Pacific Northwest
Pollution Prevention
Research Center

Analysis of Pollution Prevention Investments Using Total Cost Assessment: A Case Study in the Metal Finishing Industry

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EXECUTIVE SUMMARY

The main objective of this project was to demonstrate the feasibility of using Total Cost Assessment (TCA) as an effective decision-making tool for evaluating the costs and benefits of pollution prevention investments in the metal finishing industry. TCA is a capital budgeting method that compares all relevant costs and benefits between alternative investments or process changes. Traditional capital budgeting methods compare different capital investment alternatives using only labor and equipment costs and, more recently, environmental costs such as energy use and waste disposal. Under TCA, the scope of these environmental costs is expanded to include more indirect and intangible costs for a more complete view of the potential environmental impacts of any given change.

Pollution prevention is the reduction or elimination of waste at the source, or closed-loop recycling that takes place in a facility. In some cases, pollution is reduced not by reducing the quantity of material used but by substituting a less-toxic and/or non-regulated material for the material previously used. In other cases, the efficiency of the process is increased, thereby reducing the actual quantity of waste. Pollution prevention projects reduce the need for the treatment, transport, and disposal of wastes, and in many cases offer financial benefits to companies and reduce potential liability.

A previous research project conducted by a team of University of Washington graduate students, as part of a consulting project with the Pacific Northwest Pollution Prevention Research Center (PPRC), identified TCA as the least resource intensive and most practical method of pollution prevention analysis for small businesses. Published in *the* report *Analysis of Pollution Prevention and Waste Minimization Opportunities Using Total Cost Assessment: A Case Study in the Electronics Industry,* the study considered six different decision-making tools and their applicability to small manufacturers. The methods were assessed for their flexibility, ability to generate economic data and how they met moderate resource requirements. The methods considered were TCA, risk analysis, activity-based costing, life-cycle analysis, pollution-added accounting, and design for the environment. TCA was determined to be the most-effective method of the six.

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As a follow-up to the case study in the electronics industry, a second case study was selected. Documented in this report, the study analyzed a small metal finishing operation - Production Plating, Inc. - to determine the feasibility of applying the TCA method to quantify the costs and benefits of two pollution prevention investments in the metal finishing industry. The study consisted of: 1) a retrospective analysis of an investment in a recycling module for a powder coating system and 2) a prospective analysis of implementing a rinsewater recycling system for the company's metal plating shop.

Because Production Plating had already purchased and implemented a powder recovery system, the TCA method was applied to provide the company with a better understanding of the costs and benefits of the system. Since financial information (such as purchase price and data on job runs) was available, and the technology was fairly simple, the analysis was relatively easy to complete.

The first step in conducting an analysis of rinsewater recycling was to select a system a to analyze. The PPRC reviewed several rinsewater recycling systems that could replace Production Plating's current wastewater treatment system. Technologies reviewed included ion exchange, ultrafiltration, and reverse osmosis. It was decided to perform a preliminary TCA only on one of the options (ultrafiltration), because at the time of the analysis accurate operational data could not be collected on many of the unknown, intermediate flow lines that comprise the rinsewater process. Data could not be collected because many of the rinsewater lines were shut down for an extended period of time while several in-shop construction efforts were underway. For TCA to be a truly valuable decision-making tool, it should be applied against several available investment options. At a later date, a TCA analysis of several rinsewater recycling systems may be done.

Following are the general findings from the study:

- The retrospective analysis for the installed powder recovery system with an initial investment of $8,000 yielded a $32,368 net present value (NPV) over a IO-year period. The payback time for this investment is approximately 1.2 years, and the percentage of paint saved is 45.13 percent. The TCA analysis helped management see the true benefits associated with the implementation of this pollution prevention opportunity.

- The prospective analysis for a new rinsewater recycling system with an initial investment of $175,000 yielded a $168,697 NPV over a 10-year period. The payback time for this investment is about 2.3 years. At first glance, the investment appears unfavorable, however, when put into the context of Production Plating's operational costs, the investment proved to be economically viable. The analysis showed a favorable long-term investment with substantial cost savings.

This study demonstrated that TCA is a useful tool for economically evaluating pollution prevention opportunities within the resource constraints of many small businesses. Nevertheless, some small companies lack the capability or resources to both identify and quantify all changes in costs associated with a proposed investment or process change. TCA, or any method offinancial analysis, requires that companies invest the time to conduct the analysis, and employ project decision-makers who have an understanding of net present value and discounted cash flows. Devoting the necessary resources to evaluate investments may be a barrier for some small companies. A TCA analysis may be done using a simple worksheet; however, having access to a personal computer with software such as Excel or Lotus makes the analysis easier.

Production Plating expects to replicate the TCA analysis to evaluate future pollution prevention opportunities. The TCA framework can also help other small manufacturers make better investment decisions, both economically andenvironmentally.

INTRODUCTION

In June 1995, the PPRC held a roundtable discussion in Seattle, Washington on pollution prevention opportunities in the metal finishing industry in the Pacific Northwest. The purpose of the roundtable was for participants to share their experiences with pollution prevention, identify challenges to the implementation of pollution prevention alternatives, and discuss sources and methods of dissemination of information leading to pollution prevention initiatives. During the meeting, the metal platers identified several needs, including having a more effective, easier-to-use cost estimation method to evaluate pollution prevention projects. Most participants at the meeting said they need access to cost justification tools to determine the costs and benefits associated with the implementation of new technologies, adding that if they are unable to calculate the costs of a pollution prevention approach it is difficult to persuade management to make the investment.

The PPRC applied what was learned from a case study conducted in the electronics industry to demonstrate the feasibility of using TCA to evaluate pollution prevention investments by conducting a study in the metal finishing industry. Production Plating, a metal finisher with facilities in Mukilteo and Redmond, Washington, volunteered to analyze two projects at its facilities. The company's Redmond facility specializes in powder coating, and the Mukilteo site focuses on metal finishing (both deposition and conversion). Production Plating, with $5 million in annual sales and 100 employees, is one of the larger metal finishers in the Puget Sound area. The company uses various processes to enhance the appearance, corrosion-resistance, and hardness of metal parts in large- and small-batch sizes.

Metal finishing facilities use a number of chemicals in their operations, including acids and bases, cyanide compounds, metal compounds (such as cadmium, chromium and nickel) and a variety of solvents. Waste streams from metal finishing processes include wastewater, hazardous waste, and solid waste. As a result of the chemicals used in their operations and their associated waste streams, metal finishing facilities are one of the more heavily environmentally regulated types of businesses in the Northwest.

As a locally owned business, Production Plating is interested in implementing pollution prevention initiatives that will reduce its environmental impacts on surrounding communities, as well as improve efficiencies and cut costs. The company believes it can be more competitive by adopting more-efficient and less-polluting processes, and by staying ahead of regulatory requirements.

Production Plating wanted to evaluate the economic feasibility of implementing a powder coating capture and reuse system at its Redmond site, and a rinsewater recycling system at its Mukilteo facility. The objective of the analysis was to 1) assess the economic viability of the two pollution prevention projects, and 2) assess the feasibility of TCA as a decision tool for small manufacturers. The PPRC plans to share the results of the analysis with other Northwest metal finishers, in hopes that they will use the TCA approach to evaluate their own pollution prevention investments, and with technical assistance providers and consultants, so they are better able to help businesses understand the economic benefits of pollution prevention approaches. The goal is to develop a model for conducting TCA that can be easily replicated at other companies.

This report presents an overview of TCA, describes each pollution prevention project, discusses the methodology used in collecting the data, presents the results of the analysis, and offers recommendations. The report also details the overall feasibility of using TCA for evaluating pollution prevention projects at small businesses. Production Plating's experiences are discussed to show the challenges that may be encountered when performing a TCA. The necessary requirements for a small business to implement a TCA are identified, along with general recommendations and conclusions. The financial data is included in appendices.

TOTAL COST ASSESSMENT

In the arena of pollution prevention, many potentially beneficial projects are discounted because all the relevant costs and benefits of the project have not been included. Traditional methods of assessing the financial viability of a project utilize only the direct revenues, costs and capital investment, and overlook many of the indirect costs and benefits that could very well make an unattractive pollution prevention project a viable alternative. Total Cost Assessment (TCA) provides the tools to fully analyze andcompare one or more projects while incorporating an expanded view of indirect costs and benefits.

