TECHNICAL AND ECONOMIC ANALYSIS OF WASTE COOLANT OIL MANAGEMENT OPTIONS IN VERMONT

FINAL REPORT

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Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
John F. Kennedy Federal Building
Boston, Massachusetts 02203

and

AGENCY OF ENVIRONMENTAL CONSERVATION
State Office Building
Montpelier, Vermont 05602

Prepared by:

GORDIAN ASSOCIATES INCORPORATED
1919 Pennsylvania Ave., N.W.
Suite 405
Washington, D.C. 20006

In Association with:

RECRA RESEARCH, INCORPORATED
P.O. Box 448
Tonawanda, New York 14150

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RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide Federal, State and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

This report has been reviewed by the Region I EPA Technical Assistance Project Officer, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

EPA Region I Project Manager: Susan Hanamoto

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I
INTRODUCTION

Numerous tool manufacturing companies are located in Vermont. A waste by-product of this industry is coolant oil, which has been classified as a hazardous waste by the Vermont Agency for Environmental Conservation (AEC). Identification by the U.S. Environmental Protection Agency (EPA) of the types of waste oil (e.g., lubricating, coolant, hydraulic) which are hazardous is scheduled for publication in the Federal Register before the end of 1981. Regardless of EPA's classification, companies in the machine tool industry will have to comply with the AEC hazardous waste regulations. One regulation of special importance to the industry is the requirement that hazardous waste be sent only to approved sites. As no approved hazardous waste sites exist in Vermont, these wastes must be shipped out-of-state, an expensive procedure. Since a majority of the tool manufacturing companies are small and employ 100 to 500 people, this requirement will place an economic burden on the companies.

In an attempt to remedy this situation the AEC sought the advice of EPA Region I. As a result, EPA commissioned this study through the Technical Assistance Panels Program. The objectives of this study were to evaluate technically and economically the options for management of waste coolant oil both by individual plants and on a statewide basis. In addition, the study was to examine the feasibility of extending coolant oil life, thus reducing the quantity of waste coolant generated.

II
SUMMARY AND CONCLUSIONS

Technical

A technical evaluation was made of the three types of waste coolant oil management options:

- Lifetime extension,
- Treatment, and
- Disposal.

Closed-loop processing, which cleans the coolant oil and returns it to a machine for reuse, was found to be the most viable method of extending coolant oil lifetime. In the second category the two acceptable treatments were: (1) ultrafiltration and (2) chemical phase separation. The only suitable disposal alternative was use of outside contractors.

Economic

An economic evaluation was done on these options for both an individual plant and a statewide facility.

Individual Plant

The cost for the four management options (closed-loop, ultrafiltration, chemical phase separation, and outside contract disposal or the traditional method) were developed for a hypothetical plant. The cost data presented should be viewed as those from a hypothetical plant rather than the costs which would apply to any specific plant. As such, the cost data should be used as indicators of the expense for each management option. In addition, the procedure used to develop these costs could be followed by a reader to determine specific costs at any given plant. Such costs could then be used as a basis of discussion with vendors on their price quotations for a specific management plan (e.g., in-plant closed-loop systems, contract disposal).

Costs were developed both on a current cost basis and over the anticipated 10-year useful life of the equipment. Current costs include annualized capital costs as well as the operations and maintenance (O&M) expense. Special interest should be given to O&M expenses, or the variable costs, by readers interested in costs at a specific site. These are the costs which will vary over time. Capital or fixed costs tend to be constant over the life of the equipment, assuming straight-line depreciation.

The current costs for the six options are presented in Table 2.1. Besides the four management options, the residuals from traditional and closed-loop were divided into two suboptions: disposal by bulk transport and in drums.

Table 2.1
Rank and Current Total Cost of Each Management Option[1]

Rank	Management Option	Total Annual Cost, 1980 ($)
1	Traditional-Bulk	10,170
2	Ultrafiltration	12,960
3	Chemical Phase Separation	13,710
4	Closed-Loop - Bulk	15,020
5	Closed-Loop - Drum	17,080
6	Traditional - Drum	19,880

As mentioned above, each option has a different percentage of total costs which are variable. Consequently, in the future the total costs of these options will increase at varying rates. To determine this variation, current variable costs were projected over the expected 10-year useful life of the capital assets. Rather than project all variable costs at one rate, three variable cost item categories were used:

- Disposal,
- Coolant oil, and
- Other (e.g., labor, power).

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[1] Source: Table 6.4

Furthermore, since no agreement exists among the representatives of the hazardous waste management and coolant oil industries, six cost escalation possibilities, or scenarios, were developed. These scenarios, which were derived from conversations with these representatives, are presented in Table 2.2.

Table 2.2
COST SCENARIOS

	Disposal Costs		Coolant Oil Costs		Other Operating Costs	
Scenario	% increase	years	% increase	years	% increase	years
1	40 15	1-2 3-10	20	1-10	10	1-10
2	40 15	1-2 3-10	30	1-10	10	1-10
3	30 15	1-5 6-10	20	1-10	10	1-10
4	30 15	1-5 6-10	30	1-10	10	1-10
5	20	1-10	20	1-10	10	1-10
6	20	1-10	30	1-10	10	1-10

The projected cost data were analyzed using the present value technique. With this technique the future costs of each option were discounted to the present; thus, the annual costs over the life of the project could be summed and compared. Discounting gives more weight to the costs incurred in the early years of a project and, therefore, less weight to costs incurred in the later years. This principal is based on the time value of money. In other words, a dollar today is worth more than a dollar in the future. The current dollar can be invested. This dollar plus the investment earnings would be worth more than the future dollar alone. In terms of this analysis, the money saved in the early years with the lower cost options could be used for other investments (e.g., productive equipment).

The ranking of each of the six management options for each scenario is shown in Table 2.3. This ranking shows the sensitivity of these options to variations in future costs. A reader who seeks to develop site specific costs could use the escalation rates presented here, or any other rates felt to be more likely to occur. As a note, the U.S. Environmental Protection Agency has yet to publish regulations on the operation of hazardous waste treatment facilities. These regulations will help to define the rate at which traditional, or outside contract, costs will increase.

Table 2.3
PRESENT VALUE RANKING OF THE MANAGEMENT OPTIONS FOR EACH SCENARIO[1,2]

Rank	1	2	3	4	5	6
1	CPS	CL-B	CPS	CL-B	Trad-B	CL-B
2	Trad-B	Trad-B	Trad-B	CPS	CPS	Trad-B
3	CL-B	CPS	CL-B	Trad-B	CL-B	CPS
4	Ultra	Ultra	Ultra	Ultra	Ultra	Ultra
5	CL-D	CL-D	CL-D	CL-D	CL-D	CL-D
6	Trad-D	Trad-D	Trad-D	Trad-D	Trad-D	Trad-D

Statewide

A statewide treatment facility was found to have a lower annual operating cost than the current cost to the tool manufacturing industry for hauling the 300,000 gallons of waste coolant oil. Cost for the statewide facility was $127,490, which was $172,510 less than the $300,000 spent to transport and treat discarded oil.

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1 Rankings based on data in Table 6.7.

2 Abbreviations: Trad-D (Traditional-Drum); Trad-B (Traditional-Bulk); CL-D (Closed Loop-Drum); CL-B (Closed Loop-Bulk; CPS (Chemical Phase Separation); and Ultra (Ultrafiltration).

III

COOLANT OIL - BACKGROUND

Coolant oils are necessary for the operation of the tool manufacturing industry. These oils, which are emulsified with water at a concentration of two to ten percent, are used to:

- Cool cutting and grinding tools and the metal workpiece;
- Prevent welding, galling, or seizures as a result of metal-to-metal contact;
- Prohibit rust formation; and
- Lubricate.

After each use, coolant oil is processed to remove contaminates which include:

- Tramp oils - foreign oil (e.g., lubricant, hydraulic);
- Metal filings; and
- Suspended solids (e.g., dirt).

Coolant oils then are stored in a holding tank prior to reuse. These tanks may be centrally located or at individual machines. Individual machine tanks, or sumps, are used in plants which have a diversity of machine operations that require different types and concentrations of coolant oils. Central systems are feasible where a coolant oil with a common characteristic is acceptable to a majority of the machines.

Over time, coolant oils are subject to microbiological degradation due to anaerobic bacteria. Since these bacteria are most active in warm weather, degradation time is primarily temperature dependent. In addition, anaerobic bacteria exist only in oxygen-free environments. Therefore, sufficient aeration during use will reduce the presence of anaerobic bacteria in coolant oil. Central holding tanks, which contain aeration equipment, are able to extend the useful life of coolant oil longer than individual machine sumps. This is important because coolant oil degradation, or rancidity, is the major reason coolant oil is discarded.

IV
WASTE INVENTORY

To evaluate the problem of discarded cutting oils in Vermont and its potential solutions, current data were needed for the quantity, type, location, and characteristics of the emulsions discarded. In addition, information was needed on in-plant management practices and storage procedures for the used oil as these affect the quantity generated and the treatability/recoverability of the oil.

A questionnaire was developed to obtain this information. (See Appendix A). On January 24, 1980 the questionnaire was sent to 20 companies in Vermont. (A copy of the cover letter which accompanied the questionnaire is included in Appendix A). Twenty companies in New Hampshire also were sent the questionnaire. Firms in New Hampshire were queried so that a central treatment facility could be evaluatd on a regional bi-state basis. Such an evaluation would allow a comparison of the unit cost to process discarded coolant oil at a Vermont statewide facility and a facility serving a larger area. This comparison would indicate the service area with the lower unit cost.

Selection of the 40 firms to which the questionnaire was sent was done by Robert Nicholas of the Vermont Agency of Environmental Conservation. Companies in New Hampshire were selected after discussion with that State's Department of Health and Welfare. Identity of the companies was kept by the state agencies to maintain the privacy of the firms.

Fourteen questionnaires from the Vermont firms were returned - a return rate of 70 percent. Only four questionnaires, however, were returned from New Hampshire. This low return rate precluded an analysis of a bi-state treatment facility.

A summary of the types of oil used, processes for which the oil was used, quantity discarded, and disposal methods is presented in Table 2.1.

V

TREATMENT PROCESSES FOR EXTENDING COOLANT OIL LIFETIME

A reduction in the volume of waste coolant oil can be achieved by extending the useful lifetime of the oils. Increasing the number of times that a coolant oil can be used before being disposed of will result in a lower volume of waste coolant actually being generated. The removal of contaminants, such as bacteria growth, tramp oils, metal fines, and general suspended solids, along with using deionized water for dilution water, should make the coolant oil suitable for re-use. It may be necessary to mix the treated coolant oil with new coolant oil in order to achieve proper operating specifications.

Systems Available to Extend Coolant Oil Lifetime

- "Servi-Sump" - A portable sump cleaning unit known as "Servi-Sump" is manufactured by Production Chemicals, Inc., Manilus, New York. This heavy-duty suction system will vacuum out spent coolant oil along with metal chips and suspended solids. Premature spoilage of any new coolant oil being added to a machine sump can be prevented by thoroughly cleaning the respective machine sumps after removing the spent coolant. The "Servi-Sump" unit is equipped with both a filtering unit that removes most of the solids from the coolant oil, and a second stage centrifuge to further remove contaminants (from the filtered coolant) before returning the coolant oil to the machine sump.

- "Servi-Sump Accumix Unit" - Production Chemicals also manufactures a total coolant oil reclaim system which will remove tramp oils and provide proper coolant oil make-up, in addition to being a portable sump cleaning unit. With this unit, the vacuum sump cleaner is divided into two 150-gallon compartments for transporting both fresh and spent coolant oil to and from the machine sumps. The sump cleaner with one compartment filled with clean coolant is transported to the machine sump, where the spent coolant and debris are vacuumed into the empty compartment. A filtering unit is included for removing the larger solids contained in the spent coolant oil. The clean coolant is then pumped into the cleaned machine, ready to be used. This entire process can be completed in approximately five minutes.

The sump cleaner is then taken to the coolant reclaim center, where the dirty coolant is pumped into a holding tank and is allowed to settle. The tramp oils are then removed, as the spent coolant is automatically cycled through a "coalescing unit." This cleaned coolant is pumped into a recycled coolant holding tank, where it is stored until needed. Fresh coolant is available to replace any used or evaporated recycled coolant. The "Accumix Unit" automatically mixes and proportions the fresh coolant with deionized water, which insures a constant supply of accurately mixed coolant. This eliminates any wastes caused by inaccurate and incomplete mixing. Deionized water is used to prevent any corrosion, gummy deposits, and emulsion "splitting," caused by the mineral salts concentrating by evaporation when regular plant water is used. Refer to Figure 5.1 for a flow diagram of the "Servi-Sump Accumix Unit."

- <u>Closed Looped Coolant System</u> - This unique system manufactured by Master Chemical, Perrysburg, Ohio, is designed for unlimited coolant life when using "Trim-Sol" or other "Trim" brand coolant oils (produced by Master Chemical). The success of this system is dependent upon using both proper coolant oil formulation and proper coolant oil maintenance. The "Closed Looped System" is equipped with a machine sump cleaner which will vacuum out spent coolant, metal fines, and suspended solids, thus producing a clean machine sump. These cleaners are equipped with a filter to remove larger particle chips and range in capacity from 75 gallons with 400 pounds of chips to 700 gallons with 800 pounds of chips. These units are capable of vacuuming and filtering up to 12 gallons of coolant per minute. The cleaner transports the filtered coolant to a centrifuge which has been jointly engineered by Master Chemical and the Westfalia Centrifuge Corporation. This automatic self-cleaning centrifuge package produces separation forces up to 8,600 times that of gravity. It will effectively remove both free and emulsified tramp oils down to less than 0.5 percent concentration, metallic and silt contaminants down to 2 micron size, and 50-80 percent of the micro-organisms present. The recycled coolant is then stored ready to be used. A coolant cart transports the recycled coolant to the respective machine tools, where it is mixed with a percentage of fresh coolant. A positive displacement "Unimix" proportioning pump, using a baffled mixing chamber, is used to produce a stable, small particle size emulsion. This pump's accuracy will not be affected by changes in water pressure, flow rate, viscosities, or the level of liquid in the drums. A deinonized water unit is included in the system for the purpose of diluting the fresh coolant. Reasons for using deionized have been previously discussed in this report. Refer to Figure 5.2 for a flow diagram of the Closed Looped System.

- Cyclonic Filtration System - Almco Industrial Finishing Systems, Albert Lea, Minnesota, manufactures a "Cyclonic Filtration System" equipped with an exclusive Air-Hydro Skimmer. As the spent coolant is pumped into the Cyclonic Chamber, it accelerates downward in a spiral cyclonic motion. Particles down to 5 microns in size are separated in the lower portion of the cyclone and are subsequently discharged, with the cleaned coolant being forced out the top. The cleaned coolant is aerated as it leaves the cyclonic chamber and is pumped to an upper tank where baffles are used to reduce turbulence. The Air-Hydro Skimmer removes any tramp oils, particles, and bacteria that has floated to the surface. The twice-cleaned coolant is then stored in the lower clean fluid tank ready to be re-used. This unit is not portable and, therefore, must be installed either by the individual machine tools or by a central coolant sump.

- Tri-Max Coolant Recycling System - Dirty coolant enters the upper section of the filter at the inlet orifice on a tangent. The shape as well as the angle of the inlet nozzle initiates a downward cyclonic motion of the coolant. This centrifugal action develops the primary cyclone. As the centrifugal forces multiply themselves, solid particles are spun out to the chamber walls and down into the lower (ceramic) cyclonic chamber of the filter. The downward action, initiated in the upper nozzle, forces the solids out of the system at the discharge orifice.

  A compressive effect, resulting from the large differentials in the coolant's velocity and pressure, in the lower (ceramic) cyclonic chamber reserves the direction but not the rotation of the coolant. This forms the secondary cyclonic, a spiraling flow of cleaned coolant which passes up through the primary cyclone to the vortex finder.

  The diameter of the vortex finder is somewhat smaller than the secondary cyclone, and therefore the vortex finder accepts only the center of the upward secondary flow. The outer portion of the secondary cyclone, containing some impurities missed by the primary cyclone, is then diverted back to the primary cyclone for additional clarification.

  The clean coolant passing through the vortex finder is directed to the clean coolant storage tank or to the machine tool depending upon the application or design requirements.

  Back pressure at the discharge orifice aerates the clean coolant which will serve to inhibit bacterial growth.

- Individual Methods for Extending Lifetime - The following are individual methods which may be applied to extend the coolant oil lifetime. The use of each of them, either independently or in conjunction with each other, should extend the coolant oil lifetime.

  a. Tramp Oil Removal - any foreign oil that finds its way into the coolant oil must be removed before the coolant oil may be re-used. These tramp oils, such as hydraulic and lubricating oils, are insoluble in water and generally float to the surface of the coolant oils. The tramp oils may either be skimmed off or removed mechanically (centrifugation) and burned as fuel (if within specifications).

  b. Solids Removal - solids accumulate in the form of metallic fines and general debris. It is essential to remove these solids prior to re-using the coolant oil to prevent plugging and/or contamination.

  c. Machine Cleaning - when removing the spent coolant oil from the machine sumps, it is necessary to thoroughly clean the machine, including sumps. Any remaining coolant oil, metallic fines, or debris may cause premature spoilage of any new coolant being added. Bacteria remaining will rapidly grow, thus ruining the new coolant oil.

  d. Bactericides - the growth of anaerobic bacteria is a major cause of coolant oil spoilage. In addition to the microbiological degradation caused by the bacteria, they also produce nauseating odors and cause skin irritation. There are a number of bactericides available with some being specific to certain coolant oils.

  e. Aeration - anaerobic bacteria tend to form when coolant oils are being stored. By pumping air into the coolant oils, anaerobic conditions are reduced thus making it difficult for the anaerobic bacteria to form and grow.

  f. Deionized Water - the use of deionized water for diluting the coolant oils will be helpful in prolonging the useful lifetime of the coolant. The presence of mineral salts in normal plant water may cause corrosion, gummy deposits, and emulsion "splitting" to occur. These mineral salts may be removed by using a water deionizing system. As evaporation of the coolant occurs during normal machining operation, the mineral salts remain behind, thus increasing in concentration. As new coolant is added for makeup purposes, the resulting mineral salts concentration will be greater than in the original coolant. The mineral salts concentration will continue to increase until the coolant is removed and properly disposed.

