Case Study:
Identifying Pollution Prevention Options For a Petroleum Refinery

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Company: A large petroleum refinery
Location: Midwest
Business: Refining crude oil into several commodity products
Objective: Minimizing hazardous and nonhazardous waste from the refining process
Recommendation: To target through a comprehensive survey those waste streams with the highest potential for improvement
Bottom Line: More than 660 individual waste streams identified; twenty pollution prevention alternatives identified, representing a total projected cost savings of $3.5 million annually with each having a payback of one year or less.

Recent regulatory changes such as the Toxicity Characteristic Leaching Procedure (TCLP), Land Disposal Restrictions, the Primary Sludge Rule, and the Benzene National Emission Standard for Hazardous Pollutants (NESHAPS) have had a major impact on waste management in the petroleum refining industry. In addition, state and federal directives and regulations specifically addressing pollution prevention are compelling all industries, including the refining industry, to eliminate waste before it is generated.

This case study describes a comprehensive pollution prevention program developed by our consulting firm for a large, integrated petroleum refinery. The impetus for the program was a corporate-wide pollution prevention policy that required the refinery to develop such a program. The basic elements of the corporate policy were:

- All facilities must develop pollution prevention programs. Major facilities should develop written, facility-specific programs and groups of small, similar facilities should have one plan specific to each group. The written programs should include: waste stream inventories; the identification of pollution prevention opportunities and practices; annual, facility-specific pollution prevention goals; and an annual review of pollution prevention achievements.
- At the outset of the program, all facilities must compile data on prior pollution prevention accomplishments and then report periodically on future progress.
- Corporate headquarters will develop a program to coordinate the waste-minimization efforts at all facilities.
- The corporate hierarchy for preferred pollution prevention techniques is: (1) source reduction, (2) recycling, and (3) treatment. All waste and waste-
minimization residues must be disposed of by a method that is protective of human health and the environment.

The facility-specific pollution prevention program developed by our consulting team to meet these corporate directives is described in the following section.

The Facility and Processes
The facility for which this pollution prevention program was developed was a 150,000-barrel-per-day refinery. Its major processing units included: crude distillation, catalytic reforming, fluid catalytic cracking, alkylation, delayed coking, and sulfur recovery. Crude oil enters the refinery primarily through pipelines and travels through the processing units. Most of the finished prime fuel products, including motor gasolines, jet fuel, and diesel fuel, leave the refinery through pipelines. Other facility products include propylene, liquefied propane gas (LPG), carbon dioxide (CO₂), sulfur, and petroleum coke.

The refinery processing block occupies 200 acres of the 465-acre refinery property. A combined sewer system prohibits separate handling of storm-water runoff and process wastewaters; plant wastewater is, therefore, treated by an advanced treatment system that includes oil/water separators, dissolved air flotation (DAF) treatment, equalization, activated sludge biological treatment, and sand filtration.

A Six-Step Approach
Our company implemented a standard six-step approach in establishing the pollution prevention program. Each step is described in detail below.

• **Step 1. Initiating the project**
  A kick-off meeting with the refinery's Pollution Prevention Coordinator was held in which we outlined our implementation plan. We then divided the refinery into fifty unique processes and support areas (listed in Table 1). It is extremely important to subdivide a large facility in this manner to allow a more thorough evaluation of each area. Facility Operations Supervisors were the designated contacts for each area. Meetings were held with these supervisors to enlist the support and participation of plant personnel and to facilitate the implementation of the waste survey described in Step 2.

