initiatives for a Sustainable Environment), will operate in the Visayas and Mindanao regions of the Philippines, with support from the project field headquarters in Manila. To accomplish the objectives of the project, the IISE team will work closely with its partners to create a self-sustaining, multi-stakeholder program that will encourage adoption of environmental management systems and application of pollution prevention / cleaner production (P2/CP) technologies.

A fundamental task of the project is to conduct in-plant P2/CP assessments. The IISE project will result in the conduct of P2/CP assessments at 400 firms and a 20% reduction in pollution. To accomplish this, a "baseline" must be established at each facility that documents the current characteristics and flow of its hazardous waste streams. These data and information will be gathered by teams of appropriately trained personnel including those familiar with the processes being evaluated and P2 engineers, at a minimum. After gathering facility information, the P2 engineer will evaluate the data, establish the pollution baseline, and prepare an "alternatives evaluation." Following implementation of P2/CP alternatives, the updated potential risk would be compared to the baseline level.

1.2 Proposed Use of Models

A proposed method for establishing the baseline and measuring progress was conceptualized. The basic approach is to "measure" the level of potential risk for each chemical appearing in any of a facility's waste streams. Two models are proposed to be utilized. The first model, the Risk Reduction Measurement Model (R2M2), would be used where the waste streams of the process contain IISE-targeted chemicals. All processes would be investigated using the R2M2 unless the waste streams in the process do not contain target chemicals or chemicals likely to be added to the list of targeted compounds. Targeted chemicals are currently those on the Philippines list of 28 chemicals (RP 28) from RA 6969 and the Priority Organic Pollutants (POPs) list. These chemicals are listed in Table 1.1. (Note that tables and figures are located at the end of each section.) Additional chemicals may be added to the target list later as needed to expand the use of the risk reduction model.

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The second model that is proposed is the Mass Tracking Model (MTM). This model would be used to measure reduction of chemicals contained in waste streams of a process that do not contain targeted chemicals. This model accounts for sheer reduction in mass flow rates of waste streams. The MTM would be used when the process does not contain targeted chemicals in any of the waste streams, or does not contain chemicals likely to be added to the list of targeted chemicals in any of the waste streams.

1.3 Purpose of Report

This report documents how R2M2 will be used as the key P2/CP measurement tool for the IISE project. The algorithm is based on the U.S. Environmental Protection Agency's (EPA) Sustainable Technology Division Office (Cincinnati) research with the Waste Reduction (WAR) algorithm, which is documented in the articles included in Appendix A. Discussions between MSE and the EPA authors, Young and Cabezas, indicated the appropriateness of EPA's WAR algorithm to the IISE project. MSE requested that EPA provide a limited matrix of data used in the WAR algorithm to accommodate the chemicals that will be evaluated in the IISE project. (These data are included in Appendix B).

The R2M2 will be developed by modifying the WAR algorithm to accommodate the objectives of the project. The WAR algorithm includes relative risk values (health and environmental impact categories) for a number of chemicals, including most of the RP 28.

1.4 Report Organization

This report is divided into four sections and appendices. Following this section, Section 2 provides a description of the WAR algorithm and the development of R2M2, along with some examples. A description of the MTM is contained in Section 3. Finally, conclusions and recommendations from this task are included in Section 4.

Appendix A contains copies of articles on the development of the WAR algorithm. Appendix B contains a copy of the database values used to develop the potential environmental impact of each chemical. Appendix C contains calculations used in the examples shown in the report.

Table 1.1—IISE Target Chemicals

Chemcial	Category
Aldrin	POPs
Arsenic	RP28
Asbestos	RP28
Benzene	RP28
Beryllium	RP28
Cadmium	RP28
Carbon Tetrachloride	RP28
Chlordane	POPs
Chlorinated Ethers	RP28
Chlorofluorocarbons	RP28
Chloroform	RP28
Chromium	RP28
Cyanide	RP28
DDT	POPs
Dieldrin	POPs
Dioxins	POPs
1,2-Diphenylhydrazine	RP28
Endrin	POPs
Ethylene Dibromide	RP28
Ethylene Oxide	RP28
Furans	POPs
Halons	RP28
Heptachlor	POPs
Hexachlorobenzene	RP28 & POPs
Hexachloroethane	RP28
Lead	RP28
Mercury	RP28
Mirex	RP28 & POPs
Pentachlorophenol	RP28
Phosgene	RP28
Polybrominated Biphenyls	RP28
Polychlorinated Biphenyls (PCBs)	RP28 & POPs
Selenium	RP28
Toxaphene	POPs
Tributyltin	RP28
1,1,1-Trichloroethane	RP28
Vinyl Chloride	RP28