VI
TREATMENT PROCESSES AVAILABLE FOR SEPARATING OIL-IN-WATER EMULSIONS

When a spent coolant has reached the stage where it no longer can be further treated for re-use, it is considered a waste. This waste coolant oil must be treated and/or disposed of properly, so that it will not have any harmful effects on the environment. There are a number of treatment processes that are available for treating oil-in-water emulsions. The majority of these processes, including dissolved air flotation, electric and various adsorbents (e.g. polyvinylchloride resin), involve the removal of low concentrations of free and emulsified oils (5 to 5,000 ppm) from aqueous streams. There are two treatment processes that are applicable to the separation of waste coolant oil-in-water emulsions. These two processes are ultrafiltration and chemical phase separation.

Ultrafiltration/Reverse Osmosis

The process of ultrafiltration involves the separation of high molecular weight solutes or colloids from a solution or suspension, using a membrane filtration medium. These membranes are composed of various synthetic or natural polymeric materials, ranging from hydrophilic polymers (such as cellulose), to very hydrophobic materials (such as fluorinated polymers). Recent developments have led to the use of polyarylsulfones and various inorganic materials to contend with high temperatures and pH values.

Ultrafiltration has been successfully applied in several industrial situations, but has been limited to aqueous medias. The aqueous waste stream is forced through the porous membrane, under a hydrostatic pressure of between 10 to 100 psig, allowing the separation to occur. The solutes with a molecular weight too small to be retained by the membrane will pass through, and the larger ones will be retained at a theoretical efficiency of 100 percent. This will result in two processed streams:

- Stream of the large retained solutes and colloids, and
- Stream of the smaller molecular weight solutes

Ultrafiltration has been used in many applications and may be categorized according to functions, such as:

- Concentration - where the desired component is rejected by the membrane and taken off as a fluid concentration.
- Fractionation - where more than one solute is to be recovered and products taken from both the rejected concentration and the permeate, and
- Purification - where the desired product is a purified solvent.

Romicon, Incorporated produces a "Hollow Fiber" ultrafiltration unit whose operation is similar to Abcor's models. Romicon claims to produce the most efficient and economical ultrafiltration systems. Their claims over other systems include:

- Up to 45 percent lower capital costs, with easy installation,
- 20-50 percent lower operating costs; lower operating pressures reduce power requirements, and
- Unique backflushing capability for removing debris from membrane surface - this helps to maintain a continuous flow and prevents costly maintenance downtime. This action also increases the lifetime of the membrane cartridge by up to twice as long as other systems.

Reverse osmosis is similar in theory to ultrafiltration, only uses a smaller membrane pore size. While ultrafiltration is limited to suspended solids removal, reverse osmosis can be used to concentrate most dissolved organic and inorganic solutes from aqueous streams. Reverse osmosis systems often require the pretreatment of streams to optimize pH, remove strong oxidants, and filter out both suspended solids and firm formers. A reverse osmosis unit is often used in conjunction with ultrafiltration as a "polishing treatment" for the permeate. Directly following is a short list of components that can be rejected by a reverse osmosis membrane:

Component	Percent Rejection	Maximum Concentration Percent
Aluminum (Al^{+3})	99+	5-10
Sodium (Na^{+2})	94-96	3-4
Cadmium (Cd^{+2})	95-98	8-10
Chloride (Cl^{-1})	94-95	3-4
Sulfate (SO_4^{-2})	99+	8-12
Chromate (CrO_4^{-2})	90-98	8-12
Glucose	99.9	25
Sucrose	100	25
Protein	100	25

Osmonics, Incorporated claims to have a reverse osmosis/ultrafiltration (RO/UF) system capable of concentrating soluble oils and many non-soluble oils. Previously, these oils were avoided with reverse osmosis and ultrafiltration equipment due to the fouling of the membranes. In cases where the membranes of the RO/UF unit do plug up, special cleaners and dispersants have been developed to return the membrane to its original condition. Comparable to ultrafiltration, concentrations of up to 70 percent oil and permeates containing less than 100 parts per million of oil have been obtained from waters containing less than 1 percent soluble oil. Membranes are also available for which salts will pass through with the water or will be rejected with the oil.

The following are examples where ultrafiltration is being used in commercial application:

- Electrocoat-paint rejuvenation and rinse water recovery, as a fractionation process,
- Metal machining, rolling, and drawing-oil emulsion treatment, as a purification process,
- Protein recovery from cheese whey, as a concentration and fractionation process, and
- Textile sizing (polyvinyl alcohol) waste treatment, as a fractionation process.

When applied to the metal machining industry, ultrafiltration may be used to concentrate the oils and solids contents of the dirty spent oil-in-water emulsions from a 0.1 percent concentration to one greater than 50 percent. This enables over 95 percent of the water to be removed for treatment and a small volume of concentrate (50% oil) to be recovered for subsequent treatment or disposal. The final objective is to produce an oil concentration great enough to support combustion, thus reducing incineration costs. If a low molecular weight emulsifying agent has been used to keep the oil in suspension, this agent may permeate the membrane, thus increasing the Biological Oxygen Demand of the permeate. If the agent does indeed permeate as such, then the oil will agglomerate and plug the membrane. In this case a reverse osmosis membrane will be needed to prevent the emulsifying agent from entering the membrane structure.

Abcor, Incorporated of Wilmington, Maine, claims to be able to provide a straightforward, highly effective method for separating emulsified or soluble oils from water. Their units have noncellulosic polymer membranes capable of operating at high temperatures (up to 180°F) and a wide pH range (2.5 to 13.0). They are solvent resistant and have demonstrated a working life of several years in the treatment of oily wastewaters. Their membranes are claimed not to plug, because the emulsified oil droplets and suspended solids are larger than the pore openings (<0.005). They are effective in treating wastewater streams containing 0.1 percent to 10.0 percent oil, producing a permeate containing 10 to 50 mg/l of oils and greases and a concentrate containing 50 percent oil. If a highly soluble solvent or surfactant is present, the oil concentration of the permeate will be higher. Typical installed equipment costs range from $4 to $40 per gallon per day, and the operational costs vary from $0.003 to $0.03 per gallon of wastewater treated. These prices vary according to type of waste and system capacity. Abcor will conduct feasibility tests of small samples or will provide pilot-scale equipment on a rental basis for on-site testing and evaluation.

Chemical Phase Separation

Theory

The breaking (resolution) of an oil-in-water (o/w) emulsion, typified by the soluble coolant oils and cutting fluids, can be achieved by using various organic and/or inorganic chemicals. The resolution will occur by neutralizing the emulsion's stabilizing factors, allowing the emulsified droplets to coalesce. The net electrical charge on the o/w emmulsion is negative; therefore, a cationic (positively charged) emulsion breaker is required. This resolution treatment method is actually a two-step reaction, occurring in one procedure:

1. Coagulation - actual destruction of the emulsifying agent or neutralization of the charged oil droplets
2. Flocculation - agglomeration of the neutralized droplets into large, separable globules

When resolution occurs, a three phase separation usually takes place. The three phases vary accordingly; however, their general compositions can be considered as:

a. Top Layer - primarily free oil that has coalesced and floated to the surface; ususally low in total volume
b. Middle Layer - "rag layer"; combination of oil, water, and solids (if present) in various percentages
c. Bottom Layer - aqueous layer containing low concentrations of oil (usually 100 to 5,000 ppm), suspended solids, and dissolved organics

Organic Emulsion Breakers

The most commonly used chemicals for resolution are sulfuric acid and aluminum sulfate (referred to as the acid/alum treatment), see Figure 6.1. Most recent technologies use "organic emulsion breakers," as either a replacement for or as an enhancer for the acid/alum treatment. The advantages of using "organic emulsion breakers" are:

- Lower volume of oily sludge generated. This oily sludge can be further treated for possible oil recovery. Usually 50-75% less sludge is produced as with the inorganic chemical treatment,
- More efficient effluent containing lower concentrations of oil and suspended solids,
- Lower dosage rates are required, thus reducing costs and increasing ease of handling, and
- Converts cutting oils, rolling oils, stamping oils, synthetic cutting fluids, soaps, emulsifiers, and cleaning agents into a "float" (sludge) capable of subsequent treatment for oil recovery.

The "organic emulsion breakers" used in this process are usually cationic quaternary ammonium polyelectrolytes, and henceforth will be referred to as polymers. An acidic (pH 3 to 6) condition is necessary in this process.

When polymers are used, the three resultant separation phases can subsequently be treated. These methods, which follow directly, do not necessarily hold true when the inorganic "acid/alum," treatment program is used.

a. Bottom aqueous layer - usually contains oil (100 to 5,000 ppm) and suspended solids concentrations too large for discharging into natural waterways or into a sewer system. It may be treated in the following manner:

    1. Neutralization with sodium hydroxide to remove water soluble contaminants, such as metals, sulfates, chlorides, and some dissolved organics. An anionic or cationic polymer may be used to enhance the neutralization process. This should result in producing an effluent suitable for discharge into a sewage treatment plant.
    2. Air flotation units are often used in conjunction with the neutralization process. The dispersed air bubbles produced will help the contained oils and solid float to the surface, thus producing an effluent suitable for discharge into natural waterways.

b. Top oil layer - usually low in volume and can be combined with the middle sludge layer for subsequent treatment for oil recovery. If within specifications, usually less than 3 percent water and low in metallic contaminant concentrations, it may be used as a fuel.

c. Middle sludge layer (rag layer) - consists of water-in-oil (w/o) emulsions, typically consisting of 50 percent water and 50 percent oil and solids. It will generally be equal to approximately 10 percent by volume of the original waste coolant oil. These w/o emulsions can subsequently be treated by a process known as "demulsification" for potential fuel recovery. The "demulsification" process will be discussed in more detail later in this report. This "rag layer" may also be shipped to an oil reclaimer or a waste oil disposal firm.

Inorganic Emulsion Breakers

As previously mentioned, the most effective inorganic chemicals available for breaking waste coolant oil-in-emulsions are sulfuric acid and aluminum sulfate ("acid/alum split"). In most cases coagulation and flocculation can be achieved using acid/alum; however, the possibility of fuel recovery is greatly reduced. The mechanisms involved with acid/alum are similar to those mentioned under Organic Emulsion Breakers, with the major difference being the generation of a much larger amount of sludge.

Colloid Piepho, Inc., Skokie, Illinois, manufactures the "System RP Unit" which is capable of treating wastewaters containing emulsified oil and other water insoluble organic pollutants, such as emulsifiable animal and vegetable fats, solvents, dyestuffs, latex, and plastics. The "System RP Unit" is a complete system which produces a clean water effluent for recycling or discharge, and a stable, leaching resistant sludge. Units are available for batch treatments capacities of up to 2,500 gallons per hour, with each batch treatment taking 20 minutes for completion. The unit contains a reaction vessel which fills in 3 minutes, and is capable of supplying rapid agitation using an overhead turbine mixer. A proprietary chemical separating agent, NT-75, is added, either manually or automatically, and intensively mixed with the wastewater for 6 minutes. NT-75 is an adsorbent/self-flocculant, single chemical additive used for emulsion breaking and flocculation. NT-75 consists of a number of different chemical formulations based on their own individual performance characteristics. The resultant floc is allowed to settle for 2 minutes, and the clean supernatant liquid is drained off, passed through a filter media to remove suspended solids, and collected in a container for recycling or discharge (takes 5 minutes). The settled solids, or sludge, is placed on a band filter for dewatering and then automatically conveyed to a collection container for disposal. This sludge is claimed to be a stable, leaching resistant sludge. However, leaching potential evaluations would have to be performed for determining the proper method of disposal. The solids content of the sludge is typically of 20 to 40 percent concentration.

The "System RP Unit" is claimed to effectively remove greater than 99 percent of the emulsified oil and other dispersed contaminants, such as detergents and paints. It is also claimed to be capable of removing aromatic compounds, such as toluene. Compact systems are available that can be installed easily at a low cost and occupies 32 square feet in area. A unit of this size is capable of processing 500 gallons per hour.

Option for Demulsification of Oily Sludge

There are three components of a water-in-oil (w/o) emulsion. These components are:

- The dispersed or internal phase - being water,
- The continuous or external phase - being oil, and
- The emulsifying agent.

The components of the dispersed phase are surrounded by a film which may be negatively charged on one side and positively charged on the other. The distribution of the charges are dependent upon many factors, one being the dielectric constant of the two phases. The positive charge is usually contained in the phase with the greater dielectric constant. Demulsification, which is the breaking of the water-in-oil emulsion, occurs upon the neutralization or destruction of any emulsifying factors; thus allowing the oil droplets to coalesce and float to the surface. The neutralization and/or destruction can be achieved by one or a combination of the following:

- Heat (180-200°F) - reduces the viscosity of the oil and increases the motion of the small water droplets, thus allowing coalescence to occur; ruptures the emulsifying agent film, enabling the oil droplets to grow,
- Sulfuric Acid (1-2% by volume), or an alkalai - neutralizes and destroys the emulsifying agent film, causing the oil droplets to grow, and/or
- Demulsifier (3,000-5,000 ppm) - an organic surface - active liquid which may have dual solubility (oil and water). It reacts at the interface of the oil and water, thus rupturing the emulsifying agent.

Each of the aforementioned methods may be used independently as a demulsification process. However, when used in this manner, the required treatment ratio makes them excessively high in cost. When all three are used in conjunction with each other, the treatment dosage rates will be dramatically reduced, thus making them economically feasible. The usual results obtained in the demulsification process are:

- Top oil layer - usually consists of at least 95 percent recovery of the original oil content. The oil should contain a high BTU value, have a low water (less than 3 percent) and metallic contaminant content, and should be suuitable for use as a fuel,
- Bottom aqueous layer - containing low concentrations of oils and solids. It would most likely need subsequent treatment prior to being discharged, and
- Middle sludge layer ("rag layer") - low in volume and containing low concentrations of oil, along with water and solids. This "rag layer" either can be shipped out for proper disposal and/or possible metal recovery, or it may be treated by demulsification for further oil recovery.

Distillation

The Hoffman vacuum still has been applied for the destruction of spent water soluble coolants. Waste emulsions with up to five percent solids are pumped continuously into the still. The water is heated by steam and boiled off, leaving a thickened oil stream which would most probably be burnable or have a value. The water should be relatively pure having been distilled. It may contain some organics created by light oils in the emulsion. This water would form an excellent makeup for the next batch of water soluble coolant. The claimed advantages of the still are that it is continuous, relatively automatic, and can handle a certain variable amount of solids and tramp oils. The disadvantages of the still are that it requires steam and cooling water. However, only 25 to 30 pounds of steam are required, which is generally available or can be obtained with the addition of a small steam generator. The smallest still can handle approximately 35 gallons per hour (GPH) of water soluble or 75 GPH of solvent and is priced at approximately $20,000. Our largest still has a capability of 300 GPH soluble, 600 GHP solvent and is priced at approximately $40,000.

Considerations for Discharge of Liquid Phase Effluent from Treatment Processes

A part of the previous discussion in this section has addressed effluent oil and grease concentrations from ultrafiltration and chemical phase separation treatment machines. The range of this parameter, as claimed by the equipment manufacturer, is as follows:

Abcor UF unit	10 - 50 mg/l oil and grease
Osmonics UF/RO	less than 100 ppm oil
Colloid Piepho	less than 1% of influent (up to 250 ppm)

These ranges will be affected by equipment operating and maintenance procedures, the type of coolant oil treated and the presence of solvents in the waste coolant. Acceptability of the effluent discharge at the local sewage treatment plant will depend on the presence and type of toxic constituent (such as bacteriacides) in the discharge, the volume of effluent residue to be discharged, the type and operating flow rate of the receiving sewage treatment plant as well as concentration of oil and grease. A pre-treatment permit will be required by the State Environmental Agencies which will specify operating parameters and sampling/reporting frequencies.

In general the impact of any effluent from a coolant oil pre-treatment facility, even if such a facility were treating the entire waste coolant oil volume in Vermont, is expected to have a negligible impact on a typical municipally operated sewage treatment plant with secondary treatment.

VII
ALTERNATE ULTIMATE DISPOSAL OPTIONS

Incineration

The process of incineration for the destruction of industrial wastes has been quite limited due to the high energy requirements and stringent air-emissions specifications. Scrubbers are usually needed to prevent the escape of hazardous gases due to incomplete combustion. Complete combustion of organic substances would make the final flue gas composition to be water, carbon dioxide, elemental oxygen, and elemental nitrogen.

However, there are Industrial Incinerations available which are capable of "burning" waste waters in combination with a support fuel. Temperatures of the flue gases in excess of 900°C are needed to burn the organic contents of the waste waters.

Due to the high costs involved with incineration, it is not a very highly recommended method for waste disposal. The coolant oils and cutting fluids alone would not be capable of supporting combustion, and thus would need energy for combustion. When considering incineration for a process, you must take both the specific heats of each contained substance and the combustion products into account. It may be used after the wastes have been pretreated to obtain an oil content (greater than 50 percent) capable of supporting combustion.

Solidification/Stabilization

Solidification/Stabilization (S/S) includes many processes of immobilizing wastes, in an attempt to reduce their leaching potential and to make them unreactive. Immobilization can be achieved by encapsulating, either macro-encapsulation or micro-encapsulation, or by incorporating the contaminates into a stable crystalline lattice. This immobilization would then make the wastes amenable for landfilling. Listed following are the 5 principle categories of S/S and major reasons for eliminating the process:

a. Cement-based techniques - increased weight and bulk densities; not applicable to organic wastes
b. Lime-based techniques - increased weight and bulk densities; not applicable to organic wastes
c. Thermoplastic techniques - high economical and operational costs; not applicable to organic wastes
d. Organic Polymer techniques - (urea-formaldehyde) - not applicable to organic wastes; produces acidic conditions which increase the potential for metals leaching; contaminants are contained within a loose resin matrix.
e. Encapsulation - high costs for both materials and equipment.

Solidification/Stabilization processes are not considered to be economically and operationally feasible when disposing of wastes containing organics. In addition to the high leaching potential of the wastes, there are also increases in weights and bulk densities, thus increasing the costs of landfilling.