• **Step 2. Conducting a waste survey**
  It was estimated that ten ten-hour work days would be needed to conduct the waste surveys, based on a team of three engineers surveying two process areas or four support areas each day. A high degree of flexibility was built into the survey schedule, recognizing the unpredictable nature of demands placed on facility operations staff.
Case Study: Identifying Pollution Prevention Options for a Petroleum Refinery

Table 1. Facility Process Units and Support Areas

<table>
<thead>
<tr>
<th>Process Unit</th>
<th>Support Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkylation 1</td>
<td>Carbon monoxide boiler</td>
</tr>
<tr>
<td>Alkylation 2</td>
<td>Cooling tower 1</td>
</tr>
<tr>
<td>Alkylation 3</td>
<td>Cooling tower 2</td>
</tr>
<tr>
<td>Gasoline blender</td>
<td>Cooling tower 3</td>
</tr>
<tr>
<td>Coker 1</td>
<td>Cooling tower 4</td>
</tr>
<tr>
<td>Coker 2</td>
<td>Cooling tower 5</td>
</tr>
<tr>
<td>Carbon dioxide plant</td>
<td>Barge loading dock</td>
</tr>
<tr>
<td>Crude/vacuum 1</td>
<td>North flare</td>
</tr>
<tr>
<td>Crude/vacuum 2</td>
<td>Instrument shop</td>
</tr>
<tr>
<td>Sulfur plant</td>
<td>Laboratory</td>
</tr>
<tr>
<td>Fluid catalytic cracker</td>
<td>Loading and unloading areas</td>
</tr>
<tr>
<td>Hydrogen plant</td>
<td>Machine shop</td>
</tr>
<tr>
<td>Isocracker 1</td>
<td>Maintenance department</td>
</tr>
<tr>
<td>Isocracker 2</td>
<td>Boiler A</td>
</tr>
<tr>
<td>Linde treater</td>
<td>Boiler B</td>
</tr>
<tr>
<td>Naphtha treater/sat gas plant</td>
<td>Steam plant</td>
</tr>
<tr>
<td>Poly plant</td>
<td>Unleaded gasoline tanks</td>
</tr>
<tr>
<td>Refiner 1</td>
<td>Crude oil tanks</td>
</tr>
<tr>
<td>Refiner 2</td>
<td>Distillate tanks</td>
</tr>
<tr>
<td>Unsat gas plant</td>
<td>Decanted oil tanks</td>
</tr>
<tr>
<td>Water treatment plant</td>
<td>Bunker oil tanks</td>
</tr>
<tr>
<td>Waste water treatment plant</td>
<td>Slop oil tanks</td>
</tr>
<tr>
<td></td>
<td>Propane drums</td>
</tr>
<tr>
<td></td>
<td>Spheres</td>
</tr>
<tr>
<td></td>
<td>Welding shop</td>
</tr>
<tr>
<td></td>
<td>Water pump station</td>
</tr>
<tr>
<td></td>
<td>Warehouse</td>
</tr>
<tr>
<td></td>
<td>South flare</td>
</tr>
</tbody>
</table>

An inventory of all wastes and their available characteristics for each of the fifty areas of the refinery was developed. Gaseous emissions, discharges to the wastewater treatment system, and sources of both hazardous and nonhazardous solid waste were to be identified for each area.

To conduct the survey, one of our engineers met with the Facility Operations Supervisor for a particular area to discuss the process or activities conducted in the area. Waste-generation points were identified, and waste characterization data (e.g., flow rate, temperature, and physical characteristics) were noted. Characterization data were also obtained from process engineering files or environmental permits.

A data summary form (Figure 1) was prepared for each waste stream to aid in identifying data needs and inputting the data to a...
Figure 1. Waste Stream Data Summary Form

<table>
<thead>
<tr>
<th>Surveyor: __________________________</th>
<th>Stream no.: __________________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: ____________________________</td>
<td>Plant: ______________________________</td>
</tr>
<tr>
<td>Contact: __________________________</td>
<td>Extension: ___________________________</td>
</tr>
<tr>
<td>Process source: ____________________</td>
<td></td>
</tr>
<tr>
<td>Waste name (Specify gaseous, solid, or liquid):</td>
<td></td>
</tr>
<tr>
<td>How waste is generated (Specify process or maintenance):</td>
<td></td>
</tr>
<tr>
<td>Typical unit operating conditions:</td>
<td></td>
</tr>
<tr>
<td>Waste description (physical characterization):</td>
<td></td>
</tr>
<tr>
<td>On-site waste management technique:</td>
<td></td>
</tr>
<tr>
<td>Off-site waste management technique:</td>
<td></td>
</tr>
<tr>
<td>Existing pollution prevention technique:</td>
<td></td>
</tr>
<tr>
<td>Alternative pollution prevention technique:</td>
<td></td>
</tr>
<tr>
<td>EPA hazardous waste no.:</td>
<td></td>
</tr>
<tr>
<td>Generation rate: __________________</td>
<td></td>
</tr>
<tr>
<td>Comments: _________________________</td>
<td></td>
</tr>
<tr>
<td>Disposal costs per year:</td>
<td></td>
</tr>
</tbody>
</table>
High quantity and generation frequency waste streams generally are viewed as having the greatest potential for minimization.