Notes:

RP 28 - Philippines list of 28 chemicals from RA 6969
POPs - Priority Organic Pollutants list

SECTION 2

RISK REDUCTION MEASUREMENT MODEL

2.1 Purpose of the Model

A model is proposed for quantification of pollution-related risk reduction as a function of environmental impact for the chemicals of concern. Use of an algorithm ensures consistent application of the parameters selected for measurement. Given the number of facilities and processes that are to be investigated, consistency in the assignment of relative risk is critical to successful measurement. The model proposed for the IISE P2/CP project is based on the WAR algorithm.

2.2 Description of the WAR Algorithm

EPA's WAR algorithm has been designed to evaluate the relationship of competing process alternatives. The WAR algorithm considers input and output streams of a process. Figure 2.1 illustrates typical streams to and from a generic process. For a given process, several input streams (which may be comprised of material in the solid, liquid, or gaseous phase) are used in an effort to generate a product. The process typically also will have several non-product streams (which may be comprised of material in the solid, liquid, or gaseous phase) that result from the process. The portion of the WAR algorithm discussed below deals with the product stream and non-product output streams.

The WAR algorithm was developed primarily for comparison of process alternatives; however, one can apply the concepts of the WAR algorithm to establish an impact baseline and measure improvement over time. The algorithm assumes that each chemical stream entering and exiting a process possesses an inherent property, its potential environmental impact (PEI). The impact of chemicals found in industrial processes and in their associated waste streams is evaluated for several different impact categories. These include:

1. Global warming potential,
2. Acid rain potential,
3. Photochemical oxidation potential,
4. Ozone depletion potential,
5. Aquatic toxicity potential,
6. Terrestrial toxicity potential,

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7. Human toxicity potential by ingestion, and

8. Human toxicity potential by inhalation or dermal exposure.

The first four categories represent atmospheric impact categories. The remaining four represent local toxicological impact categories.

The PEIs for input and output streams are evaluated separately. For example, the PEI associated with the output streams of a process is calculated by analyzing each of the waste streams generated from the process. Each of the specific chemicals for each waste stream are evaluated. Based upon the impact category values associated with each chemical, the concentration of the chemical in the waste stream, and the mass flow rate of the waste stream, the PEI is determined for each chemical in each waste stream. The PEI of the process is the sum of the PEI for all the chemicals in all the waste streams of the process.

The PEI for each chemical is based upon a specific score for each of the eight impact categories. Table 2.1 provides the methodology for determining scores for each category. For example, the human toxicity potential by ingestion is based upon the lethal-dose that produced death in 50% of rats by oral ingestion (LD_{50}). The human toxicity potential by inhalation or dermal exposure is based on the time-weighted average of the threshold limit value. Scores for atmospheric categories are based upon the ratio of the chemical's adsorption/release/reaction rate compared to the reaction/release/adsorption rate of a chemical standard.

After the scores for each chemical are determined, they are normalized within each category. Normalization ensures that, on average, the impact potential for different categories will have equivalent values. The normalized values are represented by the parameter Ψ. Ψ is calculated by dividing each chemical score by the average of all the chemical scores within that category. (The database currently contains chemical scores for over 1600 chemicals.) Therefore, it is not the absolute Ψ value for each chemical that is important, but rather, the chemical's Ψ value relative to other chemicals' Ψ values. Without normalization, implicit weighting could be present in the chemical database causing unintentional bias in the calculation of the PEI indexes. Normalizing each category by the average value of entries in that category insures that the average value in that category will be unity. The units of Ψ are potential environmental impact (PEI) per kilogram (kg) of chemical.

The WAR algorithm also allows the user to weigh each of the eight impact categories above in order of importance. This weighting factor, represented by the parameter α, is a value between zero and ten. The parameter α is dimensionless. For purposes of the IISE, α is proposed to have a value of 1 for all categories.

The overall PEI per kg of chemical j, Ψ_j, is calculated using the following equation:

$$\Psi_j = \sum_k \alpha_k \Psi_{jk} \tag{1}$$

where the summation k is taken over all impact categories.

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The overall PEI of the process, I_{out}, is given by the following equation:

$$I_{out} = \sum_i I_i^{(out)} = \sum_i \dot{M}_i^{(out)} \sum_j x_{ij} \Psi_j \tag{2}$$

where the summation i and j are taken over all waste streams and chemicals, respectively, $I_i^{(out)}$ is the PEI of waste stream i, $\dot{M}_i^{(out)}$ is the mass flow rate of the waste stream i in units of kg per time, and x_{ij} is the mass fraction of component j in waste stream i. The units of I_{out} are PEI/time.