Disposal via Outside Contractors

Another ultimate disposal option which should be considered is the outside contractor. There are many large and small facilities, government approved, which specialize in the handling and ultimate disposal of hazardous wastes. Some of the major facilities providing these services are Rollins, N.J., SCA Services, and CECOS International (formerly known as Newco Chemical). There are also several small facilities that specialize in oil recovery and fuel blending. Most of the larger facilities have the capability of implementing the following disposal/treatment mechanisms: secure and intermediate chemical land burial, industrial wastewater treatment involving primary and secondary treatment, stabilization/solidification, waste oil/solvent recovery, fuel blending and incineration. The availability of these processes allows the individual waste generator to pay a contractor to handle, treat and dispose of his individual industrial wastes, thus eliminating major capital investment.

Most waste disposal facilities require that each waste be analytically characterized. The results of the waste characterization will be utilized in deciding which individual treatment/disposal mechanisms can be implemented. Oil sludges can be incinerated or landfilled but aqueous and/or organic liquids cannot be landfilled presently in the CECOS and SCA landfill facilities. Disposal of emulsified aqueous wastes via water may be acceptable for limited volumes of wastes. Generally, these wastes require evaluation to confirm that they will not phase separate nor create potential hazardous conditions when discharged into an acidic oxidizing lagoon. Another potential consideration which must be evaluated is the air emissions liberated from the wastes. Oil-emulsions liberating pungent, unpleasant odors or odors associated with solvent emissions are generally unacceptable for disposal in open lagoons, or open pits which are utilized for solidification. Solidifying these wastes generally changes the physical nature of the waste, making them amenable to land burial, and does not prevent contaminant mobilization, via air or leachate. Operations utilizing waste oils/aqueous mixtures for road covering purposes are generally being phased out and the practice limited to non-toxic materials. Disposal operations currently involving oil recovery and fuel blending with ultimate disposal via incineration are increasing significantly due to the demand for waste recovered fuels. The wastes proposed for these mechanisms are usually characterized and priced according to their BTU content, chloride and sulfur content, ash weight, chemical composition, and water content. There are incinerators which can incorporate aqueous waste materials into their system, but the wastes must be characterized prior to disposal.

Overall, the disposal of the oil/aqueous wastes via an outside contractor is an acceptable procedure which is commonly utilized by large and small waste generators. The factors to be considered when evaluating a disposal facility are:

1. Is the disposal facility in accordance with Federal and State regulations in regards to the transportation, handling, treatment and disposal of hazardous wastes?
2. Are there any liabilities which may be a problem for the generators?
3. What are the disposal costs? For example, aqueous wastes acceptable for industrial water treatment could cost 20¢ - 40¢ per gal. in bulk or $35 - $40 per 55 gal. drum for disposal. If the wastes are layered, they will require special handling and the disposal costs will increase significantly. Landfilling sludges could cost $25 - $50 per drum providing the flash point is greater than 100°F. Solidifying the waste, with subsequent land burial, will be very costly. All these prices do not reflect transportation.
4. What are the transportation costs? For an example, it would cost approximately $1500 to transport an 80 drum shipment from Boston, Mass. to SCA Services in Model City, New York. The transportation and handling costs should be seriously considered.

5. Are there any costs associated with chemically characterizing the individual wastes? Most facilities will require that the individual wastes are chemically analyzed.

Considering all the available treatment mechanisms, it appears that facilities involved in oil/solvent recovery and incineration would be the most suitable.

VIII
ECONOMICS

In this Section, the capital and operation and maintenance (O&M) costs to manage discarded coolant oil were analyzed. These costs were examined for two different conditions: (1) an individual plant and (2) a central statewide facility.

At the individual plant level, costs were developed for the two technologies -- closed-loop and treatement -- considered acceptable for emulsion processing in Sections III and IV. In addition, the traditional approach of use and discard was evaluated to provide a baseline cost. Costs for these three options were projected over a 10 year period (1980 to 1990) to show how these costs are anticipated to change during the useful life of the capital equipment. Operating costs were escalated based on six different rates of increase to show how these costs will change under various possible future conditions. The current and projected costs for each technology under the six conditions were analyzed using the present value technique. With this technique, the future costs of each option were discounted to the present thus, the annual costs over the life of the project can be summed and compared. Discounting gives more weight to the costs incurred in the early years of a project and, therefore, less weight to the cost incurred in later years. The principal behind this analytical method is that a dollar today is worth more than a dollar in the future. A current dollar can be invested. This dollar plus the investment income would be worth more than the future dollar alone. In terms of this analysis, the money saved in the early years of the options with the lower initial costs could be used for other investments (e.g., productive equipment).

Costs for a central facility were developed to determine the economic viability of this approach as an alternative to individual plant treatment/reuse of coolant oil. Only treatment was considered to be a viable option with a central facility. To evaluate the expense of this approach, the cost for the machine tool industry in Vermont to ship and treat/dispose of discarded emulsions at out-of-state sites was developed.

Individual Plant

For an individual plant the coolant oil management options determined to be viable were:

- Traditional: simply use a coolant oil until it no longer complies with performance specifications; then discard it.
- Closed-loop: recycle, or extend the useful life, of an emulsion.
- Treatment: separation of an emulsion into oil and water.

A cost analysis of these options specific to the machine tool companies in Vermont is impractical. The plants in the State vary considerably in size as well as in the type and relative importance of operations (e.g., grinding, milling, and turning). In addition, numerous operating condition variables (e.g., in-plant housekeeping practices) exist between companies. These factors affect the quantity of used emulsions generated and, thus, the cost of coolant oil management.

While the cost data presented below are inapplicable to any specific plant, these data do indicate the relative cost variation among the three options. A plant manager could use the data as an indicator of which method might be applicable to a specific location. Furthermore, the approach used in this report could be used as a guide for developing costs in a specific plant. Thus, a plant manager would have a basis upon which to evaluate proposals by the vendors of the different options for managing coolant oil.

Operating Parameters

To analyze the cost of coolant oil management a representative, hypothetical plant was developed. General statistical data on this plant are:

- Location - Windsor County
- Number of machines - 40
- Emulsion storage - Individual machine sumps
- Sump capacity - 120 gallons
- Oil/water ratio - 1:40

Windsor Country was selected as the location for this plant because the majority (85 percent) of discarded emulsions in Vermont are generated in this county. Operational data for this plant were based on the response to the Vermont discarded coolant oil questionnaire.

The amount of emulsion related discards with each option are:

- Traditional - 15,360 gallons per year
- Closed-loop - 4,630 gallons per year
- Treatment - 3,000 gallons per year - ultrafiltration
  - 900 gallons per year - chemical phase separation

With the traditional method, the amount of emulsions used is essentially the quantity discarded. Some loss takes place during use due to such factors as evaporation and spillage. An estimated 20 percent of emulsions are lost during use.

Typically, emulsion specifications vary depending on the process (e.g., grinding, turning, milling) for which a coolant oil is used. While many machines in a plant can use an emulsion with a common specification, some are unable. Only emulsions with a common specification can be processed in a central closed-loop system. For the hypothetical plant, 70 percent of emulsions have a common specification.

This is an average rate for machine tool plants. Waste generation with a closed-loop system was found to be reduced 99.75 percent relative to the traditional method. In the hypothetical plant, 20 gallons of discarded emulsions would be generated per year by the machines on the closed-loop system. The remaining 4,610 gallons were generated by those machines excluded from the recycle operation.

A plant with a separation facility will generate the same quantity of used coolant oil as a plant which uses the traditional approach. After separation of the emulsion into water and coolant oil residue, much less oil needs to be discarded. The water generated must be discarded to a sewage treatment plant prior to release to a water course (see the discussion on page 6.9).

Transportation of discarded coolant oils can be done in either drums or bulk. Drum shipment is the more expensive alternative for two reasons. First, drums take longer to load. A bulk tanker can be loaded in less than an hour, while a trailer loaded to 80 drum capacity takes almost two hours. The second reason is that incoming waste is tested at a treatment/disposal site. Each drum must be tested, whereas several samples from a bulk shipment are sufficient.

For both the traditional and closed-loop options, discards are shipped by drum or bulk methods. With treatment the quantities discarded are small enough to warrant shipment only in drums.

Cost Analysis

In this Section, the costs for the management options outlined above are developed and analyzed. To achieve these objectives the Section is divided into three parts:

- Capital and operating costs - 1980
- Cost projections to 1990
- Present value analysis

Capital and Operating Costs - 1980. These costs were developed based on the conditions outlined in the section on operating parameters.

To insure an equitable comparison among the options, all capital items were assumed to be purchased new in 1980. A plant manager should consider this assumption when evaluating a change in current disposal practices. Some of the capital items listed might be already in use in a plant, particularly those items associated with the traditional option. Such equipment would have a different annual capital cost than the figure given in the detailed cost tables in Tables 8.1 to 8.3.

The cost assumptions used to develop annual capital costs were:

- Useful life - 10 years
- Amortization Rate - 18 years

No capital cost was assessed on the options for the building space required for the equipment.

Common operating cost factors (e.g., labor) were assumed to be the same for each option. The common cost factors and costs were:

- Labor - $9.40 per hour, including fringe benefits
- Coolant oil - $4.00 per gallon

Traditional management with bulk shipment to a treatment/disposal site was determined to be the lowest cost option for the hypothetical plant in 1980, Table 8.4. Cost of this alternative was estimated to be $10,130 per year. Traditional management with drum shipment was determined to be the most expensive option. In both cases, operating costs accounted for the majority of total costs - bulk (81 percent) and drum (96 percent), Table 8.5. This is important because operating cost will increase over time, while capital costs are fixed over the useful life of the equipment.

TABLE 8.1
COST ANALYSIS
TRADITIONAL COOLANT OIL MANAGEMENT[1]

	Initial Costs Drum	Initial Costs Bulk	Life (Years)	Amortization Factor (18%)	Annual Costs Drum	Annual Costs Bulk
CAPITAL COSTS[2]						
Sump cleaner	$ 4,000	$ 4,000	10	0.223	$ 890	$ 890
Storage tank		4,600	10	0.223		1,020
TOTAL	$ 4,000	$ 8,600			$ 890	$ 1,910
OPERATING COSTS						
Labor[3]					$ 1,500	$ 1,500
Supplies[4]					1,920	1,920
Energy[5]					50	50
Maint.: 3% of total initial capital costs					120	260
Disposal[6]					15,360	4,400
Misc. (insurance, administrative and management costs) 1% of total initial capital costs					40	90
TOTAL					$18,990	$ 8,220
TOTAL ANNUAL COSTS					$19,880	$10,130

Footnotes:

[1]Data calculated by Gordian Associates from responses to the Vermont discarded coolant oil questionnaire and vendor sources.

[2]The capital items listed are those necessary for the proper control of coolant oil. A company might currently have these items and thus not have to purchase this equipment. Even so, with any capital item there is an annual cost. To determine the annual cost of capital, it was assumed that the listed capital items were purchased in April 1980.

[3]Labor costs were based on the time to empty and refill the machine sumps.

• Time to empty and refill sump	1 hour
• Annual frequency	4
• Total time	160 hours
• Number of machines	40
• Labor rate	$9.40, includes 15 percent fringe benefits.

The time to empty and refill a sump as well as annual frequency were based on the knowledge of the staff of RECRA Research of processes which use coolant oil.

The hourly rate was taken from the Dodge Mean Guide and adjusted for Vermont.

[4]Supply costs were for coolant oil.

- Annual quantity — 480 gallons
- Cost — $4.00 per gallon

[5]Energy costs was for power to operate the sump cleaner.

[6]Disposal costs were for transportation and treatment at an acceptable site. Average costs for these services were based on information given by Environmental Waste Removal, Inc. - Waterbury, Connecticut - and Chemical Recovery, Inc. - Boston, Massachusetts.

- Annual quantity discarded — 15,360 gallons
- Disposal cost

Drum	$50 per drum in shipments of 36 drums.
Bulk	$0.20 per gallon plus a shipping charge of $330.

TABLE 8.2
COST ANALYSIS
CLOSED LOOP COOLANT OIL MANAGEMENT[1]

	Initial Costs Drum	Initial Costs Bulk	Life (Years)	Amortization Factor (18%)	Annual Costs Drum	Annual Costs Bulk
CAPITAL COSTS[2]						
Sump cleaner	$ 4,000	$ 4,000	10	0.223	$ 890	$ 890
Closed-loop system complete, in place	25,000	25,000	10	0.223	5,560	5,560
Storage tank		1,150	10	0.223		260
TOTAL	$29,000	$30,150			$ 6,450	$ 6,710
OPERATING COSTS						
Labor[3]					$ 4,000	$ 4,000
Supplies[4]					640	640
Energy[5]					200	200
Maint.: 3% of total initial capital costs					870	900
Disposal[6]					4,630	2,280
Misc. (insurance, administrative and management costs) 1% of total initial capital costs					290	300
TOTAL					$10,630	$ 8,320
TOTAL ANNUAL COSTS					$17,080	$15,020

Footnotes:

[1]Data calculated by Gordian Associates from responses to the Vermont discarded coolant oil questionnaire and vendor sources.

[2]The capital items listed are those necessary for the proper control of coolant oil using a closed-loop system. A company might currently have some or all of these items and thus not have to purchase this equipment. Even so, with any capital item there is an annual cost. To determine the annual cost of capital, it was assumed that the listed capital items were purchased in April 1980.

[3]Labor costs were based on the time to empty and refill the machine sumps and to operate the closed-loop system.

	Machines: Closed-loop	Machines: Non-Closed-loop	TOTAL
• Time to empty and refill sump	1 hr.	1 hr.	
• Annual frequency	6	4	
• Total time	168 hrs.	48 hrs.	216 hrs.
• Number of machines	28	12	40

The time to empty and refill a sump as well as annual frequency were based on the knowledge of the staff of RECRA Research of processes which use coolant oil.

Closed-loop equipment operation labor requirement:

- Weekly time — 4 hours

Labor cost to empty and refill the sumps and operate the closed-loop system were assumed to be the same.

- Labor rate — $9.40, includes 15 percent fringe benefits

The hourly rate was taken from the Dodge Mean Guide and adjusted for Vermont.

[4]Supply costs were for coolant oil.

• Annual quantity	160 gallons
• Cost	$4.00 per gallon

[5]Energy costs were to power the sump cleaner and the closed-loop system.

[6]Disposal costs were for transportation and treatment at an acceptable site. Average costs for these services were based on information given by Environmental Waste Removal, Inc. - Waterbury, Connecticut - and Chemical Recovery, Inc. - Boston, Massachusetts.

• Annual quantity discarded	4,630 gallons
• Disposal cost	
Drum	$50 per drum in shipments of 36 drums.
Bulk	$0.20 per gallong plus a shipping charge of $330.

This assumes 70 percent of machine on closed-loop system with a generation rate of .25 percent per year. Machines, excluded from system, generate 4,610 gallons per year.

TABLE 8.3
COST ANALYSIS
TREATMENT COOLANT OIL MANAGEMENT[1]

	Initial Costs				Annual Costs	
	Ultra-filtration	Chemical Phase Separation	Life (Years)	Amortization Factor (18%)	Ultra-filtration	Chemical Phase Separation
CAPITAL COSTS[2]						
Sump cleaner	$ 4,000	$ 4,000	10	0.223	$ 890	$ 890
Treatment system, complete, in place	10,000	17,000	10	0.223	2,230	3,780
TOTAL	$14,000	$23,000			$ 3,120	$ 4,670
OPERATING COSTS						
Labor[3]					$ 3,460	$ 3,460
Supplies[4]					2,320	3,050
Energy[5]					200	200
Maint.: 3% of total initial capital costs					420	690
Disposal[6]					3,300	1,410
Misc. (insurance, administrative and management costs) 1% of total initial capital costs					140	230
TOTAL					$ 9,840	$ 9,040
TOTAL ANNUAL COSTS					$12,960	$13,710

Footnotes:

[1]Data calculated by Gordian Associates from responses to the Vermont discarded coolant oil questionnaire and vendor sources.

[2]The capital items listed are those necessary for the proper control of coolant oil using an on-site treatment system. A company might currently have some of these items and thus not have to purchase this equipment. Even so, with any capital items there is an annual cost. To determine the annual cost of capital, it was assumed that the listed capital items were purchased in April 1980.

[3]Labor costs were based on the time to empty and refill the machine sumps and to operate the treatment system. Sump labor requirements:

• Time to empty and refill sump	1 hour
• Annual frequency	4
• Total time	160 hours
• Number of machines	40

The time to empty and refill a sump as well as annual frequency were based on the knowledge of the staff of RECRA Research of processes which use coolant oil.

Treatment system equipment operation labor requirement:

• Weekly time	4 hours

Labor cost to empty and refill the sumps and operate the treatment system were assumed to be the same.

• Labor rate	$9.40, includes 15 percent fringe benefits

The hourly rate was taken from the Dodge Mean Guide and adjusted for Vermont.

[4]Supply costs were for coolant oil and treatment equipment.

Coolant oil:

- Annual quantity — 480 gallons
- Cost — $4.00 per gallon

Treatment - Ultrafiltration:

- Quantity — One filter each year
- Cost — $400 per filter

Treatment - Chemical Phase Separation:

- Quantity — 10 pounds flocculation agent per 100 gallons
- Cost — $0.75 per pound

[5]Energy costs were to power the sump cleaner and the treatment equipment.

[6]Disposal costs were for transportation and treatment at an acceptable site. Average costs for these services were based on information given by Environmental Waste Removal, Inc. - Waterbury, Connecticut - and Chemical Recovery, Inc. - Boston, Massachusetts.

	Ultrafiltration	Chemical Phase Separation
• Annual quantity discarded	3,000 gallons	900 gallons
• Disposal cost	$50 per drum in shipments of 36 drums. Transportation charge on shipments of less that 36 drums but more than five drums: $75. With shipments of five or less drums the charge is $127.50. In both cases, there would be four shipments per year.	

Table 8.4

Ranking Management Options Based on Total Annual Costs, 1980[1]

Rank	Management Option	Total Annual Costs, 1980 ($)
1	Traditional - Bulk	10,130
2	Ultrafiltration	12,960
3	Chemical Phase Separation	13,710
4	Closed-Loop - Bulk	15,020
5	Closed-Loop - Drum	17,080
6	Traditional - Drum	19,880

Footnote:

1. Source - Tables 6.1, 6.2, and 6.3.

The treatment options were found to be the second and third lowest cost alternatives. Ultrafiltration was less expensive ($12,960 per year) than chemical phase separation ($13,710 per year). Operating costs, however, are lower with chemical phase separation (61 percent of total costs) than with ultrafiltration (70 percent of total costs).