An enormous amount of data and information were gathered during the survey, and this form facilitated data organization.

After the waste characterization data were obtained, field inspections of each area were conducted to identify each waste-stream source. Additional data (e.g., space available, waste-handling methods, and visual flow-rate estimates) were gathered during the field inspection.

In all, over 660 individual waste streams were found. The evaluation was not limited to those wastes that exit the plant; internally generated waste streams also were documented.

At the completion of the waste survey, a computerized waste stream inventory was prepared. Figure 2 illustrates a typical database file. From this database, relationships among processes and waste streams could be depicted graphically. For example, Figure 3 presents the distribution of waste streams across the three media for the entire refinery. Figure 4 further shows a typical distribution of waste streams across five process areas. These types of graphical representations were useful for evaluating which waste streams and process areas should be investigated further.

**Step 3. Screening waste streams**

An effective pollution prevention program should concentrate efforts on waste streams that critically require improvement or that show the most promise for pollution prevention. Six criteria were selected for establishing investigation priorities of waste streams at the refinery:

- Waste quantity and frequency,
- Waste management costs,
- Regulatory impact,
- Safety and health risks,
- Pollution prevention potential and ease of implementation, and
- Demonstrated effectiveness in other refineries and industries

Each of the criteria for the waste streams in all fifty areas was rated from zero through five, with higher scores rating a higher priority. These ratings were input to the database, and total scores for each stream were calculated. The streams were then ranked in numerical order. Each criterion and its rating application is briefly discussed in the following section.

Waste quantity and frequency—High quantity and generation frequency waste streams generally are viewed as having the greatest potential for minimization. As such, waste quantity and generation frequency were evaluated and annualized generation rates were...
### Figure 2. Example Database File:

<table>
<thead>
<tr>
<th>Sort Code</th>
<th>Stream Number</th>
<th>Process Source</th>
<th>Waste Generation Method</th>
<th>Waste Name and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C01</td>
<td>FCC-2944-01S</td>
<td>Catalyst regenerator</td>
<td>Continuous removal of catalyst from regenerator</td>
<td>Spent catalyst: Gray, solid powder consisting of Al203, Si02, and carbon</td>
</tr>
<tr>
<td>C02</td>
<td>FCC-DIST-02L</td>
<td>Light, heavy, and total catalyst distillate treaters</td>
<td>Caustic washing of hydrocarbons</td>
<td>Phenolic caustic: spent sodium hydroxide containing cresylic acids</td>
</tr>
<tr>
<td>C03</td>
<td>FCC-FUGIT-03A</td>
<td>Miscellaneous equipment, pumps, and piping</td>
<td>Fugitive emissions</td>
<td>Fugitive emissions: gaseous hydrocarbons</td>
</tr>
<tr>
<td>C04</td>
<td>FCC-1044-04L</td>
<td>Stripper feed coalescer</td>
<td>Foul condensate collection</td>
<td>Foul condensate: water containing sulfur compounds</td>
</tr>
<tr>
<td>C05</td>
<td>FCC-SAMP-05L</td>
<td>Process sampling points</td>
<td>Purging of sample lines</td>
<td>Sample waste: Generally hydrocarbon streams</td>
</tr>
<tr>
<td>C06</td>
<td>FCC-PADS-06L</td>
<td>Concrete pads</td>
<td>Collection of precipitation</td>
<td>Surface water runoff: Water contaminated with hydrocarbons</td>
</tr>
<tr>
<td>M01</td>
<td>FCC-2944-07S</td>
<td>Catalyst regenerator</td>
<td>Replacement of old catalyst during turn-around maintenance of regenerator</td>
<td>Spent Catalyst: Gray, solid powder consisting of Al203, Si02, carbon, and refractory material.</td>
</tr>
</tbody>
</table>

Calculated. Streams were rated according to media, with gaseous streams rated relative to other gaseous streams, liquid streams rated relative to other liquid streams, and solid streams rated relative to other solid streams.

