Environment Canada
Environmental Protection Service

Environnement Canada
Service de la protection de l'environnement

# Evaluation of the "Lectro Clear Z" Electrocoagulation Process for Meat Packing Wastewater Treatment

Technology Development
Report EPS 4-WP-82-1

Water Pollution Control Directorate
January 1982

## ENVIRONMENTAL PROTECTION SERVICE REPORT SERIES

Technology Development Reports describe technical apparatus and procedures, and results of laboratory, pilot plant, demonstration or equipment evaluation studies. They provide a central source of information on the development and demonstration activities of the Environmental Protection Service.

Other categories in the EPS series include such groups as Regulations, Codes, and Protocols; Policy and Planning; Economic and Technical Review; Surveillance; Training Manuals; Briefs and Submission to Public Inquiries; and, Environmental Impact and Assessment.

Inquiries pertaining to Environmental Protection Service Reports should be directed to the Environmental Protection Service, Department of the Environment, Hull, Quebec, Canada, K1A 1C8.

## SÉRIE DE RAPPORTS DU SERVICE DE LA PROTECTION DE L'ENVIRONNEMENT

Les rapports sur le développement technologique décrivent l'outillage et les procédés techniques, ainsi que les résultats des études portant sur les laboratoires, les installations d'essai, les démonstrations, ou l'évaluation des équipements. Ces rapports constituent une source centrale de renseignements sur les activités et la mise en valeur du Service de la protection de l'environnement.

Les autres catégories de la série de rapports du S.P.E. comprennent les groupes suivants: règlements, codes et accords; politique et planification; analyse économique et technique; surveillance; guides de formation; rapports et exposés à l'enquête publique; et impacts environnementaux.

Les demandes relatives aux rapports du Service de la protection de l'environnement doivent être adressées au Service de la protection de l'environnement, ministère de l'Environnement, Hull (Québec), Canada K1A 1C8.

# EVALUATION OF THE "LECTRO CLEAR Z" ELECTROCOAGULATION PROCESS FOR MEAT PACKING WASTEWATER TREATMENT

by

Western Industrial Laboratories Limited
Edmonton, Alberta

for the

Water Pollution Control Directorate
Environmental Protection Service
Environment Canada

Report No. EPS 4-WP-82-1
January 1982

## REVIEW NOTICE

Cat No EN 43-4/82-1E
ISBN 0-662-11832-4
BEAUREGARD PRESS LIMITED

## ABSTRACT

Serious sewage treatment problems have been encountered by the City of Lethbridge, Alberta, because of the large number of food processing plants located there. The city's sewage service by-law provides heavy penalties for plants discharging effluents surpassing the limits set for BOD, suspended solids, and grease. Plants that install wastewater treatment facilities can, however, obtain rebates on previously paid penalties. With this incentive, the Swift Canadian Company Limited meat packing plant selected a Lectro Clear Z (LCZ) unit to improve the quality of wastewater being discharged to the city's system. Because this unit would require practically no chemical flocculant addition, it was anticipated that some added revenue could be gained by recovery of by-products from the wastewater.

The Lectro Clear Z unit was installed in the early summer of 1979. However, due to a variety of problems, primarily associated with the electrical system, a consistent level of operation was not attained until February 1980. Detailed information concerning an eight-week evaluation conducted in March and April 1980 is provided in this report.

As a result of the test run it was determined that the LCZ unit could achieve BOD and suspended solids reductions of about 55 to 65 percent on the total "existing" catch basin effluent. In addition to achieving an acceptable level of treatment, it was confirmed that by-product recovery from the LCZ skimmings was possible.

With the assistance of the Toronto engineering staff and the Lethbridge plant staff of Swift Canadian Company, an economic evaluation of the system was made.

## RÉSUMÉ

Lethbridge, en Alberta, a dû faire face à de graves problèmes d'épuration des eaux usées à cause des nombreuses usines de produits alimentaires qui y sont situées. Son règlement prévoit des peines sévères à l'endroit des usines qui rejettent des effluents dont la DBO et la teneur en matières en suspension et en graisses dépassent les limites établies. Toutefois, les usines qui s'équipent d'installations d'épuration peuvent se faire rembourser une partie des amendes acquittées antérieurement; c'est ce qui a amené la conserverie de viande de la Swift Canadian Company Limited de se doter d'une unité "Lectro Clear Z" (LCZ). Comme cette unité n'aura presque pas besoin d'ajouts de floculant chimique, on prévoit réaliser un certain revenu supplémentaire de la récupération de sous-produits des eaux usées.

L'unité a été installé au début de l'été 1979, mais à cause de divers problèmes, associés principalement au système électrique, elle n'a pas pu atteindre un régime de fonctionnement constant avant février 1980. Le présent rapport contient de plus amples renseignements sur l'évaluation de huit semaines menée en mars et avril 1980.

Suite à la mise à l'essai, on a déterminé que l'unité LCZ pourrait réduire de 55 à 65% la DBO et la teneur en MES de l'effluent "actuel" du bassin collecteur. L'unïté ne procure pas seulement un traitement acceptable, mais elle permet de récupérer certains sous-produits des matières flottantes.

L'évaluation économique a été effectuée avec l'aide des ingénieurs de Toronto et du personnel de Lethbridge de la compagnie.

## TABLE OF CONTENTS

## TABLE OF CONTENTS (CONT'D)

## LIST OF FIGURES

## LIST OF TABLES

## SUMMARY

### Conclusions

1. The Lectro Clear Z unit proved capable of reducing BOD and suspended solids concentrations in meat packing plant wastewater by 50 to 70 percent.
2. The LCZ unit had relatively little effect on the soluble BOD/COD content of the wastewater.
3. The success of the LCZ unit depends on good housekeeping practices in the plant and regular inspection and maintenance of LCZ operation.
4. Float material from the LCZ unit contained more moisture (90-92 percent) than anticipated, but was economically suitable for rendering into saleable by-products. The high moisture content of the float solids was attributable, in part, to the skimmer operation and various electrical malfunctions, most notably electrode problems.
5. Although the LCZ unit proved capable of producing an effluent within the City of Lethbridge's sewer service by-law standards, frequent malfunctions in its electrical system seriously affected its reliability.
6. The problems encountered with the LCZ's electrical system were partially attributed to variations in the conductivity of the wastewater caused by differences in the blood content, and changes in the mineral content of the city water supply. The remaining source of difficulty appeared to be related to an electrode contact malfunction, as well as the inability of the rectifier to effectively handle significant variations in voltage.

### Recommendations

1. Particular attention should be paid to the specifications, installation and operating parameters relating to the electrical components of LCZ units in future applications.
2. Because the LCZ relies heavily on pH control for efficient operation it is recommended that a maintenance procedure be established for regular inspection and cleaning of electrodes to minimize malfunctions due to fouling of the probes.
3. The effect on the LCZ process of variations in the conductivity of the wastewater treated should be investigated, and provisions made to monitor conductivity and maintain it within acceptable limits, if necessary.

4. It is recommended that the effects of wastewater temperature on the LCZ process be investigated.
5. Because the moisture content of recovered skimmings has considerable influence on the economics of the rendering process, the time interval for skimming the LCZ float material should be investigated to determine the operating program that will yield the optimum moisture content.
6. Hydrogen sulphide should be monitored in all LCZ installations and particular attention paid to ventilation.
7. It is recommended that LCZ units be provided at the time of manufacture with access for sampling influent, effluent and float material.
8. Although not highlighted during the study, a form of sedimentation/equalization preceding the LCZ is essential to remove discrete readily-settleable solids and to smooth out daily flow variations.

## ACKNOWLEDGEMENTS

This demonstration project was jointly funded by Swift Canadian Company Limited and Environment Canada's DPAT (Demonstration of Pollution Abatement Technology) program.

Mr. Lyle Norrie, Mr. Lorne Smith and Mr. Ron Gardner of Swift Canadian cooperated in carrying out the project throughout the submission, installation, and study phases.

Mr. Wayne Bissett, Mr. Jim Haskill and Ms. Vicky Jones of Environment Canada contributed to the report and assisted in its preparation.

# 1 INTRODUCTION

The City of Lethbridge is located in southern Alberta, about 95 km north of the U.S. border at an elevation of 885 m on the plateau to the east of the Oldman River. The city depends upon this river, which has a limited flow, for both water supply and waste disposal.

The combination of relatively flat areas of good soil, a fairly long growing season, with hot, sunny weather through the middle of the summer, and the availability of adequate water supplies from irrigation systems has created a very large agricultural area characterized by the production of many kinds of vegetables. A high acreage of sugar beets has laid the foundation for a large sugar refining industry, while market garden vegetables support considerable vegetable processing and canning. Large areas outside the irrigated districts produce cereal grains such as wheat, oats, barley and rye, and support a large acreage of oil seeds. Finally, the ranch lands in the area are large producers of beef cattle which, in turn, are fed on the extensive crop of feed grains, and on the by-proudcts of the food processing plants.

Lethbridge is a centre for a wide variety of food processing industries. These include vegetable processing and canning plants, an oil seed and margarine plant, a flour and feed milling plant, a poultry processing plant, meat packing and processing plants, a distillery and a brewery. Some of these plants operate on a large scale, and together they account for about a third of the total flow of wastewater from the city. This has created some serious sewage treatment problems for this relatively small city with a population of approximately 52 000.

Effluents from food processing plants are usually characterized by high biochemical oxygen demand (BOD), suspended solids, and sometimes grease loadings. In addition, these plants tend to have somewhat irregular effluents, both in quality and quantity, varying greatly from season to season, day to day and often hour to hour. These heavily loaded and erratic flows have created serious operating problems for the Lethbridge sewage treatment plant. The problem is further compounded by the strict limits placed by the Alberta Department of Environment on treatment plant discharges to the Oldman River, which has low flows during the latter part of the summer, and is ice-covered during the winter.

Since 1970, modifications have been made to Lethbridge's treatment plants, including construction of activated sludge units at the North plant to afford secondary treatment at that point. Initial problems with fats and grease were largely overcome by initiation of pretreatment at the industrial plants. However, various other factors, including the nature of the waste and the extremely variable flow, combined to produce relatively poor quality effluent for a secondary treatment system, and the solids loading has frequently exceeded Government of Alberta limits.

Two approaches were taken in attempting to rectify the problem. The earliest was the setting of an industrial sewage by-law. Under this law, plants are charged on the basis of the volume of sewage discharged to the city system. In addition, limits were set on the BOD, suspended solids and grease loadings in waste from the various industries. Surcharges are levied on the industries according to the extent that each plant fails to meet these limits.

The first limits were set in 1975 and have since been lowered twice, in 1977 and 1979, as follows:

| | 1 Oct. 75 | 1 Oct. 77 | 1 Oct. 79 |
|---|---|---|---|
| Suspended Solids (mg/L) | 800 | 600 | 300 |
| BOD (mg/L) | 800 | 600 | 300 |
| Grease (mg/L) | 300 | 200 | 100 |

The basis upon which individual plants are assessed is reached by a somewhat complex set of formulae. A discussion of this by-law and examples of its application appear in Appendix I.

The second approach to the sewage treatment program was initiated recently. A cooperative industrial waste pretreatment plant is to be built by the City of Lethbridge near the site of the present main treatment plant. Waste from seven industrial plants participating in the cooperative program will be brought to the 9 100 $m^3$/d pretreatment plant through a series of special collector sewers. The combined industrial wastewater will be pretreated to the by-law loading limits before discharge to the municipal treatment plant.

Two of the larger industrial plants in Lethbridge, Swift Canadian and Palliser Distilleries, elected not to join the cooperative plan. Swift Canadian meat packers decided to install its own treatment system. The city offers rebates on previously paid surcharges to plants that choose this alternative. The system chosen, a Lectro Clear

Z (LCZ) unit, also offered the company the potential for recovery of saleable by-products from its wastewater, and appeared capable of producing an effluent that would meet the stringent new sewage by-law limits.

# 2 LECTRO CLEAR Z PROCESS DESCRIPTION

## 2.1 General

Aside from complete biological treatment, there is a wide selection of alternative wastewater treatment systems. They all depend basically upon some method of promoting flocculation of the fine suspended solids in the wastewater, so that these may be removed from the system. Some floc tends to be heavier than water, and normally such floc is encouraged to settle to the bottom of the reaction vessel, from which it is removed as bottom sludge. Some floc, naturally lighter than water, tends to float and the resultant floating mat of floc is scraped off into troughs by skimmers. Under "natural" conditions this tends to separate organic material, such as fats, oils and similar material from inorganic substances such as silt, sand and fine gravel. The separation is, however, usually far from perfect, and there has been a tendency towards attempting to float as much of the flocculated material as possible. In the case of such industries as meat packing, this usually results in better recovery of fats and grease which can potentially be recovered for rendering.

Flocculation-flotation-settling processes divide logically into two operations:

a) floc formation, and
b) promoting settling or flotation of the floc.

Floc formation tends to occur naturally in many wastewaters. Numerous schemes have been attempted to promote settlement or flotation of floc. Where settling is desired, some kind of weighting material is sometimes added to promote formation of a heavier floc. Clays, such as bentonite, are an example. Flotation depends upon maintaining a light floc, and assisting flotation with an ascending stream of gas bubbles. The earliest attempt and probably still the most common method, is dissolved air flotation (DAF). In this method, air is dissolved in all or part of the wastewater by pressurizing the water. When the pressure is released, the air comes out of solution and bubbles are formed which rise to the surface carrying the floc with them. DAF usually requires some chemical addition to achieve efficient removals.

Basic DAF floc formation is often slow and usually far from perfect, so many modifications have been introduced to improve the process. These range from pH adjustment, to chemical addition and electrolysis, and various combinations of these.

Chemical addition is one of the oldest and perhaps still the most effective method. It has the disadvantage of being relatively costly because of the continual use of chemical, and is likely to become more so as the cost of chemicals increases. Further disadvantages are the contamination of potential by-products, especially the float material, with undesirable quantities of chemical, and the production of significant quantities of material for disposal. Electrolysis and pH adjustment are newer methods, some aspects of which are still in an experimental stage. The Lectro Clear Z process uses these methods in combination.