2.3 R2M2 Description

One of the limitations of the WAR algorithm is that the relative risk or probability of environmental impact is not addressed. For example, consideration is not given between the scenario where a waste stream enters the environment uncontrolled and another where proper waste management practices are in place. The former situation represents a higher risk than the latter. For the IISE project, risk reduction is a key objective for the P2/CP program; progress measurements, therefore, should be a function in terms of risk reduction.

The Risk Reduction Measurement Model is proposed as a useful variation of the WAR algorithm to accommodate the need to account for risk reduction. A modification to the WAR algorithm for this project incorporates a new parameter accounting for the probability of the waste stream being released to the environment in certain cases. The disposition of the waste stream is important because, for example, the environmental impact of the discharge of a liquid waste stream to the site soil and groundwater is much greater than the impact of the same liquid stream captured in drums and treated at an approved facility. Thus, the relative risk posed by PEI in a process can be reduced if a waste stream can be more effectively managed.

The introduction of a risk coefficient, β, is proposed to modify the WAR equation. Incorporation of β modifies the result of the WAR algorithm to yield a term PEI*, which can be called "risk-reduced potential environmental impact." The overall PEI* of a chemical is given by the equation:

$$\Psi_j^* = \sum_k \beta_k \alpha_k \Psi_{jk} \tag{3}$$

The PEI* of the process is calculated using Equation 2. An example of the usefulness of the risk coefficient is illustrated in the case of personnel protective equipment (PPE) that is implemented in a painting process. Appropriate PPE reduces the human toxicity potential by inhalation or dermal exposure; β can be used to distinguish the relative risk of a hazardous solvent and/or metallic pigment in the breathing zone of the worker versus the case where the worker wears PPE. Thus in this case, a β value less than 1 (assumed for PPE usage in that the risk of exposure to the user is reduced) would reduce the net PEI* level. A value of β can be assumed for each relevant environmental impact category.

In general, β would be assigned a value of 1 in the baseline scenario. If a process

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change (or housekeeping change) is made, the value of β would be adjusted to a value less than 1 as appropriate. The parameter is meant to be more of a "fine tune" adjustment to PEI*, and is not expected to have as much significance as, for example, those processes where highly toxic chemicals are replaced with those less toxic. Rather, it will serve as a tool to accommodate reduction in risk where changes in housekeeping or disposition of wastes may be the only possible alternatives available at a facility. Preliminary examples of β values are shown in Table 2.2.

The model logic is shown in Figure 2.2. This logic is a necessary preliminary design step prior to construction of the program that will be used to calculate the PEI* of the process. The logic of the model begins by identification of the process. Next, a waste stream and its characteristics, such as mass flow rate and management/disposition of the waste, are identified. The appropriate β value for the disposition/exposure is retrieved. Then, each chemical is identified, and its Ψ values are retrieved. The concentration of the chemical in the waste stream is input, and the PEI* of the chemical is calculated. This is repeated for any additional chemicals. The PEI* value of all chemicals is summed to determine the waste stream PEI*. This procedure is repeated for each waste stream from the process. The PEI* of the waste streams is summed to determine the overall PEI* of the process.

2.4 R2M2 Inputs

PEI* must be calculated for each process in which R2M2 is employed. Each process may be comprised of several waste streams, and several chemicals may be found in each waste stream. Figure 2.3 illustrates the flow logic of identifying all the information inputs required for the algorithm.

After the processes at the facility have been identified and chosen for evaluation in the R2M2, the process must be looked at in detail in an effort to identify all the waste streams in the process and the waste stream flow rates. Each waste stream is then investigated to determine the chemicals in the waste stream and their concentrations. Only chemicals on the target list (or those that are likely to be added to the target list) will be investigated.

2.5 Examples of Use of R2M2

2.5.1 Painting Process

In this first example, a painting process uses a paint containing toluene, 1,2,4-trimethylbenzene, and zinc oxide. All the VOCs in the paint are assumed to act as carriers and volatize to the atmosphere. Output streams for this process are the VOC stream (to the atmosphere) and paint overspray. The amount of paint overspray depends on the efficiency of the paint gun and the experience of the painter. The overspray contains the pigment in the paint.