TCA is a capital budgeting method whereby all relevant costs and benefits for a given project are accounted for and used to compare the project with the current approach used or other alternatives. The Tellus Institute of Boston, Massachusetts highlighted some key characteristics of TCA in its P2/FINANCE for Screen Printers user's manual: "TCA differs from conventional practices in four key ways, because it:

- Expands the cost inventories, savings, and revenue structures to include indirect, less-tangible items typically omitted from project analyses;
- Emphasizes the accurate allocation of costs and savings to specific process and product lines rather than lumping them as overhead costs;
- Extends the time horizon of the analysis to account for longer-term costs and savings typical of pollution prevention investment; and
- Uses profitability indicators capable of incorporating the time value of money and longer-term costs and savings" - such as net present value (NPV), which is discussed below.

One important concept is that of relevant costs/benefits. When comparing one alternative to another, only those costs/benefits that will change should be included. If the cost or benefit remains the same regardless of what is 'implemented, it is excluded. The relevant costs/benefits are then grouped into a tier system depending on type of cost. These tiers are as follows:

Tier 0: Usual costs such as direct labor, materials, equipment, etc.
Tier 1: Hidden, or indirect costs such as monitoring, reporting, record keeping and permit requirements
Tier 2: Future liability costs, such as remedial actions and personal injury
Tier 3: Less tangible costs such as customer response, employee relations, and corporate image

Tier 0 costs can usually be quantified using a business' existing internal tracking systems, while athorough project analysis can often quantify Tier 1 costs that ate typically buried in overhead. Often, the costs/benefits in Tiers 2 and 3 are difficult to quantify, in which case they should be accounted for qualitatively.

Another important concept is that of the time value of money. Receiving a dollar today is worth more than receiving a dollar tomorrow. This concept gives rise to the method of "discounting." By utilizing discount rates (expressed as annual percentages that are analogous to interest rates) and applying them against future cash flows, a company can aggregate the discounted cash flows to arrive at a single number, which can be compared to the aggregate number of other discounted streams of cash flows. These "net present values" will illustrate which cash flow stream is worth more in today's dollars. This simplifies the decision process when trying to choose one project over another. The most financially advantageous will have the highest NPV.

Another consideration in calculating the present value of an investment is deciding what discount (or interest) rate to use. The higher the discount rate, the lower the future costs and benefits are compared to today's values. The nature of most pollution prevention investments is such that their benefits are more likely to be realized over a longer period of time compared to the initial investment costs. By calculating the full costs of operation, including all environmental costs, firms may begin to view pollution prevention opportunities differently. A company should inquire with its finance company or bank to determine an appropriate discount rate.

Choice of Depreciation Method

There are many ways to depreciate a capital investment. It is important to note that, when using the TCA methodology, the method used to depreciate an investment can have a significant effect on the NPV generated. Choice of depreciation method is company specific, however, generally it is advisable to depreciate an investment as rapidly as possible to maximize the attractiveness of the project. Rapid depreciation increases the total adjusted cash flow in the earlier years of the project, which results in an increased NPV since TCA takes into account the time value of money.

Straight-line depreciation is the most simple depreciation method but also results in the lowest NPV when using the TCA methodology. Most investments should be evaluated using the Modified Accelerated Cost Recovery System (MACRS) to obtain a more favorable evaluation. It is also worthwhile to investigate whether the investment being evaluated qualifies under Section 179 of the federal tax code for a special accelerated depreciation. Section 179 allows a business to depreciate $17,500 above and beyond what would be allowed by the MACRS in the first year if the business has taxable income in that year and if the total assets purchased in the year-are less than $200,000. The amount allowed decreases by $1 for every dollar below $17,500 of taxable income the company has in the year and for every dollar above $200,000 of assets the company has purchased in the year until $0 allowed is reached.

To summarize, there are many methods available to depreciate a capital investment. TCA analyses generate more favorable results when investments are depreciated more rapidly. Individuals using TCA are encouraged to investigate what depreciation methods are allowable for investments by consulting the federal and state tax codes and conferring with a tax advisor or professional accountant.

CASE STUDY 1: ANALYSIS OF POWDER RECOVERY SYSTEM

Background

Powder coating is a dry painting process that involves coating electrostatically-charged parts with finely powdered paint. The powder is applied through a spray gun inside a specially designed spray booth. After the surface of the part is covered with powder, it is sent through a 400-degree Fahrenheit oven that bakes the paint onto the part. This process results in a more durable, superior quality finish than traditional wet painting methods. A diagram of a typical powder coating process is shown in Appendix A.

The analysis of Production Plating's powder coating shop in Redmond involved a retrospective financial evaluation for the implementation of powder recovery. The powder recovery process involves the use of a large recovery unit that attaches to the existing vacuum and filtration system within the spray booth. The recovery unit is mobile and simply slides into place behind the existing spray booth (see Appendix B for a diagram of the recovery unit). The unit contains additional filters and pumps that allow powder, which is vacuumed from the spray booth, to be returned to the spray gun feed container for reapplication. The value of the powder recovery process is that less powder is needed, resulting in substantial cost savings and less wasted powder being sent to landfills. The wasted powder is classified as a nonhazardous waste.

Methodology

The analysis for the powder recovery process was based on the continuous job runs of one part-a component of a computer system. The part was chosen as a representative sample because it was run consistently for a significant period of time before (several months) and after powder recovery was initiated. Therefore, it was possible to make a uniform comparison between the powder coating process before and after the recovery process was implemented. This comparison was a valuable means of eliminating a possible source of variation. The company's records system included all the data needed to perform the analysis (see Appendix C for data on powder recovery job runs).

Implementation of TCA

Applying the TCA framework to assess the economic feasibility of the powder recovery system was a relatively simple task because the number of variables that changes after the investment was made were minimal. Most of the attention focused on Tiers 0 and 1 costs, as would be expected for a material that is classified as nonhazardous. Costs that qualify for inclusion in these tiers include direct labor, materials, equipment (Tier 0) and hidden, or indirect, costs such as monitoring, reporting, record keeping and permit requirements (Tier 1). For this analysis, Washington state sales tax on initial equipment purchased was not included because Production Plating qualified for a sales tax exemption under Washington state law. Other companies in Washington state may be able to take advantage of this tax exemption as well.

Many costs typically associated with the first two tiers were not included in the analysis because they were judged to be immaterial. For example, since the recovery unit is mobile and simply slides into place behind the existing spray booth, downtime and installation costs were minimal. Operations and maintenance time for the new unit was also found to be minimal. The significant costs and benefits include the cost of the unit, the cost of filter replacements (needed every three to four years), and the benefit (or savings) from wasting powder and, therefore, needing to buy less and spend less on disposal. The disposal costs of $42/ton used in the analysis is Production Plating's current cost for solid waste disposal. A salvage value of $2,000 was also included, and is based on Production Plating's estimate of the cash value of the equipment at the end of the project.

Many other costs and benefits were difficult to quantify. Tier 2 costs include future liability costs, such as remediation actions and personal injury costs. Tier 3 costs and benefits include less tangible items, such as customer response, employee relations, and corporate image. Many of the categories in Tiers 2 and 3 were considered, but no dollar values were assigned. They were included simply to provide an overall perspective of all possible costs and benefits.

Example of Job

The powder coating of the computer part was deemed a viable one for powder recovery because of the large number of parts being run and the long-term commitment by the manufacturer to continue to make the part.

Production levels have remained in the range of 500- 1,000 parts per week for six months, and the same color of powder is always used to coat the part.

The savings realized from the installation of the powder recovery unit is substantial. Prior to powder recovery, the average amount of powder used per part was approximately 0.20 lbs. After recovery was implemented and the recovery unit went through a "break-in" period, the amount of powder per part dropped to 0.11 lbs. This break-in period occurs because the inside of a new powder recovery unit must become coated with powder before it will operate at optimal efficiencies. Based on an average production run of approximately 650 parts per week and $3.50 per pound for powder, Production Plating would realize a savings of $10,876 per year - a 45.13 percent savings for powder costs alone (see Appendix D). (Note: Additional energy required to run the system when it is fully coated was assumed to be minimal, and therefore was not included in the analysis.) The figure of 650 parts per week was used for the TCA because this is the production level Production Plating expects to meet regularly over the next several years.

Results

The savings from the recovery of powder is significant. If the figures are incorporated into the TCA spreadsheet template, along with other costs and benefits, the result is a positive NPV of $18,334 with a payback period of approximately 1.2 years. This figure is based on a recovery unit useful life expectancy of five years, with a production level of approximately 650 parts per week, a paint cost of $3.50 per pound, and a powder savings of 45.13 percent (see Appendix D). If a project life of 10 years is used, the NPV increases to $32,368 (see Appendix E). At Production Plating's request, this analysis was performed using a simple straight-line depreciation method. Use of other depreciation methods, as discussed on page 5, could improve the NPV of this investment.