## 2.2 Lectro Clear Z System

The basic principle of the Lectro Clear Z process is formation of a floc through adjustment of the pH of the wastewater and the addition of a very small amount of chemical, accompanied by some breakdown of water in the system by electrolysis to form hydrogen and oxygen. The pH of the wastewater is adjusted to the zero Zeta potential, at which point the average surface charge on particulates is approximately zero. In the case of packing house wastewater, this is reached in the pH range 4.0-4.5. Once the surface charges have been neutralized, there is a tendency for the minute particles in suspension to agglomerate to form a floc.

Hydrogen and oxygen, formed at electrodes, stream to the surface of the liquid as bubbles which attach themselves to the floc fragments, carrying them upwards and picking up further fragments of floc in the process. Eventually these particles form a mat on the surface supported by the gas bubbles. This mat is skimmed off by a conventional skimming system into a trough which runs to a holding tank.

Lectro Clear Z process units are custom-tailored for the installations they are to serve, since the effluents treated, chemicals available and electrical power requirements can vary widely. The design parameters required are established by on-site testing.

The operating manual for the unit installed at the Swift Canadian plant in Lethbridge gives the following description*:

> "The raw waste is pumped from the existing basin to the electro-coagulation cell, the waste stream is exposed to the electrolytic gas bubbles which combine with the embryo floc. Polymer is added in the pipe run before the cell and the clarifier. As the

---

*"Operating Manual for Lectro Clear Z Wastewater Treatment System - Swift Canadian Company Limited, Lethbridge, Alberta", issued by Sutherland-Schultz Limited, 859 Courtland Avenue East, Kitchener, Ontario, July 17, 1979.

polymer mixes with the solution, it produces a larger, more buoyant floc. The current density and therefore bubble generation is highest in the area upstream of the basin baffle where much of the total floc will rise. The waste stream passes through the clarifier and then is piped to the city sewer.

Drain lines from the electrocoagulation cell and from the clarifier sections are intended to provide a means to clean settled sludge from the bottom of these vessels as needed. The sulphuric acid, caustic and polymer solutions are fed into the waste stream by means of individual metering pumps which have adjustable pumping rates so that the amount of chemical added can be varied to suit contaminant levels and waste stream flow rates. Additional flexibility can be achieved by varying the concentration of the chemical solution or slurry. The polymer pump is associated with two chemical tanks - a 1000 gallon [4546 L] main tank and a 250 gallon [1140 L] side tank. The chemicals are mixed in the large tank and after being mixed, are gravity fed into the smaller tank through the interconnecting piping and valves. The pump empties the 1000 gallon tank first and while the next batches of solutions are being prepared in the large tank, the side tank is used to continue the process treatment.

The 1000 gallon tank is equipped with a mixer. Once in solution, the polymer does not require further mixing.

The electrical phase of Lectro Clear Z involves the use of low voltage, relatively high current DC power and special alloy electrodes to produce microbubbles of hydrogen and oxygen gas. Electrodes are located in both the electrocoagulation cell and the clarifier and DC power is supplied to them by two rectifiers - one for each vessel. Because deposits on the cathodic (negative) electrode act as an electrical insulator, a reversing switch is used to alternate the polarity of each electrode. These cathodic deposits are dissipated while the electrode is used as an anode. Since some base metal is consumed when electrodes are used as anodes, polarity reversal also equalizes the useful life of all of the electrodes. These operations require polarity reversals once each day."

The Lectro Clear Z unit installed at Lethbridge was designed to process a maximum of 600,000 Igal/day (2 730 $m^3$/d). The normal operating range is 300 000 - 400 000 Igal/day (1 400 - 1 800 $m^3$/d).

Unlike many flocculation-flotation processes, the LCZ system does not require the addition of significant quantities of chemicals to promote floc formation. Sulphuric acid and sodium hydroxide are used for pH control, and a small amount of anionic polymer (approximately 3 mg/L) is added. The float material is therefore essentially free of the chemicals, usually metal salts, that would be present in flocs from many similar systems. This factor was important in the selection of the LCZ process for the Swift Canadian plant, because it was desirable that the float material be suitable for rendering into inedible tallow and animal protein feed (cracklings) for sale. As this material had previously been wasted, this represented an additional source of revenue for the company.

# 3 INSTALLATION AT SWIFT CANADIAN COMPANY LIMITED PLANT

## 3.1 Plant Description

The Swift Canadian plant in Lethbridge was started up in March 1971, and was designed exclusively for beef processing. The rated capacity of the plant is 600 head per day (eight-hour shift), though a maximum of 650-670 head has been reached. Only minor changes have been made in the main section of the plant since it was first opened; two cookers and a blow tank having been added to the rendering section. At present, six cookers are in operation in the inedible rendering section, and one in the edible section.

Processing is basically limited to fresh beef, though in 1979-1980 packaging facilities were added to market primal cuts of top grade meats.

Plant water use figures from the City of Lethbridge meter are shown as part of Appendix II. Water use during the evaluation period (March-April 1980) varied between 2.27 and 3.40 $m^3$ per head processed, based on the water used during the operating day (0800 h to midnight), which accounts for about 79 percent of the total water consumed by the plant.

## 3.2 Original Treatment System

Prior to installation of the Lectro Clear Z unit, wastewater treatment provisions consisted of a large catch basin and a bar screen. Wastewater was discharged directly from the basin to the city sewer. The basin interrupted the wastewater flow, allowing floating solids, including fat, to rise to the surface where a skimmer removed them for transfer to rendering. The remaining solids settled as sludge, which a scraper moved to a collection pit. This was periodically pumped out to trucks and hauled away to a dump site. The amount of sludge hauled varied somewhat, but averaged two loads per day, approximately 23 $m^3$. The majority of the fine solids that did not either rise or sink passed out in the plant effluent, frequently producing very heavy BOD and suspended solids loadings.

Between the first quarter of 1977 and the third quarter of 1979 the average plant effluent concentration was 674 mg/L BOD and 429 mg/L suspended solids. These concentrations were marginally above and below the 600 mg/L limits set by the city in 1977 and 1978, but far above the 300 mg/L limit now in force. The LCZ unit went into partial operation in mid1979, and full operation in March 1980. Since that time the effluent, as analyzed by the city, appears much improved (Appendix II).

Between March and April 1980, the catch basin effluent varied from a high of 1 520 mg/L to a low of 550 mg/L for BOD and a high of 1 274 mg/L to a low of 408 mg/L for suspended solids. This would have represented figures for plant effluent to the city sewage system had the LCZ unit not been in place. A noticeable feature of the original catch basin effluent was the tremendous daily variation in BOD and suspended solids values, probably representing daily changes in plant processes and housekeeping operations.

During the trial run in March-April 1980, samples of the existing catch basin float solids were taken three times a week at the time of pumping out to rendering, and analyzed for moisture (Appendix III). There were wide variations in the moisture content, but examination of the figures suggests an average content of about 50 percent. While determination of the fat content was not requested, the appearance of the samples after heating to drive off moisture suggested a heavy fat content.

As in the case of the liquid effluent from the existing catch basin, it may be assumed that essentially no change has taken place in the float solids since installation of the Lectro Clear Z unit.

During the March - April trial run, samples of bottom sludge from the existing catch basin were taken on a daily basis and analyzed for moisture. Results of these analyses are also shown in Appendix III. As will be noted from the table, on the average, the moisture content of this sludge was remarkably uniform, averaging slightly over 90 percent by weight. It can be assumed that prior to installation of the Lectro Clear Z unit, this sludge was not greatly different in quantity or consistency.

### 3.3 Anticipated Benefits from LCZ Installation

Two principal benefits were anticipated from the installation of the Lectro Clear Z unit:

i) a reduction of the sewer service charges; and
ii) additional by-product recovery.

Both were financially important to Swift Canadian Company Limited, and the City would obtain some relief from the operational problems at its treatment plant. BOD and suspended solids concentrations in the plant's wastewater were expected to be reduced to the City of Lethbridge by-law discharge levels. By installing a treatment unit to upgrade treatment facilities to meet the by-law requirements, the company would become eligible for a rebate of a portion of surcharges previously paid (banked for three years). A further benefit accrues if the reduction in waste strength equals 65 percent of the plant's long-term average loadings.

The second principal benefit anticipated from the installation of the Lectro Clear Z system was the potential for additional by-product recovery. Unlike many flocculation-flotation processes, the LCZ system can achieve a satisfactory effluent without the use of metal salts as flocculent aids. Aside from sulphuric acid and sodium hydroxide for pH control only a small amount of anionic polymer is added (approximately 3 mg/L). Thus, the float material is essentially free from chemicals and can be rendered into inedible tallow and cracklings, providing an additional source of revenue and eliminating a solid waste disposal problem.

### 3.4 Installation and Start-up of LCZ

Since the Lectro Clear Z was installed beyond the existing catch basin, very few changes in the original waste treatment system were required. The catch basin effluent became the LCZ unit influent, with the catch basin acting as an equalization tank and providing removal of coarse solids. A line was installed from the float collection trough on the electro-coagulation section of the Lectro Clear Z unit to a holding tank. The float skimmings accumulate in the holding tank and are pumped periodically to the plant's rendering section, where they are cooked with the float from the original catch basin to produce inedible tallow and cracklings. Figure 1 shows the principal components of the treatment system. The main LCZ unit, and all the required accessory equipment, chemical and electrical, is housed in a single building connected to the back of the plant.

Operating parameters for the LCZ unit (i.e., pH, chemical dosages and electrical current densities) were set on the basis of the original pilot tests performed on-site and were not substantially changed during the trial conducted in March and April 1980.

The Lectro Clear unit was started up in July 1979. Almost immediately there were problems with the electrical system. Trouble developed in the no. 1 rectifier, which supplies current to the electrodes in the clarifier-settling section of the unit. A three-phase VPC (Voltage Phase Control) board was replaced by a representative of Sutherland-Schultz Limited and Dorren Electric in Lethbridge, and the unit placed back in operation. In August, representatives of Clinton Supply Company were called in to check the no. 2 rectifier, which supplies current to electrodes in the electrocoagulation section.

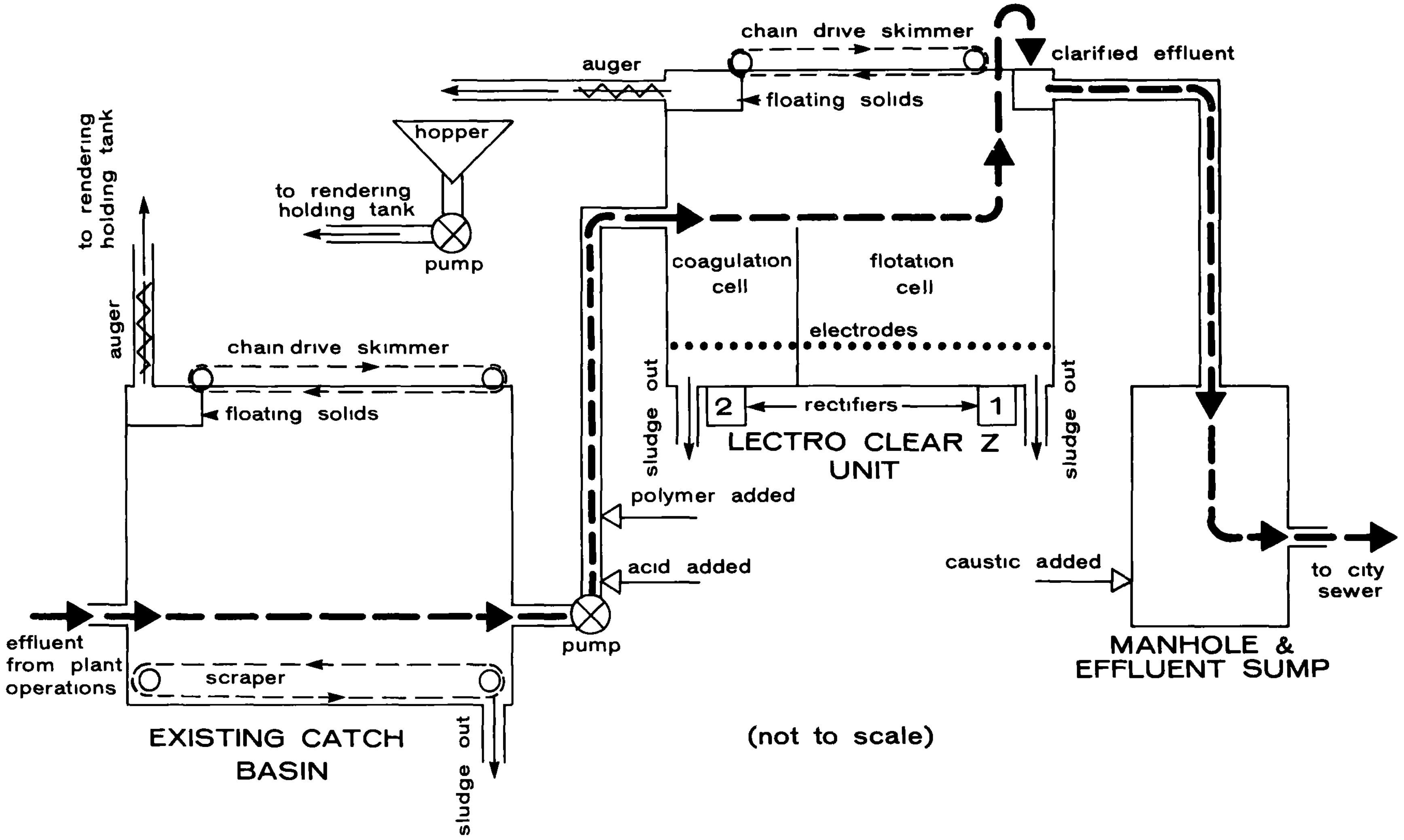

FIGURE 1 SCHEMATIC OF LECTRO CLEAR Z INSTALLATION AT SWIFT CANADIAN COMPANY LIMITED, LETHBRIDGE, ALBERTA

It was discovered that a secondary winding had blown, due possibly to vapour in the cooling tube, which caused the tube to heat up and disintegrate. A three-phase VPC board in this portion of the unit had to be replaced twice.