A possible advantage with chemical phase separation is the ability claimed by equipment vendors to treat other hazardous waste streams (e.g., paint sludges), which might be generated by a company. In addition, the oil/flocculent agent product has been claimed to be able to pass EPA's criteria for a non-hazardous waste. This claim was discounted in the cost analysis. Disposal cost for the waste, therefore, was based on the assumption that the waste product was hazardous.

Closed-loop processing was determined to have relatively high first year operating costs. Annual system costs would be $15,020 with bulk shipment and $17,080 with drum shipment.

Table 8.5

Capital, Operating, and Total Annual Costs
By Management Option For Individual Plants, 1980[1]

Management Option	Annual Costs($) Capital	Operating	Total
Traditional			
Drum	890	18,990	19,880
Bulk	1,910	8,220	10,130
Closed-loop			
Drum	6,450	10,630	17,080
Bulk	6,710	8,320	15,020
Treatment			
Ultrafiltration	3,120	9,840	12,960
Chemical Phase Separation	4,670	9,040	13,710

Cost Projections. To analyze the cost of the managment options over the 10 year useful life of the equipment, projections were made to 1990. During this time, all capital costs (the fixed costs) remained constant; only the operating (the variable costs) were increased. The rate at which specific operating cost items will increase, however, will vary. three categories of cost items were identified:

- Disposal,
- Coolant Oil, and
- Other Operating Costs.

[1] Source Tables 8.1,8.2, and 8.3

Rather than increase the cost items based on one set of inflation factors, six cost scenarios were developed, Table 8.6. This approach was taken because representatives of the hazardous waste management and coolant oil manufacturing industries were unable to give a single rate at which these cost items would increase. For example, cost increases ranging form 0.0 to 100.0 percent were given for hazardous waste management during the next few years. Instead, a range of rates at which these costs might escalate were given. The mid-range escalation rates were used for this report.

The purpose of these scenarios is to show the change in operating, and thus total costs, under several inflation rates for each cost item. Under these different rates, the ranking of the management options will vary each year. Those options with a high percentage of operating costs to total costs (e.g., traditional) fare the worst under the scenarios with the high escalation rates.

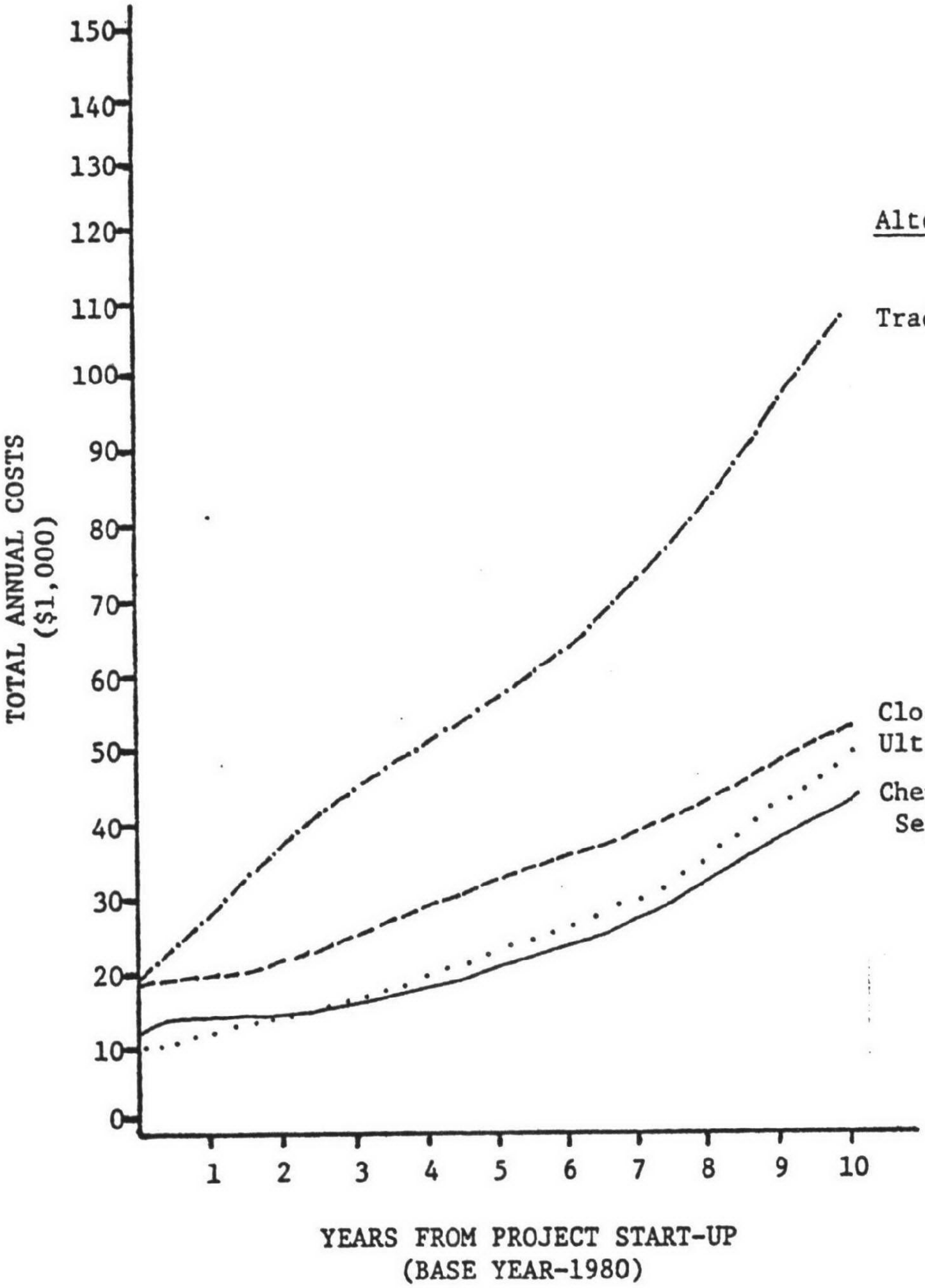
Table 8.6

Cost Scenarios

Scenario	Disposal Costs		Coolant Oil Costs		Other Operating Costs	
	% increase	years	% increase	years	% increase	years
1	40 15	1-2 3-10	20	1-10	10	1-10
2	40 15	1-2 3-10	30	1-10	10	1-10
3	30 15	1-5 6-10	20	1-10	10	1-10
4	30 15	1-5 6-10	30	1-10	10	1-10
5·	20	1-10	20	1-10	10	1-10
6	20	1-10	30	1-10	10	1-10

Figure 8.1 through 8.12 show graphically the total annual costs over the 10 year period of this study for each management option under the six scenarios. Detailed annual cost projections for each option under the scenario are given in Appendix B. The management options are divided into two groups by scenario: (1) drum transport and (2) bulk transport. Costs for the two treatment processes are shown in both groups. Also shown on each graph is the present value of the projected costs. Present value, which is discussed in the next section, was used to evaluate the cost projections.

FIGURE 8.1



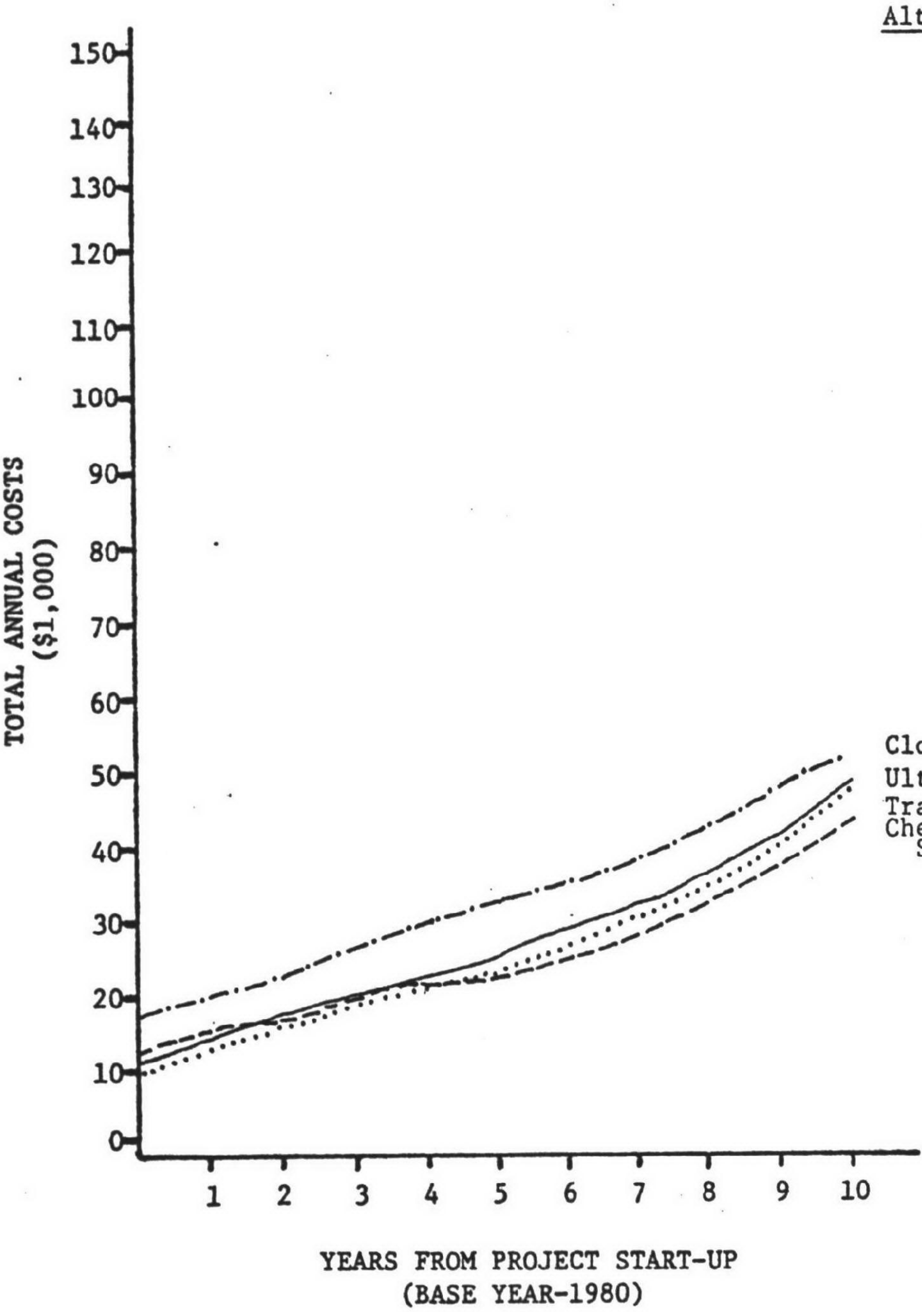
Alternative	Present Value	Present Value Rank
Traditional	$231,100	4
Closed-Loop	$131,720	3
Ultrafiltration	$106,370	2
Chemical Phase Separation	$ 99,500	1

SCENARIO 1 - DRUM BASIS [1]

Footnote:

[1] Data for these cost projections were taken from Appendix A.

FIGURE 8.2



Alternative	Present Value	Present Value Rank
Closed-Loop	$132,890	4
Ultrafiltration	$106,370	3
Traditional	$ 98,460	1
Chemical Phase Separation	$ 99,500	2

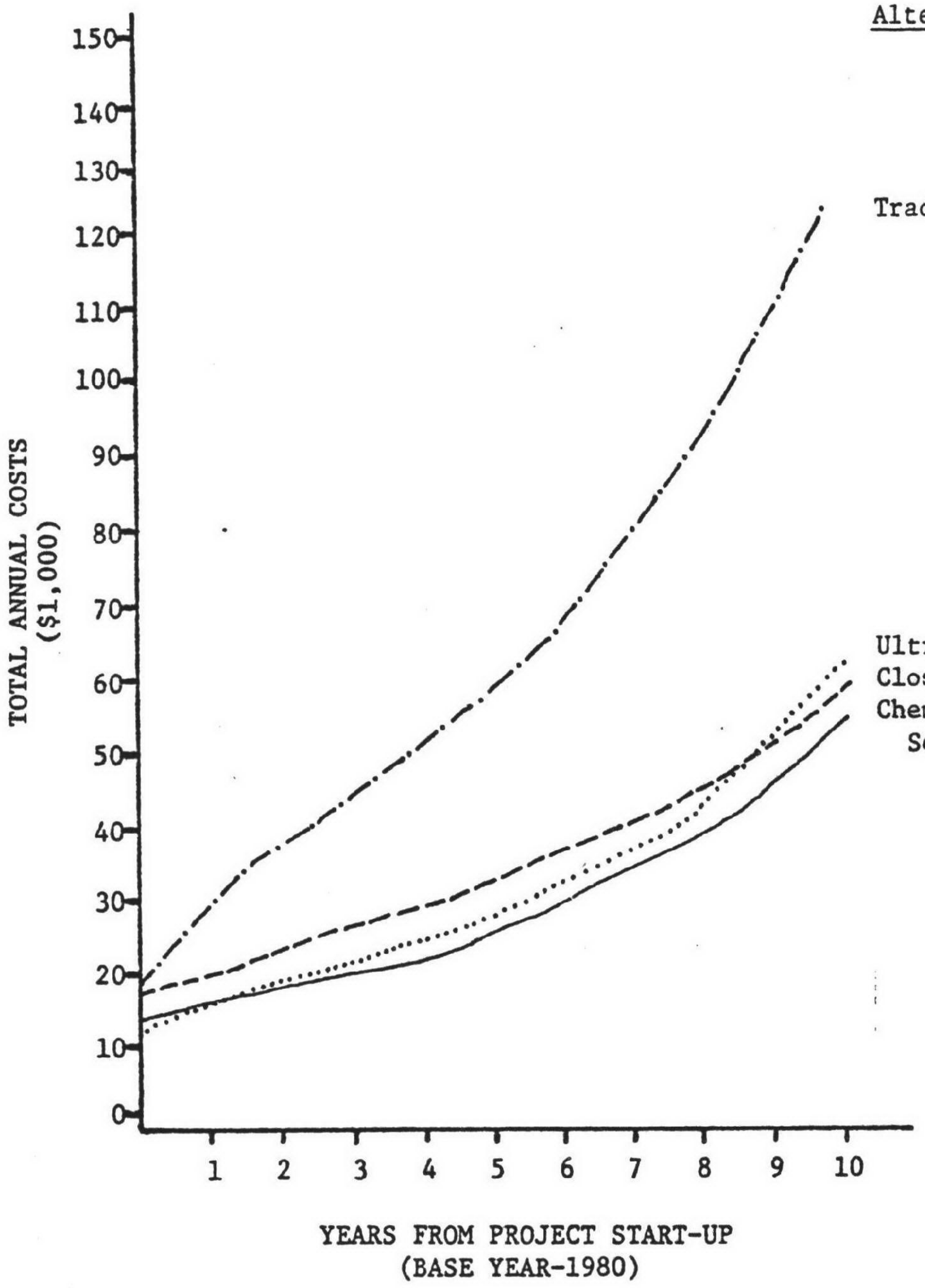
SCENARIO 1 - BULK BASIS [1,2]

Footnotes:

[1] Data for these cost projections were taken from Appendix A.

[2] Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal both with the traditional and closed-loop approaches.

FIGURE 8.3



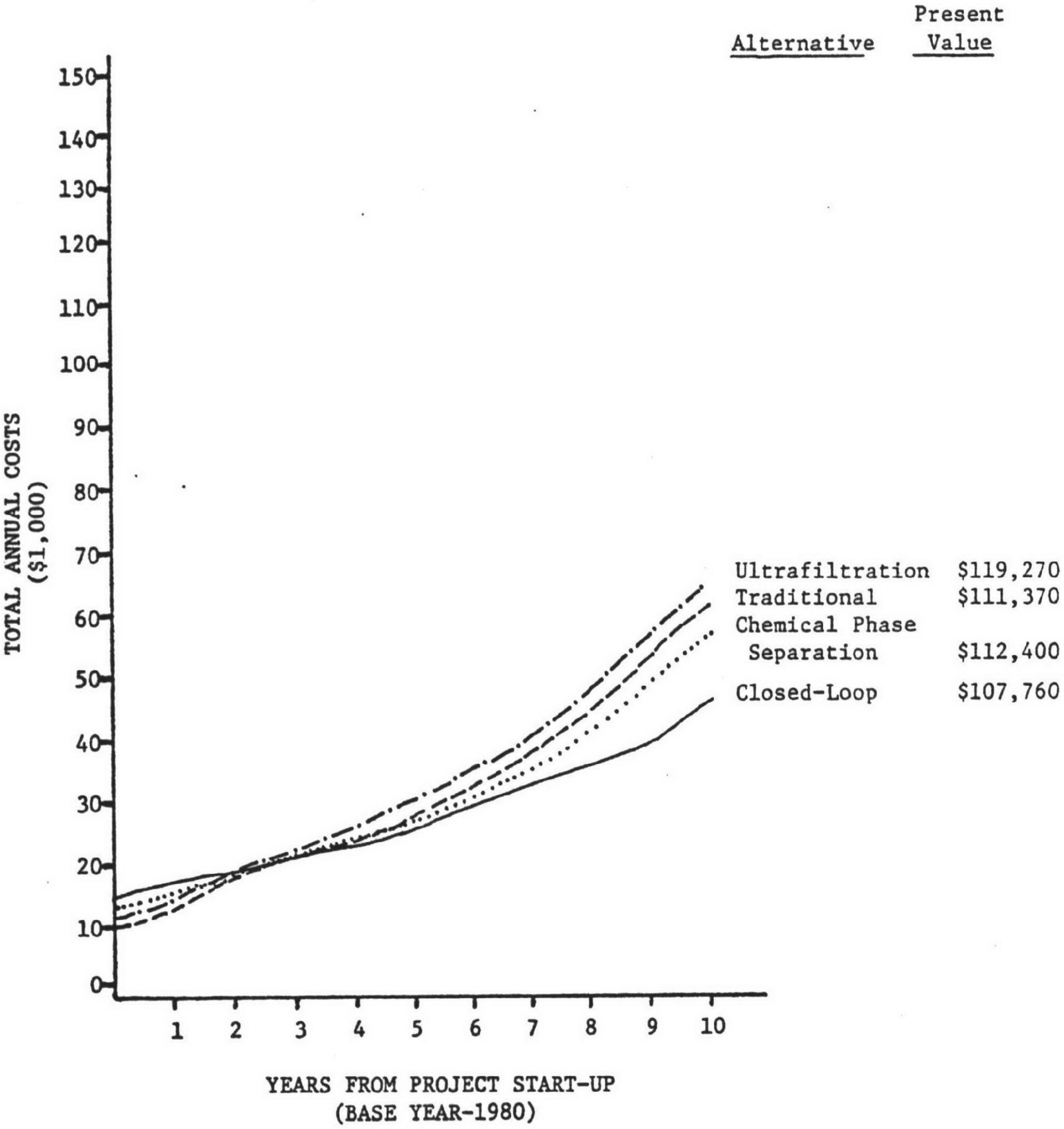
Alternative	Present Value	Present Value Rank
Traditional	$244,000	4
Ultrafiltration	$119,270	2
Closed-Loop	$136,020	3
Chemical Phase Separation	$112,400	1

SCENARIO 2 - DRUM BASIS [1]

Footnote:

[1] Data for these cost projections were taken from Appendix A.

