# POLLUTION PREVENTION TIPS

## A First Step to Waste Reduction: The Six-Step Waste Audit

### Introduction

Now that State and Federal regulations are imposing more stringent limits on industrial facilities, it has become apparent that the traditional end-of-pipe treatment methods only move pollutants from one media to another. The once simple approach of treatment and disposal is a major expense and liability. Further, these practices may not provide adequate levels of control for pollutants now permitted.

In view of the current emphasis on environmental protection, industry managers who face increasing treatment costs yet wish to remain good corporate neighbors are forced to investigate alternate technologies for the elimination of waste. One such technology is waste reduction.

The reduction of waste at its source, where possible, coupled with the recovery, reuse, and recycle of wastes that cannot be eliminated, prevents pollution. Pollution prevention reduces and sometimes eliminates the need for treatment. Recovery, reuse, or sale of " waste" has in some cases resulted in new profit sources.

The best first step to waste reduction and, ultimately, total waste management, is a waste audit. Before pollution prevention can become the new way of doing business, industry and business managers must have a thorough understanding of what a waste is, where it comes from, what processes create it, and what technologies are available to eliminate it.

A waste audit can provide such an understanding. A simple audit comprising six steps that are easy to follow and understand can help identify the types, sources, and quantities of wastes being generated? More importantly, the audit can pinpoint the practices and procedures that generate waste. The final steps of the audit help managers develop the most cost-effective solutions to waste management and etablish necessary waste reduction training for employees.

**Pollution Prevention Program**
N.C. Department of Environment, Health, and Natural Resources

October 1993

## Definition

A waste audit can be considered a first step in a self-help process for determining the practices, procedures, and operating parameters that have resulted in high waste loads, excess water usage, environmental noncompliance, and reduced profitability.[3] An audit provides for collection and evaluation of the technical and financial data necessary to select waste reduction techniques.[1] With the identification of sources, quantities, and general types of waste, appropriate technology can be applied that will promote waste reduction at its source and/or recovery of lost product. The technology also will generate both short- and long-term economic and environmental benefits.

## Benefits of Audits

A waste audit can generate cost savings through a wealth of reductions:

- Reduced loss of raw ingredients or products;
- Reduced treatment costs;
- Reduced environmental fines or surcharges; and
- Reduced worker exposure and liabilities.

Additionally, new profit sources may be found through recovery of " waste" for reuse either within the plant or at other facilities.

Industry executives appreciate the significance of the corporate image, i.e., that the company is viewed as a good corporate neighbor. An intangible but very real benefit of a waste reduction program is that any negative publicity about environmental noncompliance is diminished or prevented. Public perception that a product is being produced by a responsible company and an environmentally safe method is a very real issue.

## Step No. 1: Corporate Commitment

The first step, which is critical to a successful waste audit and, ultimately, any waste management plan, is a clear, concise corporate commitment. A corporation's failure to commit fully the time, personnel, and financing required is one of the most formidable opponents of waste reduction and proper waste management. Management's full commitment is required if an effective program is to succeed.[4]

A detailed, written corporate policy concerning waste reduction and the environment should be developed. This document should not only outline policies and procedures for dealing with waste but should also detail organizational and individual responsibilities for all waste-related activities. Further, this policy should establish realistic yet achievable environmental goals for the company.

Employees will be aware of the degree of commitment set forth at the corporate level and will rise or fall to the level that is expected or allowed. It is, therefore, important to have realistic goals that can be achieved, recognized, and rewarded.

## Step No. 2: Select an Audit Team

Only after a corporate policy is written and distributed to all managers and supervisors should an audit team be selected. A waste audit can be performed by a single person, a team of employees, or outside consultants. The team approach is preferable as it draws from a variety of perspectives and a broad knowledge base. Table 1 lists suggested staffing for a waste audit team.