In September an SCR (selenium rectifier) in the primary circuits of the flotation cell (no. 1) rectifier blew and had to be replaced. This put the no. 1 rectifier back in service, though on a somewhat irregular basis. Early in November there was further trouble with the no. 1 rectifier as the SCR had again blown. Representatives of Sutherland-Schultz and Clinton Supply Company, together with the Lethbridge plant electricians, checked the no. 1 rectifier systems. The unit was finally put back into service. However, almost immediately, one of the transformers blew to ground and the no. 1 rectifier was again shut down. Finally, about the end of November, the no. 1 rectifier was disconnected, crated and shipped to Chicago for repairs. It was returned to Lethbridge in January and re-installed during the early part of the month.

At the time the rectifier was reinstalled, a complete check was carried out on the voltage regulation in the whole plant since it was suspected that insufficient regulation of the system voltage may have contributed to the recurring breakdowns. It was discovered that the plant voltage was ranging between 420 and 520. This range exceeded the specified input voltage limit for the LCZ unit of 460 ± 10 percent.

Steps were taken to ensure that the plant voltage was maintained within a range acceptable for the LCZ. As no further breakdowns of the no. 1 rectifier have occurred since the re-installation in January 1980, the efforts to regulate the plant voltage were apparently successful in improving the LCZ unit's reliability. A check of plant voltage in July 1980 showed a range of 488 to 490 volts.

# 4 EVALUATION PROGRAM

## 4.1 Wastewater Sampling and Analysis

The Lectro Clear Z unit was installed early in 1979. However, the evaluation program was delayed several times due to the electrical problems. Final arrangements for the program were not completed until a meeting held at the plant in Lethbridge on February 25, 1980, and sampling commenced on that date. As a result of discussions at the meeting, it was decided to regard the week of February 25-29 as a trial period, so that the actual evaluation program began on March 3 and extended to April 25, covering eight weeks of operation.

The sampling program of the evaluation called for composite samples of influent and effluent to be taken during the normal plant operating period from 0800 h to 1600 h, and the cleanup period from 1700 h to midnight. It soon became evident that the 0800 h - 1600 h period usually produced significantly higher loadings in the LCZ influent than did the 1700 h - midnight shift. The LCZ unit appeared capable of achieving a BOD reduction in the range of 50 to 70 percent, with a corresponding reduction in suspended solids. As might be expected, somewhat higher percentage reductions were usually obtained when influent BOD and suspended solids were higher. In spite of the improved performance of the LCZ on the more heavily loaded influent, the effluent quality during the operating period was poorer than that during the clean-up shift. In addition, the improved performance during the operating shift was not good enough to provide an effluent BOD in the range of 225-250 mg/L (required for 65 percent improvement in removal and payment of rebate) when the influent BOD exceeded approximately 600 mg/L.

It became evident that attainment of a satisfactory effluent from the LCZ unit would be dependent upon providing a reasonably good quality of influent. Much time and effort was expended during the evaluation run in attempting to improve what might be broadly described as housekeeping practices that could affect the quality of the influent wastewater reaching the LCZ. Careful attention to plant processing and clean-up operations was encouraged and, in particular, very strict attempts were made to limit the amount of blood entering the waste streams. Results achieved indicate that these efforts were largely successful.

An important decision taken at the outset was to run chemical oxygen demand determinations on all wastewater samples as well as the biochemical oxygen demand analyses. This was based principally upon the very much improved control of the operation that would result from using COD concentrations. The standard five-day duration of the BOD determination causes a minimum lapse of six days between taking the samples and obtaining the results. In view of the nature of the project and the likelihood of having to make revisions during the course of the run, it was felt this interval of almost a week between sampling and reporting of results was unacceptable. With COD analyses, it was possible to take samples one day, refrigerate them overnight, fly them to the laboratory in Edmonton the following morning for analysis and, if necessary, results could be telephoned to the Lethbridge plant the same afternoon.

In general, a fairly consistent ratio of BOD to COD was observed throughout the test run, BOD/COD usually being in the range of 0.45 to 0.60. Using an average of 0.55, BOD concentrations could be anticipated with reasonable accuracy within 24-36 hours of taking the samples.

A further important reason for the decision to run COD determinations as well as BOD was the generally much more reliable nature of the COD determination. In spite of careful adherence to Standard Methods*, BOD results have occasionally tended to be quite unpredictable. Particularly in conducting experimental work, this necessitates freezing a portion of each sample so that it may subsequently be re-run if the first set of analyses proves inconclusive.

Because of the difficulty of measuring flows at any given time, and because flow to the LCZ unit was maintained constant, it was decided to take hourly samples of equal size throughout the sampling period. Influent samples were taken from a line cut into the influent line just before the unit. At the beginning of the program, samples of the effluent were taken from the overflow weir at the outlet of the settling section of the LCZ unit. Since this would have required that someone climb a 4.5-m vertical iron ladder to take the sample, a sampling line was cut into the trough just below the weir so that samples could be taken from the floor below the unit.

---

* American Public Health Association, American Society of Civil Engineers, American Water Works Association, Water Pollution Control Federation, Standard Methods for the Examination of Water and Wastewater, 14th edition, 1975.

Each hour a sample of approximately one-half litre was taken at the influent. This was poured into a four-gallon (18-L) covered plastic container. A similar sample of the effluent was also taken and poured into another plastic container. These containers were kept just outside of the door of the building housing the LCZ unit. Since the weather was cool, it was considered that this would provide adequate refrigeration. At the end of each shift, the sample in each four-gallon container was thoroughly mixed and then poured into one-quart (1-L) plastic bottles. These were frozen in the plant freezer and held overnight for air shipment to Edmonton. The samples were delivered in Edmonton shortly after noon on the day following sampling and the COD determination usually made the same afternoon.

Because of the relatively short period between sampling and analysis, as well as the requirement that BOD determinations be made on all samples, no chemical additions or preservatives were used. Refrigeration and, in some cases, freezing of the samples was considered adequate under the circumstances. This treatment of the samples was greatly assisted by weather conditions, outdoor temperatures fluctuating between about -5°C and +5°C during most of the eight-week period.

The analytical procedures used are described in Appendix III.

## 4.2 Analytical Results

All data obtained from the sampling/analytical program is provided in Appendix III. As described, samples were composited by shift, rather than for the operating day (0800 h - midnight) or the 24-hour day. No night samples were taken. Water passing through the plant between midnight and 0800 h consists principally of cooling water used in the plant refrigeration system, and LCZ rectifiers are usually shut down approximately two hours after the end of the clean-up shift.

The performance of the LCZ unit in terms of BOD, suspended solids, and fat, oil and grease (FOG) removals is summarized in Table 1. The analytical results are presented graphically in Figures 2, 3 and 4.

The averaged results from the evaluation program's operating and cleanup shift samples of the LCZ unit effluent are compared with results obtained by the City of Lethbridge on samples composited over 24 hours in Table 2. Although the evaluation program samples and the city's samples were taken at different locations, over slightly different time periods, and by different methods, and were analysed by different laboratories, the analytical results show remarkably good agreement. The city's 24-hour

TABLE 1 SUMMARY OF LECTRO CLEAR Z PERFORMANCE TREATING MEAT PACKING PLANT WASTEWATER

| | BOD | | | Total Suspended Solids | | | FOG | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Influent (mg/L) | Effluent (mg/L) | % Rem. | Influent (mg/L) | Effluent (mg/L) | % Rem. | Influent (mg/L) | Effluent (mg/L) | % Rem. |
| Mar. 3 | 1365 | 533 | 61 | 1086 | 492 | 55 | 193 | 66 | 66 |
| 4 | 679 | 295 | 57 | 580 | 154 | 73 | 129 | 35 | 73 |
| 5 | 803 | 423 | 47 | 653 | 209 | 68 | 95 | 38 | 60 |
| 6 | 611 | 258 | 58 | 447 | 137 | 69 | 41 | 8 | 80 |
| 10 | 1002 | 584 | 42 | 738 | 396 | 46 | 158 | 60 | 62 |
| 11 | 714 | 439 | 39 | 545 | 287 | 47 | 90 | 44 | 51 |
| 12 | 1220 | 492 | 60 | 912 | 300 | 67 | 209 | 58 | 72 |
| 13 | 751 | 506 | 33 | 667 | 380 | 43 | 69 | 23 | 67 |
| 14 | 485 | 280 | 42 | 616 | 335 | 46 | 60 | 29 | 52 |
| 17 | 454 | 241 | 47 | 413 | 168 | 59 | 37 | 13 | 65 |
| 18 | 431 | 172 | 60 | 428 | 57 | 87 | 41 | 4 | 90 |
| 19 | 877 | 291 | 67 | 661 | 160 | 76 | 154 | 24 | 84 |
| 20 | 579 | 207 | 64 | 708 | 184 | 74 | 101 | 16 | 84 |
| 21 | 596 | 242 | 59 | 461 | 249 | 46 | 82 | 20 | 76 |
| 24 | 495 | 229 | 54 | 473 | 127 | 73 | 54 | 9 | 83 |
| 25 | 564 | 228 | 60 | 453 | 142 | 69 | 82 | 16 | 80 |
| 26 | 540 | 218 | 60 | 449 | 126 | 72 | 27 | 4 | 85 |
| 27 | 377 | 228 | 60 | 362 | 169 | 53 | 28 | 11 | 61 |
| 28 | 576 | 230 | 60 | 513 | 121 | 76 | 34 | 9 | 74 |
| 31 | 607 | 319 | 47 | 414 | 112 | 73 | 74 | 13 | 82 |
| Apr. 1 | 471 | 201 | 57 | 417 | 91 | 78 | 16 | 4 | 75 |
| 2 | 529 | 269 | 49 | 375 | 105 | 72 | 32 | 24 | 24 |
| 3 | 450 | 167 | 63 | 461 | 188 | 59 | 40 | 9 | 78 |
| 7 | 923 | 362 | 61 | 706 | 241 | 66 | 167 | 61 | 63 |
| 8 | 451 | 196 | 57 | 284 | 89 | 69 | 45 | 7 | 84 |
| 9 | 430 | 162 | 62 | 346 | 114 | 67 | 27 | 4 | 85 |
| 10 | 574 | 191 | 67 | 478 | 77 | 84 | 93 | 5 | 95 |
| 11 | 745 | 252 | 66 | 648 | 121 | 81 | 248 | 44 | 82 |
| 14 | 950 | 467 | 51 | 667 | 307 | 54 | 129 | 50 | 61 |
| 15 | 521 | 256 | 51 | 361 | 187 | 48 | 46 | 24 | 48 |
| 16 | 542 | 239 | 56 | 330 | 72 | 78 | 31 | 5 | 84 |
| 17 | 648 | 256 | 60 | 468 | 106 | 77 | 53 | 8 | 85 |
| 18 | 795 | 245 | 69 | 550 | 126 | 77 | 125 | 23 | 82 |
| 21 | 764 | 250 | 67 | 541 | 95 | 82 | 104 | 14 | 87 |
| 22 | 546 | 163 | 70 | 397 | 37 | 91 | 48 | 3 | 94 |
| 23 | 596 | 240 | 60 | 485 | 121 | 75 | 57 | 13 | 77 |
| 24 | 481 | 153 | 68 | 313 | 42 | 87 | 35 | 5 | 86 |
| 25 | 452 | 225 | 50 | 441 | 153 | 65 | 23 | 9 | 61 |
| Average | 647 | 284 | 57 | 522 | 173 | 68 | 81 | 21 | 74 |