Table 2.3 shows a summary table of the calculations used in determining the process PEI*. Calculations for determining the percent of each chemical in each of the waste streams is shown in Appendix C. While the concentration of toluene and 1,2,4-

trimethylbenzene in the paint is 9 percent and 1 percent, respectfully, the concentrations increase to 19.6 percent and 2.2 percent in the VOC stream. The concentration of zinc oxide increases from 3 percent in the paint to 5.3 percent in the pigment waste stream.

Similarly, the mass of paint used by the process in a year is 235.8 kg. The mass of the VOC waste stream is 101.4 kg per year, and the mass of the pigment waste stream is 67.2 kg per year. The material applied to the product accounts for the balance of the pigment.

In the baseline case, the values of beta are set to a value of 1. The PEI* of each chemical is calculated, and then the PEI* of all the chemicals in all the waste streams is summed to give the process PEI*. The annual process PEI* for this process is calculated to be 40.

The alternative case utilizes a paint that does not contain any targeted chemicals. Therefore, the PEI* of the alternative is 0, and the PEI* reduction is 100 percent.

2.5.2 Kerosene Bath

Kerosene is often used to keep away insects in furniture manufacturing in the Philippines. Bamboo stock may be submersed in a kerosene bath for preservation. In this example, a 450 gallon bath is used to submerse the bamboo until needed in the process. Currently, the bath is emptied and refilled with kerosene every thirty days. The recommendations to reduce pollution are to cover the bath and ensure it is located out of direct sunlight in effort to reduce evaporative losses. These methods are expected to allow the bath to be emptied and refilled every 40 days. The calculated annual PEI*s of 4,500 and 3,400 for the Baseline and P2 Alternative 1, respectively, are shown in Table 2.4.

The second P2 alternative for this process is for the workers to wear PPE. Wearing of gloves when handling the bath and treated bamboo would reduce the value of β to 0.5. The annual PEI for Alternative 2 is 3,800.

The third alternative is to combine Alternatives 1 and 2. The annual PEI* for Alternative 3 is 2,900. This represents a 36 percent reduction in annual PEI from the baseline case.

Figure 2.1—Process Flow Diagram

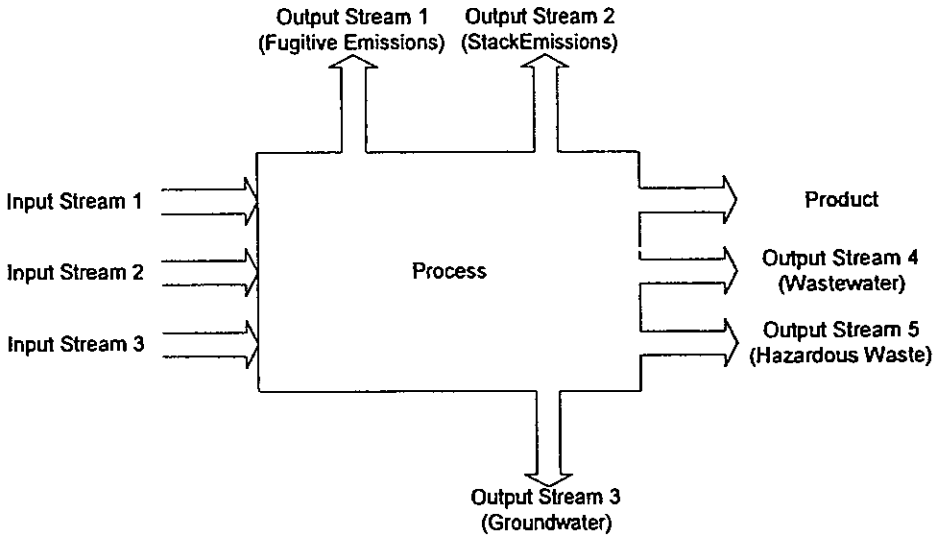

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Figure 2.2—R2M2 Logic Diagram