FIGURE 8.4



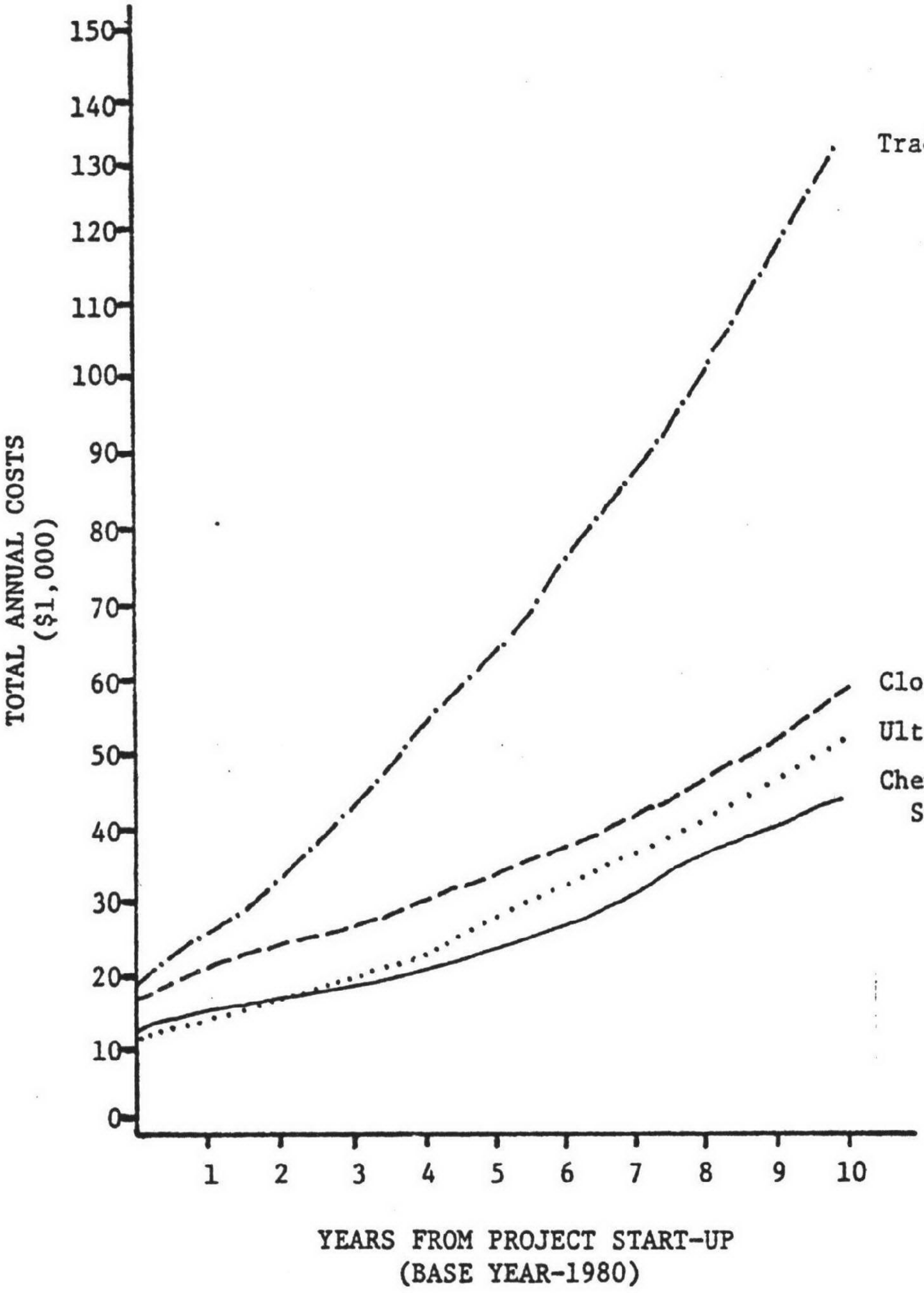
SCENARIO 2 - BULK BASIS [1,2]

Footnotes:

1 Data for these cost projections were taken from Appendix A.

2 Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal both with teh traditional and closed-loop approaches.

FIGURE 8.5



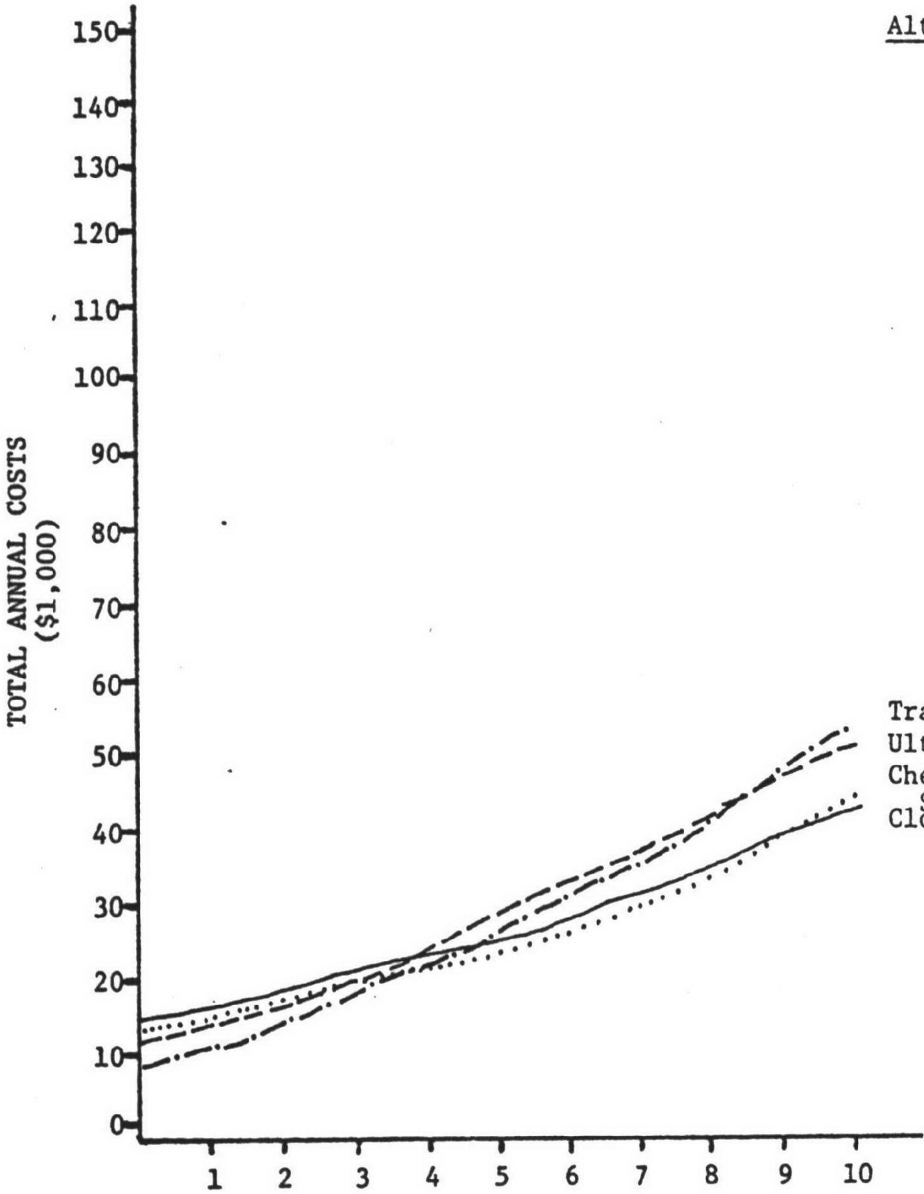
Alternative	Present Vlaue	Present Value Rank
Traditional	$255,570	4
Closed-Loop	$136,020	3
Ultrafiltration	$111,730	2
Chemical Phase Separation	$101,790	1

SCENARIO 3 - DRUM BASIS[1]

Footnote:

1 Data for these cost projections were taken from Appendix A.

FIGURE 8.6



Alternative	Present Value	Present Value Rank
Traditional	$105,610	2
Ultrafiltration	$111,730	4
Chemical Phase Separation	$101,790	1
Closed-Loop	$107,160	3

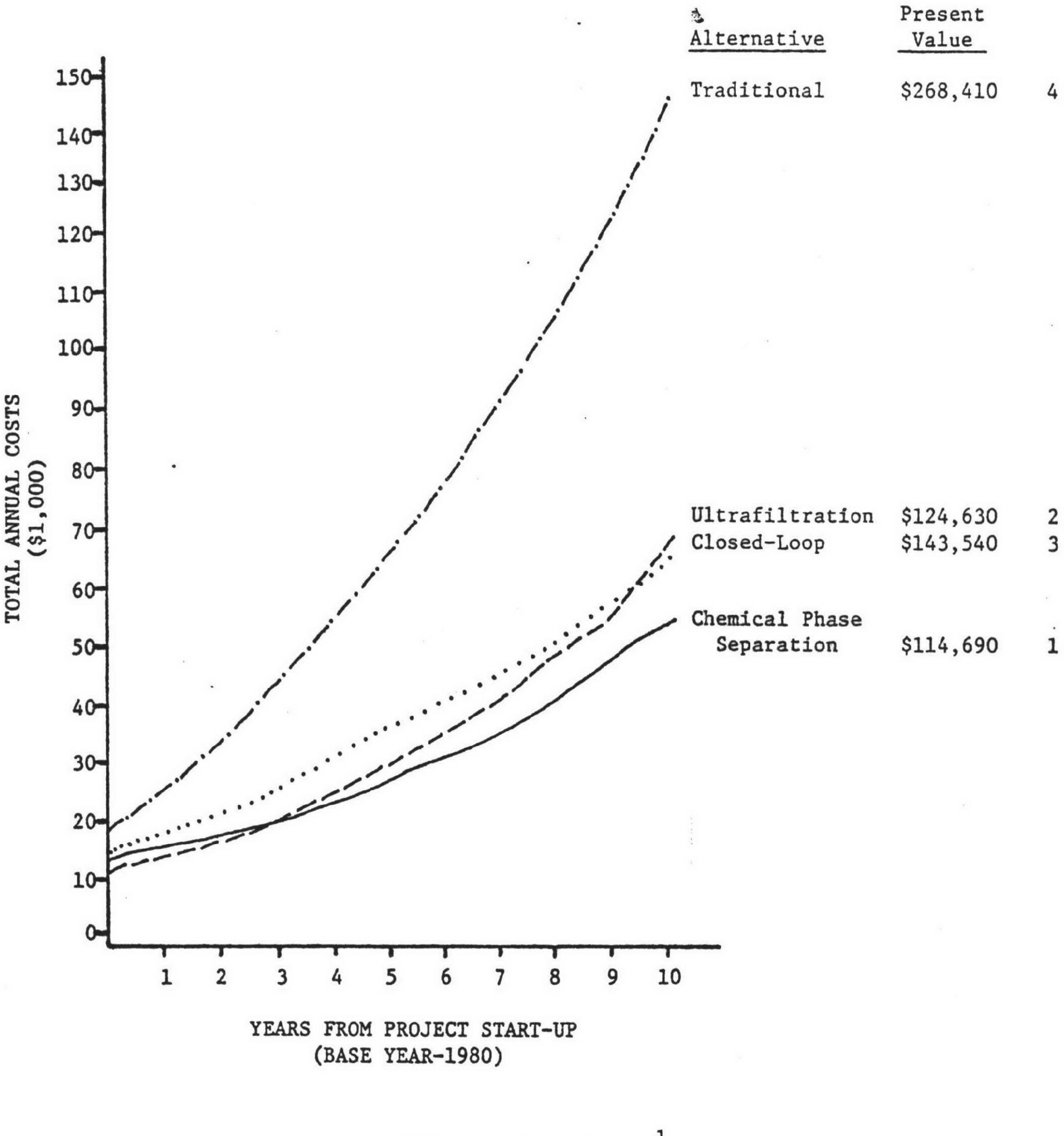
SCENARIO 3 - BULK BASIS [1,2]

Footnotes:

[1] Data for these cost projections were taken from Appendix A.

[2] Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal both with the traditional and closed loop approaches.

FIGURE 8.7

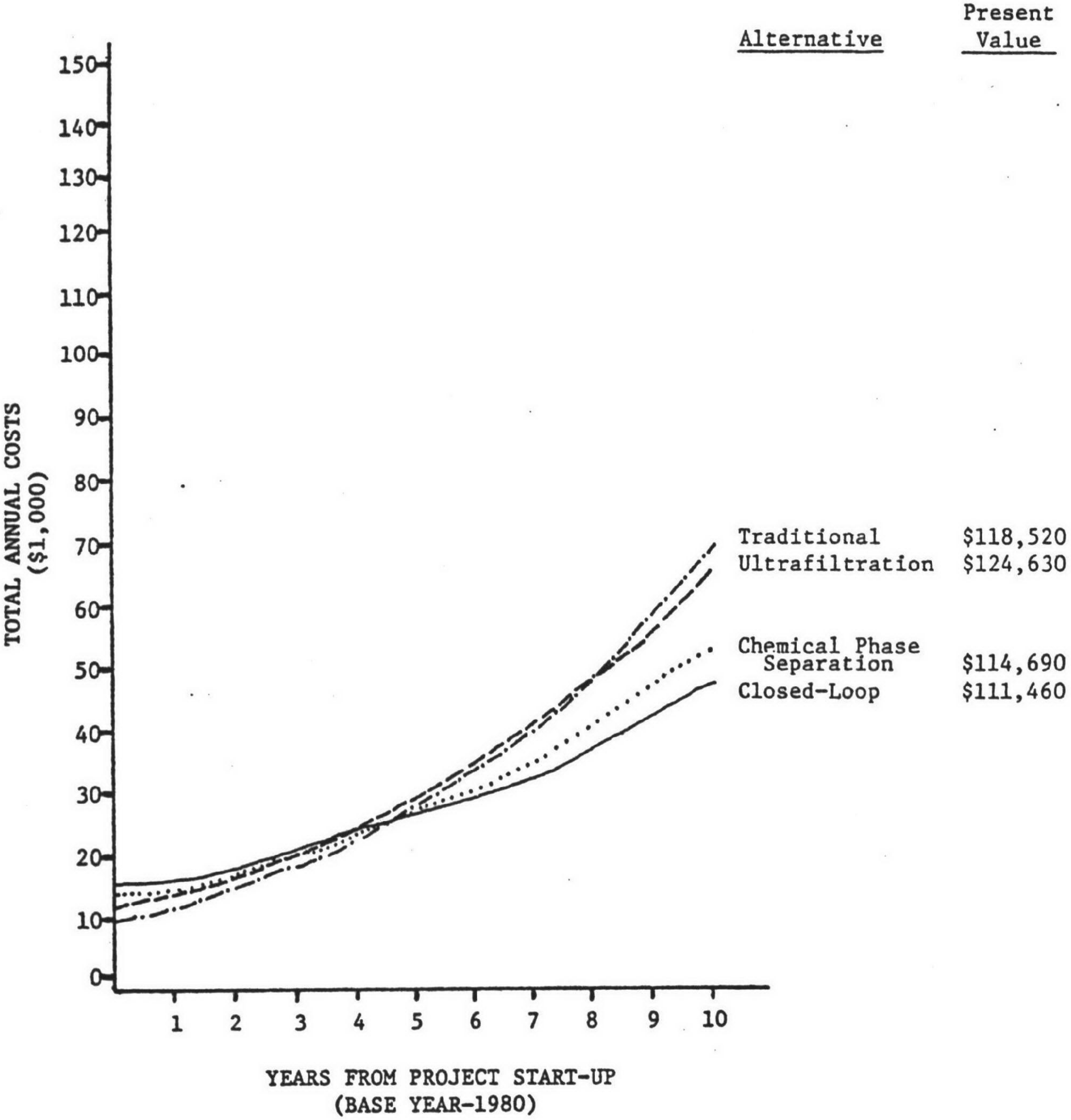


SCENARIO 4 - Drum Basis [1]

Footnote:

[1] Data for these cost projections were taken from Appendix A.