Team members should be considered of equal rank, and all ideas and concerns should be attended to and evaluated for merit. The interests and particular expertise each team member brings to the group will produce different areas and levels of concern; for example, management is not always aware of or familiar with the daily operations and concerns of the process line or clean-up crews.

The team leader should be technically competent, and he or she also should feel comfortable with the job. That comfort derives from the appropriate authority and an adequate budget that have been delegated to get the job done.[2]

**Table 1. Suggested Staffing for Audit Team by Organization/Position**

- Management
- Engineering
- QA/AC
- Shipping/Receiving
- Budget/Finance
- Treatment/Pretreatment
- **Maintenance**
- **Process Line**
- Clean-Up Crew

# Step No. 3: Gather Background Data/Construct Flow Diagram

## Gather Background Data

**Before the causes of and reasons for waste generation can be identified, the audit team must collect an assortment of background information. This information will enable the team to thoroughly understand the facility operationally and financially, which is critical to the success of the waste audit. Four types of data should be collected:**

- **Production/Process,**
- **Waste stream,**
- **Financial, and**
- **General.**

**Sources of these data are listed in Table 2.2**

**To understand the waste problems in the facility (and the construction of a process flow diagram (Step No. 4)), the audit team must have thorough knowledge of each unit process and its interaction with other processes. For these reasons, certain of the data should be set up in tabular form as it is collected. Such a table not only makes for easy transfer of information to the flow diagram, it also serves as a useful reference for future activities. These data will be critical during the in-plant survey.**

**- An example of data to be put in the table are those for each process unit. For each unit, the table should include a functional description and associated inputs,**

## Table 2. Sources of Background Information

### Production/Process

- Plant Flow Diagrams and Plant Blueprints (as built)
- Sewer Locations: Process/ Domestic/Storm/City
- Purchasing and Shipping Records
- Material Safety Data Sheets
- Operating Manuals
- Water Use Records (By Shift and During Down Times)
- Potable Water Locations
- Production Records/ Schedules

### Waste Stream Information

- Manifests, Annual Reports and Related RCRA Information, SARA Reporting Data
- Environmental Monitoring Reports
- Environmental Permits (Solid Waste, Hazardous Waste, NPDES, Pre-treatment, Air Emissions)
- Information on Any Regulatory Violations
- Location of All Waste Collection/Storage Points
- Diagrams of All Waste Treatment Units & Operating Manuals
- Alternate Waste Disposal Option (Animal Food, Renderer, etc.)

### Financial Information

- Water and Sewer Costs (Including Pretreatment or On-Site Treatment)
- Solid and Hazardous Waste Management Costs
- Labor, Energy, and Raw Product Costs
- Waste Management Contracts/Billings

### General Information

- Current Recovery/Reuse/ Recycle Practices
- Previous Environmental Audits
- Vendor Information

outputs, and waste streams. In addition to major equipment, this listing should include all ancillary processes. Although they may not have a direct effect on processing, these processes can have a direct effect on the waste stream as, for example, on cooling tower discharges.

- Another useful table to set up is one that tracks raw material from purchasing through each process to shipment of final product.[4]

### Construct Flow Diagram

Using the background data gathered, the audit team can construct a detailed flow diagram of the plant as follows:

- All inputs and outputs for each process should be identified as to the source, quantity, type, and concentration.
- All waste streams, e.g., liquid, solid, air, hazardous/toxic, should be identified along the process line.
- Cleaning/dumping and make-up activities should be noted along with any recovery/recycle/reuse efforts.

Figure 1 is an example of a simple, labelled plant flow diagram.

The background information, tabular information, and the labelled flow diagram will help identify any data conflicts, problem areas, and locations that need to be monitored. Further, these information tools will identify wastes that are particularly expensive to dispose, wastes generated from expensive raw materials, or wastes that cause handling or discharge problems?

## Step No. 4: Conduct a Plant Survey

With all information in hand, the audit team conducts the in-plant survey. This survey is designed to verify existing data, locate missing data and areas for monitoring, and identify additional waste streams.