A sensitivity analysis (based on life expectancy of five years) performed for various factors allows for the determination of the changes that would result from various scenarios (see Appendix F). The results indicate that the factor with the biggest impact is production level. If an adequate production level cannot be maintained, the financial viability of the equipment disappears. For example, if the number of parts per week drops from the current 650 to 325 due to a drop in production, the NPV drops by 65 percent. The payback period jumps to more than 2.5 years. However, if the production rate doubles to 1,300 parts per week, the NPV increases dramatically to $42,338, and the payback is reduced to just over six months.

Other factors that have a significant affect on the economic analysis are the paint cost and the percentage of paint saved using powder recovery. Appendix F also shows the results of changing these values. The results indicate that paint costs cannot drop too low, and that consistent powder recovery rates must be maintained to make the investment attractive. Tier 2 and Tier 3 cost/benefits of the recovery system relative to the old system are shown in Appendix G. These costs/benefits include: materials handling, equipment handling, and future liability (Tier 2); and corporate image, environmental image, customer response, and market share (Tier 3).

A significant factor that should be considered is the assumed useful life of the equipment. A shorter useful life makes the investment appear less worthwhile as compared to the 5-year useful life scenario. (Again, refer to Appendix D for a 5-year time horizon and Appendix E for a lo-year time horizon.)

Recommendations

Based on the positive results of the analysis, implementing the powder recovery system appears to be an economically and environmentally wise investment for Production Plating. As long as the company is running large, long-termjobs or multiple small jobs that use the same color of powder, it will save money using the powder recovery system. The time period required to qualify as "long-term" depends on the size of the job run and the amount of paint used per part. Production Plating is attempting to move toward more large, long-term jobs or multiple small jobs that use the same powder color.

CASE STUDY 2: ANALYSIS OF PLANT RINSEWATER RECYCLING

Background

The metal plating process is chemical and water intensive. Due to the chemicals and waste streams associated with Production Plating's metal plating facility in Mukilteo, the site has a greater environmental risk than the powder coating facility. To meet regulatory requirements, Production Plating's goal is to decrease the amount of water used for and discharged from the rinsewater process. In doing so, the company would not only reduce its costs associated with water usage, but also reduce the environmental impact of the facility.

Currently, Production Plating's rinsewater system is a multi-staged process (a basic diagram is shown in Appendix H). The various rinsewater baths use plain tap water as a base liquid. Spent rinsewater is collected in four different surge tanks, depending on the type of rinsewater. The four types of rinses are non-heavy metal, acid/chrome, mildly alkaline/cleaner, and alkaline. The non-heavy metal rinsewater is pH adjusted and discharged directly to the sanitary sewer. The acid/chrome rinsewater is first sent through a reduction step, labeled tank "3- 1," that converts hexavalent chrome in the water to trivalent chrome, a much less hazardous form. After additional mixing takes place in tank 3-2, the mildly alkaline/cleaner rinsewater is added to the acid/chrome rinsewater in tank 3-3. Any necessary adjustment of pH also takes place in tank 3-3 through the addition of sulfuric acid or caustic solution using metering pumps. The mixed acid/chrome and mildly alkaline/cleaner solution then are equilibrated in tank 3-4.

The alkaline rinsewater is alternately pH adjusted and equilibrated in tanks 4-1 through 4-4. The contents of tanks 4-4 and 3-4 are combined in another tank, and a chemical coagulant is added. Next, the mixed rinsewater is pumped through a flash mixer where flocculent is added and delivered to a clarifier. Sludge from the clarifier is processed in a filter press to reduce the water content. The sludge then dries at room temperature and is shipped off-site as hazardous waste. The clarified water is sent through a sand filter. After sand filtering, the water is either sent to a final pH adjustment and discharged to the sanitary sewer, or added back to the mildly alkaline/ cleaner surge tank, along with water discharged from the filter press, for additional processing. The entire rinsewater treatment occupies approximately 5 percent of Production Plating's operating floor, displacing revenue-generating floor space.

The PPRC identified several alternatives that could allow Production Plating to reduce or reuse rinsewater. One alternative was a rinsewater recycling system that would decrease the amount of water discharged by 90 percent. The system is an ultrafiltration system offered by Zenon Environmental Systems, and would replace the chemical additive and filtration processes of Production Plating's current system. This change would result in more available floor space, less chemical additives, less chemical handling, and decreased water usage.

Methodology

With the help of the PPRC and the Washington Department of Ecology's Toxic Use Reduction Program, options to reduce Production Plating's rinsewater use and discharges were investigated. An evaluation of the company's Mukilteo plating shop showed several opportunities to reduce the overall use of rinsewater prior to the installation of a rinsewater recycling system. For example, opportunities include minor modifications in the operational approach taken by shop workers during processing (drain times were not long enough, resulting in cross-contamination of rinses); the installation of several additional, strategically located rinsewater baths; and replacement of existing ball valves used tocontrol rinsewater flows to the rinse baths with gate valves or solenoid valves connected to conductivity meters. Implementing these minor modifications has the potential to reduce overall rinsewater flows in the process by 50 to 90 percent, or more. These recommendations followed from a logical pollution prevention approach to decision-making, which favors reduction in use before considering recycling.

The PPRC and Washington Department of Ecology recommended that Production Plating make the minor process modifications before formally considering investing in a rinsewater recycling system to reuse water on site. While pursuing implementing the changes, Production Plating wanted to analyze the costs associated with its current wastewater treatment system and the economics of installing a rinsewater recycling system for its current flow rate (27,500 gallons per day).

The PPRC reviewed several rinsewater recycling systems that could replace Production Plating's current wastewater treatment system, including ion exchange, ultrafiltration, and reverse osmosis. It was decided to perform a preliminary TCA analysis on only one of the options, because at the time of the analysis accurate operational data could not be collected on many of the unknown, intermediate flow lines that comprise the rinsewater process. Data could not be collected because many of the rinsewater lines were shut down for an extended period of time while several in-shop construction efforts were underway. At a later date, when the entire shop is fully operational, the necessary data can be collected and an accurate TCA analysis of several rinsewater recycling systems may be done.

Ultrafiltration was selected as a candidate for a preliminary TCA analysis because it has less ongoing chemical requirements than ion exchange and much lower pressure requirements than reverse osmosis. The PPRC worked with Aqueous Engineering, the Seattle-area representative of Zenon Environmental Systems, to develop preliminary cost data for a rinsewater recycling system using ultrafiltration.

Implementation of TCA

While the PPRC was gathering cost data, the University of Washington students collected data from Production Plating to determine current operational costs. Costs such as direct labor, materials, and equipment are considered Tier 0 and hidden, and indirect costs such as monitoring, reporting, record keeping, and permit requirements are considered Tier 1. Tier 0 costs for Production Plating include chemicals for the rinsewater treatment, worker and management labor, monitoring costs, and filter costs. Tier 1 costs obtained from Production Plating include violation fees (current and future), labor used for testing and reporting, and sludge disposal costs.

Tier 0 costs were estimated as follows. Operations and maintenance expenses were estimated by Production Plating by estimating the number of labor hours (both management and nonmanagement) required to check the system and make adjustments. Estimated management and nonmanagement labor rates were also provided by Production Plating. Sludge handling expenses were based on Production Plating's estimates of the amount of labor involved with preparing the sludge and conveying it to a dumpster for pickup. Chemical additive expenses were based on actual chemical usage data for July through December 1995. This data was then annualized to arrive at projections for future expenses. Water input and disposal expenses were based on current usage levels from the water utility bills and were averaged to arrive at a daily rate.

Tier 1 costs were estimated as follows. Sampling, testing, and reporting expenses were based on estimates provided by Production Plating for the estimated amount of management labor expended to sample the rinsewater and for reporting requirements of local POTW and the Washington Department of Ecology. Sludge disposal expenses were based on current monthly costs to haul away the current levels of sludge produced by the filtration process of the rinsewater system. Expenses for penalties and fines are based on historical data for the past year when Production Plating had been fined twice ($2,000 and $1,000) by Ecology. While the company is striving to incorporate pollution preventing measures, it wanted to account for possible future fines. The current amount of $3,000 was used to project future fines, however, according to representatives from the Washington Department of Ecology, it is likely that future fines would be significantly higher. Nonetheless, the $3,000 value was used for this analysis. All Tier 1 costs, once accumulated, were annualized and projected to arrive at the cash flows expended to operate the current rinsewater system.