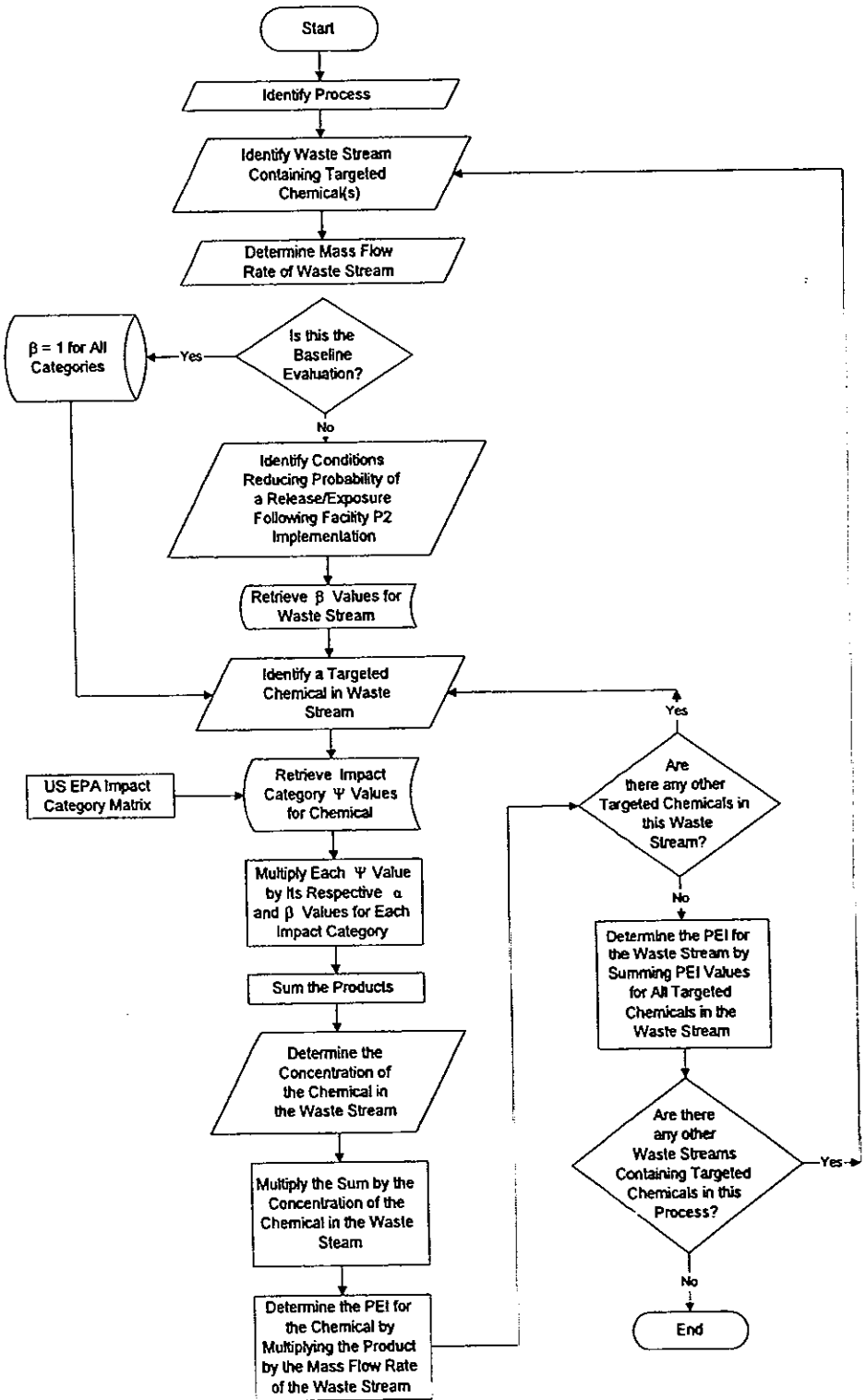

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Figure 2.3— R2M2 Baseline Data Collection Flow Sheet