Waste management costs—The cost to handle, treat, and dispose of waste streams is a key factor in deciding whether to implement
## Fluid Catalytic Cracking Unit

<table>
<thead>
<tr>
<th>Current Pollution Prevention Technique</th>
<th>Alternative Pollution Prevention Technique</th>
<th>Generation Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-site: Stored in spent catalyst hopper, removed in dumpsters Off-site: Reuse</td>
<td>Dump spent caustic based on the percent cresylic acid content rather than level control</td>
<td>10 tons/week</td>
</tr>
<tr>
<td>On-site: Stored in tanks, pumped to railcar loading area Off-site: shipped via railcar and barge</td>
<td>Replace flanges with welded joints where possible</td>
<td>800 barrels/month</td>
</tr>
<tr>
<td>Discharged to atmosphere</td>
<td>Pump to foul condensate system</td>
<td></td>
</tr>
<tr>
<td>Pumped to foul condensate system on level control</td>
<td>Pump to foul condensate system</td>
<td></td>
</tr>
<tr>
<td>Drained to sewer, to oily ditch, and then to WWTU</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td>Discharged to sewer, to oily ditch, to WWTU</td>
<td>Install settling basin strainers, mesh, and cloth filters to minimize solids in sewer</td>
<td>Not monitored</td>
</tr>
<tr>
<td>On-site: Material is removed from regenerator using a vacuum truck and then stored in dumpsters Off-site: Landfill</td>
<td></td>
<td>50 tons/4 yrs.</td>
</tr>
</tbody>
</table>

*See SARA 313 report for applicable Section 313 chemicals.*

Pollution prevention controls. In this case, specific costs were reviewed for each stream when the data were available. The costs of solid streams were rated according to whether they generated hazardous or nonhazardous waste. Liquid streams were rated using three criteria:

- The amount of handling conducted prior to discharge to
the waste water treatment unit (WWTU);
- Their organic content; and
- High, medium, or low solids content.

The costs of gaseous streams were rated according to those costs incurred to maintain existing control programs. Gaseous stream sources without controls or control programs were rated low, and those with controls or control programs were rated high.

**Regulatory impact**—Noncompliance with regulations requires immediate corrective action. A review of future regulatory actions enables well planned, cost-effective compliance. In addition, pollution prevention controls will be increasingly regulation-driven.

In assessing this criterion, each stream was reviewed to determine whether existing or potential regulatory action may adversely impact current management practices. Gaseous streams were reviewed for compliance with federal and state air regulations. Water and solid streams were reviewed for compliance with potentially applicable Resource Conservation and Recovery Act (RCRA) regulations, the TCLP, benzene-containing waste regulations, and the Primary Sludge Rule. Streams that were out of compliance or that could be affected by proposed regulations were rated high. Streams that were in compliance and would probably not see regulatory changes were rated low.

**Safety and health risks**—Worker safety and health risks are important issues to address when evaluating pollution prevention projects. Prominent risk areas need to be identified. Those existing management practices that had a high potential for adversely affect-
ing worker safety and health were rated high; those that had a low potential were rated low.

Pollution prevention potential and ease of implementation—Waste streams for which pollution prevention controls can be implemented quickly and at a low cost should be given a high priority in any pollution prevention program. Waste streams for which pollution prevention controls were judged to require minor costs and controls were rated high; those judged to require significant costs and controls were rated low.