At Production Plating's request, this analysis was performed using a simple straight-line depreciation. Use of other depreciation methods could improve the NPV of this investment.

Information for the new rinsewater recycling system from Zenon Environmental Systems and the associated operational costs were provided by the PPRC. These costs are discussed below.

<u>Results</u>

<u>Cost Using Current System</u>

The cost analysis for the current rinsewater system showed that annual operating expenses were approximately $123,000 for the first year, and rose steadily there after due to inflation. Production Plating's main cost driver for its current system is water. The company incurs charges for water inflow ($1.50 per gallon) as well as water outflow ($4.50 per gallon). At an average usage of 27,500 gallons per day, water represents approximately 35 percent of the company's process costs. Any reduction in water usage reduces the cost substantially. The other major cost drivers are sludge handling anddisposal (20 percent), chemical additives (21 percent), andoperations and maintenance labor (20 percent). These costs are shown in Appendix I for the current system and Appendix J for the proposed rinsewater recycling system. Appendix K shows the chemical additive costs for the current system.

<u>Cost of Rinsewater Recycling Svstem</u>

The preliminary TCA analysis (see Appendix L) for recycling rinsewater using ultrafiltration yielded a positive NPV of $168,697. This figure represents the savings of using the rinsewater recycling system compared to Production Plating's existing system over a lo-year horizon, and is the amount of money the company would save over a IO-year period if it invested in the rinsewater recycling system.

This analysis was based on a preliminary estimate of the cost and performance of the new ultrafiltration system manufactured by Zenon Environmental Systems. The preliminary estimate can be further refined when current construction efforts at Production Plating are completed, and real operational rinsewater samples can be taken and analyzed for use in a revised engineering analysis. The assumed initial capital cost of $175,000 is a typical value for a fully automated ultrafiltration system capable of processing the 27,500 gallons per day required for the rinse lines in the plant. Other assumptions used in the estimate were:

- $50,000 is the estimated salvage value of the existing equipment, which could be sold if the ultrafiltration unit was installed. The $50,000 figure was included in the analyses in year 0 and offsets part of the purchase cost of the new system. Including the current system's salvage value in the new system's economic analysis is not typically done. Typically, the salvage value of the old equipment is calculated into the economic analysis for the old equipment. The approach used in this case study was requested by Production Plating.

- After 10 years, the new system is given a $0 salvage value. This was done to offset the salvage value on the old system that was claimed, as discussed above.

- By installing the ultrafiltration system, it is estimated that water used in the rinsewater lines would be reduced by 90 percent. This figure needs to be verified by laboratory tests performed when current construction efforts are completed at the facility.

- The labor required for system maintenance was reduced to reflect the increased automation of the new process.

- The reduced chemicals required for the new system were based on typical requirements for a metal plating rinsewater recycling unit operating at 27,500 gallons per day.

- It is estimated that the amount of sludge generated, and requiring disposal, would be reduced by 70 percent. This percentage of reduction in sludge is typical when using the system designed by Zenon Environmental Systems.

The main Tier 0 cost is the purchase price for the new system - $175,000. At first glance, it seemed too high for Production Plating. When put into the context of the company's operational costs, Tier 1 cost savings, and other intangible factors (Tier 2 and Tier 3 costs/benefits), the alternative proved to be viable and productive with a payback period of about 2.3 years. If an analysis had not been done, the rinsewater recycling system easily could have been overlooked or dismissed as not financially feasible.

Intangible factors add information to the decision-making process. These factors are difficult to measure, but can have significant influence. For example, moving to the Zenon system would reduce much of the employees' need to handle some waste treatment chemicals. This would reduce the opportunity for human errors and would potentially decrease the likelihood of worker injury. These factors are indicated in Appendix M, and are an important part of Tier 2 and Tier 3 costs in TCA.

The analysis is based on the assumption that the Zenon system is a viable alternative for Production Plating's processes. A detailed compatibility analysis is currently being conducted to determine whether the system is acceptable. It must also be noted that the costs used in arriving at the positive NPV above are preliminary estimates. A pilot test using a Zenon-like unit must be done to assess the actual reduction in water and chemical additive usage rates. The TCA analysis should be continually updated to reflect new information to ensure the financial viability of the project.

Recommendations

Prior to investing in any rinsewater recycling system, Production Plating is considering several, less capital-intensive alternatives that will reduce its water usage substantially. The environmental "hierarchy" of resource use indicates that businesses should ***reduce*** first, then ***reuse.*** Once reduction is accomplished and new water flow rates are established, another detailed TCA analysis should be performed to assess the financial viability of installing an ultrafiltration rinsewater recycling system.

However, in lieu of data for possible reduction options, the positive results of the preliminary analysis indicate Production Plating should consider installing the Zenon system. Assuming this alternative is compatible with Production Plating's processes, it is an economically and environmentally viable solution.

It is also recommended that Production Plating use TCA for future pollution prevention decisions. Initially, Production Plating experienced "sticker shock" when told how much the Zenon system would cost. However, the TCA analysis showed a favorable long-term investment with substantial cost savings.

CONSIDERATIONS FOR USING TCA IN SMALL BUSINESSES

The main objective of this project was to demonstrate the feasibility of using TCA for evaluating pollution prevention investments in the metal finishing industry. One of the challenges in using TCA with small companies is getting the decision makers to view costs and benefits more broadly. While TCA can provide a well-structured method for approaching investment analysis, it still requires time, effort, and skills beyond the scope of those available by many in the industry. For example, most small companies typically measure projects in terms of payback, without regard for the time value of money. The nature of most pollution prevention investments is such that their benefits are likely to be realized over a longer period of time compared to the initial investment costs. In most cases there must be a clear financial benefit for a small business to undertake any investment, environmental or otherwise. To the extent that. TCA can be presented in a form that is relatively quick and easy to use, it can be a valuable tool for metal finishing companies to make more-informed pollution prevention investment decisions.

Performance of TCA at Production Plating

Production Plating, like most small companies, has limited resources. While the company is interested in understanding new ways to analyze project decisions for the long term, the realities of near-term resource needs are always a concern. While having access to a personal computer with software such as Excel or Lotus is not essential to conduct a TCA analysis, it does make it easier. One challenge to using TCA at Production Plating is the availability of computer hardware and software. The Redmond facility has no personal computers. Even if calculations were made without the use of computers, project decision-makers would need to have an understanding of net present value and discounted cash flows.

Analysis of Powder Recovery System

The changes associated with implementing the powder coating recovery process were minor. And, because it was a retrospective analysis, and data was available for both before and after the powder recovery unit was installed, the TCA analysis for this process was easy to perform. This is important for two reasons. First, many of the metal platers in the initial industry roundtable mentioned the importance of actually seeing the benefits of proposed systems. The powder recovery TCA analysis showed positive results for an *existing* project. Second, the analysis showed that even for relatively simple projects, TCA can provide a much better understanding of the true costs and benefits over the longer term.

Analysis of Rinsewater Recycling: System

The rinsewater recycling project was a successful demonstration of a more complex use of TCA. This analysis presented challenges because of the significant capital investment and process complexity. The relatively high cost of a new rinsewater recycling system makes it more difficult to justify to management, even though the long-term benefits are much greater than the benefits of the powder recovery system. As discussed on page 9, the TCA for rinsewater recycling presented in this report is very preliminary and will need to be refined to be truly useful for decision-making.

Feasibility Within the Metal Finishing Industry

TCA has been shown to be an effective tool for evaluating pollution prevention investments. But, is it feasible to gain widespread use within the metal finishing industry? The two projects conducted for Production Plating emphasize the need for economic analysis tools to be relatively quick and easy to use. Smaller companies typically do not have the expertise to apply the TCA framework to prospective projects.

There is also the issue of customization; each shop has a slightly different process and job stream. The nature of job shops is that they are driven by customer relationships, product quality, reliable service, and price. Each shop may use a proprietary process or technology to give it an advantage over the competition. The use of TCA by itself does not represent a proprietary advantage. However, the sharing and demonstration of TCA for particular projects within an industry presents challenges of information sensitivity.