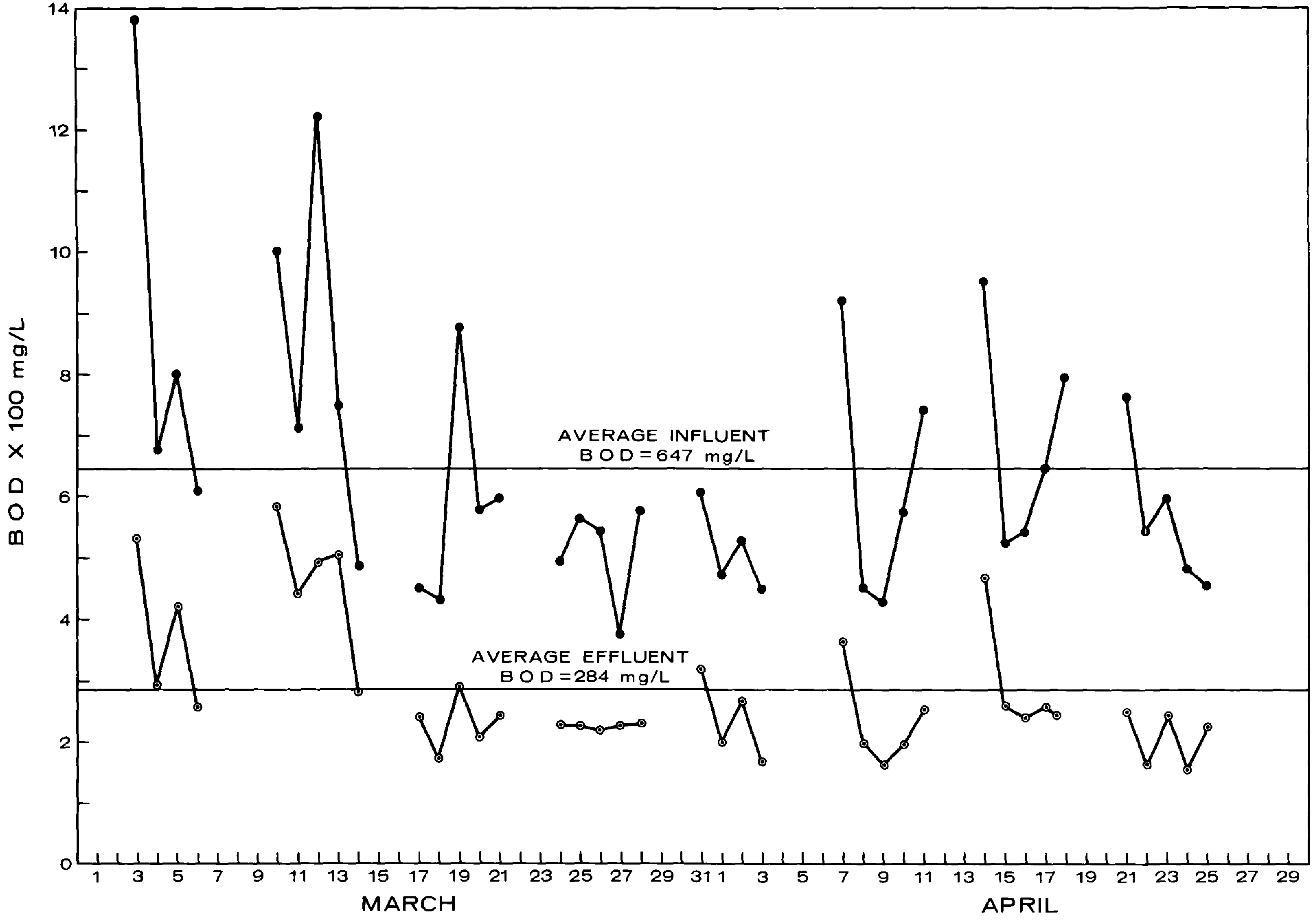

FIGURE 2 BOD CONCENTRATIONS IN LCZ INFLUENT AND EFFLUENT

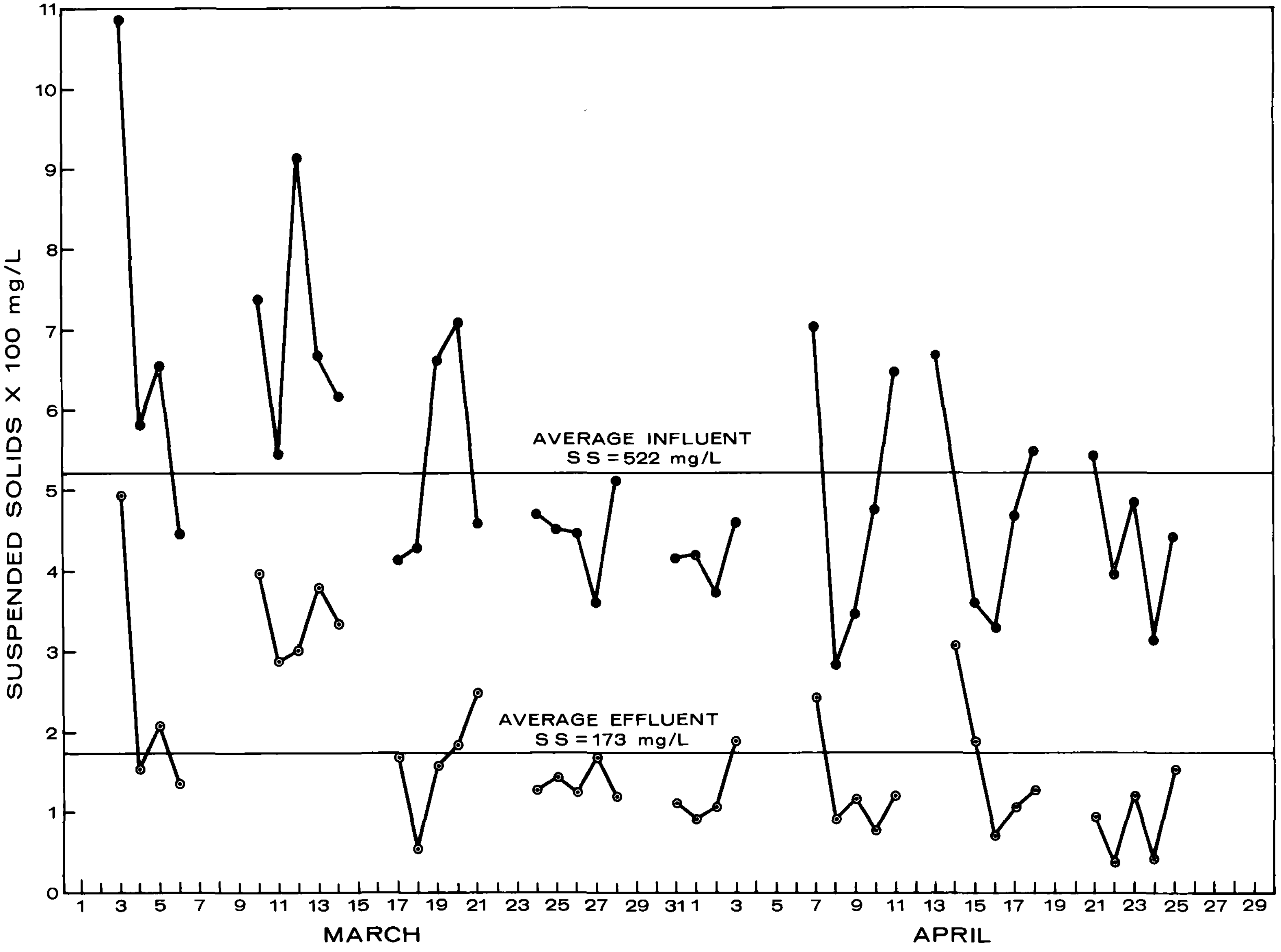

FIGURE 3 SUSPENDED SOLIDS CONCENTRATIONS IN LCZ INFLUENT AND EFFLUENT

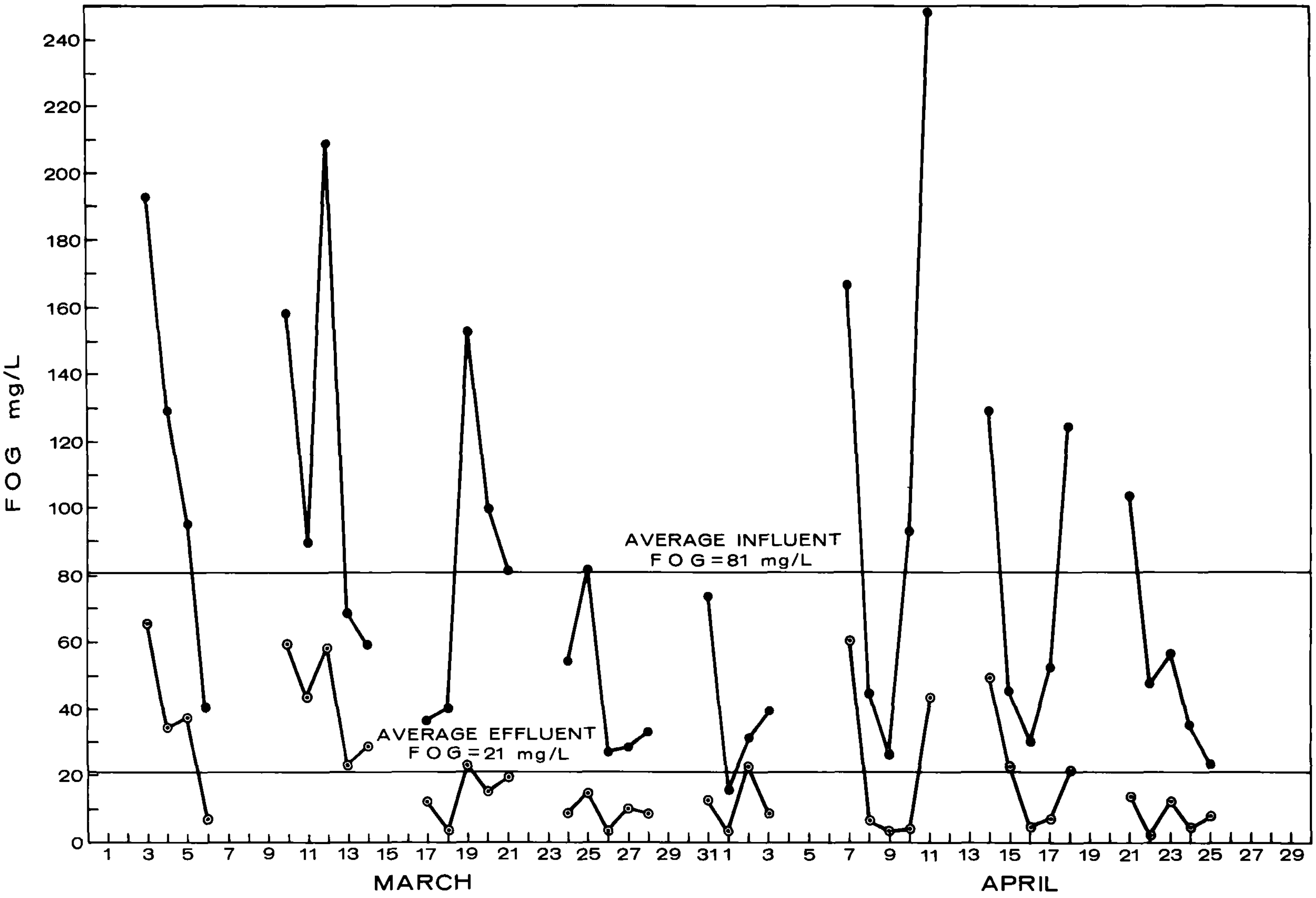

FIGURE 4 FAT, OIL AND GREASE CONCENTRATIONS IN LCZ INFLUENT AND EFFLUENT

TABLE 2 COMPARISON OF ANALYTICAL RESULTS FROM EVALUATION PROGRAM AND CITY OF LETHBRIDGE DATA

| | BOD (mg/L) | | Suspended Solids (mg/L) | |
|---|---|---|---|---|
| Date* | LCZ Program** | City*** | LCZ Program** | City*** |
| March 3 | 535 | 385 | 515 | 199 |
| 4 | 295 | 309 | 154 | 155 |
| 5 | 423 | 347 | 209 | 200 |
| 6 | 258 | 195 | 137 | 124 |
| 13 | 506 | 495 | 380 | 286 |
| 20 | 207 | 240 | 184 | 151 |
| 24 | 229 | 197 | 127 | 165 |
| 25 | 228 | 213 | 142 | 148 |
| 26 | 218 | 224 | 126 | 170 |
| 27 | 228 | 188 | 169 | 145 |
| April 2 | 269 | 240 | 105 | 120 |
| 10 | 191 | 200 | 77 | 95 |
| 17 | 256 | 213 | 106 | 120 |
| 24 | 153 | 174 | 42 | 98 |
| Average | 281 | 259 | 177 | 155 |

* Missing dates are those for which no city data were available.

** Concentrations are the weighted averages of composite samples for two shifts per day; night flows excluded.

*** Automatically composited daily samples, including night flows.

composites averaged about 10 percent lower than the averaged shift samples, which can be attributed to the inclusion of the plant cooling water discharged at night.

The results for soluble COD and BOD (Appendix III) indicate that the Lectro Clear Z was relatively unsuccessful in reducing this characteristic. The soluble COD/BOD is probably due largely to protein and other organic material that may be partially water soluble. One substance of this type is blood. Although it was originally suggested that the anionic polymer, with pH control and the electrolytic effect, may cause coagulation of dissolved and colloidal material, rendering it susceptible to flocculation, the results indicate that in practice, very little coagulation and flocculation of dissolved material actually takes place.

This emphasizes the importance of limiting the amount of blood entering the plant's waste streams through good housekeeping and maintenance practices.

### 4.3 Operation

Operation of the Lectro Clear Z is relatively simple. Once the operating parameters have been determined, i.e. flow, pH setting, polymer addition, skimming rate, and electrical current density, the plant as installed at Lethbridge is reasonably self-operating. However, this is not to say that supervision and maintenance can be done away with. Control of pH is, for example, quite critical, and while this is basically an automatic system, the equipment responsible for this function is subject to breakdowns including electrical malfunctions and electrode fouling. This occurred on April 2, when the pH of the wastewater passing through the system fell to between 3.75 to 4.00, and on April 3, when it ranged from 3.25 to 5.40. BOD reduction during a significant part of this period was not satisfactory. Trouble was located in the sensing unit, which in turn is supposed to control the acid feed. The same observations could be made concerning any of the other portions of the automatic regulating equipment.

Probably the most trouble-prone portion of the Lectro Clear Z was the electrical system. From the time the unit was first installed electrical problems plagued the operation. In fact, between July 1979 and January 1980, the unit was frequently either partially or wholly inoperative because of electrical problems. Worst of all, the unit would operate well for several days, then have to be shut down due to an electrical failure. This in turn meant that the only treatment received by the effluent was that provided by the existing catch basin. Under terms of the Lethbridge sewage by-law, two or three days ineffective waste treatment may easily nullify weeks of effective waste treatment. A very high premium must therefore be placed on the reliability of treatment equipment, and the Lectro Clear Z unit was unable to provide this during its early operation.

Following re-installation of the no. 1 rectifier in January 1980, the electrical system appeared to work reasonably well, although best results appeared to be obtained when the rectifiers were run at voltages higher than those suggested in the operating manual. Current density in the electrical system is one of the parameters referred to in the operating manual that has to be adjusted to local operating conditions.

The following settings were suggested by the manufacturer for the Lectro Clear Z unit:

| | No. 1 Rectifier Flotation Section | No. 2 Rectifier Electrocoagulation Section |
|---|---|---|
| Voltage | 12 d.c. | 8 d.c. |
| Amperes | 2500 | 3000 |

However, to obtain a good level of operation, it was found necessary to run at a higher voltage, as indicated below:

| | No. 1 Rectifier Flotation Section | No. 2 Rectifier Electrocoagulation Section |
|---|---|---|
| Voltage | 20-25 | 15-17 |
| Amperes | 2000 | 2000 - 2500 |

It is possible that, within certain limits, it may be found desirable to adjust these settings to meet requirements of individual systems.

After the evaluation period (March-April 1980), two problems were discovered that could have significantly affected operation of the LCZ system. The first problem was discovered in the electrode system. Fuse holders required by local legislation malfunctioned and it has been estimated that up to 60 percent of the electrodes may have been inoperative during the study. This may have contributed to the increased voltage requirements. The second problem involved the conductivity of the wastewater. Background information indicated that the pilot tests, upon which the initial operational parameters were based, may have been affected by the absence of blood-containing curbing installed later on the kill floor, and the level of mineral salts in the city water supply.