FIGURE 8.8



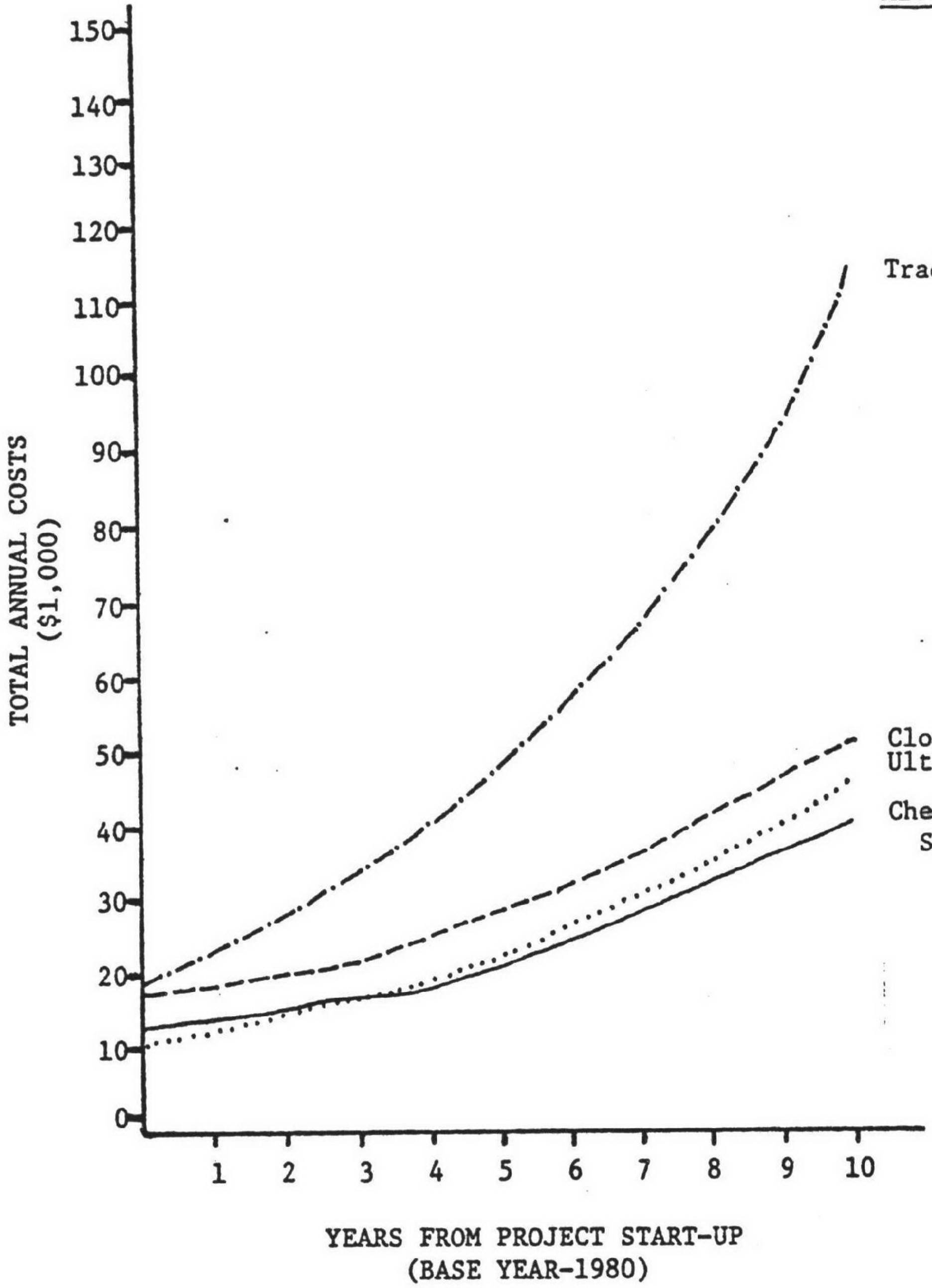
SCENARIO 4 - BULK BASIS [1,2]

Footnotes:

1 Data for these cost projections were taken from Appendix A.

2 Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal both with the traditional and closed loop approaches.

FIGURE 8.9



Alternative	Present Value	Present Value Rank
Traditional	$205,620	4
Closed-Loop		3
Ultrafiltration	$100,890	2
Chemical Phase Separation	$ 97,160	1

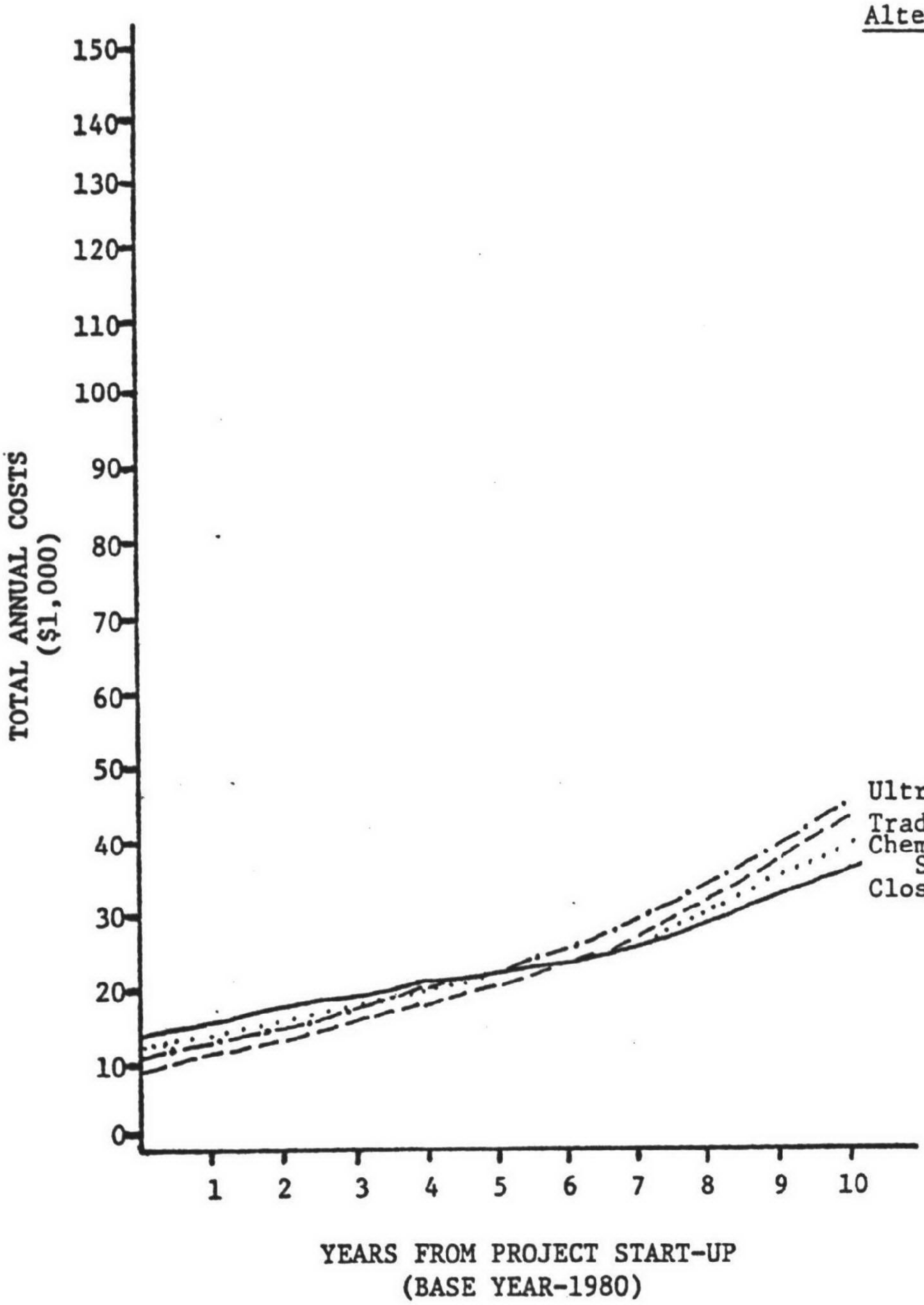
SCENARIO 5 - DRUM BASIS [1]

Footnote:

[1] Data for these cost projections were taken from Appendix A.

FIGURE 8.10

Alternative	Present Value	Present Value Rank
Ultrafiltration	$100,890	4
Traditional	$ 91,160	1
Chemical Phase Separation	$ 97,160	2
Closed-Loop	$ 99,670	3



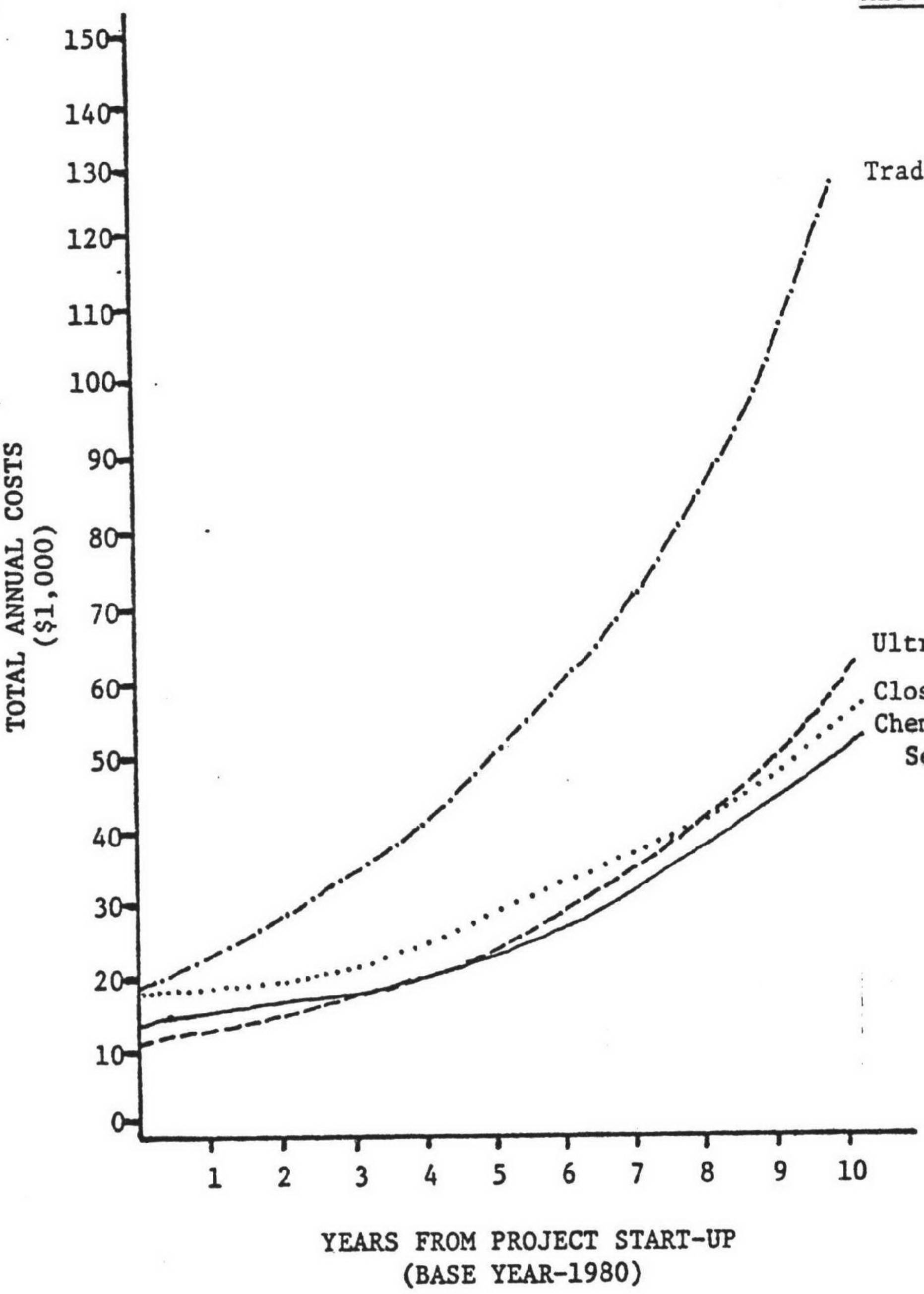
SCENARIO 5 - BULK BASIS [1,2]

Footnotes:

[1] Data for these cost projections were taken from Appendix A.

[2] Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal both with the traditional and closed loop approaches.

FIGURE 8.11



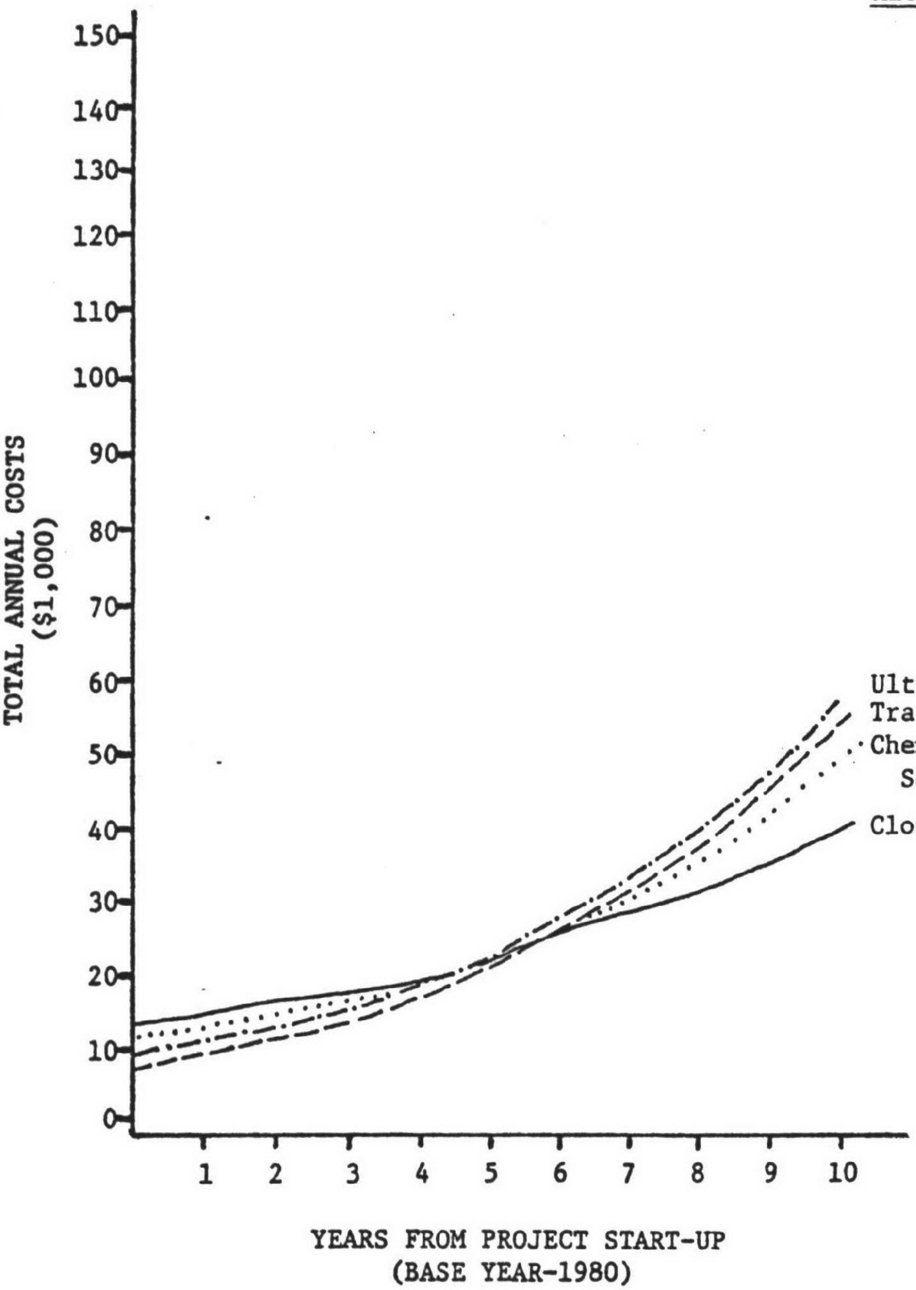
Alternative	Present Value	Present Value Rank
Traditional	$218,450	4
Ultrafiltration	$113,790	2
Closed-Loop	$128,340	3
Chemical Phase Separation	$110,060	1

SCENARIO 6- DRUM BASIS [1]

Footnote:

[1] Data for these cost projections were taken from Appendix A.

FIGURE 8.12



Alternative	Present Value	Present Value Rank
Ultrafiltration	$113,790	4
Traditional	$104,070	2
Chemical Phase Separation	$110,060	3
Closed-Loop	$103,980	1

SCENARIO 6 - BULK BASIS [1,2]

Footnotes:

[1] Data for these cost projections were taken from Appendix A.

[2] Ultrafiltration and chemical phase separation are treatment processes which generate small waste quantities, which would be discarded in drums. These options are presented as alternatives to bulk disposal with the traditional and closed loop approaches.

<u>Present Value Cost Analysis</u>. This analytical method is based on the principle that a dollar today is worth more than a dollar in the future. The resoning behind this method is that today's dollar can be invested and, thus, today's dollar plust the investment income would have a higher value than the future dollar alone. To assess alternative projects, future savings (earinings) are discounted to the present and summed so that comparisons can be made. The discount rate used in this study was the prime interest rate in effect in April 1980. Since the prime rate is the cost lenders charge for money, an investment has to be able to save (earn) at least that much to be conomically justifiable. The prime rate used was 18 percent. A lower prime rate would benefit those options with a high percentage of capital costs to total costs (e.g., closed-loop, treatment), since future savings would be discounted at a lower rate.

A comparison of the summation of the yearly present values for each project will indicate which project is preferable given the stated conditions. In this case the project with the lowest present value is preferable.

The present value of each management option under the six scenarios is given in Table 8.7. In Table 8.8, the management options are ranked in order present value with those options with the lowest present value ranked first.

Table 8.7

Present Values For Each Management Option[1.2]

Management Option	Present Value by Scenario ($) 1	2	3	4	5	6
Traditional						
Drum	231,100	244,000	255,570	268,410	205,620	218,450
Bulk	98,460	111,370	105,610	118,520	91,160	104,070
Closed-loop						
Drum	131,720	136,020	139,240	143,540	124,030	128,340
Bulk	103,460	107,760	107,160	111,460	99,670	103,980
Treatment						
Ultrafiltration	106,370	119,270	111,730	124,630	100,890	113,790
Chemical Phase Separation	99,500	112,400	101,790	114,690	97,160	110,060

Footnotes:

1. Source - Appendix B
2. All data rounded to the nearest 10.

Table 8.8

Present Value Ranking of the Management Options for Each Scenario[1.2]

Rank	1	2	3	4	5	6
1	CPS	CL-B	CPS	CL-B	Trad-B	CL-B
2	Trad-B	Trad-B	Trad-B	CPS	CPS	Trad-B
3	CL-B	CPS	CL-B	Trad-B	CL-B	CPS
4	Ultra	Ultra	Ultra	Ultra	Ultra	Ultra
5	CL-D	CL-D	CL-D	CL-D	CL-D	CL-D
6	Trad-D	Trad-D	Trad-D	Trad-D	Trad-D	Trad-D

Footnotes:

1. Rankings based on data in Table 6.7.
2. Abbreviations: Trade-D (Traditional-Drum); Trade-B (Traditional-Bulk); CL-D (Closed Loop-Drum); CL-B (Closed Loop-Bulk); CPS (Chemical Phase Separation); and Ultra (Ultrafiltration).