Therefore, the goal is to develop a model for conducting TCA that can be easily replicated at other companies in the metal finishing industry. First and foremost, businesses need to be willing to expand their scope of environmental costs and benefits. Production Plating has shown its willingness to do this by actively working with the PPRC. To build an appropriate model for widespread use, more feedback should be received on the requirements of the industry. The Production Plating case studies, in combination with feedback from other companies, could be used as a baseline for developing such a model. The PPRC has a crucial role to play by acting as a catalyst for changing the way small companies view pollution prevention investments. In cases where companies lack knowledge of technologies, the PPRC can help by providing the necessary information to businesses. The Washington Department of Ecology, or other state regulatory agencies, can also help businesses evaluate pollution prevention alternatives using the TCA method.

Requirements for Small Businesses to Implement TCA

Following are some of the requirements of using TCA to effectively evaluate the costs/benefits of pollution prevention investments, which were identified during this project:

- A project leader should be identified to coordinate the collection, quantification, organization, and analysis of data. This person may delegate tasks to others, but an overall project champion is critical.

- Money will need to be spent on data collection, technology searches, additional staff time, and potential equipment acquisition.

- A personal computer and software (Excel or Lotus) is recommended to perform a detailed TCA to reduce calculation time. However, for companies without access to such tools, the analysis can also be done using a simple worksheet.

- An understanding of capital budgeting concepts, such as NPV and discounted cash flows, is needed. This is required not only of the person completing the analysis, but for the decision-makers who will use the TCA results to make pollution prevention investments.

- A willingness to modify/augment existing accounting systems so that finer details on costs for individual inputs, outputs, processes, and jobs can be tracked. This data tracking may not need to come from existing systems, but could be done from a separate or new system.

CONCLUSIONS & RECOMMENDATIONS

Based on the study performed by the University of Washington project team and the recommendations the team presented to the PPRC, the following conclusions and recommendations were developed by the PPRC.

- TCA is a valuable tool for analyzing pollution prevention investments in the metal finishing industry, both past investments or prospective projects. TCA also does tend to promote pollution prevention investments by making them more appealing than they would appear using less comprehensive methods of project analysis.

- Computer tools can reduce the time required to do the calculations for TCA, but are not a requirement. Templates in the form of computer spreadsheets for performing TCA that are customized for metal finishers would help metal finishers or consultants they hire to conduct a TCA.

- Most small metal finishers are capable of using TCA, but they must be willing to commit the time and resources required to understand the method and concepts associated with the time value of money up-front to be able to use TCA independently. This time commitment is roughly equivalent to one day worth of labor time. Although this is not a significant amount of time, many smaller businesses are not able (or not willing) to set this amount of time aside. Smaller businesses may be able to overcome this barrier to using TCA if conveniently located and scheduled TCA training workshops can be offered that include hands-on use of the method. This training would allow a business person to try the method, which is likely to increase his or her comfort in using it when calculating future investment decisions.

- While TCA is particularly useful for analyzing pollution prevention investments, because it helps show their true value, TCA is actually a useful tool for helping make decisions on whether to invest in almost any project. This point was specifically mentioned by Production Plating when post-study discussions took place to find out the company’s impressions of TCA. Even if a particular project has little or no environmental considerations, TCA can still be used to measure the value of a project in a way that accounts for the time value of money. It may be that promotion of TCA as a valuable decision-making tool for small businesses would be enhanced by promoting it without the associated label of it being specifically intended for environmental projects.

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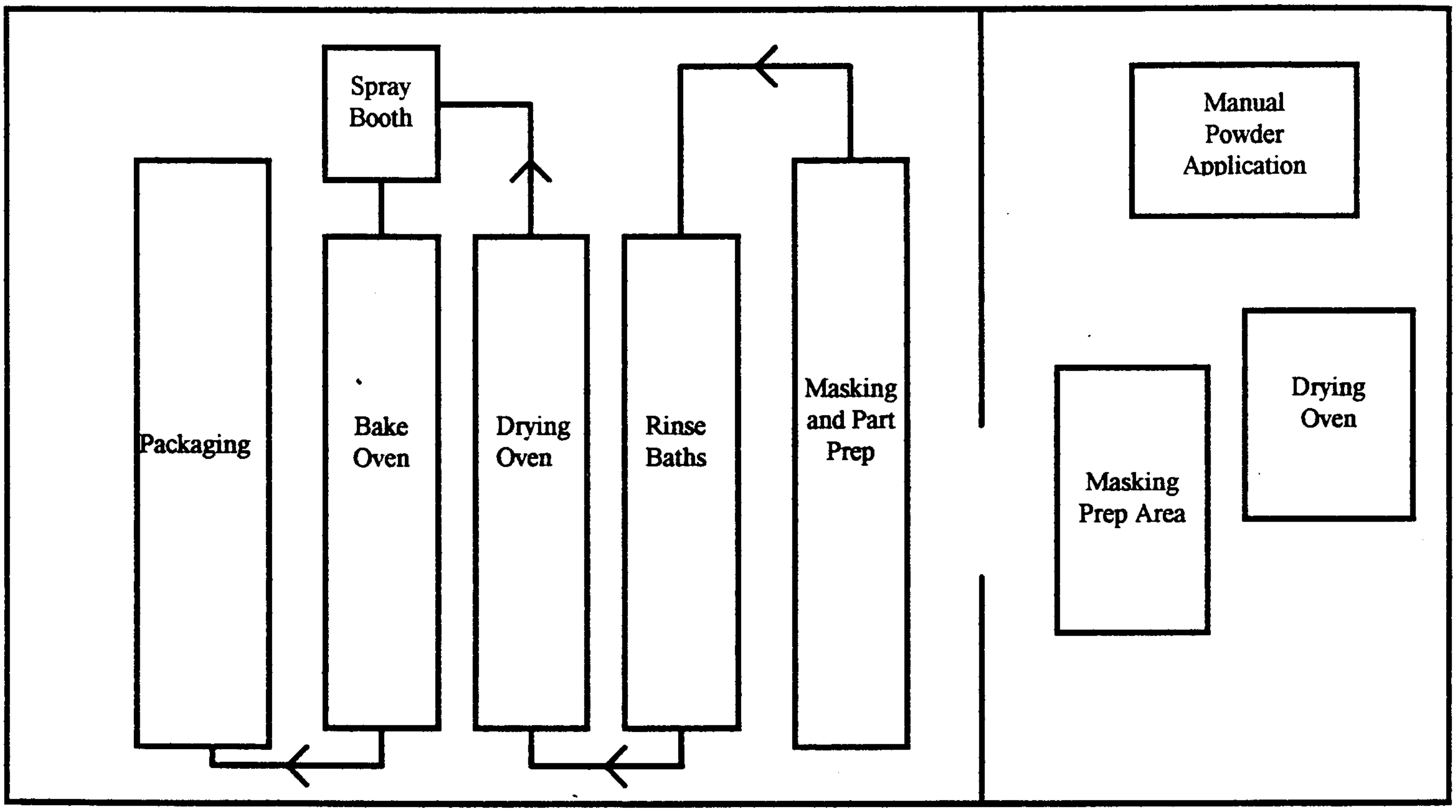
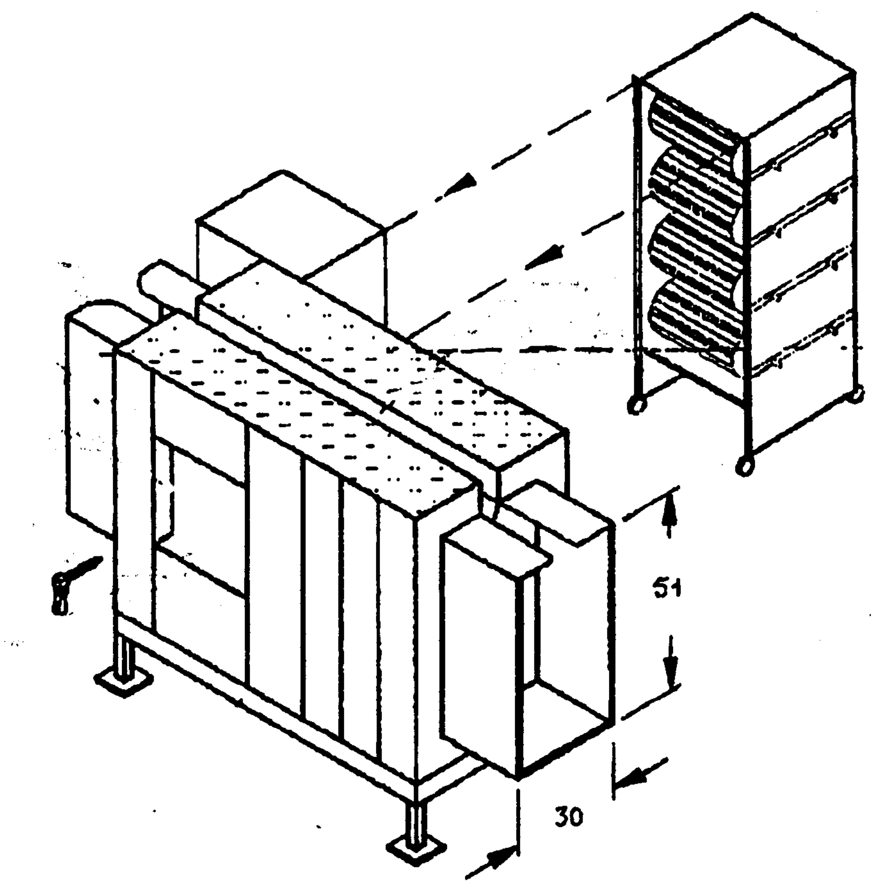
Appendix A