Blood containment was introduced at the beginning of the evaluation program. However, during the pilot testing and start-up period for the LCZ unit, inadequately controlled blood was entering the wastewater system instead of being directed to the plant's holding tanks. Blood is a good electrolyte and could have affected the conductivity of the wastewater during the pilot tests.

Lethbridge's water supply is subject to elevated mineral salt concentrations caused by altered sub-surface hydrology when local irrigation operations cease. As the pilot testing was carried out during this annual elevation of mineral salts in the city's water, a second possible influence on the conductivity of the packing plant's wastewater was introduced.

If both of these factors are superimposed, the conductivity of the Swift Canadian plant's wastewater would have been high during the pilot tests, and the voltage requirements set for the LCZ system would have been low.

During inital start-up of the full-scale LCZ, the operating parameters established from the pilot testing were used. At that time the only influence upon the conductivity of the wastewater would have been the blood. This would probably have maintained good conductivity in the system throughout the operating day, but dilution would significantly lower the conductivity during the clean-up shift. In restrospect, this could have caused some of the early electrical problems encountered with the rectifiers, aside from manufacturing defects. Upon re-installation of the no. 1 rectifier, voltage suppression was installed to minimize the range of the incoming voltage; this appeared to stabilize the operation.

When Swift Canadian checked the diurnal variation of the wastewater's conductivity it exhibited a broad range of values. Over the five days monitored, values as high as 10 000 μmhos and as low as 800 μmhos were observed, with corresponding voltage readings as follows:

| | Conductivity (μmhos) | |
|---|---|---|
| | High (10 000) | Low (800) |
| Voltage (Rectifier 1) | 9.5 | 29.5 |
| Voltage (Rectifier 2) | 6.5 | 25.5 |

It was determined that the low conductivity placed an excessive demand on the LCZ rectifier, requiring an input voltage outside the tolerances of the rectifiers.

### 4.4 Hydrogen Sulphide

During the entire trial run a distinct odour of hydrogen sulphide was noted in the area housing the Lectro Clear Z unit. This probably was caused by partial decomposition of protein material in the waste during electrolysis. Tests for hydrogen sulphide were made at a number of points. All confirmed presence of the gas, although none found levels that actually exceeded provincial safety limits except one test made in a sump into which the treated effluent runs before discharge to the city sewer. A forced-air ventilation system in the LCZ area is probably responsible for maintaining a fairly low $H_2S$ level in the atmosphere and, as long as ventilation is properly installed and maintained, no great hazard likely exists. It was also noted that the sludge accumulating in the clarifier-settling section of the unit, which has to be cleaned out from time to time, was nearly black in colour, and had a strong odour of hydrogen sulphide. This condition may have been aggravated by the electrical malfunctions previously noted, which left material to decompose anaerobically.

### 4.5 Skimmings Recovery

One of the benefits anticipated from use of the Lectro Clear Z process was the recovery of a substantial quantity of float material or skimmings from the coagulation section which would contain considerable fat and be free from chemical additives such as ferrous sulphate. This material would then be available for transfer to the rendering section, providing an additional source of revenue.

During the March - April trial run, samples were taken three times daily from the trough at the head end of the Lectro Clear Z unit where the float skimmings were being moved by auger to the tank from which they are pumped into the rendering system. These grab samples were combined into a daily composite of LCZ float material. These composites were analyzed for moisture content and some of them for fat content. Results of these analyses are shown in one of the tables in Appendix III. The float solids averaged about 92 percent moisture, while on a dry basis the solids analyzed to about 50 percent fat. Thus, the entire volume of float material as recovered during the run averaged about five percent fat. This was well below results originally anticipated and led to some investigation of the skimming procedure.

Apparently, during the test run, the skimmer was operated on a continuous basis, and no suggestion had been made that this procedure be changed. Later, skimming was changed to operate "15 minutes on - 15 minutes off". One set of grab samples indicated that this produced a float material with a moisture content of 91.08 percent, hardly any improvement over continuous skimming. Samples were again taken in June and analysed, with the following results:

| Sample Date | Skimming Interval | Moisture by Wt. |
|---|---|---|
| 4 June, 1980 | 15 min. on - 15. min. off | 88.73% |
| 16 June, 1980 | 6 min. on - 1 hour off | 87.66% |

## 4.6 Economic Considerations

The potential for the recovery of saleable by-products was a major factor in selecting the LCZ unit for use at the Swift Canadian plant. The costs of operating the LCZ unit and rendering the by-products are estimated and compared with the revenue gained in Appendix IV. This comparison is summarized in Table 3. Excluding the capital cost of the unit and the savings anticipated in surcharges to the City of Lethbridge, the LCZ unit was estimated to provide approximately $500/day net revenue to the plant. Two variables could significantly affect this estimate:

- the number of head of cattle processed per day, and
- the moisture content of the skimmings to be rendered.

The figures in Table 3 assume 600 head of cattle processed per day. If the plant through-put were to fall to 400 head/day, the projected daily revenue would be cut from about $1070 to about $720, with only a slight reduction in the associated operating costs. Table 3 also shows that the steam cost for rendering a 92 percent moisture skimming is about $175/day higher than for rendering a skimming containing only 80 percent moisture. This places great economic importance on reducing the moisture content in the skimmings.

Although the LCZ system produced a float with an average of 92 percent moisture content during the study, the return on investment calculations assumed 80 percent. This was considered to be realistic and attainable, since the system operated at this point shortly after the study when most of the electrical problems were solved.

The original capital cost of installing the LCZ unit was $522 000. This comprises $137 000 for the building, and $385 000 for the equipment, including all costs associated with construction and installation. Allowing for an estimated income of about $270 000 per year from the sale of recovered by-products, and operating costs of about $117 000 per year, several cases were developed to determine possible rates of return on investment. Table 4 shows the returns on investment and pay back periods for the base

TABLE 3 COMPARISON OF LCZ UNIT OPERATING COSTS AND REVENUE FROM BY-PRODUCT RECOVERY

| Variable | Cost/day* | Revenue Gained/day* |
|---|---|---|
| LCZ Unit | | |
| Polymer | $ 7.84 | |
| Acid | 28.62 | |
| Caustic | 44.01 | |
| Electricity | 33.00 | |
| Labour | 96.88 | |
| Maintenance | 120.00 | |
| By-product Recovery | | |
| Labour | 22.50 | |
| Steam (80% moisture/ 92% moisture) | 115.71/289.28 | |
| By-product Sale** | | |
| Meat meal | | $ 407.55 |
| Tallow | | 662.35 |
| Totals | $468.56/642.13 | $1069.90 |

* 1979
** Assumes processing of 600 head/day.

TABLE 4 SUMMARY OF RETURN-ON-INVESTMENT CALCULATIONS

| | R.O.I. (%) | Payback Period (years) |
|---|---|---|
| Base Case | 16.6 | 4.9 |
| Surcharge Considered | 28.8 | 3.2 |
| ACCA (without surcharge) | 21.4 | 3.5 |

case, using only the operating expenses and by-product revenue; a second case which incorporates non-payment of city surcharges as income; and, a third example allowing for Environment Canada's Accelerated Capital Cost Allowance (ACCA). The detailed calculations are presented in Appendix IV.

## 5 DISCUSSION OF RESULTS

At its best, during the evaluation trial in Lethbridge, the Lectro Clear Z unit was able to achieve quite impressive reductions in BOD and suspended solids, the BOD reduction averaging around 60 percent. It produced a float (skimmings) material that contained relatively small amounts of metals and could be rendered to produce saleable by-products. Analysis of dried LCZ float material by Environment Canada yielded results as shown below:

| Element | ppm |
|---|---|
| Aluminum | 600 |
| Calcium | 2400 |
| Cadmium | 0.6 |
| Chromium | 138 |
| Copper | 30 |
| Iron | 5400 |
| Manganese | 8.7 |
| Nickel | 1.5 |
| Lead | 7.5 |
| Zinc | 85 |
| Sodium | 2360 |

The float material recovered during the Lethbridge evaluation contained considerably more moisture than had been anticipated (about 90 -92 percent). Whether this percentage of moisture can be decreased by altering the skimming procedure, for example by allowing the mat of floating material to build up and using the skimmer only a few minutes out of every hour, could be determined only by conducting an experimental program in which different skimming intervals were used, and the resultant skimmed material analyzed for moisture.

In many municipalities, and certainly under the by-law in force at Lethbridge, a high premium is put on the reliability of the waste treatment process. A day of poor treatment conditions may nullify several days or weeks of satisfactory treatment insofar as loading penalties are concerned. Because of electrical system problems encountered, this has so far proved to be the weakest point in the Lectro Clear Z process.

In the final analysis, application of the Lectro Clear Z process rather than a different in-plant treatment process, or allowing wastewater to go to a municipal system with a minimum of treatment and accepting the financial penalties, becomes largely a question of balancing costs. Apart from the original capital cost of the Lectro Clear system, the principal costs of the LCZ unit operation are incurred by power consumption and operator wages, plus whatever maintenance is required. Because of the relatively short operating history of the unit, little information is available concerning possible maintenance costs; however, reasonable estimates using plant information have been made and are given in Table 3. Since no treatment unit of any complexity can be expected to function indefinitely without some supervision it is not likely that the LCZ unit would differ significantly. However, by controlling pH, and maintaining current densities and other operating parameters, an acceptable effluent is attainable.

As the Lectro Clear Z is primarily an electrical system of treatment rather than a chemical system, it follows that it is reasonably power intensive compared to a conventional DAF system. This is not to say that no chemical costs are involved, since acid and sodium hydroxide additions are necessary for pH control. Costs for power and chemical use at Lethbridge are given in Appendix IV. Comparison of this aspect of LCZ operation with a system using more chemical and perhaps less power would depend upon the relative cost of chemicals and power, and a projection of these costs into the future. Although DAF units require extra equipment of other types (compressors and pumps) and typically employ higher chemical additions, they may prove similar to the LCZ in actual operating cost. However, the typical DAF unit has little potential for producing a saleable by-product. As already suggested, the value of potential by-products is likely to vary from one type of operation to another.

The Lectro Clear Z appears to offer considerable promise in the field of non-biological waste treatment. Its full potential can be determined only by more extensive experimental operation on various types of wastewater, and under a variety of operating conditions.

# 6 CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Electrical System

Since the LCZ relies primarily on its electrical system to achieve the desired wastewater treatment results, it is important that attention be paid to all electrical aspects of the installation. It was in this area that the most persistent operating problems were encountered in the Lethbridge unit. Frequent malfunctions during the first six months of operation either reduced the efficiency of the unit or shut it down completely. Various causes have been suggested for these malfunctions.

Insufficient regulation of voltage reaching the plant from the city system has apparently resulted in wide swings and excessive voltage applied to the rectifiers, causing them to overload and burn out. Faulty components within the rectifier system have also been suggested, and in fact some of these units have been replaced. In the fall of 1980 increasing resistance to current flow suggested possible deterioration in the electrodes. Investigation appears to have located the problem in the contacts where the electrodes join the rest of the electrical system.

Early in the operation of the unit it appeared that adequate treatment could only be achieved by using a higher voltage on the rectifiers than recommended by the manufacturers. It was later surmised that this may have been due to a lack of attention to the conductivity of the wastewater during the pilot tests. The use of higher voltage may in itself have either caused or aggravated the electrical problems. After the study ended the water-cooled rectifiers were replaced with a newer design of air-cooled units. These rectifiers apparently are capable of handling higher voltage shifts.

Since the Lethbridge LCZ installation was essentially an experimental unit, many of the electrical problems may be regarded as the type of "bugs" that appear during the break-in of any new process. Nevertheless, the unexpected appearance and stubborn persistence of these problems suggest the advisability of tighter specifications for manufacture, installation and operation of the electrical components. This includes identification of the components most likely to cause operating problems. Replacements for these should be kept on hand so that operation of the LCZ unit would not be interrupted for long periods.

## 6.2 Conductivity of Wastewater

Wide variations in the wastewater's conductivity may have significantly contributed to the electrical problems encountered by necessitating an increase in voltage applied to the rectifiers. Yet nowhere in LCZ literature, including the pilot study report, is reference made to the importance of conductivity regulation. In addition to the possible changes in conductivity caused by variations in the blood content of the wastewater and the mineral content of the city water supply, another variable was introduced during the evaluation period. At the Lethbridge plant there is a hide-processing system using a brine tank. This tank had formerly overflowed from time to time into the wastewater system. Among the housekeeping measures undertaken was elimination of this overflow, since it was thought the brine might carry undesirable dissolved protein material into the waste system. Unfortunately, this also reduced the amount of brine in the wastewater. Although it seemed probable that the conductivity of the wastewater could have been affected, leading in turn to increased voltage requirements to the LCZ unit, such discharges may have been too infrequent to cause significant variations.

In view of the demonstrated importance of wastewater conductivity, it is recommended that studies be undertaken to determine the effect of wastewater conductivity on LCZ operation. Provisions should be made for continuously monitoring wastewater conductivity, and for providing a method of keeping it within desired limits if necessary. This should be supplemented by provision of a means of suppressing the effects of changing conductivity on the rectifiers.

### 6.3 pH Adjustment

The importance of pH control to LCZ operation has already been mentioned. Maintenance of the influent pH in the desired range of about 4.0 - 4.5 is accomplished by feeding sulphuric acid to the influent stream at a preset rate. This addition is monitored by a pH sensing electrode set in the line beyond the point where the acid is added. This is supposed to measure and record pH of the incoming LCZ feed and make automatic adjustments of acid feed rates to maintain the desired pH. On at least one occasion during the March-April trial period this system failed to function, causing inferior BOD and solids removal. A somewhat similar arrangement for pH control is used where caustic is added to the LCZ effluent to bring it to the range 5.5 - 6.5 before discharge to the city sewer.

Because of the possibility of failure in these sensing and control units, it is recommended that samples of LCZ influent and effluent be taken routinely twice a shift by the operator and checked by use of a laboratory pH meter.