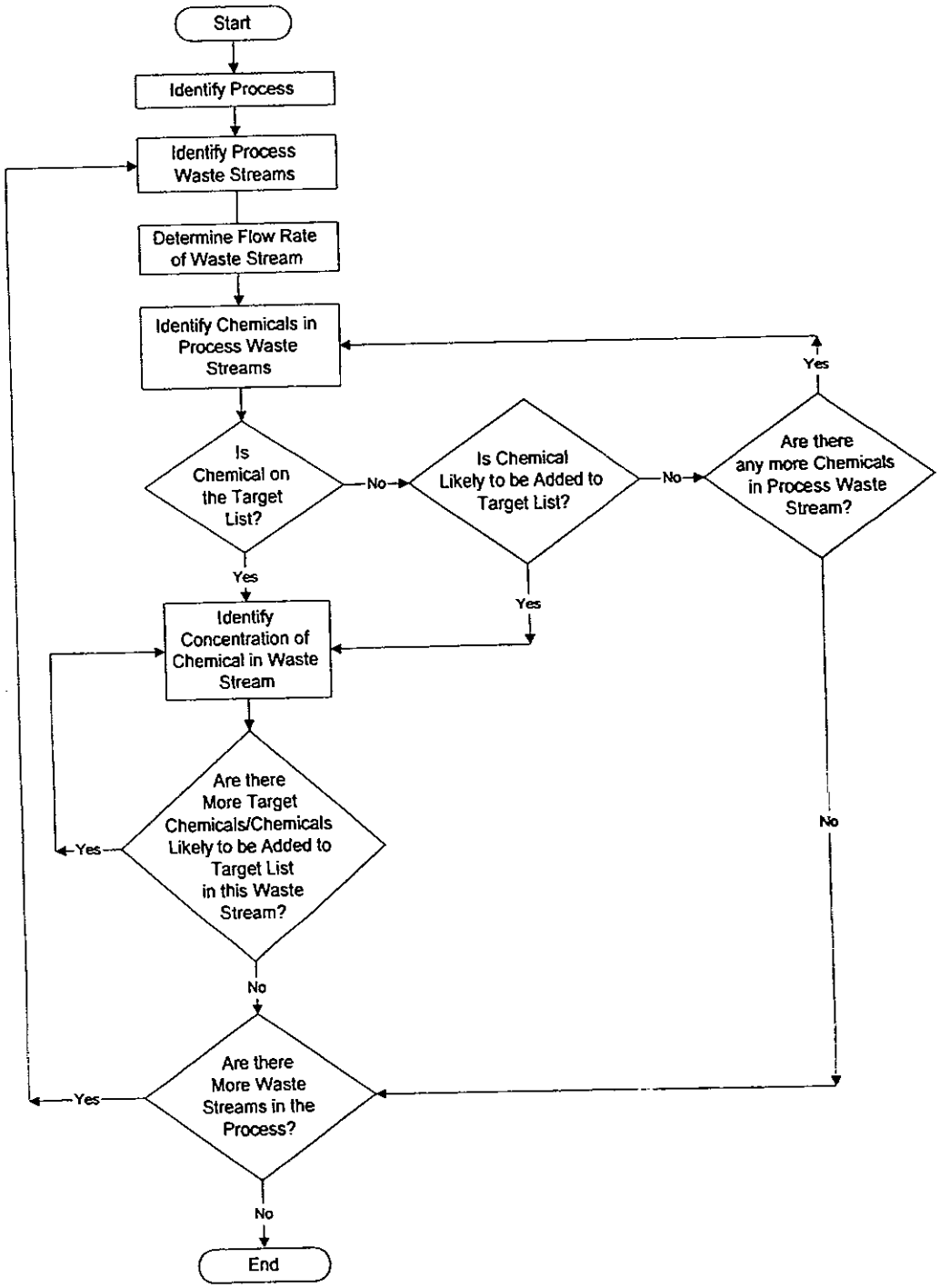

Table 2.1—Description of Parameters Used to Develop Ψ Values

Category	Description
Global Warming Potential	Ratio of the extent to which a unit of mass of a chemical adsorbs infrared radiation to the extent that CO_2 adsorbs infrared over a base time frame of 100 years.
Acidification Potential	Ratio of the release of a hydrogen ion in the atmosphere as promoted by a chemical to the rate of release of a hydrogen ion as promoted by SO_2.
Photochemcial Oxidation Potential	Ratio of the rate at which a unit mass of chemical reacts with a hydroxyl radical to the rate at which a unit mass of ethylene reacts with a hydroxyl radical.
Ozone Depletion Potential	Ratio of the rate at which a unit mass of chemical reacts with ozone to form molecular oxygen to the rate at which a unit mass of CFC-11 (trichlorofluoromethane) reacts with ozone to form molecular oxygen. The chemical must contain a chlorine or bromine atom.
Aquatic Toxicity Potential	The inverse of the lethal concentration that produced death in 50% of a representative species of fish.†
Terrestrial Toxicity Potential	The inverse of the lethal-dose that produced death in 50% of rats by oral ingestion.††
Human Toxicity Potential by Ingestion	The inverse of the lethal-dose that produced death in 50% of rats by oral ingestion.††
Human Toxicity Potential by Inhalation or Dermal Exposure	The inverse of the time-weighted average (TWA) of the threshold limit value (TLV).‡

Notes:

† The source of the lethal concentration that produced death in 50% of a representative species of fish, fathead minnows, (LC_{50}) is AQUIRE, ECOSAR, Parger's *Environmental Contaminant Reference Handbook*, 1995, and *Handbook of Environmental Data on Organic Chemicals,* by Karel Verschueren.