Production Plating
Powder Coating Facility Process Flow



Appendix B

Production Plating
Powder Recovery System



Appendix C
Production Plating - Powder Recovery Data
(Savings Based on Job Runs from 3/8/96 to 4/18/96)

Date	Parts Qty	Pwdr Used (lbs.)	Time to Run (minutes)	Pwdr Price ($/lb.)	Job Total ($)	Powder % (of price)	Check	Pounds/Part (lbs. used/qty.)
				(Before Powder Recovery)				
7/27/95	64	8	35	5.65	239.36	19.00%	18.88%	0.1250
8/11/95	85	21.5	103	5.65	317.9	40.00%	38.21%	0.2529
9/20/95	267	45.5	200	5.65	1692.78	15.10%	25.74%	0.1704
10/16/95	80	14.5	40	4.8	299.2	23.20%	23.26%	0.1813
10/17/95	192	32.5	115	4.8	1217.28	21.70%	21.72%	0.1693
10/28/95	320	67		5.65	2028.8		31.63%	0.2094
11/3/95	**486**	**127**	**300**	**5.65**	**3470.52**	**21.00%**	**39.48%**	**0.2613**
11/10/95	**491**	**88.5**	**275**	**5.65**	**3112.94**		**27.23%**	**0.1802**
11/17/95	483 (two job run)							
11/22/95	**594**	**127.5**	**305**	**5.65**	**3765.96**	**32.50%**	**32.43%**	**0.2146**
12/1/95	474 (adjustment)							
12/8/95	**458**	**100**	**320**	**5.65**	**2903.72**	**32.90%**	**32.98%**	**0.2183**
12/15/95	**560**	**134**	**368**	**3.85**	**3550.4**	**24.60%**	**24.63%**	**0.2393**
12/21/95	**544**	**130**	**332**	**3.8**	**3448.96**	**24.20%**	**24.28%**	**0.2390**
12/29/95	**483**	**84**	**283**	**3.85**	**3062.22**	**18.00%**	**17.90%**	**0.1739**
1/19/96	**542**	**93**	**269**	**3.85**	**3398.24**	**17.80%**	**17.66%**	**0.1716**
1/26/96	**548**	**91.5**	**334**	**3.85**	**3474.32**	**17.20%**	**17.19%**	**0.1670**
2/2/96	**511**	**108**	**269**	**3.85**	**3239.74**	**21.70%**	**21.76%**	**0.2114**
				Weighted ave. of lbs/part				**0.2077**
				(Using Powder Recovery)				
2/9/96	590	107	297	3.5	3740.6	16.90%	16.97%	0.1814
2/16/96	1088	211	430	3.5	7169.92	18.10%	18.15%	0.1939
2/23/96	992	159	455	3.5	6537.28	14.90%	15.00%	0.1603
3/1/96	608	123	277	3.5	4006.72	18.90%	18.93%	0.2023
3/8/96	***1080***	***184.5***	***461***	***3.5***	***7117.2***	***15.90%***	***15.99%***	***0.1708***
4/5/96	***346***	***26.5***	***183***	***3.5***	***2245.54***	***7.20%***	***7.17%***	***0.0766***
4/12/96	***759***	***70***	***391***	***3.5***	***4925.91***	***8.60%***	***8.63%***	***0.0922***
4/18/96	***509***	***26***	***270***	***3.5***	***3303.41***		***4.78%***	***0.0511***
				Weighted ave. of lbs/part(3/8 to 4/18 only)				**0.1140**

Total percentage of paint saved.	**45.13%**
Future Average Parts per week:	650
Lbs Powder Saved per week:	60.92
Dollars Saved/Week at $ 3.5/lb	$213
Estimated Annual Savings(assuming 51 op. weeks/year) =	**$10,875**

Appendix D

Production Plating

Powder Recovery Total Cost Assessment

(Using paint savings of 45.13% and 5 year time horizon)

Assumptions:	
Paint Cost (per lb.)	$3.50
Pounds used per year (before recovery)	6885.26
Percentage of paint saved (after recovery)	45.13%
Pounds of Paint Recovered	3107.32
Paint Disposal Cost ($/ton)	$42
Inflation Rate	5%
Discount Rate	15%
Useful Life (years)	5
Tax Rate	40%
Disposal Rate Increase	10%

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Tier 0 (Costs)/Benefits						
Procurement						
New Equipment	($8,000)					
Salvage Value						$2,000
Operating Changes						
Materials - Paint Savings		$10,876	$11,419	$11,990	$12,590	$13,219
Waste Disposal Savings		$65	$72	$79	$87	$96
New Filters					($1,200)	
Total Tier 0 (Costs)/Benefits	($8,000)	$10,941	$11,491	$12,069	$11,477	$15,315
Total Operating Net Benefit	0	$10,941	$11,491	$12,069	$11,477	$15,315
Less Depreciation Expense	0	($1,600)	($1,600)	($1,600)	($1,600)	($1,600)
Total Taxable Income	($8,000)	$9,341	$9,891	$10,469	$9,877	$13,715
Less Taxes		($3,736)	($3,956)	($4,188)	($3,951)	($5,486)
Add back depreciation		$1,600	$1,600	$1,600	$1,600	$1,600
Total Yearly Net Cash Flow	($8,000)	$7,205	$7,535	$7,882	$7,526	$9,829

Net Present Value	**$18,334**
Payback	1.2 years

Appendix E

Production Plating

Powder Recovery Total Cost Assessment

(Using paint savings of 45.13% and a 10 year time horizon)

Assumptions:	
Paint Cost (per lb.)	$3.50
Pounds used per year (before recovery)	6885.26
Percentage of paint saved (after recovery)	45.13%
Pounds of Paint Recovered	3107.32
Paint Disposal Cost ($/ton)	$42
Inflation Rate	5%
Discount Rate	15%
Useful Life (years)	10
Tax Rate	40%
Disposal Rate Increase	10%

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Tier 0 (Costs)/Benefits											
Procurement											
New Equipment	($8,000)										
Salvage Value											$1,000
Operating Changes											
Materials - Paint Savings		$10,876	$11,419	$11,990	$12,590	$13,219	$13,880	$14,574	$15,303	$16,068	$16,872
Waste Disposal Savings		$65	$72	$79	$87	$96	$105	$116	$127	$140	$154
New Filters					($1,200)				($1,200)		
Total Tier 0 (Costs)/Benefits	($8,000)	$10,941	$11,491	$12,069	$11,477	$13,315	$13,985	$14,690	$14,230	$16,208	$18,026
Total Operating Net Benefit	0	$10,941	$11,491	$12,069	$11,477	$13,315	$13,985	$14,690	$14,230	$16,208	$18,026
Less Depreciation Expense	0	($800)	($800)	($800)	($800)	($800)	($800)	($800)	($800)	($800)	($800)
Total Taxable Income	($8,000)	$10,141	$10,691	$11,269	$10,677	$12,515	$13,185	$13,890	$13,430	$15,408	$17,226
Less Taxes		($4,056)	($4,276)	($4,508)	($4,271)	($5,006)	($5,274)	($5,556)	($5,372)	($6,163)	($6,890)
Add back depreciation		$800	$800	$800	$800	$800	$800	$800	$800	$800	$800
Total Yearly Net Cash Flow	($8,000)	$6,885	$7,215	$7,562	$7,206	$8,309	$8,711	$9,134	$8,858	$10,045	$11,135

Net Present Value	$32,368
Payback	1.2 years

Appendix G

Production Plating

Powder Recovery Total Cost Assessment

Qualitative factors (powder recovery relative to historical system)

Tier 2	(Costs)/Benefits
Materials handling	+
Equipment handling	
Future liability	+