Probes on the continuous monitoring system should be checked and cleaned on a regular basis, and the read-out system checked and calibrated at regular intervals. A record should be kept and any differences between the continuous monitor readings and the laboratory pH meter readings should be noted and immediate steps taken to locate and remedy the problem.

### 6.4 Chemical Facilities

The additives used (acid, caustic and polymer) are brought to the proper strength by adding water and are stored in feed tanks, the polymer in a plastic tank and the caustic and acid in plastic-lined metal tanks.

It is recommended that these be marked or monitored in appropriate units, and that the quantities used per shift be recorded as an additional check on the rate of chemical usage.

### 6.5 Temperature of LCZ influent

Few references are made anywhere to optimum temperature of operation for the LCZ process, although about 40°C has been suggested as the maximum desirable. Because of the lack of definite directions on temperature, no effort was made during the trial run to adjust the temperature of unit feed water. However, temperatures were taken hourly on the influent and effluent. Temperatures varied from a low of 25°C to a high of 40°C. Most readings were in the range of 30 to 40°C. It appears likely that too high a temperature may affect the stability of the polymer and have undesirable effects upon grease recovery.

It is recommended that the effects of temperature on the LCZ process be investigated during pilot testing. Depending upon the findings, measures should be taken to monitor and control operating temperatures within optimum limits.

### 6.6 Skimming LCZ Float Material

Little attention is paid in the LCZ unit operating instructions to the timing of skimming operations. During the trial run in March-April 1980, skimming was carried on continually. The recovered skimmings during the study had a moisture content of about 92 percent. This was much higher than was expected based on the pilot tests.

It is evident that more attention should be paid to the timing of skimming operations, since the moisture content of the skimmings has a considerable influence on the economics of the rendering process. It is likely that different time intervals for skimming may be necessary with different wastes. Past experience with other systems with skimming devices suggests that continuous operation does not allow sufficient time for formation of the float, while dissociation of the skimmings blanket may result if it is left too long.

It is recommended that samples be taken from the recovered float skimmings and analyzed for moisture to determine the best skimming program. This sampling and analysis should be carried out periodically to ensure efficient operation of the skimming sequence.

### 6.7 Hydrogen Sulphide Formation

Throughout the test run a distinct odour of hydrogen sulphide was evident in the LCZ building. Tests were run using both $H_2S$-sensitive paper discs (Hach) and a Draeger hand-operated $H_2S$ tester. Presence of $H_2S$ was confirmed at all points in the building, although the only point showing a dangerous level was in the pit into which the LCZ effluent discharged. However, this situation may have been aggravated by the inefficient operation of the electrodes.

The presence of $H_2S$ at all points at which tests were made indicates a potential hazard. It should be noted, too, that relatively little information is available concerning the effect of long-term exposure to low levels of $H_2S$.

It is recommended that particular attention be paid to ventilation in all LCZ installations, and that regular $H_2S$ monitoring programs be conducted.

### 6.8 Accessibility and Safety

As originally installed at Lethbridge, the LCZ unit had no real provison for taking samples, and holes had to be cut to install sample collection lines.

It is recommended that all LCZ units be provided at time of manufacture or installation with access for easy sampling of at least the influent, effluent and recovered float material.

General accessibility of the Lethbridge unit was only fair. Access to the tank at the influent end and along the west side was cramped and awkward. The top of the reaction basin, some 4.5 m above the floor, could be reached only by a vertical iron ladder without guards. There were no platforms or catwalks for access to any point away from the top of this ladder, and points across the tank had to be reached by placing planks across the top.

It is recommended that ladders be protected by some type of guard to minimize danger of falling, and that railed catwalks be provided to give access to the top of the reaction basin.

### 6.9 Turbulence in Coagulation Section

During the sampling program, considerable turbulence was noted in the coagulation section of the unit. This tended to break up and disperse the float blanket and possibly hindered proper flocculation. The most likely cause of this turbulence at the time of the study appeared to be the flow from the LCZ influent line. Subsequent investigation revealed a loose baffle in this section.

It is recommended that inlet structures be provided with velocity breakers and adequate structures to direct the flow to reduce the potential for interference with the float. The inlet system should be checked regularly for undue turbulence and the cause corrected if turbulence appears to be interfering with stability of the floc blanket.

### 6.10 Laboratory Control of Process

No system, no matter how well designed nor how fully automated can be counted on to operate forever without some measure of control. Mention has already been made of the failure of the automated pH control unit. This failure, suspected because of erratic performance of the recording apparatus, was confirmed very quickly because routine checks were made during the test program on the pH of the LCZ influent by taking samples which were checked on a laboratory pH meter.

The LCZ literature makes no suggestions concerning adequate laboratory control of the process. Yet the possibly serious consequences of faulty operation indicate that it is important to ensure that the unit is operating efficiently. This is particularly critical in view of the severe penalties that may result from release of wastewater with characteristics above the limits set by the municipality, or the financial loss which may result from inefficient recovery of by-products.

It is recommended that a laboratory control program be instituted to monitor:

1) LCZ effluent
   a. COD determination once daily on a composite of at least three hourly samples.
   b. pH check at least twice daily to ensure the effluent is within pH limits.

2) LCZ influent
   a. Laboratory pH check of the influent twice daily to ensure influent is within pH limits.

b. Twice daily check of temperature of incoming wastewater.

c. Twice daily check of conductivity of incoming wastewater.

3) LCZ float material (skimmings)

Samples should be taken at least three times per shift from the trough into which LCZ float material is skimmed. These should be composited to make up a single daily sample which should be checked for moisture content. A record should be kept of the intervals of skimmer operation and this correlated on a chart against moisture in the recovered skimmings. If the moisture content appears to be too high, or shows a continuing tendency to rise, adjustment of the skimming interval should be considered. However, other process variables should also be examined.

No provision has been suggested for laboratory control of suspended solids or grease and fats. Suspended solids reductions were found to run roughly parallel to BOD/COD reductions, and the COD determination, which is relatively quick and accurate when carefully performed, is likely to give a sufficiently good routine check on the acceptability of the effluent. Grease was not found to be a problem in the LCZ application at Lethbridge and, as analysis for grease is time-consuming, no suggestion has been made that it be carried out.

This is not to say that regular checks for both suspended solids and grease should be overlooked as a possible requirement in LCZ installations operating in other plants or under other conditions. Adequate laboratory control, tailored to requirements of the individual installation is a requisite for efficient operation of the system.

## 6.11 Pretreatment Requirements

Preparation of the wastewater prior to the LCZ unit received little attention during the study because a form of pretreatment, the existing basin, was already in place. However, for a new plant or one without an existing basin it is essential that some kind of sedimentation and equalization be considered. Sedimentation allows discrete or readily settleable material to be removed, thus eliminating a potential electrode fouling problem in the LCZ, and the need for excessive sludge removal equipment. Equalization of the waste stream will smooth out large variations in flow and enhance the operation of the LCZ.

# APPENDIX I

## CITY OF LETHBRIDGE

## SEWER SERVICE BY-LAW

## APPENDIX I - CITY OF LETHBRIDGE SEWER SERVICE BY-LAW

The basis upon which individual industrial plants are assessed is a somewhat complex set of formulae. A basic service charge is levied, based upon the volume of wastewater produced by the plant. This is supplemented by a heavy surcharge which depends upon the plant's failure to remain below the maximum allowed BOD, suspended solids and grease loadings. The method used in making these calculations is shown below.

1) Basic Service Charge

This is calculated on the basis of:

a. volume of waste put out by the individual industrial plant;
b. the BOD loading of the individual waste; and
c. the suspended solids (SS) loading of the individual waste.

a. Volume. A sum that includes quarterly operating costs plus debt retirement for the present sewage treatment plant is assigned to each industrial plant. This sum varies with the sewage treatment plant operating cost.
The industrial plant's volume service charge is calculated using:

$$C \times \frac{P}{V} \times 0.4$$

where: C = the variable operating cost plus debt retirement,
P = volume of waste from the individual plant,
V = total volume of city sewage.

b. BOD Service Charge. This is determined using:

$$C \times \frac{\text{lb BOD contributed by individual plant}}{\text{total lb BOD loading reaching city sewage plant}} \times 0.3$$

c. SS Service Charge. This charge is calculated using the same formula as for BOD, using SS loading figure.
The basic service charge for each plant is calculated on a quarterly basis.

2) Surcharges. When the effluent from any individual plant exceeds the by-law limits set 1 October 1979 (i.e., 300 mg/L for BOD, 300 mg/L for suspended solids, and 100 mg/L for grease) a further surcharge is applied. The surcharge is 0.5 x quarterly service charge for every day the plant is over these limits, irrespective of whether it is over the limit on one parameter or on all three.

The BOD, suspended solids and grease loadings from each plant are calculated on the basis of a comprehensive analytical program carried out on a random selection of plants. At each plant an automatic sampling and compositing device is located on the effluent line. This device takes hourly samples from the line, based on the measured volume of flow each hour. Five composite samples are taken during a week. The sample containers are picked up each morning from Monday to Friday, so that the samples represent daily composites for Monday through Thursday, and a three-day composite for Friday, Saturday and Sunday.

Nine plants are involved in this sampling program. Prior to the beginning of each quarter, the names of the nine plants are drawn at random, the order in which they are drawn determining the order in which they will be sampled during the quarter. Only suspended solids are analyzed each day during any five-day testing period; BOD and grease are analyzed once or twice a week at random. On the basis of these tests, the number of days the plant may be in violation during any one quarter is five days. However, if a plant initially has a fairly high volume service charge, this surcharge may increase its sewer service costs very substantially.

For example, if a plant has a basic service charge of \$10 000 and is in violation of the specified limits on all five days of a test period, its total sewer service charge plus surcharge for the quarter would amount to:

5 days x 0.5 x \$10 000 = \$25 000 + \$10 000 = \$35 000

During the first quarter of 1978 when the Swift plant was in violation of the limits on four of five test days. During the quarter, the basic service charge was \$13 292.96. Application of the surcharge increased this as follows:

4 days x 0.5 x \$13 292.96 = \$26 585.92

This figure plus the original service charge of \$13 292.96 produces a total sewer service charge plus surcharge for the quarter of \$39 878.88.

The surcharge provides considerable incentive to reduce loadings as far as possible, and certainly to keep them below the maximum specified limits.

Plants that have joined the city's pretreatment program are completely excluded from the application of the present sewage treatment by-law. Under the new arrangement, each industry is assigned a proportion of the industrial pretreatment plant costs. The proportion assigned to any plant is calculated on the plant's volume of wastewater, its BOD loading, and its loading of suspended solids, all assessed in proportion to the total loading on the pretreatment plant. This assessment is weighted 40 percent for volume, 30 percent for BOD and 30 percent for suspended solids. Each industry will be charged a proportion of the $2 000 000 capital cost and a similar proportion of the monthly operating cost, the charge based on the plant's proportion of the total loading reaching the pretreatment facility. The quarterly analytical program referred to earlier will be carried on and the monthly operating charge to the industry will be adjusted according to the percentage of time the industry is in excess of limits, based on previous performance.

In addition, the city is offering to all plants an incentive to upgrade their effluent. Fifty percent of the surcharge paid by an industry over the past three years is available for rebate to plants that spend the money upgrading waste treatment facilities. Additionally, if the industry can remove 65 percent of the average BOD and suspended solids concentrations over the past three years, up to 70 percent of the surcharges paid is repayable.

# APPENDIX II

## CITY OF LETHBRIDGE
## DATA FOR EFFLUENT FROM SWIFT CANADIAN COMPANY LIMITED 1977-80

## NOTES TO APPENDIX II

1) All data in this appendix are from City of Lethbridge sewage treatment plant.
2) Samples were composited during the periods indicated by an automatic sampler in the Swift Canadian effluent line outside the plant. Normally, samples were composited from about 11:00 a.m. one day to 11:00 a.m. the following day. Where a three-day interval is shown this indicates a week-end, i.e., a.m. Friday to a.m. Monday.
3) Because of the system used for calculating city surcharges, only five composite samples are completely analyzed during each quarter. The sampling period is chosen at random (see Appendix I).
4) All analytical work on the samples was done at the City of Lethbridge sewage plant laboratory.
5) The Swift Canadian LCZ equipment was in partial operation commencing in the third quarter of 1979 and in continual operation during the first quarter (24-31 March) of 1980.