†† The source of lethal-dose that produced death in 50% of rats by oral ingestion (LD_{50}) is *Sax's Dangerous Properties of Industrial Materials*, by Richard J. Lewis, 3rd Edition, the *Hazardous Substance Data Bank*, and the *Registry of Toxic Effects of Chemical Substances,* edited by Doris V. Sweet.

‡ The source of the time-weighted average (TWA) of the threshold limit value (TLV) is the Occupational Safety and Health Administration, the American Conference of Governmental Industrial Hygienists, and the National Institute for Occupational Safety and Health.

Table 2.2—Preliminary R2M2 Beta Values

Condition		Impact Category							
		HTPI	HTPE	ATP	TTP	GWP	ODP	PCO	AP
Process Pollution Control									
PPC-1	Replace Paint Booth Water Curtain w/ Dry Filter	1	1	0.5	1	1	1	1	1
PPC-2	Improve Paint Booth Overspray Collection	0.7	0.7	1	0.5	0.9	0.9	0.9	0.9
PPC-3	Combine PPC-1 and PPC-2	0.7	0.7	0.5	0.5	0.9	0.9	0.9	0.9
Waste Management Practices									
WMP-1	Install Secondary Containment	1	0.7	0.5	0.5	1	1	1	1
WMP-2	Install Check Valves on Water Supply System In Vicinity of Process Waste Lines	0.5	0.9	0.9	1	1	1	1	1
WMP-3	Install Pressure Relief Valve on Pressure Vessel	1	0.5	1	1	0.7	0.7	0.7	0.7
Personal Protection Equipment									
PPE-1	Use Appropriate Respirator	1	0.5	1	1	1	1	1	1
PPE-2	Use Appropriate Splash Protection (Boots, Gloves, etc.)	0.7	0.7	1	1	1	1	1	1
General Housekeeping Practices									
GHP-1	Segregate Waste Streams	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.9
GHP-2	Establish / Implement Waste Handling Procedures	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

otes:

HTPI = Human toxicity potential by ingestion
HTPE = Human toxicity potential by inhalation or demeral exposure
ATP = Aquatic toxicity potential
TTP = Terrestrial toxicity potential (same method as HTPI)
GWP = Global warming potential
ODP = Ozone depletion potential
PCO = Photochemcial oxidation potential
AP = Acid rain potential

Table 2.3—Example Calculation: PEI of a Painting Process

Case	Waste Stream	Chemical	RP28/ POPs	Psi Values (impact/kg chemical) HTPI	HTPE	ATP	TTP	GWP	ODP	PCO	AP	Beta Values (dimensionless) HTPI	HTPE	ATP	TTP	GWP	ODP	PCO	AP	ΣβαΨ (impact/kg chemical	χ (%)	χ ΣβαΨ (impact/kg)	M (kg/year)	PEI (impact/year)
Baseline																								
	VOC	Toluene	n	0.0781	0.0004	0.0645	0.078			1.157		1	1	1	1	1	1	1	1	1.4	19.6%	0.270	101.4	27
	VOC	1,2,4-Trimethylbenzene	n	0.0781	0.0024	0.2863	0.078			2.466		1	1	1	1	1	1	1	1	2.9	2.2%	0.064	101.4	6.5
	Pigment	Zinc Oxide	n	0.7632	0.0591	0.001	0.763					1	1	1	1	1	1	1	1	1.6	5.3%	0.084	67.2	5.6
	Process PEI																							**40**
Alternative: Use of a High Acrylic Coating that does not contain targeted compounds																								0
		None																						0
	Process PEI																							
	PEI Reduction Between Alternative and Baseline																							**100%**

Notes:

HTPI = Human toxicity potential by ingestion
HTPE = Human toxicity potential by inhalation or demeral exposure
ATP = Aquatic toxicity potential
TTP = Terrestrial toxicity potential (same method as HTPI)
GWP = Global warming potential
ODP = Ozone depletion potential
PCO = Photochemcial oxidation potential
AP = Acid rain potential