The ranking information in Table 8.8 fails to indicate that any of the options is the preferable choice. In fact, the top four ranked options (closed loop, bulk; chemical phase separation; ultrafiltration; and traditional, bulk) are all typically within a 10 percent range. The variation in ranking and the small percentage difference between the options indicates that none of the top four options is economically preferable to others, at least under the conditions outlined in this report.

A reader who wishes to evaluate which management options to use in a plant should use this report as guide for developing site specific cost data. As stated throughout this section, the information is based on a hypothetical plant. Consequently, the results reported in this study are only indicators, not definitive costs. In addition, changes in economic conditions which cause the interest rate to rise or fall will affect the ranking of each option. Options which have relatively high capital costs will be most affected by these changes. Variations from the escalation rates forecast will cause operating costs also to grow at different rates. Again, this will have an affect on the ranking of the options.

In summary, readers concerned about coolant oil management at a specific plant should use this report as a guide in determining costs at the plant. This gives a manager a basis upon which to discuss with representatives of close-loop, treatment, and treatment/disposal companies the cost of the services offered. In other words, a manager will be able to develop site specific cost data prior to meeting with a vendor. Therefore, the manager will be in a position to more fully understand the cost data presented by a vendor to justify any given approach to coolant oil management.

CENTRAL TREATMENT FACILITY

Implied in this approach is the shipment of the waste coolant oil generated in Vermont to a central site for treatment. The objective of such a facility would be to reduce the cost which the machine tool industry must bear for the proper management of discarded emulsions through economies of scale.

This evaluation of the economic viability of a central treatment facility was divided into three phases. In the first phase the total amount of waste coolant oil generated in the State was quantified. Costs to build and operate a central treatment facility were determined in the second phase. In addition, the cost to the machine tool industry to continue its current practices was developed. These costs are compared in the third phase.

Waste Quantity

About 300,000 gallons of coolant oil emulsions will be generated in 1980. This rate was interpolated from the responses to the Vermont discarded coolant oil questionnaire. For the purpose of this evaluation, it was assumed that emulsions will continue to be discarded at this rate. This assumption was based on the condition that those respondents who expressed interest in closed-loop or treatment systems would forgo this option if a central treatment facility were available.

Management Cost

The cost to management used coolant oil in Vermont were developed on two basis: current practice and central treatment.

Current Practice An estimated $300,000 will be spent by the machine tool industry in Vermont to transport and treat discarded coolants in 1980. This cost does not reflect the expense incurred by those companies which recycle or treat their coolants on-site. The factors used to determine these costs were:

- Quantity: 6,000 barrels of emulsion will be discarded with 50 gallons per 55-gallon drum.
- Cost: $50.00 per barrel for hauling and processing at sites in New England.

Central Treatment A cost analysis of a central treatment facility required estimates on the following three factors:

- Hauling cost from individual plants to a central facility,

- Costs of facility operation, and
- Disposal cost for treatment residue.

A first step in the determination of hauling costs was to locate the facility. Springfield, which is the major source (85 percent) of coolant oil, was designated as the facility location to minimize transportation cost. The estimated hauling costs to deliver waste coolant oil to a Springfield site would be $32,550, shown on Table 8.9.

Table 8.9

Hauling Cost To Central Treatment Facility In Vermont

Source	Percent of Emulsions Discarded	Quantity Discarded (Gallons)	Mileage to Site	Hauling Cost
Springfield	85	255,000	10	$11,480
Lyndonville	10	30,000	105	14,180
Other	5	15,000	106	6,890
Total	100	300,000	221	$32,550

Lyndonville is another area with a concentration of machine tool companies. The remaining companies in Vermont are located throughout the State. Since exact locations for all these plants were unavailable, an estimated mileage was used. This estimated was the average distance from the 14 county seats to Springfield. All mileage information was obtained from the American Automobile Association. Rate charges for hauling coolant oils were obtained from the St. Johnsbury Trucking Company.

Costs for facility operation are based primarily on three considerations: (1) treatment system used, (2) land and construction, and (3) labor.

Although both ultrafiltration and chemical phase separation could be used to treat coolant oil emulsions at a central facility, the latter method was selected. This treatment method was selected based on chemical ability to treat other hazardous wastes (e.g., paint sludge), in addition to coolant oil emulsions. In addition, the residue containing the coolant oil has passed the EPA leachate test as a non-hazardous waste according to vendor claims. For the purpose of this analysis, a conservative approach was taken and all residue was considered to be hazardous.

An estimated five acres would be needed to house the central treatment facility. To protect the equipment and one employee, a building should be constructed. Sufficient room would be required for equipment, office space and storage. A sewer connection would be needed for discharge of the separated water. Site development would have to include the protection measures required for a hazardous waste treatment facility.

A full-time employee would be needed on-site. However, actual operating time was estimated to be only 600 hours per year. This employee's responsibilities would include equipment operation and record keeping. In fact, if a central facility were built, other types of hazardous waste (e.g., paint and electroplating wastes) probably would be treated at the site. Consequently, the employee would have tasks associated with these other wastes and, thus, would be used more fully than indicated here. Even so, the cost of a full-time employee was used to analyze this option both to be conservative in assessing these alternatives and because no guarantees exist that other wastes would be treated at such a facility.

Annual cost to operate a central treatment facility has been estimated to be $127,490, Table 8.10. This figure is comprised of $27,220 for annual capital costs and $100,270 for operating expenses.

Based on an estimated statewide cost to transport and treat discarded coolants of $300,000, the cost of a central treatment facility would be $172,510 less in 1980.

TABLE 8.10
COST ANALYSIS
CENTRAL TREATMENT FACILITY[1]

	Initial Costs	Life (Year)	Amortization Factor (18%)	Annual/ Costs
CAPITAL COSTS				
Storage Tanks	$9,200	10	0.223	$ 2,050
Treatment system, complete in place[2]	$17,000	10	0.223	3,790
Construction & Land	$114,350	20	0.187	21,380
Building: 1,100 sq. ft. @ $45/sq.ft. 49,500				
Site development: 55% of building 27,350				
Land: 5 acre @ $7,500/acre[4] 37,500				
TOTAL	$140,550			$ 27,220
OPERATING COSTS				
Labor[5]				18,000
Supplies[6]				22,500
Energy[7]				8,000
Maintenance: 5% of initial equipment costs				1,310
Disposal[8]				16,500
Transportation[9]				32,550
Misc: (insurance, administrative and management costs) 1% of total initial capital costs				1,410
TOTAL				$100,270
TOTAL ANNUAL COSTS				$127.490

Footnotes:

1. Data calculated by Gordian Associates from response to the Vermont discarded coolant oil questionnaire and vendor sources.

2. Treatment system is a chemical phase separation unit.

3. Site development costs were based on a higher than normal (30 percent of building) cost because the site would be used as a hazardous waste treatment facility.

4. Labor costs were based on the assumption that one employee would be needed at the facility full time. This person would be responsible for equipment operations as well as administering (e.g., bookkeeping) the facility. Actual work would be less than the 2,080 hours in a full work-year. Even so, the operator would need to be at the facility to receive shipments upon arrival. While shortened hours of operation would be possible, hiring a qualified operator/administrator at less than the stated rate of pay would be difficult.

5. Supply costs wre for the treatment equipment:

• Quantity Treated	300,000 gallons
• Unit Quantity	10 pounds of flocculation agent per 100 gallons of emulsion
• Unit Costs	$0.75 per pound

6. Energy costs were to power the treatment equipment and to light and heat the building.

7. Disposal costs were based on the following conditions:

• Generation rate of oily residue	5.5 gallons per 100 gallons treated
• Quantity treated	300,000 gallons
• Costs	$50 per drum in shipment of 36 drums

8. Treansportation costs were based on the following conditions:

• Cost	$4.75 per 100 pounds - shipped 105 miles within Vermont, which was the average shipping distance.

Transportation cost information was obtained from St. Johnsburg Trucking Company St. Johnsburg, Vermont.

APPENDIX A

SAMPLE QUESTIONNAIRE AND COVER LETTER

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION
Air and Solid Waste Programs, State Office Bldg.
Montpelier, Vermont 05602

DIVISION OF ENVIRONMENTAL ENGINEERING

Department of Fish and Game
Department of Forests, Parks, and Recreation
Department of Water Resources
Environmental Board
Division of Environmental Engineering
Division of Environmental Protection
Natural Resources Conservation Council

January 24, 1980

Dear

The Vermont Agency of Environmental Conservation, in conjunction with the New Hampshire Department of Health and Welfare, has received a grant from the USEPA to study a common environmental and economic problem - treatment and disposal of waste coolant oil emulsions. Forthcoming hazardous waste regulations from both states as well as the Federal government will require immediate attention to this problem and an expeditious solution. These rules will prohibit land disposal of all oils and will require~~ment~~ shipment to treatment facilities in southern New England - an expensive option. A regional solution will take advantage of the economics of scale and will hopefully result in the development of a treatment and disposal facility central in the Vermont-New Hampshire region.

An independent contractor has been selected by the EPA to compile information about the usage of the various coolant oil products in New Hampshire and Vermont, to evaluate the feasibility of existing technologies for treatment of these products when they become wastes, and to make recommendations for environmentally and economically sound management practices. Information on the coolants you use and discard is needed to determine which options will be acceptable in the region. Therefore, I am asking you to give the enclosed questionnaire your personal attention. A prompt response will enable us to develop a solution to this problem in a timely manner.

To maintain the confidentiality of your answers, information which would identify your company has been excluded from the questionnaire. Through a tracking system, the AEC will be able to determine which companies respond. In this way, outside individuals, including our consultants, will be unable to match responses with specific companies.

A copy of the final report will be forwarded to each respondent upon completion.

Sincerely,

Robert Nichols
Hazardous Waste Engineer

RN:lah

Enclosure

DISCARDED COOLANT OIL QUESTIONNAIRE

Please complete this questionnaire as thoroughly as possible, and return with any further information you feel is important.

1. Plant location (county):

2. Coolant oils purchased (please attach manufacturer's specification sheets for oils listed below)*:

	Brand Name	Manufacturer	Quantity (indicate units e.g., gallons)	Frequency (indicate times purchased per period, e.g., month)
(A)				
(B)				
(C)				
(D)				
(E)				

3. Coolant oil extenders:

- Are extenders used: Yes______ No______
- Quantity of oil saved last two years (indicate units, e.g., gallons):

  1979______________; 1978______________

- Describe techniques/chemicals used to extend oil life:______

  ____

  ____

  ____

  ____

- Describe plans to save oil through extenders and estimate oil savings:

  ____

  ____

  ____

  ____

4. Process characteristics*:

- Indicate oil-to-water emulsion ratio by (1) brand name, (2) process function (e.g., grinding), and (3) quantity discarded.

Brand Name	Ratio (Oil/Water)	Process (e.g., grinding)	Quantity Discarded (Estimate if exact quantity unknown.)
(A)			
(B)			
(C)			
(D)			
(E)			

5. Discarded coolant oil management:

- Combined storage with other materials (e.g., solvents, greases, tramp oils):

  Yes ____ No ____

  Describe materials: ____

  ____

- Type of storage: Drums ____ Bulk ____

- Material layering during storage: Yes ____ No ____

- Physical appearance:

Clarity	State
Clear ____________	Liquid ____________
Cloudy ____________	Semi-solid ____________

- Are emulsions currently treated or recycled at your plant:

  Yes ____ No ____

  Describe process used (e.g., ultrafiltration, reverse osmosis):

  ____

  ____

  ____

- Name and location of disposal site for emulsions or residues:

____

____

- Waste management costs:

Disposal $________ per ________

Transportation $________ per ________

- Describe plans for recycling, treatment, or disposal of your discarded emulsions:

____

____

____

____

____

____

____

* Please use reverse side if additional space is needed.

Return by February 12, 1980
to:

Robert Nichols
Air and Solid Waste Programs
Agency of Environmental Conservation
State Office Building
Montpelier, Vermont 05602

APPENDIX B

COST PROJECTION DATA FOR EACH MANAGEMENT OPTION UNDER THE SIX COST ESCALATION SCENARIOS

Traditional, Scenario 2, Bulk Basis

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4400.00	6160.00	8623.99	9917.58	11405.21	13115.99	15083.38	17345.88	19947.76	22939.91	26380.89
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
TTL. COST	10130.00	12655.99	16077.78	18574.71	21580.69	25214.75	29626.77	35006.08	41592.49	49690.48	59687.60
YRLY PV CONTRIB		10725.42	11546.82	11305.16	11131.12	11021.64	10974.74	10989.35	11065.26	11203.10	11404.27
PRES. VAL		10725.42	22272.24	33577.41	44708.52	55730.16	66704.87	77694.19	88759.44	99962.50	111366.75

***** PRESENT VALUE= 111366.75******

TRADITIONAL, SCENARIO 3, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4400.00	5720.00	7435.99	9666.78	12566.80	16336.83	18787.34	21605.44	24846.24	28573.17	32859.13
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
TTL. COST	10130.00	12023.99	14409.78	17423.43	21239.89	26084.35	29796.37	34097.68	39084.66	44869.99	51585.30
YRLY PV CONTRIB		10189.82	10348.89	10604.46	10955.34	11401.75	11037.57	10704.18	10398.08	10116.29	9856.20
PRES. VAL		10189.82	20538.72	31143.18	42098.52	53500.27	64537.84	75242.00	85640.06	95756.31	105612.50

***** PRESENT VALUE= 105612.50******

TRADITIONAL, SCENARIO 4, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4400.00	5720.00	7435.99	9666.78	12566.80	16336.83	18787.34	21605.44	24846.24	28573.17	32859.13
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
TTL. COST	10130.00	12215.99	14889.78	18323.90	22742.28	28435.58	33330.73	39265.63	46490.97	55323.74	66165.81
YRLY PV CONTRIB		10352.54	10693.62	11152.52	11730.25	12429.50	12346.82	12326.54	12368.45	12473.16	12642.04
PRES. VAL		10352.54	21046.16	32198.67	43928.92	56358.43	68705.19	81031.69	93400.12	105873.25	118515.25

***** PRESENT VALUE= 118515.25******

TRADITIONAL, SCENARIO 5, BULK BASIS P

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4400.00	5280.00	6335.99	7603.19	9123.82	10940.58	13138.29	15765.95	18919.13	22702.95	27243.53
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
TTL. COST	10130.00	11583.99	13309.79	15359.84	17796.91	20696.11	24147.32	28258.18	33157.55	38999.77	45969.70
YRLY PV CONTRIB		9816.94	9558.89	9348.49	9179.48	9046.49	8944.98	8871.00	8821.23	8792.80	8783.25
PRES. VAL		9816.94	19375.84	28724.33	37903.80	46950.30	55895.27	64766.27	73587.50	82380.25	91163.44

***** PRESENT VALUE= 91163.44******

TRADITIONAL, SCENARIO 6, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4400.00	5280.00	6335.99	7603.19	9123.82	10948.58	13138.29	15765.95	18919.13	22702.95	27243.53
COOLANT	1920.00	2496.00	3244.80	4218.25	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
TTL. COST	10130.00	11775.99	11789.78	16260.31	19299.30	23047.34	27681.68	33426.14	40563.86	49453.52	60550.24
YRLY PV CONTRIB		9979.66	9903.62	9896.55	9954.39	10074.24	10254.22	10493.36	10791.61	11149.68	11569.09
PRES. VAL		9979.66	19883.28	29779.82	39734.22	49808.46	60062.68	70556.00	81347.56	92497.19	104066.25

***** PRESENT VALUE=   104066.25******

CLOSED LOOP, SCENARIO 1, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	6482.00	9074.79	10436.00	12001.40	13801.60	15871.84	18252.60	20990.48	24139.05	27759.89
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	19595.99	22931.98	25126.07	27626.05	30476.43	33728.39	37440.91	41681.93	46529.82	52074.96
YRLY PV CONTRIB		16606.78	16469.41	15292.53	14249.26	13321.58	12494.12	11753.70	11089.06	10490.51	9949.75
PRES. VAL		16606.78	33076.19	48368.72	62617.98	75939.50	88433.56	100187.25	111276.25	121766.75	131716.50

***** PRESENT VALUE=   131716.50******

CLOSED LOOP, SCENARIO 2, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	6482.00	9074.79	10436.00	12001.40	13801.60	15871.84	18252.60	20990.48	24139.05	27759.89
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	19659.99	23091.98	25426.22	28126.85	31260.17	34906.51	39163.56	44150.71	50014.41	56935.14
YRLY PV CONTRIB		16661.02	16584.32	15475.22	14507.56	13664.16	12930.54	12294.49	11745.85	11276.13	10878.37
PRES. VAL		16661.02	33245.34	48720.55	63228.12	76892.25	89822.75	102117.19	113863.00	125139.12	136017.44

***** PRESENT VALUE=   136017.44******

CLOSED LOOP, SCENARIO 3, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	6019.00	7824.69	10172.09	13223.70	17190.80	19769.41	22734.82	26145.03	30066.77	34576.77
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	19132.99	21681.87	24862.15	28848.36	33865.62	37625.96	41923.12	46836.48	52457.54	58891.84
YRLY PV CONTRIB		16214.40	15571.61	15131.90	14879.71	14803.04	13937.91	13160.79	12460.37	11826.96	11252.23
PRES. VAL		16214.40	31786.01	46917.91	61797.62	76600.62	90538.50	103699.25	116159.56	127986.50	139238.69

***** PRESENT VALUE= 139238.69*****

CLOSED LOOP, SCENARIO 4, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	6019.00	7824.69	10172.09	13223.70	17190.80	19769.41	22734.82	26145.03	30066.77	34576.77
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	19196.99	21841.87	25162.30	29349.16	34649.37	38804.09	43645.78	49305.25	55942.13	63752.02
YRLY PV CONTRIB		16268.64	15686.52	15314.59	15138.02	15145.62	14374.33	13701.58	13117.16	12612.59	12180.84
PRES. VAL		16268.64	31955.16	47269.75	62407.76	77553.37	91927.69	105629.25	118746.37	131358.94	143539.75