Tier	
Corporate image	+
Environmental image	+
Customer response	+
Market share	+

Appendix F

Production Plating

Powder Recovery Total Cost Assessment

(Using paint savings of 45.13% and 5 year time horizon)

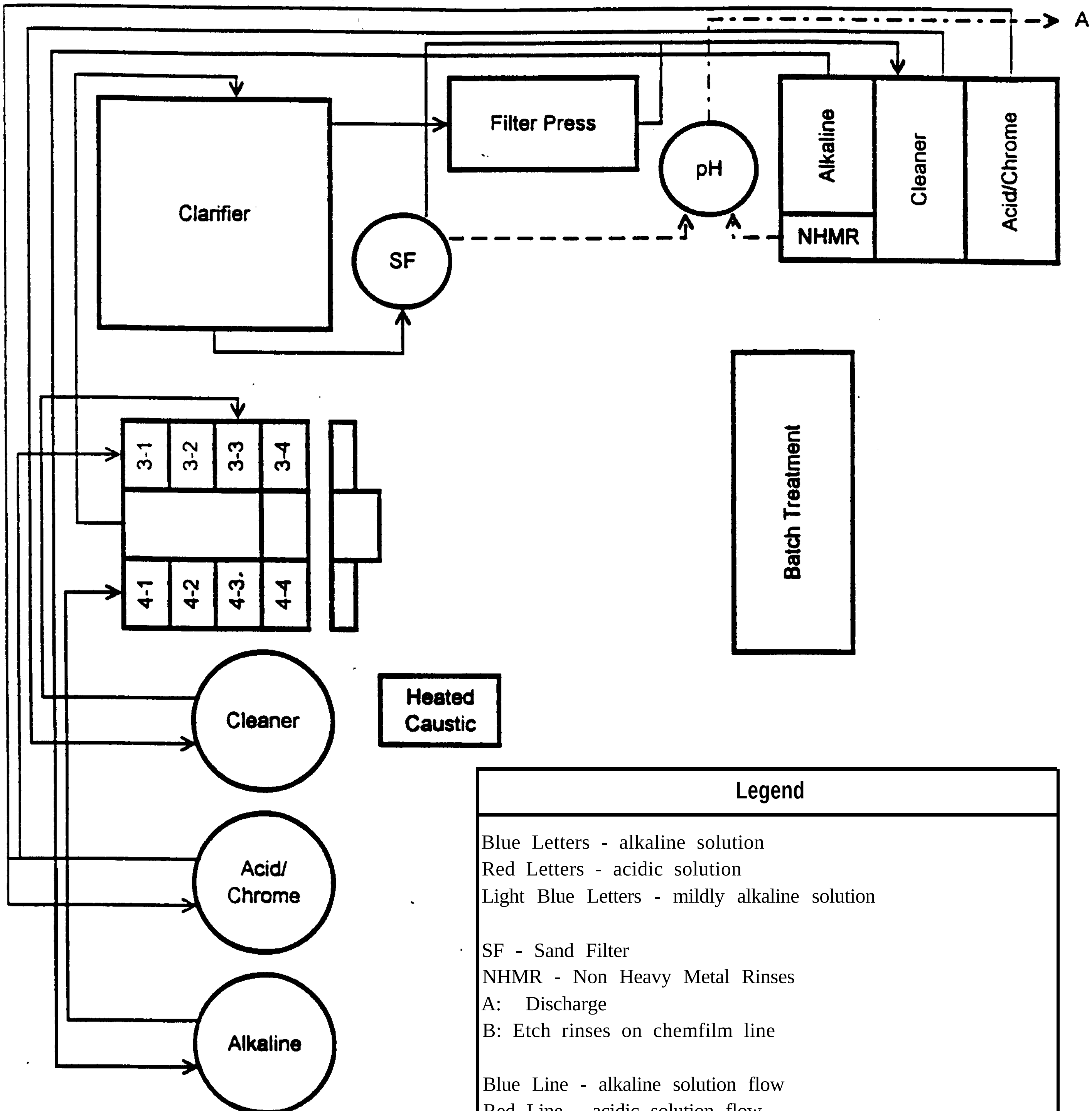
Sensitivity Analysis

Baseline NPV **$18,334**

Category	Baseline Value	New Value	New NPV
Discount Rate	15%	10%	$ 21,942
		20%	$ 15,377
Inflation	5%	3%	$ 17,523
			$ 19,175
Paint Cost	$3.50	7 %	$ 11,521
		$4.50	$ 25,148
% of Paint Saved	45.13%	20%	$ 4,968
		30%	$ 10,287
		50%	$ 20,924
Parts Coated per Week	650	325	$ 6,332
		1,300	$ 42,338

Appendix H

Production Plating
Metal Plating Waste Rinsewater Treatment Process Flow Diagram



Legend

Blue Letters - alkaline solution
Red Letters - acidic solution
Light Blue Letters - mildly alkaline solution

SF - Sand Filter
NHMR - Non Heavy Metal Rinses
A: Discharge
B: Etch rinses on chemfilm line

Blue Line - alkaline solution flow
Red Line - acidic solution flow
Light Blue Line - mildly alkaline solution flow
Dark Green Line - coagulated metal solution flow
Light Green Line - precipitated solution flow
Alternating Dashed Blue Line - effluent flow
Dashed Blue Line - pH adjustable solution flow
Brown Line - sludge flow

Appendix I

Production Plating

Metal Plating Rinsewater System Current Costs

Assumptions:

Labor - Waste Treatment	Hourly Wage Rate	Hours	
Operations/Maintenance (non-mgmt)	$10.00	3	per shift
Operations/Maintenance (mgmt)	$25.00	4	per month
Sludge Handling	$10.00	1	per shift
Sampling / Testing	$25.00	1	per month
Reporting	$25.00	3	per quarter

Sample Testing Costs	$100 per month	
Water	Usage (gal/day)	Cost (1000 gal)
Input	27,500	$1.50
Disposal	27,500	$4.50
Sludge Disposal (per 3 month period)	$4,150	
Inflation Rate	5%	
Discount Rate	15%	
Tax Rate	40%	

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Tier 0 Costs											
Operating Expenses											
Direct Labor											
Operations & Maintenance	$0	($24,600)	($25,830)	($27,122)	($28,478)	($29,901)	($31,397)	($32,966)	($34,615)	($36,345)	($38,163)
Sludge Handling	$0	($7,800)	($8,190)	($8,600)	($9,029)	($9,481)	($9,955)	($10,453)	($10,975)	($11,524)	($12,100)
Total Direct Labor	$0	($32,400)	($34,020)	($35,721)	($37,507)	($39,382)	($41,352)	($43,419)	($45,590)	($47,870)	($50,263)
Materials											
Chemical Additives	$0	($26,388)	($27,708)	($29,093)	($30,548)	($32,075)	($33,679)	($35,363)	($37,131)	($38,988)	($40,937)
Water Input	$0	($10,725)	($11,261)	($11,824)	($12,416)	($13,036)	($13,688)	($14,373)	($15,091)	($15,846)	($16,638)
Water Disposal	$0	($32,175)	($33,784)	($35,473)	($37,247)	($39,109)	($41,064)	($43,118)	($45,273)	($47,537)	($49,914)
Total Materials	$0	($69,288)	($72,753)	($76,391)	($80,210)	($84,221)	($88,432)	($92,853)	($97,496)	($102,371)	($107,489)
Total Tier 0 Costs	$0	($101,688)	($106,773)	($112,112)	($117,717)	($123,603)	($129,783)	($136,272)	($143,086)	($150,240)	($157,752)
Tier 1 Costs											
Direct Labor											
Sampling & Testing	$0	($300)	($315)	($331)	($347)	($365)	($383)	($402)	($422)	($443)	($465)
Reporting	$0	($300)	($315)	($331)	($347)	($365)	($383)	($402)	($422)	($443)	($465)
Total Direct Labor	$0	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)
Sample Testing Costs	$0	($1,200)	($1,260)	($1,323)	($1,389)	($1,459)	($1,532)	($1,608)	($1,689)	($1,773)	($1,862)
Sludge Disposal	$0	($16,600)	($17,430)	($18,302)	($19,217)	($20,177)	($21,186)	($22,246)	($23,358)	($24,526)	($25,752)
Penalties & Fines	$0	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)	($3,000)
Total Tier 1 Costs	$0	($21,400)	($22,290)	($23,225)	($24,206)	($25,236)	($26,318)	($27,454)	($28,646)	($29,899)	($31,214)
Total Operating Expenses	$0	($123,088)	($129,063)	($135,336)	($141,923)	($148,839)	($156,101)	($163,726)	($171,732)	($180,139)	($188,966)
Add Income Tax Expense	$0	$49,235	$51,625	$54,134	$56,769	$59,536	$62,440	$65,490	$68,693	$72,056	$75,586
Net Cash Flows	$0	($73,853)	($77,438)	($81,202)	($85,154)	($89,303)	($93,661)	($98,236)	($103,039)	($108,083)	($113,380)