Demonstrated effectiveness in other refineries and industries—Waste streams for which pollution prevention controls have been effective in other refineries are significant. Essentially, this criterion can be used to gauge how successful particular controls would be at the subject refinery. Waste streams that are similar to streams that have been controlled in other industries are also important to identify for the same reason. Waste streams that have been successfully controlled at other refineries were rated high. Waste streams that were similar to streams that were successfully controlled in other industries were rated medium to high. Streams for which previous control was not established were rated low.

When all of the streams had been rated according to the criteria,
they were ranked based on the results. Figure 5 presents the number of waste streams by numerical rating for all identified waste streams. All waste streams with a rating of 18 or higher were selected for further evaluation in the pollution prevention program. A number of streams below this level were equally rated, and because the budget constrained the number of streams that could be further evaluated, we opted to focus on those with higher ratings. Figure 6 shows the specific areas of the refinery that have the greatest number of highly rated waste streams. As presented in this figure, the coker and the tank farms were focal areas for pollution prevention efforts. In all,
fifty waste streams were selected for developing pollution prevention options.

Such a detailed method for screening waste streams is not always necessary. If the number of waste streams is low, a simple evaluation of the stream information by the project team may be sufficient for setting priorities. Additionally, any waste stream screening procedure is subjective. In this case, for example, a bias was purposely built into the screening procedure so that waste streams contributing solids to the wastewater treatment system would be rated higher. However, even without a bias built into the screening criteria, the process of rating each stream is highly subjective. This bias does not render inaccurate results; it ensures that key waste streams receive higher priorities.

- **Step 4. Developing pollution prevention options**

Pollution prevention options for each of the fifty waste streams were generated primarily through brainstorming with the project team and the refinery process experts. The data gathered on each waste stream were reviewed and evaluated during the session to identify approaches for reducing generation rates. Some of the approaches and techniques considered are discussed in the following sections.

*Inventory management and improved operations*—In this approach the following ideas were evaluated:
Inventory and trace all raw materials;
Purchase fewer toxic and more nontoxic production materials;
Improve material receiving, storage, and handling practices;
Maintain strict preventive maintenance programs; and
Implement employee training and management feedback.

**Equipment Modifications**—Procedures to modify equipment include:

- Installing equipment that produces minimal or no waste;
- Redesigning equipment production lines to produce less waste;
- Improving equipment operating efficiency;
- Modifying equipment to enhance or permit materials recovery or recycling; and
- Eliminating sources of leaks or spills.

**Production process modifications**—In this approach, processes could be modified to:

- Optimize reactions and raw materials use;
- Substitute nontoxic for toxic raw materials;
- Redesign or reformulate end products to have minimal or no toxicity; and
- Reduce waste generation.

**Recycling and reuse**—In this approach the following ideas were evaluated:

- Install closed-loop systems for direct recycle;
- Recycle on-site or off-site for reuse;
- Segregate wastes by type of recovery;
- Separate toxic from nontoxic wastes; and
- Participate in waste exchanges.

In exploring the options, we also conducted an extensive literature search to identify additional pollution prevention approaches and techniques. This search was moderately successful and should be more so in the future as increased emphasis is placed on this area and more literature is published on this topic.

Approximately five pollution prevention options or techniques were identified for each of the fifty key waste streams for a total of 250 options.
Step 5. Screening the options

Because a detailed technical and economic evaluation is time-consuming and expensive, the options were screened for further evaluation. Screening methods ranged from an informal review by team members to the use of quantitative decision-making tools. Some options, such as procedural or administrative changes, require little or no capital investment. These options may be clearly desirable and are generally categorized as good operating practices. These may include such practices as:

- Segregation of processes or materials,
- Changes in materials handling and inventory procedures,
- Preventative maintenance,
- Production scheduling, and
- Minor operational changes.

More sophisticated pollution prevention and treatment options require a more focused, detailed evaluation. The following criteria are typically used to evaluate pollution prevention options:

- Product quality,
- Safety and occupational health factors,
- Production constraints and flexibility,
- Space requirements,
- Installation time and production downtime,
- Reliability,
- Commercial availability,
- Proven performance in a similar application,
- Permitting requirements and schedule,
- Regulatory constraints,
- Environmental side effects, and
- Expertise and skill level required for operation and maintenance.