***** PRESENT VALUE= 143539.75*****

CLOSED LOOP, SCENARIO 5, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	5556.00	6667.19	8000.62	9600.75	11520.89	13825.07	16590.07	19908.08	23889.69	28667.62
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	18669.99	20524.38	22690.69	25225.40	28195.71	31681.62	35778.38	40599.53	46280.46	52982.69
YRLY PV CONTRIB		15822.03	14740.31	13810.28	13011.02	12324.66	11735.93	11231.79	10801.09	10434.29	10123.19
PRES. VAL		15822.03	30562.34	44372.62	57383.64	69708.25	81444.12	92675.87	103476.94	113911.19	124034.37

***** PRESENT VALUE= 124034.37*****

CLOSED LOOP, SCENARIO 6, CRUM BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	4630.00	5556.00	6667.19	8000.62	9600.75	11520.89	13825.07	16590.07	19908.08	23889.69	28667.62
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5360.00	5896.00	6485.59	7134.14	7847.55	8632.30	9495.53	10445.07	11489.57	12638.52	13902.37
TTL. COST	17080.00	18733.99	20684.38	22990.84	25726.20	28979.46	32859.74	37501.04	43068.30	49765.05	57842.87
YRLY PV CONTRIB		15876.27	14855.22	13992.97	13269.33	12667.24	12172.34	11772.58	11457.89	11219.91	11051.81
PRES. VAL		15876.27	30731.49	44724.46	57993.79	70661.00	82833.31	94605.87	106063.75	117283.62	128335.37

***** PRESENT VALUE= 128335.37*****

CLOSED LOOP, SCENARIO 1, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	2280.00	3192.00	4468.80	5139.11	5909.98	6796.47	7815.93	8988.32	10336.56	11887.04	13670.09
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5400.00	5940.00	7533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
TTL. COST	15030.00	16610.99	18634.39	20142.42	21853.20	23795.72	26003.35	28514.57	31373.76	34632.13	38348.90
YRLY PV CONTRIB		14077.10	13382.93	12259.31	11271.62	10401.32	9632.48	8951.44	8346.62	7808.03	7327.11
PRES. VAL		14077.10	27460.04	39719.35	50990.97	61392.29	71024.77	79976.22	88322.34	96130.87	103457.98

***** PRESENT VALUE= 103457.98 *****

CLOSED LOOP, SCENARIO 2, BULK BASI

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	2280.00	3192.00	4468.80	5139.11	5909.98	6796.47	7815.93	8988.32	10336.56	11887.04	13670.09
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5400.00	5940.00	6533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11
TTL. COST	15030.00	16673.99	18794.39	20442.57	22354.00	24579.46	27181.47	30237.23	33842.53	38116.71	43209.08
YRLY PV CONTRIB		14130.51	13497.86	12442.01	11529.98	10743.95	10068.92	9492.28	9003.46	8593.71	8255.79
PRES. VAL		14130.51	27628.36	40070.37	51600.35	62344.30	72413.19	81905.44	90908.87	99502.56	107758.31

***** PRESENT VALUE= 107758.31*****

CLOSED LOOP, SCENARIO 3, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	2280.00	2964.00	3853.20	5009.15	6511.89	8465.45	9735.26	11195.54	12874.86	14806.09	17026.99
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5400.00	5940.00	6533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11
TTL. COST	15030.00	16381.99	18018.79	20012.45	22455.11	25464.69	27922.67	30721.79	33912.05	37551.18	41705.80
YRLY PV CONTRIB		13883.05	12940.83	12180.22	11582.13	11130.89	10343.49	9644.39	9021.96	8466.20	7968.56
PRES. VAL		13883.05	26823.88	39004.10	50586.23	61717.13	72060.56	81704.94	90726.87	99193.06	107161.62

***** PRESENT VALUE= 107161.62*****

CLOSED LOOP, SCENARIO 4, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	2280.00	2964.00	3853.20	5009.15	6511.89	8465.45	9735.26	11195.54	12874.86	14806.09	17026.99
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5400.00	5940.00	6533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11
TTL. COST	15030.00	16445.99	18178.79	20312.61	22955.91	26248.44	29100.79	32444.45	36380.83	41035.76	46565.98
YRLY PV CONTRIB		13937.29	13055.74	12362.91	11840.44	11473.48	10779.91	10185.18	9678.75	9251.83	8897.18
PRES. VAL		13937.29	26993.03	39355.93	51196.37	62669.85	73449.75	83634.87	93313.62	102565.44	111462.56

***** PRESENT VALUE= 111462.56*****

CLOSED LOOP, SCENARIO 5, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10

DISPOSAL	2280.00	2736.00	3283.20	3939.84	4727.80	5673.36	6808.03	8169.63	9803.55	11764.26	14117.11
COOLANT	640.00	768.00	921.60	1105.92	1327.10	1592.52	1911.03	2293.23	2751.88	3302.25	3962.70
OTHER	5400.00	5940.00	6533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11
TTL. COST	15030.00	16153.99	17448.79	18943.14	20671.02	22672.61	24995.44	27695.88	30840.74	34509.35	38795.92
YRLY PV CONTRIB		13689.83	12531.46	11529.41	10661.92	9910.45	9259.14	8694.48	8204.87	7780.40	7412.58
PRES. VAL		13689.83	26221.29	37750.70	48412.62	58323.06	67582.19	76276.62	84481.44	92261.81	99674.37

***** PRESENT VALUE= 99674.37*****

CLOSED LOOP, SCENARIO 6, BULK BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	2280.00	2736.00	3283.20	3939.84	4727.80	5673.36	6808.03	8169.63	9803.55	11764.26	14117.11
COOLANT	640.00	832.00	1081.60	1406.08	1827.90	2376.27	3089.15	4015.89	5220.65	6786.84	8822.88
OTHER	5400.00	5940.00	6533.99	7187.39	7906.12	8696.73	9566.39	10523.02	11575.32	12732.84	14006.11
TTL. COST	15030.00	16217.99	17608.79	19243.30	21171.82	23456.35	26173.56	29418.54	33309.52	37993.93	43656.10
YRLY PV CONTRIB		13744.07	12646.37	11712.09	10920.22	10253.03	9695.56	9235.27	8861.66	8566.02	8341.20
PRES. VAL		13744.07	26390.44	38102.53	49022.75	59275.78	68971.31	78206.56	87068.19	95634.19	103975.37

***** PRESENT VALUE= 103975.37*****

TREATMENT OPTION, SCENARIO 1, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	4620.00	6467.99	7438.19	8553.91	9836.99	11312.54	13009.41	14960.82	17204.93	19785.66
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6860.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14729.99	17507.38	19545.99	21892.26	24595.30	27712.42	31310.59	35468.07	40276.46	45843.00
YRLY PV CONTRIB		12483.05	12573.54	11896.32	11291.82	10750.87	10265.61	9829.23	9435.92	9080.64	8759.04
PRES. VAL		12483.05	25056.59	36952.91	48244.73	58995.60	69261.19	79090.37	88526.25	97606.87	106365.87

***** PRESENT VALUE= 106365.87*****

TREATMENT OPTION, SCENARIO 2, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	4620.00	6467.99	7438.19	8553.91	9836.99	11312.54	13009.41	14960.82	17204.93	19785.66
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6860.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14921.99	17987.37	20446.46	23394.65	26946.53	31246.77	36478.54	42874.37	50730.21	60423.54
YRLY PV CONTRIB		12645.76	12918.27	12444.37	12066.74	11778.62	11574.85	11451.59	11406.29	11437.52	11544.89
PRES. VAL		12645.76	25564.03	38008.40	50075.14	61853.77	73428.56	84880.12	96286.37	107723.87	119268.75

***** PRESENT VALUE= 119268.75*****

TREATMENT OPTION, SCENARIO 3, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	4290.00	5576.99	7250.08	9425.09	12252.61	14090.50	16204.07	18634.67	21429.86	24644.33
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6860.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14399.99	16616.37	19357.88	22763.45	27010.92	30490.39	34505.24	39141.92	44501.39	50701.67
YRLY PV CONTRIB		12203.38	11933.64	11781.83	11741.17	11806.77	11294.66	10832.12	10413.31	10033.18	9687.37
PRES. VAL		12203.38	24137.02	35918.85	47660.02	59466.79	70761.44	81593.50	92006.81	102039.94	111727.25

***** PRESENT VALUE= 111727.25*****

TREATMENT OPTION, SCENARIO 4, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	4290.00	5576.99	7250.08	9425.09	12252.61	14090.50	16204.07	18634.67	21429.86	24644.33
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6960.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14591.99	17096.37	20258.35	24265.83	29362.15	34024.74	39673.20	46548.23	54955.14	65282.21
YRLY PV CONTRIB		12366.10	12278.36	12329.88	12516.09	12834.52	12603.90	12454.48	12383.69	12390.06	12473.21
PRES. VAL		12366.10	24644.46	36974.34	49490.43	62324.95	74928.81	87383.25	99766.94	112156.94	124630.12

***** PRESENT VALUE= 124630.12*****

TREATMENT OPTION, SCENARIO 5, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	3960.00	4752.00	5702.39	6842.87	8211.44	9853.72	11824.46	14189.36	17027.22	20432.66
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6860.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14069.99	15791.38	17810.19	20181.22	22969.75	26253.61	30125.64	34696.61	40098.75	46490.00
YRLY PV CONTRIB		11923.73	11341.14	10839.86	10409.28	10040.33	9725.21	9457.25	9230.68	9040.57	8882.66
PRES. VAL		11923.73	23264.87	34104.72	44514.00	54554.33	64279.55	73736.75	82967.37	92007.94	100890.56

***** PRESENT VALUE= 100890.56*****

TREATMENT OPTION, SCENARIO 6, ULTRAFILTRATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	3300.00	3960.00	4752.00	5702.39	6842.87	8211.44	9853.72	11824.46	14189.36	17027.22	20432.66
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	4260.00	4686.00	5154.59	5670.04	6237.04	6860.74	7546.81	8301.48	9131.62	10044.78	11049.25
TTL. COST	12600.00	14261.99	16271.38	18710.66	21683.61	25320.98	29787.96	35293.60	42102.91	50552.50	61070.54
YRLY PV CONTRIB		12086.44	11685.87	11387.91	11184.20	11068.07	11034.46	11079.61	11201.05	11397.45	11668.50
PRES. VAL		12086.44	23772.30	35160.21	46344.41	57412.49	68446.94	79526.50	90727.50	102124.94	113793.44

***** PRESENT VALUE= 113793.44******

TREATMENT OPTION, SCENARIO 1, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1974.00	2763.60	3178.14	3654.86	4203.08	4833.54	5558.57	6392.35	7351.20	8453.87
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16
TTL. COST	13710.00	15228.99	17107.48	18765.89	20666.15	22846.62	25352.18	28235.37	31557.79	35391.73	39822.12
YRLY PV CONTRIB		12905.93	12286.34	11421.52	10659.40	9986.51	9391.30	8863.84	8395.63	7979.34	7608.65
PRES. VAL		12905.93	25192.27	36613.80	47273.20	57259.71	66651.00	75514.81	83910.44	91889.75	99498.37

***** PRESENT VALUE= 99498.37******

TREATMENT OPTION, SCENARIO 2, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1974.00	2763.60	3178.14	3654.86	4203.08	4833.54	5558.57	6392.35	7351.20	8453.87
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16
TTL. COST	13710.00	15420.99	17587.48	19666.36	22168.54	25197.86	28886.54	33403.33	38964.10	45845.49	54402.67
YRLY PV CONTRIB		13068.64	12631.07	11969.58	11434.32	11014.26	10700.54	10486.20	10366.01	10336.22	10394.50
PRES. VAL		13068.64	25699.71	37669.29	49103.61	60117.87	70818.37	81304.56	91670.56	102006.75	112401.25

***** PRESENT VALUE= 112401.25******

TREATMENT OPTION, SCENARIO 3, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1833.00	2382.90	3097.76	4027.09	5235.21	6020.49	6923.56	7962.09	9156.40	10529.86
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16
TTL. COST	13710.00	15087.99	16726.79	18685.51	21038.38	23878.76	26539.14	29600.37	33127.54	37196.94	41898.11
YRLY PV CONTRIB		12786.44	12012.93	11372.60	10851.40	10437.67	9830.98	9292.35	8813.25	8386.34	8005.30
PRES. VAL		12786.44	24799.37	36171.97	47023.37	57461.04	67292.00	76584.31	85397.50	93783.81	101789.06

***** PRESENT VALUE= 101789.06******

TREATMENT OPTION, SCENARIO 4, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1833.00	2382.90	3097.76	4027.09	5235.21	6020.49	6923.56	7962.09	9156.40	10529.86
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
TTL. COST	13710.00	15279.99	17206.78	19585.98	22540.77	26229.99	30073.49	34768.33	40533.85	47650.70	56478.65
YRLY PV CONTRIB		12949.15	12357.66	11920.66	11626.32	11465.41	11140.22	10914.71	10783.62	10743.21	10791.15
PRES. VAL		12949.15	25306.81	37227.47	48853.79	60319.20	71459.37	82374.06	93157.62	103900.81	114691.94

***** PRESENT VALUE= 114691.94******

TREATMENT OPTION, SCENARIO 5, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1692.00	2030.40	2436.48	2923.77	3508.53	4210.23	5052.27	6062.73	7275.27	8730.32
COOLANT	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16
TTL. COST	13710.00	14946.99	16374.29	18024.23	19935.07	22152.07	24728.87	27729.08	31228.17	35315.81	40098.57
YRLY PV CONTRIB		12666.95	11759.77	10970.12	10282.32	9682.91	9160.40	8704.90	8307.94	7962.22	7661.47
PRES. VAL		12666.95	24426.72	35396.85	45679.16	55362.07	64522.48	73227.37	81535.31	89497.50	97158.94

***** PRESENT VALUE= 97158.94******

TREATMENT OPTION, SCENARIO 6, CHEMICAL PHASE SEPARATION BASIS

	YEAR 0	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
DISPOSAL	1410.00	1692.00	2030.40	2436.48	2923.77	3508.53	4210.23	5052.27	6062.73	7275.27	8730.32
COOLANT	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
OTHER	5710.00	6281.00	6909.09	7599.99	8359.98	9195.98	10115.57	11127.12	12239.82	13463.79	14810.16
TTL. COST	13710.00	15138.99	16854.28	18924.70	21437.45	24503.30	28263.23	32897.04	38634.48	45769.56	54679.12
YRLY PV CONTRIB		12829.66	12104.50	11518.18	11057.23	10710.66	10469.64	10327.26	10278.31	10319.10	10447.32
PRES. VAL		12829.66	24934.16	36452.34	47509.57	58220.23	68689.87	79017.12	89295.44	99614.50	110061.81

***** PRESENT VALUE= 110061.81******

Traditional, Scenario 1, Drum Basis

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Disposal	15360.00	21504.00	30105.60	34621.44	39817.66	45786.86	52654.88	60553.12	69636.08	80081.50	92093.72
Coolant	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
Other	1710.00	1881.00	2069.10	2276.01	2503.60	2753.96	3029.36	3332.29	3665.52	4032.07	4435.27
Tcl. Cost	19880.00	26579.00	35829.50	41105.21	47189.57	54208.39	62307.32	71655.10	82447.22	94910.32	109307.08
Yrly Pv Contrib		22524.58	25732.19	25017.90	24339.86	23694.99	23080.60	22494.33	21934.11	21398.11	20884.70
Pres. Val		22524.58	48256.77	73274.67	97614.53	121309.51	144390.11	166884.44	188818.55	210216.66	231101.36

***** Present Value = 231101.36 *****

Traditional, Scenario 2, Drum Basis

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Disposal	15360.00	21504.00	30105.60	34621.44	39814.66	45786.86	52654.88	60553.12	69636.08	80081.50	92093.72
Coolant	1920.00	2496.00	3244.80	4218.23	5483.70	7128.80	9267.43	12047.65	15661.93	20360.50	26468.63
Other	1710.00	1881.00	2069.10	2276.01	2503.60	2753.96	3029.36	3332.29	3665.52	4032.07	4435.27
Tcl. Cost	19880.00	26771.00	36309.50	42005.68	48691.96	56559.62	65841.67	76823.06	89853.53	105364.07	123837.62
Yrly Pv Contrib		22687.29	26076.92	25565.95	25114.77	24722.73	24389.83	24116.68	23904.47	23754.97	23670.52
Pres. Val		22687.29	48764.21	74330.16	99444.93	124167.66	148557.49	172674.17	196578.64	220333.61	244004.13

***** Present Value = 244004.13 *****

Traditional, Scenario 3, Drum Basis

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Disposal	15360.00	19923.80	25900.94	33671.22	43772.59	56904.36	65440.02	75256.02	86544.42	99526.09	114455.00
Coolant	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
Other	1710.00	1881.00	2069.10	2276.01	2503.60	2753.96	3029.36	3332.29	3665.52	4032.07	4435.27
Tcl. Cost	19880.00	24998.80	31624.84	40154.99	51147.50	65325.89	75092.46	86358.00	99355.56	114354.91	131668.36
Yrly Pv Contrib		21185.42	22712.47	24439.57	26381.31	28554.55	27816.62	27109.94	26432.37	25782.01	25157.15
Pres. Val		21185.42	43897.89	68337.46	94718.77	123273.32	151089.93	178199.87	204632.24	230414.25	255571.40

***** Present Value = 255571.40 *****

Traditional, Scenario 1, Bulk Basis

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Disposal	4400.00	6160.00	8623.99	9917.58	11405.21	13115.99	15083.38	17345.88	19947.76	22939.91	26380.89
Coolant	1920.00	2304.00	2764.80	3317.76	3981.31	4777.57	5733.08	6879.69	8255.62	9906.75	11888.09
Other	1900.00	2090.00	2299.00	2528.90	2781.78	3059.96	3365.95	3702.55	4072.80	4480.07	4928.08
Ttl. Cost	10130.00	12463.99	15597.78	17674.23	20078.30	22863.52	26092.41	29838.12	34186.18	39236.73	45107.05
Yrly Pv Contrib		10562.71	11202.10	10757.11	10356.20	9993.89	8665.50	9366.98	9094.89	8846.22	8618.43
Pres. Val		10562.71	21764.80	32521.91	42878.11	52872.00	62537.50	71904.44	80999.31	89845.50	98463.87

***** Present Value = 98463.87 *****