Sampling/Monitoring. If detailed data are not available on waste streams or water usage, or if new waste streams are identified during the survey, sampling/monitoring should be conducted. This testing should take place over a period of time to assure accurate, representative samples. If the facility produces a variety of products, sampling should be performed during production of each product. Water usage should be monitored such that usage by shift and/or product may be determined. Data collected here can be added to the flow diagram and extrapolated to monthly or yearly totals.

Processes and Clean-Up Operations. In addition to sample collection, it is extremely important that the audit team observe all processes and clean-up operations from material receiving through product shipping. All shifts and activities should be observed on more than one occasion. The use of video cameras is also recommended as a tape can serve as both a useful reference and a training tool.

By observing these process clean-up activities and talking with line personnel, the audit team can spot obvious waste-generating practices such as the dumping of unacceptable product into floor drains or dumpsters.

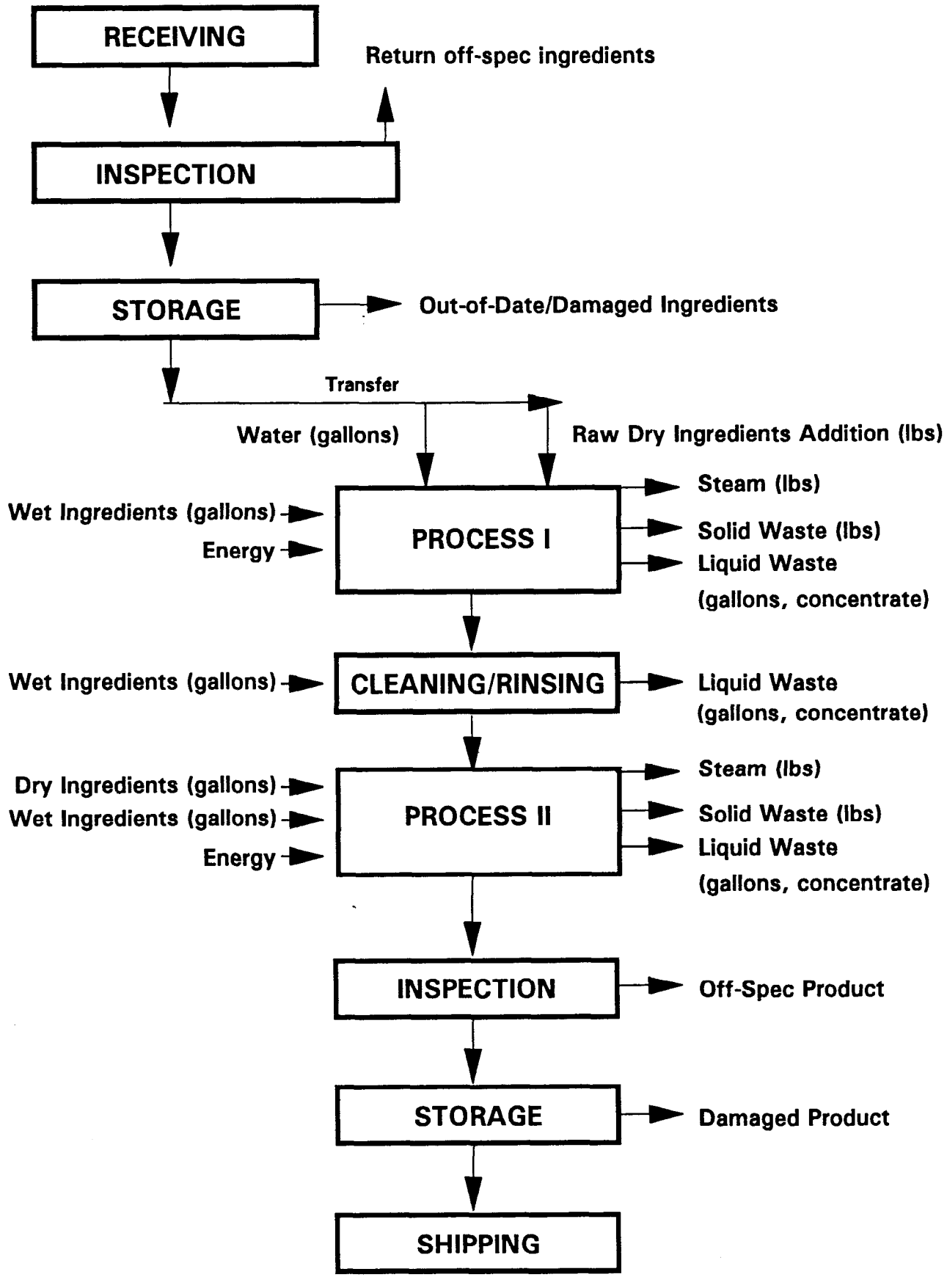


**Figure 1. Generic plant flow diagram.**

Table 3 lists examples of information that can be obtained from an in-plant survey. Appendix A lists areas of waste generation and processes on which information should be gathered.[2,5]

Upon completion of the in-plant survey, all data should be reviewed and updated for accuracy and completeness. At this point, the following information should be available for each waste stream:

- Point of origin.
- Current handling/treatment/disposal.
- Physical/chemical characteristics.
- Quantity generated.
- Rate of generation (lb/unit product).
- Variations in generation rate.
- Potential for contamination or upset.
- Cost to manage.[4]

## Step No. 5: Materials Balance

With all data collected, two materials balances should be performed, process-by-process and overall plant. It should be pointed out that these balances are mass quantities, i.e. they are derived from the basic formula: ***Ingredients In - Product Out = Waste Generation***.