In this case, we selected six criteria for screening the pollution prevention options. The options were rated in the same manner as the waste streams, with values of zero through five, and similar calculations were performed to establish the order of preference for the options. The six criteria are described in the following sections.

Pollution prevention hierarchy—Pollution prevention techniques fall into one of four waste management strategies: source reduction, recycling, incineration/treatment, or secure land disposal. Environmental Protection Agency guidance presents a hierarchy of pollution prevention techniques that favor source reduction and recycling over treatment or land disposal. The type of pollution prevention technique is rated according to this recommendation to ensure that preferred techniques are given higher priority.
Reduction of waste volume or disposal/treatment cost—The cost to handle, treat, and dispose waste streams is a key factor in deciding to implement pollution prevention controls. Pollution prevention approaches that result in volume reduction (and, usually, disposal or treatment cost reduction) were rated highly under this criterion.

Ease of implementation—Low cost pollution prevention options that can be implemented quickly either through procedural changes or minor equipment modifications were given a high priority in the pollution prevention program.

Proven performance—Pollution prevention techniques that have been successfully implemented in other refineries should be closely considered. In addition, waste minimization techniques used in other industries should be evaluated for applicability. The probable degree of success of specific options can be estimated under this criterion.

Safety and health risks—The potential impact on worker safety and health as a result of implementing a given pollution prevention option must be evaluated, and obvious risk areas must be identified. Priority was given to management practices that had the potential to improve worker safety and health conditions.

Quantifiable results—Pollution prevention techniques must be economically justifiable. Emphasis should be placed on those options for which success can be estimated so that resources can be allocated appropriately.

Once the pollution prevention options were rated, a screening procedure similar to that for screening waste streams was applied. The result was a prioritized list, in numerical order, of the 250 pollution prevention options, which was then reviewed by the refinery to ensure it adequately reflected their priorities.

Figure 7 presents the distribution of the rating scores for pollution prevention options identified for the selected stream areas of the refinery. As this figure shows, pollution prevention options for the coker unit received the highest scores, hence the highest priority, in the screening process.

A group of twenty options—those with the highest scores—was selected for further evaluation. The selection of these options was based in part on budget constraints.

• Step 6. Evaluating high-priority pollution prevention options

Evaluation of the highest-priority pollution prevention options consisted of preparing a preliminary conceptual design for each option and performing a simple economic analysis. Each of the options
posed unique challenges; for ease of explanation, a general approach is presented.

For capital-intensive options, the preliminary designs included simple flow diagrams and major equipment identification and specification. Cost estimates were prepared based on published data, vendor quotes, or past costing experience. Capital costs estimates had an accuracy goal of ± 50 percent.

Cost savings were then estimated for the proposed options. Labor
costs, waste disposal costs, product recovery costs, and utilities costs were some of the elements that were evaluated. The total capital cost of the proposed option was then divided by the anticipated cost savings to calculate a payback period. In cases where capital costs were low or not required, only annual cost savings were estimated.

In performing the cost estimating, it is advisable to directly measure certain key parameters. For example, flow, spillage amounts, solids concentration, and other parameters should be directly measured to ensure a more accurate cost analysis.

**Program Results**

The following represents several of the 20 pollution prevention options that were evaluated in the project. A brief description and the estimated economic justification are presented.

**Reduce generation of empty oil drums**

The refinery purchased large quantities of lubricating oils in 55-gallon drums. These oil drums were received at the facility and distributed to various locations within the facility. Refinery personnel indicated the reason for purchasing certain materials in drums was that the 55-gallon container size was the easiest to handle at the various operations. We suggested bulk purchasing (via tank truck) of frequently used oils and filling tote bins as intermediate storage. Personnel could then transfer the oils from the tote bin to reusable drums, buckets, or other containers. This would reduce the generation of empty drums and their associated handling costs.

Based on estimated yearly usage, the facility generates approximately 1,600 empty 55-gallon drums, most of which contain motor and lubricating oils. These empty drums are returned to the vendor for recycling. The annual cost savings associated with bulk purchases of lubricating oils and recovery of oils remaining in the used drums was approximately $25,000. The minor capital costs required for this alternative had a payback period of about nine weeks.