Table 2.4—Example Calculation: PEI* of a Kerosene Bath Process

Case	Chemical	RP28/ POPs	Psi Values (impact/kg chemical) HTPI	HTPE	ATP	TTP	GWP	ODP	PCO	AP	Beta Values (dimensionless) HTPI	HTPE	ATP	TTP	GWP	ODP	PCO	AP	ΣβαΨ (impact/kg chemical	χ (%)	χ ΣβαΨ (impact/kg)	M (kg/year)	PEI (impact/year)
Baseline																							
	Kerosene	n	0.08	0	0.1	0.08	0	0	0	0	1	1	1	1	1	1	1	1	0.3	99.0%	0.278	16,158	4,499
	Process PEI*																						4,500
Alternative 1: Covering Bath, Moving out of direct Sunlight, extends life of Kerosene and maintains volume such that bath is replaced every 40 days instead of 30 days.																							
	Kerosene	n	0.08	0	0.1	0.08	0	0	0	0	1	1	1	1	1	1	1	1	0.3	99.0%	0.278	12,119	3,374
	Process PEI*																						3,400
Alternative 2: Workers begin wearing PPE (gloves and respirators) when handling material in bath and treated Bamboo stock.																							
	Kerosene	n	0.08	0	0.1	0.08	0	0	0	0	0.5	0.5	1	1	1	1	1	1	0.2	99.0%	0.236	16,158	3,809
	Process PEI*																						3,800
Alternative 3: Combine Alternatives 1 & 2																							
	Kerosene	n	0.08	0	0.1	0.08	0	0	0	0	0.5	0.5	1	1	1	1	1	1	0.2	99.0%	0.236	12,119	2,857
	Process PEI*																						2,900
	PEI Reduction Between Alternative 3 and Baseline																					**PEI Reduction =**	**36%**

Notes:

HTPI = Human toxicity potential by ingestion
HTPE = Human toxicity potential by inhalation or demeral exposure
ATP = Aquatic toxicity potential
TTP = Terrestrial toxicity potential (same method as HTPI)
GWP = Global warming potential
ODP = Ozone depletion potential
PCO = Photochemcial oxidation potential
AP = Acid rain potential

SECTION 3

MASS TRACKING MODEL

3.1 Introduction

The MTM is proposed for tracking pollution reduction for processes where the R2M2 is not used. The MTM can be used to address either a gross parameter, such as biological oxygen demand (BOD), or a specific chemical. As stated in Section 1.2, the MTM would only be used when the process does not contain targeted chemicals in the any of the waste streams, or does not contain any chemicals likely to be added to the list of targeted chemicals in the any of the waste streams. MTM is designed as a less rigorous approach to measuring pollution reduction than R2M2.

3.2 Description of MTM

The MTM is proposed to be used to measure reduction of mass loading of selected a parameter. The concentration of a chemical in the waste stream multiplied by the flow rate would determine the mass loading for that chemical in the wastestream. Summing the mass loading from each waste stream yields the mass loading from the process. Non-chemical specific parameters that could be used for the MTM include BOD, total organic carbon (TOC), and chemical oxygen demand (COD). These chemicals would not generally include IISE-targeted chemicals, since the R2M2 would be utilized for targeted chemicals. Similar to R2M2, a baseline scenario would be established for each process evaluated.

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SECTION 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The following conclusions are presented with respect to P2/CP measurement model development:

1. The IISE Project assumes that environmental risk is an appropriate parameter for measuring P2/CP progress.
2. Reduction of environmental risk can be quantified in a relative sense by comparing baseline risk to the risk determined following implementation of P2 alternatives. The proposed methodology for measurement is based on research conducted by the US EPA.
3. US EPA's "WAR" algorithm is suitable for use in the IISE project and can be enhanced by incorporating a probability factor. The proposed R2M2 algorithm allows the user to insert a coefficient that reduces the calculated potential environmental impact for cases in which probability of environmental impact is reduced.
4. Not all of P2/CP assessments will use the R2M2. Where IISE-targeted chemicals are not present, a waste loading model, MTM, will be used.

4.2 Recomendations

The following recommendations are proposed for the next steps in the P2/CP portion of the IISE project:

1. The IISE team should develop concurrence on using the R2M2/MTM approach for the P2/CP assessment task. MSE should be authorized to meet with US EPA within the next month to review MSE's approach and obtain EPA's concurrence.
2. The R2M2 conceptual model should be fully developed into a user-friendly tool that can be used by the P2/CP personnel of the IISE team. Specifically, Visual Basic or other commonly available software can be used to write the R2M2 program that walks the user through the P2/CP evaluation process. This task should be authorized by Chemonics International prior to the conduct of further P2/CP training. MSE is prepared to lead the model preparation.

3. MSE should be authorized to further expand the beta table, consulting with the IISE team in Cebu.
4. The P2/CP assessment training should be authorized to MSE. The training should incorporate general information on P2, R2M2, and MTM. The course should be "hands-on" in the nature allowing participants to walk through the evaluation process for actual IISE project participants.