### Process-By-Process Balance

The process-by-process balance will pinpoint areas of greatest waste generation and water, resources, and material usage. These areas/processes translate to points with the greatest potential for waste reduction, waste elimination, and recovery/reuse/recycle opportunities.

### Overall Plant Balance

The second materials balance, the overall plant balance, tracks activities not necessarily associated with a single unit process. Areas to be considered in this balance include:

- Discharges to floor drains.
- Discharges to storm drains.
- Bypasses.
- Cleaners/disinfectants and biocides used.
- Fugitive air emissions.
- Operational, clean-up, maintenance procedures.
- Effects of incoming/outgoin traffic (delivery persons, vehicles).[4]

These balances will pinpoint obvious as well as inconspicuous areas of waste and pollution generation.

## Step No. 6: Evaluation of Reduction Alternatives

An evaluation of waste reduction alternatives should always begin with low-tech options and proceed to high-tech options. Low-tech approaches usually provide the "biggest bang for the buck" and involve employees at the plant floor level. The procedure to identify, evaluate, and select applicable reduction technologies will depend on the complexity of the plant and quantity and variety of wastes generated. Successful procedures range from simple group discussions and evaluations by team members to complex computer modeling. Whether simple or

## Table 3. Examples of Information Gathered From In-Plant Survey

### Material Delivery and Storage

- Material Transfer, Handling and Storage Procedures
- Evidence of Leaks or Spills
- Inventory of Materials
- Condition of Pipes, Pumps, Tanks, Valves, and Storage/Delivery Area

### Production Process

- Exact Sources of all Process Waste
- Waste Plow: Source, Quantity and Concentration
- Operational Procedures
- Sources of Intermittent Waste Streams (cleaning, batch dumps)
- Condition of all Process Equipment: Lines, Pumps, Tanks, Pipes, Valves, etc.
- Leaks/Spills: Evidence of and potential sources of
- Conveyor Equipment: Misalignment
- Maintenance Procedures and Schedule

### Waste Management

- Operational Procedures for Waste Treatment Units (all media)
- Quantity and Concentration of all Treated Wastes and Residues
- Waste Handling Procedures
- Efficiency of Waste Treatment Units
- Waste Stream Mixing

complex, all approaches should follow these basic steps:

1. List all waste streams.
2. Identify, perhaps via "brainstorming," potential waste reduction techniques for each stream. All ideas generated during this step should be considered. Often, the simplest or most far-fetched suggestions have the greatest positive impact.
3. Evaluate, first, the technical aspects of each technique such as the effect on product, reliability, and actual waste reduction potential. Next, evaluate the economic and regulatory aspects such as CAA, CWA, FDA, RCRA, and OSHA requirements.
4. Based on life-cycle costs, select the most cost-effective reduction techniques.[2]

In addition to waste reduction techniques for specific waste streams, facility-wide reduction plans should be formulated that include the following components:

- Recycling programs,
- Material inventory/handling,
- Maintenance/operating procedures, and
- Clean-up practices.

## Liability

Another aspect of the technical evaluation to be considered is liability for both individuals and the company. Figure 2 depicts the range of risk and liability associated with various waste management options.[3,6]

## Financial Feasibility

In addition to the technical analysis, a financial feasibility analysis must be performed, By using a life-cycle cost analysis, a pay-back period can be calculated. The cost analyses should include capital expenditures and operating and maintenance costs and should be weighed against treatment and disposal costs.

All costs associated with a waste reduction alternative should be tabulated. These include initial cost and costs for equipment replacement, energy, chemicals, and operations.

These waste reduction costs must then be weighed against the obvious costs of the facility's current waste management practices such as treatment and disposal. The costs of the waste reduction alternative also must be weighed against the less obvious costs of traditional waste management methods:

- Loss of raw material.
- Loss of product.
- Total treatment costs including those for time, space, electricity, etc.
- Increased landfill tipping fees.
- Increasingly complex and ever-changing reporting requirements.
- Compliance with more stringent discharge regulations such as the possibility of zero limits for some wastes.
- Negative public perception.
- Liability for waste generated.
- Personal, civil, and criminal liability.

Once the technical and financial evaluations are complete, the alternatives that can be implemented immediately and those that are long-range goals for an on-going waste reduction plan can be determined. The alternatives that can be implemented immediately should provide the "breathing room" required for a more detailed engineering and administrative approach to the long-term alternatives.

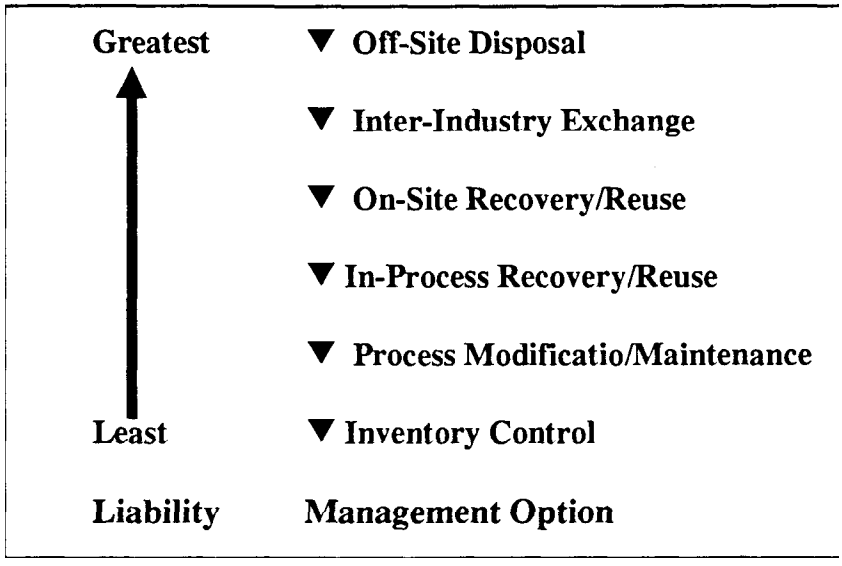


**Figure 2. Liability associated with waste management options.**

### Implementation/Employee Training/Follow-Up

Implementation. With the waste audit and alternatives evaluation completed, an implementation plan and schedule may he established.