**Reduce coke-cutting water fines**

Coke fines and water generated from the coke-cutting operation entered an in-ground sump where the solids and water separated by gravity. The settled solids were recovered with a rake/conveyor system. The water exited the sump through a weir and entered the sewer system. A refinery study indicated that over twenty-five tons a year of coke fines entered the sewer system from the separator. The proposed pollution prevention alternative was to retrofit the sump with an inclined plate separator to increase the separation efficiency.

The annual cost savings associated with the increased recovery of product (coke) and the reduction in oil/water separation solids was approximately $250,000.
Use reformer scrubber water in desalting units

The refinery used city water as make-up water for the crude desalting units and discharged water from its reformer off-gas scrubber to the WWTU. The acidic composition of the scrubber water made it suitable for use in the desalter units. By using the scrubber water in this fashion, the refinery could reduce the hydraulic loading to the WWTU and reduce consumption of city water. To implement this alternative, the scrubber water would be hard-piped to the desalter water storage tank. Existing pumps were available, so capital costs were limited to piping, insulation, and installation.

The annual cost savings associated with reducing the hydraulic loading to the WWTU and eliminating city water usage at the desalters was approximately $450,000. The projected payback was six months.

Provide secondary containment in tank truck loading area

Vacuum tower residual material was transported off site to an asphalt plant for further processing. When a spill occurred, the material and impacted soils were collected, mixed with a solidification agent for stabilization, and disposed of at a landfill. We proposed to pave and curb the area for the collection of the spilled material. This would minimize the volume of waste generated and allow for the collection and reclamation of the material.

The annual cost savings associated with the recovery of usable product and the reduction in waste disposal costs was approximately $12,000.

Reduce coke spillage

Petroleum coke was cut directly from the coking units into railroad hopper cars. Overfilling of the cars was common and degraded the quality of the spilled coke and increased the amount of solids entering the wastewater treatment system. We proposed cutting the coke into a double-roll crusher and conveying the coke to an intermediate storage silo. The railcars would then be loaded from the storage silo. This approach would collect, filter, and dewater the coke prior to storage. Additionally, the storage silo would provide a buffering capacity for process fluctuations and enable a controlled loading of railcars.

The annual cost savings associated with product coke recovery and oil/water separator sludge handling and disposal was approximately $900,000. The projected payback for this alternative was one year.

Lessons Learned

Several noteworthy lessons were learned in the course of this project. These lessons fall into the following categories:

- Waste survey approach,
An effective survey approach included identifying contacts, conducting interviews, reviewing records, and documenting information.

Survey data management

Waste survey approach—An effective survey approach included identifying contacts, conducting interviews, reviewing records, and documenting information. Appropriate facility contacts were identified with the aid of the plant’s environmental staff. Subsequent contacts were identified during the initial interviews. These contacts included company personnel such as operators and unit engineers and outside contractors in charge of in-plant activities (e.g., maintenance and tank cleaning). The outside contractors proved to be a valuable source of information because they were very familiar with waste management activities throughout the facility.

To maintain consistency and to focus in-plant interviews, the fifty process and support areas were divided into three major groups—the light ends, the heavy ends, and the maintenance and utilities units—and one of our engineers was assigned to survey each group. The engineers conducting interviews were thus able to address successive unit operations and to follow products from the beginning of any process to its end.

In addition to personnel interviews, the review of plant records was an important step in obtaining information. As with many large industrial facilities, the refinery maintains a large file of records, so it was necessary to be selective in our review. The records that proved to be most useful were the facility’s process flow diagrams, the National Pollution Discharge Elimination System (NPDES) permits, the RCRA permits, and hazardous waste manifests.

Survey data management—Transferring the information gathered in personnel interviews and in the review of plant records to the database was a critical step in the successful completion of the pollution prevention program. The survey form developed was effectively linked to the database used for the project. This greatly reduced data management and manipulation efforts.