Net Present Value ($439,108)

Appendix J

Production Plating

Metal Plating Rinsewater System Alternative Costs

Assumptions:

Labor - Waste Treatment	Hourly Wage Rate	Hours	
Operations/Maintenance (non-mgmt)	$10.00	1	per shift
Operations/Maintenance (mgmt)	$25.00	4	per month
Sludge Handling	$10.00	1	per shift
Sampling / Testing	$25.00	1	per month
Reporting	$25.00	3	per quarter

Sample Testing Costs $100 per month

Chemical Additives	$650 per month	
Water	Usage (gal/day)	Cost (1000 gal)
Input	2,750	$1.50
Disposal	2,750	$4.50
Sludge Disposal (per 3 month period)	$2,900	
Inflation Rate	5%	
Discount Rate	15%	
Tax Rate	40%	
Useful Life of Equipment	7	

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
New Technology											
Capital Expense - New Technology	($175,000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lost Profit During Installation	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Installation:											
Labor	($1,100)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Materials	($2,000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Installation Expense	($3,100)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Start-Up Labor	($800)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Permitting Labor	($200)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
New Technology Cash Flows	($179,100)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Salvage Value - Old Equipment	$50,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tier 0 Costs											
Operating Expenses											
Direct Labor											
Operations & Maintenance	$0	($9,000)	($9,450)	($9,923)	($10,419)	($10,940)	($11,487)	($12,061)	($12,664)	($13,297)	($13,962)
Sludge Handling	$0	($7,800)	($8,190)	($8,600)	($9,029)	($9,481)	($9,955)	($10,453)	($10,975)	($11,524)	($12,100)
Total Direct Labor	$0	($16,800)	($17,640)	($18,522)	($19,448)	($20,421)	($21,442)	($22,514)	($23,639)	($24,821)	($26,062)
Materials											
Chemical Additives	$0	($7,800)	($8,190)	($8,600)	($9,029)	($9,481)	($9,955)	($10,453)	($10,975)	($11,524)	($12,100)
Water Input	$0	($1,073)	($1,126)	($1,182)	($1,242)	($1,304)	($1,369)	($1,437)	($1,509)	($1,585)	($1,664)
Water Disposal	$0	($3,218)	($3,378)	($3,547)	($3,725)	($3,911)	($4,106)	($4,312)	($4,527)	($4,754)	($4,991)
Membrane Replacement	$0	($8,840)	($9,282)	($9,746)	($10,233)	($10,745)	($11,282)	($11,846)	($12,439)	($13,061)	($13,714)
Total Materials	$0	($20,930)	($21,977)	($23,075)	($24,229)	($25,441)	($26,713)	($28,048)	($29,451)	($30,923)	($32,469)
New Equipment Depreciation	$0	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	($25,000)	$0	$0	$0
Total Tier 0 Costs	$0	($62,730)	($64,617)	($66,597)	($68,677)	($70,861)	($73,154)	($75,562)	($53,090)	($55,744)	($58,532)
Tier 1 Costs											
Direct Labor											
Sampling & Testing	$0	($300)	($315)	($331)	($347)	($365)	($383)	($402)	($422)	($443)	($465)
Reporting	$0	($300)	($315)	($331)	($347)	($365)	($383)	($402)	($422)	($443)	($465)
Total Direct Labor	$0	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)	($600)
Sample Testing Costs	$0	($1,200)	($1,260)	($1,323)	($1,389)	($1,459)	($1,532)	($1,608)	($1,689)	($1,773)	($1,862)
Sludge Disposal	$0	($11,600)	($12,180)	($12,789)	($13,428)	($14,100)	($14,805)	($15,545)	($16,322)	($17,138)	($17,995)
Penalties & Fines	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Tier 1 Costs	$0	($13,400)	($14,040)	($14,712)	($15,418)	($16,158)	($16,936)	($17,753)	($18,611)	($19,511)	($20,457)
Total Operating Expenses	$0	($76,130)	($78,657)	($81,309)	($84,095)	($87,020)	($90,091)	($93,315)	($71,701)	($75,256)	($78,989)
Add Income Tax Expense	$0	$30,452	$31,463	$32,524	$33,638	$34,808	$36,036	$37,326	$28,680	$30,102	$31,595
Add Back Depreciation	$0	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$0	$0	$0
Net Cash Flows	($129,100)	($20,678)	($22,194)	($23,786)	($25,457)	($27,212)	($29,054)	($30,989)	($43,020)	($45,153)	($47,393)

Net Present Value ($270,411)

Appendix K

Production Plating

Metal Plating Chemical Additive Costs (Current System)

	Units	Unit Cost	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95	6-mo Totals	Annual Totals	Annual Cost
Midfloc	Lbs.	$0.80	270	1,620	1,620	1,080	810	540	5,940	11,880	$9,504
Caustic Soda 50% (Tech)	Lbs.	$0.15	-	1,900	1,530	1,580	850	2,040	7,900	15,800	$2,370
Acid Sulfuric 66 Carb	Lbs.	$0.1374	-	788	1,350	900	225	675	3,938	7,875	$1,082
Acid Sulfuric 66 Drum	Lbs.	$0.095	350	-	700	700	-	700	2,450	4,900	$466
Sodium Bisulfuite Andhydride	Lbs.	$0.450	650	800	1,000	1,400	1,000	1,250	6,100	12,200	$5,490
Caustic Soda 50% Low Freeze	Lbs.	$0.105	3,000	4,500	1,750	-	4,500	3,000	16,750	33,500	$3,518
Sodium Hypochlorite	Gal.	$0.965	106	132	106	106	106	106	662	1,324	$1,278
Polymer	Lbs.	$5.06	10	-	-	100	80	75	265	530	$2,682

Appendix L

Production Plating

Metal Plating Comparative Total Cost Assessment

Assumptions:

Inflation Rate	5%
Discount Rate	15%
Tax Rate	40%
Useful Life of Equip	7

Tier 0 (Costs)/Benefits	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Procurement											
New Equipment:											
Purchase Price	($175,000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Installation Expenses	($3,100)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Other Labor	($1,000)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Salvage Value	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Retired Equipment:											
Net Salvage Value	$50,000	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Procurement Expenses	($129,100)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Add Change in Tier 0 Operating Expenses	$0	$38,958	$42,156	$45,514	$49,040	$52,742	$56,629	$60,710	$89,996	$94,496	$99,221
Total Tier 0 (Costs)/Benefits	($129,100)	$38,958	$42,156	$45,514	$49,040	$52,742	$56,629	$60,710	$89,996	$94,496	$99,221
Tier 1 (Costs)/Benefits											
Add Change in Tier 1 Operating Expenses	$0	$8,000	$8,250	$8,513	$8,788	$9,078	$9,381	$9,700	$10,036	$10,387	$10,757
Total Change in (Costs)/Benefits	($129,100)	$46,958	$50,406	$54,027	$57,828	$61,819	$66,010	$70,411	$100,032	$104,883	$109,977
Less Taxes	$0	($18,783)	($20,163)	($21,611)	($23,131)	($24,728)	($26,404)	($28,164)	($40,013)	($41,953)	($43,991)
Add Back Depreciation Expense	$0	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$25,000	$0	$0	$0
Total Change in Yearly Cash Flow	($129,100)	$53,175	$55,244	$57,416	$59,697	$62,092	$64,606	$67,247	$60,019	$62,930	$65,986

Net Present Value **$168,697**

Payback Period **2.3 years**

Appendix M
Production Plating
Metal Plating Comparative Total Cost Assessment

Qualitative Factors (Alternative relative to current system)

Tier 2	(Costs)/Benefits
Less Chemical Handling	+
Improved Air Quality	+
Risk of chemical accidents	+
Risk of new system not working	
Work space	+
Toxicity	+
Liability	+
Solid Waste	+
Paper Work	+
Chemical Additive Monitoring	+
Emission violations	+
Manual errors	+
Worker Injury	+
Tier 3 (Costs)/Benefits	
Employee Moral	+