Implementation should also involve a low-tech-to-high-tech approach. Quick victories with low-tech, people-oriented solutions will enhance implementation efforts. To implement the waste reduction program, the corporate waste reduction policy should have designated a specific position or team charged with the following responsibilities:

- Devise a realistic implementation schedule,
- Ensure that the schedule is kept,
- Monitor for backsliding toward wasteful practices, and
- Assure compliance with environmental regulations.

The employee or team should be champions, i.e., true believers in waste reduction.

The implementation schedule can serve three major purposes. First, it can be used to track progress toward a less wasteful, more efficient, and more profitable operation; second, it keeps the issue of waste reduction in the forefront of the company's daily activities; and third, it demonstrates the company's "good faith," particularly if there are current noncompliance or public relations problems associated with the facility.

Employee Training. Employee training is the first waste reduction alternative to be considered for implementation. Training programs should be both process-specific and activity-specific, and they should outline expectations for all employees from top management to the clean-up crew. All employees should be included. Training sessions should be designed to meet the following objectives:

- They should be positive learning experiences.
- The level of communication should be appropriate to each group: technical terms used in management training may not be understood or appreciated by maintenance crews.
- They should encourage positive, cooperative attitudes ("You have been doing a good job, but we now have to use this new and better approach which is required by new regulations designed to help protect the environment"). On the other hand, negative reinforcement usually does not elicit positive behavior ("The way you have been working is wrong" or " You guys have really messed up and now we are in trouble with the regulators.")
- They should teach waste awareness. Most employees do not see as wastes the materials they are in contact with, put their hands in, or work with on a daily basis .
- They should be repeated on a regular basis and should allow for input and questions by employees.
- They should emphasize that each person's actions can have a positive effect on the environment, plant profitability, and, ultimately, his/her own job security.

Employees usually become eager, active participants of a waste reduction program once someone takes the time to instruct them on the basics of waste reduction including:

- What a waste is (anything that is discharged to the environment whether it be water, air, or solid or hazardous waste) and
- Where waste comes from (anything, even product, that goes down the drain, into the dumpster, and/or into the air).

Training should emphasize the basics of waste prevention/reduction:

- Eliminate waste at the source.
- Operate and maintain equipment properly.
- Use dry clean-up procedures, and do not use hoses as brooms. The tools for dry clean-up, i.e., brooms, shovels, vacuums, should be placed in easily accessible areas.
- Do not dump leftover or off-spec product.
- Conserve water: water conservation and its importance should be explained.
- Ensure inventory management and control.

Employee-Related Follow-Up. There are two types of follow-up: employee-related and waste-related. Many firms have discovered that the best follow-up to on-going employee training is an employee suggestion/awards program. Such programs keep enthusiasm high, generate pride, cost little, and offer a large payback to the company.

Waste-Related Follow-Up. The second area of follow-up is waste related. Initial data obtained during the audit can serve as a baseline from which improvement can be measured. An on-going waste sampling and resource use monitoring program should be established.

Monitoring/sampling results can be evaluated per process, per shift, or per unit product to determine the progress made as well as identify areas that need additional attention or are

backsliding. Such data, when presented simply and graphically, can go a long way toward boosting employee pride and enthusiasm.

A large graph depicting water use, waste loads to the sewer, and/or solid waste generation can be an effective presentation. Such graphs are vivid reminders of a job well done or of backsliding. Company-wide rewards can be offered for the achievement of present goals marked on the graphs.

### Case Study: Maola Milk and Ice Cream

People Against Waste (P.A.W.) was created by Maola Milk and Ice Cream in New Bern, N. C. The program is designed to involve employees in the waste reduction program and encourage them to search for waste sources. The prompt and detailed response sent to each employee who submits a waste reduction suggestion accounts for the success of this program.