Data management was facilitated by assigning each waste stream a unique code, media identifiers, and a waste management code. Stream codes were developed using existing equipment numbers. This approach made the data more understandable to plant personnel. Media identifiers were also included to differentiate between gaseous, liquid, and solid waste streams. This enabled database sorting as presented in Figure 1. The media identifiers are intended to make the pollution prevention database more useful to future environmental programs. For example, gaseous emission sources can be identified for use in the refinery’s Superfund Amendments and Reauthorization
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Act (SARA) Title III Section 313 reporting or to aid in assessing the impact of the Clean Air Act amendments.

Waste management codes were included in the database records to enable sorting according to management methods (e.g., recycled, landfilled, or discharged to WWTU). These codes are also intended to be used in future environmental programs.

Screening and evaluation constraints—The purpose of the screening step was to objectively evaluate each waste stream and pollution prevention option and to identify streams and options warranting further investigation; however, as previously mentioned, the screening procedure was somewhat biased toward solids loading to the WWTU. We found that this bias did not hinder our investigation and, in fact, was intentional to a large degree. Nevertheless, it is important to note such a bias.

Developing pollution prevention options—In the course of developing the pollution prevention options, it became obvious that general industry pollution prevention experience can be directly applied to refinery operations. This is especially true in maintenance and housekeeping areas such as spillage due to tank truck loading and unloading. This lesson enabled us to use data from many more sources and draw on valuable experience. Ideas from plant personnel were also valuable. When interviewed, many of the operators and engineers offered useful ideas that had been developed through day-to-day experience, and many were pleased to have a forum to express their ideas.

Pollution prevention issues—Several pollution prevention issues surfaced throughout the project, including the following:

- The solids loading to the WWTU was a major focus of the refinery before and after the subject study. This focus proved to be justified because the oil/water separator bottoms represent the single largest waste stream managed off site.
- New regulations affecting the refining industry necessitate a comprehensive inventory of waste generation. (For example, the TCLP may directly impact the management of certain wastes currently being managed as nonhazardous.) A comprehensive inventory enables quick identification of particular waste streams and more efficient alteration of management practices. Such an inventory should be included in any pollution prevention program.
- Management and operating personnel may hesitate to alter long-standing maintenance procedures. Involving resistant management and plant-level personnel in the
pollution prevention program may greatly reduce their objections. In this case, such participation proved very effective.

- Raw material substitution does not offer the refining industry many viable opportunities to reduce waste generation (as compared to the chemical processing industry where raw material substitution offers a wide array of opportunities). Rather, the majority of long-term pollution prevention opportunities appears to be in modifying processes. For example, fine tuning certain unit operations and catalyst substitutions may impact waste generation levels. However, the refining industry has long been pursuing process modifications such as these for improved efficiency, product performance, and economic performance. Such modifications generally require long development periods and large amounts of research funding, so the results may not be seen for quite a while.

- Of all pollution prevention options for a refinery, housekeeping practices present the most cost-effective opportunities to reduce waste generation and the cost associated with waste management. This is especially true in the coking operations where large amounts of coke are routinely spilled.

- In-plant accountability for waste generation and handling may play a key role in successful waste reduction. For this reason, waste management costs should be charged to the operating unit from which it was generated. This approach may provide unit managers with another way to gauge pollution prevention efforts and the effect they have on the bottom line.

The Bottom Line
As a result of our program, 660 individual waste streams were identified at the refinery, fifty key waste streams were selected for investigation of pollution prevention options, and twenty of these options were evaluated economically. The projected cost savings associated with implementing these twenty options was approximately $3.5 million a year. Moreover, every option evaluated had a payback period of less than one year.

With the establishment of the computer database, the refinery's pollution prevention program has a comprehensive data storage and retrieval system that can be revised and updated as needed. Another benefit is that the methodology used to screen and rank waste streams and pollution prevention options has become an integral part of the refinery's pollution program and will continue to be used by refinery personnel.
Finally our approach demonstrates that for a large, complex facility, a comprehensive review and evaluation of waste streams and pollution prevention options is cost-effective and pays dividends.

Note

1. Paradox 3.0 database software was used for this application.