No suggestion is considered too small for response. At Maola, the response is accompanied by a visible reward (a P.A.W. lollipop) and recognition in a newsletter. At the end of each month, employees who submitted the top ideas receive additional recognition and rewards ranging from money to dinner gift certificates to P.A.W. caps. The awards increase for the best (most significant waste reduction) suggestions received during the year.

The keys to the success of a program of this type are, first, a champion for the cause of waste reduction and, second, prompt, detailed response to all suggestions. Depending on his or her duties, each employee will have different areas and levels of concern.

## Conclusion

North Carolina's industry base is extremely diverse; it comprises a rich variety of products that utilizes different materials, processing techniques, and market uses. This diversity is apparent not only in the array of final products but also in the variety of wastes created.

The identification of waste streams and technologies for reducing or eliminating these wastes is the purpose of a waste audit. Many facilities have found that the simplest approaches to waste reduction, dry clean-up and employee training, are the most effective approaches to waste reduction. By conducting a waste audit, a facility should be able to pinpoint waste generation sources and eliminate or reduce them. The results are less waste, more profit, reduced liability, and improved public image.

# References


1. **Laughlin, R.G.W., B. Forestall, and M. McKim. "Food Processing Industry."** *Technical Manual-- Waste Abatement, Reuse, Recycle and Reduction Opportunities.* **Ontario, Canada: Environment Canada, 1984.**

2. **Pollution Prevention Program. Developing and Implementing a Waste Reduction Program. Raleigh, NC: North Carolina Department of Natural Resources and Community Development, 1988.**

3. **Ontario Waste Management Corporation.** *Industrial Waste Audit and Reduction Manual.* **Ontario, Canada, 1987.**

4. **Pojasik, R.B. "Waste Minimization: Planning, Auditing and Implementation."** *Processing Waste Reduction: The Ongoing Saga.* **Medford, MA: Tufts University Center for Environmental Management, 1986.**

5. **Richardson, S. "Pollution Prevention Pays for Food Plants."** *-Proceedings: Water Conservation, Waste Management, and Environmental Compliance for Food Plants.* **Raleigh, NC: Redfern and Associates, 1988.**

6. **U.S. Environmental Protection Agency.** *Manual for Waste Minimization Opportunity Assessment.* **Cincinnati, OH: EPA Office of Research and Development, 1988.**

# Appendix A. Checklist for Conducting the In-Plant Survey

## Receiving/Shipping

- ☐ Are improper inventory controls causing ingredients to become out-of-date or raw material to spoil?
- ☐ Are raw materials lost during transfer activities?
- ☐ Is a single supplier repeatedly sending off-spec materials?

## Process Line Operating Procedures and Equipment Maintenance

- ☐ Is product being lost from improper equipment fit and/or leaking lines, pumps, valves, etc.?
- ☐ Do spillages occur from overfilling or mixing activities?
- ☐ Are collection barrels or tanks used for off-spec product? What is the procedure for handling bad batches? Are they dumped down the drain?
- ☐ Are drip pans used to catch product, oils, etc.? How are the the collected materials disposed?
- ☐ Are there carry-over losses such as entrainment losses from vacuum pumps?
- ☐ Are dry ingredients allowed to pile up or blow around the facility?
- ☐ Do all employees know how to operate their equipment correctly?
- ☐ Is product lost to freeze-on or burn-on?
- ☐ Is residual product left in lines, vats, and/or mixers and washed into drains during clean-up?

## Clean-Up Activities

- ☐ Is all unused or off-spec product collected, i.e., kept out of the drain?
- ☐ Are dry clean-up activities employed prior to wash down?
- ☐ Are high-pressure hoses with automatic shut off valves used?
- ☐ Do all floor drains have screens?
- ☐ Have all detergents and disinfectants been evaluated for their waste load contribution? Are minimum amounts used?

## Miscellaneous

- ☐ Have all possible recycle/reuse methods for water, liquids, and solids been investigated?
- ☐ Have alternate uses for non-reusable/recyclables been examined?
- ☐ Are lights left on during the day?