## APPENDIX II DATA ON EFFLUENT FROM SWIFT CANADIAN PLANT - LETHBRIDGE

| Period | Water Used ($m^3$) | Suspended Solids (mg/L) | BOD (mg/L) | Grease (mg/L) |
|---|---|---|---|---|
| 1977 FIRST QUARTER | | | | |
| 7-8 Feb. | 2558 | 461 | 560 | 391 |
| 8-9 Feb. | 2045 | 512 | 765 | 354 |
| 9-10 Feb. | 2088 | 641 | 766 | 379 |
| 10-11 Feb. | 1533 | 482 | 632 | 287 |
| 11-14 Feb. | 2806 | 611 | 631 | 403 |
| 1977 SECOND QUARTER | | | | |
| 25-26 May | 1665 | 219 | 498 | 102 |
| 26-27 May | 1849 | 505 | 803 | 370 |
| 27-30 May | 2826 | 349 | 627 | 208 |
| 30-31 May | 1858 | 528 | 1069 | 337 |
| 31 May - 1 June | 1730 | 579 | 1148 | 443 |
| 1977 THIRD QUARTER | | | | |
| 6-7 Sept. | 2387 | 431 | 693 | 248 |
| 7-8 Sept. | 2354 | 268 | 443 | 107 |
| 8-9 Sept. | 2494 | 373 | 623 | 201 |
| 9-12 Sept. | 3927 | 307 | 546 | 154 |
| 12-13 Sept. | 2268 | 375 | 556 | 204 |
| 1977 FOURTH QUARTER | | | | |
| 17-18 Oct. | 1764 | 342 | 632 | 187 |
| 18-19 Oct. | 1566 | 240 | 431 | 109 |
| 19-20 Oct. | 1759 | 760 | 1177 | 566 |
| 20-21 Oct. | 1555 | 237 | 356 | 140 |
| 21-24 Oct. | 2926 | 230 | 258 | 124 |
| 1978 FIRST QUARTER | | | | |
| 23-24 Jan. | 1362 | 825 | 966 | 406 |
| 24-25 Jan. | 2447 | 457 | 754 | 221 |
| 25-26 Jan. | 2826 | 454 | 465 | 211 |
| 26-27 Jan. | 2249 | 498 | 578 | 239 |
| 27-30 Jan. | 2931 | 317 | 442 | 146 |
| 1978 SECOND QUARTER | | | | |
| 23-24 May | 1807 | 214 | 442 | 83 |
| 24-25 May | 1773 | 553 | 762 | 364 |
| 25-26 May | 1501 | 429 | 743 | 290 |
| 26-29 May | 2504 | 413 | 621 | 308 |
| 29-30 May | 1439 | 615 | 991 | 475 |

## APPENDIX II DATA ON EFFLUENT FROM SWIFT CANADIAN PLANT - LETHBRIDGE (cont'd)

| Period | Water Used ($m^3$) | Suspended Solids (mg/L) | BOD (mg/L) | Grease (mg/L) |
|---|---|---|---|---|
| 1978 THIRD QUARTER | | | | |
| 13-14 Sept. | 1572 | 234 | 276 | 94 |
| 14-15 Sept. | 1419 | 277 | 435 | 172 |
| 15-18 Sept. | 2529 | 384 | 483 | 200 |
| 18-19 Sept. | 1425 | 530 | 861 | 501 |
| 19-20 Sept. | 1422 | 446 | 589 | 324 |
| 1978 FOURTH QUARTER | | | | |
| 25-26 Oct. | 1597 | 454 | 695 | 302 |
| 26-27 Oct. | 1232 | 393 | 627 | 257 |
| 27-30 Oct. | 2110 | 349 | 568 | 196 |
| 30-31 Oct. | 1337 | 662 | 1156 | 511 |
| 31 Oct. - 1 Nov. | 1379 | 363 | 646 | 217 |
| 1979 FIRST QUARTER | | | | |
| 17-18 Jan. | 1326 | 385 | 546 | 204 |
| 18-19 Jan. | 1388 | 419 | 432 | 279 |
| 19-22 Jan. | 1377 | 500 | 833 | 327 |
| 22-23 Jan. | 1186 | 549 | 916 | 315 |
| 23-24 Jan. | 1238 | 264 | 552 | 128 |
| 1979 SECOND QUARTER | | | | |
| 11-12 June | 1000 | 479 | 807 | 203 |
| 12-13 June | 1095 | 543 | 1095 | 330 |
| 13-14 June | 1163 | 410 | 856 | 177 |
| 14-15 June | 1068 | 237 | 616 | 101 |
| 15-18 June | 979 | 327 | 721 | 177 |
| 1979 THIRD QUARTER | | | | |
| 30-31 Aug. | 1906 | 125 | 174 | --- |
| 31 Aug. - 4 Sept. | 2017 | 148 | 132 | --- |
| 4-5 Sept. | 1950 | 131 | 292 | 20 |
| 5-6 Sept. | 1795 | 110 | 73 | 8 |
| 6-7 Sept. | 1885 | 125 | 88 | 18 |
| 1979 FOURTH QUARTER | | | | |
| 19-20 Nov. | 1657 | 191 | 301 | 51 |
| 20-21 Nov. | 1729 | 287 | 450 | 80 |
| 21-22 Nov. | 1929 | 264 | 361 | 120 |
| 22-23 Nov. | 1748 | 207 | 269 | 49 |
| 23-26 Nov. | 2049 | 324 | 446 | 159 |

## APPENDIX II DATA ON EFFLUENT FROM SWIFT CANADIAN PLANT - LETHBRIDGE (cont'd)

| Period | Water Used ($m^3$) | Suspended Solids (mg/L) | BOD (mg/L) | Grease (mg/L) |
|---|---|---|---|---|
| 1980 FIRST QUARTER | | | | |
| 24-25 Mar. | 1939 | 165 | 197 | 38 |
| 25-26 Mar. | 1962 | 148 | 213 | 59 |
| 26-27 Mar. | 1980 | 170 | 224 | 34 |
| 27-28 Mar. | 1942 | 145 | 188 | 47 |
| 28-31 Mar. | 2280 | 160 | 238 | 32 |

# APPENDIX III

# ANALYTICAL METHODS AND RESULTS

## APPENDIX III ANALYTICAL METHODS AND RESULTS

### Analytical Methods - Description

Unless otherwise noted, all references are to Standard Methods For Examination of Water and Waste Water, 14th Edition, 1975.

Biochemical Oxygen Demand (BOD). Method 507 (p. 543). In general, three different dilutions of the samples were used. In spite of taking all possible precautions, there was occasional difficulty in obtaining a reasonable set of results on the various dilutions. Because of this, it became routine procedure to freeze the residue of all samples so that some material would be available if the initial BOD determination appeared doubtful.

Chemical Oxygen Demand (COD). Method 508 (p. 550). The dichromate reflux method was used, employing a silver sulphate catalyst, and mercuric sulphate to minimize chloride interference. Blanks were run with each set of samples. Occasional results were obtained that did not appear logical. In such cases, the determination was repeated, the relative rapidity of the determination making this repetition relatively simple.

Suspended Solids (Non-filtrable Residue) (SS). Method 208D (p. 94). The method outlined was followed, using Cooch crucibles fitted with Reeve Angel glass fibre filter discs grade 934AH. No serious problems were encountered. Determinations were made in duplicate, the average of the two results being reported.

Oil and Grease. Method 502A (p. 515). Freon was used as the extracting solvent. Since the samples were composites that had been handled several times, some slight loss of grease by adhesion to the walls of the containers was possible. It was considered that, in view of the relatively non-greasy nature of the samples, any such loss would be minimal.

Ammonia Nitrogen.

- Orion Research 95-10 Ammonia Electrode.
- Orion Research 407A/L Specific Ion Meter.

Details of the method are contained in Orion Research Manual for the 95-10 ammonia electrode, issued with the equipment, and in the manuals accompanying the 407A/L specific ion meter. The apparatus is calibrated using a set of standards prepared by dissolving 0.382 g reagent grade $NH_4Cl$ in 50 ml distilled water, and diluting to 100 ml to make 100 ml of a 1000 ppm (N) standard solution. Standards of 100 and 10 ppm are prepared from the original by serial dilution. The 407A/L specific ion meter has a direct reading scale so that each standard should register at the appropriate point on the scale. Similarly, the N content of the samples to be tested can be read directly from the scale.

Comparison of this method with former methods such as Nesslerization have given excellent checks. Aside from speed and simplicity of operation, this method has the advantage of not requiring a distillation procedure, which almost invariably results in loss of ammonia.

Soluble BOD/COD. On two days each week, samples were checked for soluble BOD and COD. This was done by filtering the samples through no. 40 Whatman filter paper and then analyzing the filtrate in the usual manner. It was noticeable that the BOD and COD were substantially lower than for the corresponding unfiltered samples, especially in the case of the influents. It was also quite evident that the reduction of soluble BOD through the LCZ unit was in most cases relatively slight.

Sludge Samples.

1) Moisture - Standard Method 208A (p. 91)
Analysis of Water and Sewage, Theroux, Eldridge and Mallmann, third ed., McGraw-Hill, 1943, p. 70, Moisture of Sewage Sludge.

These methods are similar, although the standard method 208A is actually intended for use with water samples. The Theroux, Eldridge and Mallmann method is summarized as follows:

a. Ignite, cool in a dessicator and weigh a clean evaporating dish of about 50 ml capacity.
b. Mix the sludge thoroughly and pour approximately 25 ml into the dish.
c. Reweigh immediately, avoiding delay as the sludge changes in weight rapidly.
d. Evaporate on a water bath until dry.
e. Place in a 103°C oven for at least one hour, cool in a dessicator and weigh.

Calculation:

$$\frac{\text{Loss in weight (g)} \times 100}{\text{Weight of wet sludge (g)}} = \text{percent moisture}$$

2) Suspended Solids (Non-filtrable residue) - Standard Method 208D, Total Nonfiltrable Residue dried at 103-105°C - Total Suspended Matter.

This method was used for sludge solids from the electrocoagulation section of the LCZ unit because in most cases it appeared that the solids content was very low.

3) Oil & Grease - Standard Methods 502D (p. 519). Because it was felt desirable to determine the average fat content of skimmings from the LCZ unit, some of the samples were analyzed using method 502D.

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>26 Feb. 80 | 1513 | 756 | 0.50 | --- | 688 | 103 | 3.63 | 22.1 | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>26 Feb. 80 | 878 | 413 | 0.47 | 46 | 334 | 53 | 3.38 | 22.4 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>26 Feb. 80 | 801 | 423 | 0.53 | --- | 318 | 43 | 3.77 | 30.5 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>26 Feb. 80 | 649 | 349 | 0.54 | 17 | 198 | 18 | 3.69 | 31.1 | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>27 Feb. 80 | 2170 | 1204 | 0.55 | --- | 964 | 105 | 3.99 | --- | 348 | 196 | 0.56 | --- |
| Effluent<br>0800 h-1600 h<br>27 Feb. 80 | 1569 | 813 | 0.52 | 32 | 388 | 56 | 3.93 | --- | 302 | 178 | 0.59 | 9.2 |
| Influent<br>1700 h-2400 h<br>27 Feb. 80 | 1366 | 676 | 0.49 | --- | 352 | 15 | 3.85 | --- | 528 | 308 | 0.58 | --- |
| Effluent<br>1700 h-2400 h<br>27 Feb. 80 | 1365 | 706 | 0.52 | NIL | 352 | 15 | 3.81 | --- | 451 | 308 | 0.68 | NIL |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | NH$_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>28 Feb. 80 | 1105 | 532 | 0.48 | --- | 458 | 19 | 4.59 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>28 Feb. 80 | 531 | 280 | 0.53 | 47 | 190 | 5 | 4.27 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>28 Feb. 80 | 805 | 421 | 0.52 | --- | 336 | 18 | 3.73 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>28 Feb. 80 | 524 | 290 | 0.53 | 31 | 162 | 7 | 3.75 | --- | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>29 Feb. 80 | 2543 | 1329 | 0.52 | --- | 1020 | 51 | 4.05 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>29 Feb. 80 | 1968 | 923 | 0.47 | 31 | 780 | 25 | 3.77 | --- | --- | --- | --- | --- |
| Influent<br>0900 h-1600 h<br>3 Mar. 80 | 2795 | 1520 | 0.54 | --- | 1274 | 225 | 4.94 | 11.7 | 311 | 188 | 0.60 | --- |
| Effluent<br>0900 h-1600 h<br>3 Mar. 80 | 982 | 537 | 0.55 | 65 | 356 | 77 | 4.27 | 9.5 | 371 | 185 | 0.50 | 1.6 |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>1700 h-2400 h<br>3 Mar. 80 | 2164 | 1175 | 0.54 | --- | 856 | 153 | 5.77 | 27.5 | 272 | 157 | 0.58 | --- |
| Effluent<br>1700 h-2400 h<br>3 Mar. 80 | 1004 | 529 | 0.53 | 55 | 658 | 53 | 4.49 | 25.1 | 364 | 202 | 0.55 | NIL |
| Influent<br>0800 h-1600 h<br>4 Mar. 80 | 1593 | 757 | 0.48 | --- | 622 | 120 | 4.69 | 19.5 | 360 | 198 | 0.55 | --- |
| Effluent<br>0800 h-1600 h<br>4 Mar. 80 | 675 | 304 | 0.45 | 60 | 164 | 38 | 4.53 | 19.0 | 317 | 160 | 0.50 | 19.2 |
| Influent<br>1700 h-2400 h<br>4 Mar. 80 | 1140 | 573 | 0.50 | --- | 524 | 142 | 4.30 | 28.7 | 362 | 190 | 0.52 | --- |
| Effluent<br>1700 h-2400 h<br>4 Mar. 80 | 570 | 262 | 0.46 | 54 | 130 | 31 | 4.41 | 28.5 | 368 | 190 | 0.52 | NIL |
| Influent<br>0900 h-1600 h<br>5 Mar. 80 | 1972 | 1010 | 0.51 | --- | 854 | 105 | 5.07 | --- | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>5 Mar. 80 | 1026 | 567 | 0.55 | 44 | 336 | 67 | 4.49 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent 1900 h-2400 h 5 Mar. 80 | 746 | 550 | 0.74 | --- | 408 | 83 | 4.57 | --- | --- | --- | --- | --- |
| Effluent 1900 h-2400 h 5 Mar. 80 | 459 | 245 | 0.53 | 55 | 51 | 3 | 4.49 | --- | --- | --- | --- | --- |
| Influent 0800 h-1600 h 6 Mar. 80 | 1474 | 727 | 0.47 | --- | 546 | 55 | --- | --- | --- | --- | --- | --- |
| Effluent 0800 h-1600 h 6 Mar. 80 | 609 | 294 | 0.48 | 60 | 142 | 11 | --- | --- | --- | --- | --- | --- |
| Influent 1700 h-2400 h 6 Mar. 80 | 821 | 450 | 0.55 | --- | 310 | 22 | --- | --- | --- | --- | --- | --- |
| Effluent 1700 h-2400 h 6 Mar. 80 | 392 | 210 | 0.54 | 53 | 130 | 3 | --- | --- | --- | --- | --- | --- |
| Influent 0900 h-1500 h 7 Mar. 80 | 1304 | 626 | 0.48 | --- | 564 | 70 | --- | --- | --- | --- | --- | --- |
| Effluent 0900 h-1500 h 7 Mar. 80 | 542 | 292 | 0.54 | 53 | 170 | 14 | --- | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>1000 h-1600 h<br>10 Mar. 80 | 2692 | 1218 | 0.45 | --- | 852 | 189 | 6.13 | 26.0 | 463 | 247 | 0.53 | --- |
| Effluent<br>1000 h-1700 h<br>10 Mar. 80 | 1450 | 687 | 0.47 | 44 | 484 | 79 | 5.65 | 24.5 | 355 | 168 | 0.47 | 32 |
| Influent<br>1700 h-2400 h<br>10 Mar. 80 | 2191 | 748 | 0.34 | --- | 604 | 121 | 4.73 | 33.3 | 404 | 200 | 0.50 | --- |
| Effluent<br>1700 h-2400 h<br>10 Mar. 80 | 1080 | 463 | 0.43 | 38 | 292 | 38 | 4.09 | 32.5 | 359 | 192 | 0.53 | 4 |
| Influent<br>0800 h-1600 h<br>11 Mar. 80 | 1762 | 860 | 0.49 | --- | 728 | 120 | 4.81 | 23.9 | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>11 Mar. 80 | 1101 | 488 | 0.44 | 43 | 358 | 59 | 4.32 | 23.1 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>11 Mar. 80 | 1013 | 485 | 0.48 | --- | 282 | 47 | 4.23 | 29.0 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>11 Mar. 80 | 823 | 371 | 0.45 | 24 | 186 | 22 | 4.01 | 28.0 | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>12 Mar. 80 | 2823 | 1577 | 0.56 | --- | 1164 | 328 | 4.28 | --- | 369 | 181 | 0.49 | --- |
| Effluent<br>0900 h-1600 h<br>12 Mar. 80 | 923 | 496 | 0.54 | 69 | 294 | 84 | 4.46 | --- | 330 | 158 | 0.48 | 13 |
| Influent<br>1700 h-2400 h<br>12 Mar. 80 | 1604 | 800 | 0.50 | --- | 616 | 70 | 4.74 | --- | 543 | 272 | 0.50 | --- |
| Effluent<br>1700 h-2400 h<br>12 Mar. 80 | 1006 | 488 | 0.49 | 39 | 306 | 27 | 4.33 | --- | 505 | 255 | 0.50 | 6 |
| Influent<br>0800 h-1600 h<br>13 Mar. 80 | 1580 | 864 | 0.55 | --- | 758 | 77 | 4.38 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>13 Mar. 80 | 980 | 513 | 0.52 | 41 | 366 | 14 | 4.28 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>13 Mar. 80 | 1271 | 602 | 0.47 | --- | 546 | 59 | 3.87 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>13 Mar. 80 | 861 | 497 | 0.58 | 17 | 398 | 35 | 3.98 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>14 Mar. 80 | 1815 | 587 | 0.32 | --- | 870 | 76 | 4.32 | --- | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>14 Mar. 80 | 898 | 360 | 0.40 | 39 | 474 | 41 | 4.02 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>14 Mar. 80 | 778 | 365 | 0.47 | --- | 318 | 41 | 4.11 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>14 Mar. 80 | 347 | 187 | 0.54 | 49 | 171 | 14 | 4.18 | --- | --- | --- | --- | --- |
| Influent<br>0900 h-1600 h<br>17 Mar. 80 | 956 | 503 | 0.53 | --- | 488 | 47 | 4.24 | 18.6 | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>17 Mar. 80 | 522 | 240 | 0.46 | 52 | 192 | 21 | 4.09 | 17.1 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>17 Mar. 80 | 795 | 400 | 0.50 | --- | 332 | 27 | 4.28 | 27.9 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>17 Mar. 80 | 474 | 244 | 0.55 | 39 | 142 | 4 | 4.10 | 26.0 | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>18 Mar. 80 | 948 | 482 | 0.51 | --- | 524 | 52 | 4.19 | 20.0 | 224 | 112 | 0.50 | --- |
| Effluent<br>0800 h-1600 h<br>18 Mar. 80 | 288 | 156 | 0.54 | 68 | 64 | 1 | 4.25 | 19.3 | 193 | 102 | 0.52 | 8.9 |
| Influent<br>1700 h-2400 h<br>18 Mar. 80 | 827 | 372 | 0.45 | --- | 315 | 29 | 4.40 | 24.3 | 264 | 143 | 0.54 | --- |
| Effluent<br>1700 h-2400 h<br>18 Mar. 80 | 343 | 190 | 0.55 | 49 | 49 | 8 | 4.39 | 24.9 | 267 | 146 | 0.55 | NIL |
| Influent<br>0900 h-1600 h<br>19 Mar. 80 | 1921 | 964 | 0.50 | --- | 776 | 214 | 4.34 | --- | 268 | 147 | 0.55 | --- |
| Effluent<br>0900 h-1600 h<br>19 Mar. 80 | 538 | 267 | 0.50 | 72 | 139 | 26 | 4.50 | --- | 225 | 126 | 0.49 | 14.3 |
| Influent<br>1700 h-2400 h<br>19 Mar. 80 | 1616 | 758 | 0.47 | --- | 502 | 70 | 4.34 | --- | 326 | 148 | 0.45 | --- |
| Effluent<br>1700 h-2400 h<br>19 Mar. 80 | 654 | 320 | 0.49 | 58 | 188 | 22 | 4.18 | --- | 293 | 129 | 0.44 | 12.8 |

## APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | NH$_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>20 Mar. 80 | 1512 | 675 | 0.45 | --- | 873 | 139 | 4.37 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>20 Mar. 80 | 453 | 217 | 0.48 | 68 | 204 | 19 | 4.45 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>20 Mar. 80 | 1083 | 456 | 0.42 | --- | 498 | 52 | 4.36 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>20 Mar. 80 | 343 | 195 | 0.57 | 57 | 158 | 12 | 4.28 | --- | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>21 Mar. 80 | 1065 | 600 | 0.56 | --- | 438 | 88 | 4.1 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>21 Mar. 80 | 429 | 278 | 0.58 | 54 | 330 | 20 | 4.6 | --- | --- | --- | --- | --- |
| Influent<br>1600 h-1900 h<br>21 Mar. 80 | 1123 | 592 | 0.53 | --- | 490 | 75 | 3.6 | --- | --- | --- | --- | --- |
| Effluent<br>1600 h-1900 h<br>21 Mar. 80 | 384 | 199 | 0.52 | 66 | 149 | 21 | 4.9 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>1000 h-1500 h<br>24 Mar. 80 | 1089 | 592 | 0.54 | --- | 568 | 78 | 5.64 | --- | --- | --- | --- | --- |
| Effluent<br>1000 h-1500 h<br>24 Mar. 80 | 408 | 227 | 0.56 | 61 | 116 | 6 | 4.58 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>24 Mar. 80 | 677 | 362 | 0.53 | --- | 342 | 21 | 5.42 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>24 Mar. 80 | 450 | 232 | 0.52 | 36 | 142 | 12 | 4.41 | --- | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>25 Mar. 80 | 1329 | 672 | 0.51 | --- | 598 | 111 | 4.55 | 14.7 | 216 | 130 | 0.60 | --- |
| Effluent<br>0800 h-1600 h<br>25 Mar. 80 | 358 | 198 | 0.55 | 71 | 132 | 17 | 4.88 | 14.5 | 198 | 100 | 0.51 | 23 |
| Influent<br>1700 h-2400 h<br>25 Mar. 80 | 787 | 409 | 0.52 | --- | 269 | 46 | 4.52 | 19.9 | 191 | 116 | 0.61 | --- |
| Effluent<br>1700 h-2400 h<br>25 Mar. 80 | 517 | 265 | 0.51 | 35 | 154 | 14 | 4.22 | 20.3 | 164 | 116 | 0.71 | NIL |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>26 Mar. 80 | 1146 | 580 | 0.51 | --- | 446 | 33 | 4.64 | 15.1 | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>26 Mar. 80 | 362 | 173 | 0.48 | 70 | 85 | 3 | 4.40 | 14.3 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>26 Mar. 80 | 1051 | 483 | 0.46 | --- | 454 | 18 | 3.82 | 24.5 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>26 Mar. 80 | 608 | 282 | 0.46 | 42 | 183 | 6 | 3.90 | 24.9 | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>27 Mar. 80 | 947 | 440 | 0.46 | --- | 442 | 27 | 4.34 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>27 Mar. 80 | 642 | 308 | 0.48 | 30 | 258 | 15 | 4.49 | --- | --- | --- | --- | --- |
| Influent<br>1800 h-2400 h<br>27 Mar. 80 | 579 | 300 | 0.52 | --- | 264 | 30 | 4.30 | --- | --- | --- | --- | --- |
| Effluent<br>1800 h-2400 h<br>27 Mar. 80 | 248 | 130 | 0.52 | 57 | 60 | 5 | 4.56 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | NH$_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>1000 h-1600 h<br>28 Mar. 80 | 1440 | 683 | 0.47 | --- | 640 | 42 | 4.42 | --- | 275 | 143 | 0.52 | --- |
| Effluent<br>1000 h-1600 h<br>28 Mar. 80 | 519 | 255 | 0.49 | 63 | 150 | 13 | 4.30 | --- | 236 | 134 | 0.57 | 6.3 |
| Influent<br>1700 h-2400 h<br>28 Mar. 80 | 881 | 433 | 0.49 | --- | 344 | 24 | 3.92 | --- | 245 | 145 | 0.59 | --- |
| Effluent<br>1700 h-2400 h<br>28 Mar. 80 | 426 | 198 | 0.47 | 54 | 82 | 4 | 3.89 | --- | 285 | 155 | 0.54 | NIL |
| Influent<br>0900 h-1600 h<br>31 Mar. 80 | 1456 | 740 | 0.51 | --- | 544 | 113 | 4.50 | 34.7 | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>31 Mar. 80 | 740 | 386 | 0.52 | 48 | 142 | 18 | 3.47 | 43.0 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>31 Mar. 80 | 874 | 474 | 0.54 | --- | 284 | 34 | 4.18 | 33.1 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>31 Mar. 80 | 453 | 250 | 0.56 | 47 | 81 | 7 | 3.85 | 33.0 | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | NH$_3$N (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent 0800 h-1600 h 1 Apr. 80 | 798 | 466 | 0.58 | --- | 496 | 17 | 4.08 | 20.6 | 243 | 127 | 0.52 | --- |
| Effluent 0800 h-1600 h 1 Apr. 80 | 361 | 195 | 0.54 | 58 | 110 | 6 | 4.17 | 21.1 | 239 | 122 | 0.51 | 4 |
| Influent 1700 h-2400 h 1 Apr. 80 | 793 | 476 | 0.60 | --- | 324 | 15 | 4.06 | 27.5 | 336 | 183 | 0.54 | --- |
| Effluent 1700 h-2400 h 1 Apr. 80 | 373 | 207 | 0.55 | 57 | 68 | 1 | 4.09 | 26.3 | 338 | 170 | 0.50 | 7 |
| Influent 0900 h-1600 h 2 Apr. 80 | 1134 | 672 | 0.59 | --- | 460 | 33 | 3.79 | --- | --- | --- | --- | --- |
| Effluent 0900 h-1600 h 2 Apr. 80 | 469 | 282 | 0.60 | 58 | 124 | 35 | 3.77 | --- | --- | --- | --- | --- |
| Influent 1700 h-2400 h 2 Apr. 80 | 642 | 348 | 0.54 | --- | 266 | 30 | 3.85 | --- | --- | --- | --- | --- |
| Effluent 1700 h-2400 h 2 Apr. 80 | 454 | 252 | 0.56 | 28 | 81 | 9 | 4.00 | --- | --- | --- | --- | --- |

## APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>3 Apr. 80 | 880 | 490 | 0.56 | --- | 482 | 31 | 3.25 | --- | 240 | 173 | 0.72 | --- |
| Effluent<br>0800 h-1600 h<br>3 Apr. 80 | 245 | 151 | 0.62 | 69 | 156 | 9 | 3.62 | --- | 171 | 127 | 0.74 | 27 |
| Influent<br>1700 h-2400 h<br>3 Apr. 80 | 704 | 397 | 0.56 | --- | 432 | 53 | 5.40 | --- | 293 | 202 | 0.69 | --- |
| Effluent<br>1700 h-2400 h<br>3 Apr. 80 | 323 | 190 | 0.59 | 52 | 230 | 10 | 4.60 | --- | 246 | 173 | 0.70 | 14 |
| Influent<br>0900 h-1600 h<br>7 Apr. 80 | 1905 | 1248 | 0.65 | --- | 934 | 253 | 4.80 | --- | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>7 Apr. 80 | 920 | 488 | 0.53 | 61 | 366 | 102 | 4.88 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>7 Apr. 80 | 919 | 509 | 0.55 | --- | 416 | 58 | 4.26 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>7 Apr. 80 | 358 | 199 | 0.56 | 60 | 83 | 9 | 4.20 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | Soluble COD/BOD COD (mg/L) | Soluble COD/BOD BOD (mg/L) | Soluble COD/BOD BOD/COD | Soluble COD/BOD % BOD Reduction |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Influent<br>0800 h-1600 h<br>8 Apr. 80 | 959 | 530 | 0.55 | --- | 468 | 59 | 4.37 | 18.8 | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>8 Apr. 80 | 329 | 190 | 0.58 | 64 | 98 | 10 | 4.34 | 19.0 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>8 Apr. 80 | 749 | 359 | 0.48 | --- | 69 | 79 | 4.45 | 25.7 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>8 Apr. 80 | 335 | 203 | 0.61 | 43 | 78 | 3 | 4.13 | 25.3 | --- | --- | --- | --- |
| Influent<br>0900 h-1600 h<br>9 Apr. 80 | 918 | 481 | 0.52 | --- | 404 | 25 | 4.34 | 22.2 | 356 | 177 | 0.50 | --- |
| Effluent<br>0900 h-1600 h<br>9 Apr. 80 | 277 | 175 | 0.63 | 64 | 134 | 4 | 4.22 | 22.0 | 308 | 148 | 0.48 | 16 |
| Influent<br>1700 h-2400 h<br>9 Apr. 80 | 665 | 370 | 0.56 | --- | 278 | 30 | 4.30 | 20.3 | 259 | 134 | 0.52 | --- |
| Effluent<br>1700 h-2400 h<br>9 Apr. 80 | 276 | 146 | 0.53 | 61 | 90 | 4 | 4.39 | 24.3 | 251 | 121 | 0.48 | 10 |

## APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>10 Apr. 80 | 970 | 609 | 0.63 | --- | 538 | 122 | 4.38 | --- | 275 | 158 | 0.57 | --- |
| Effluent<br>0800 h-1600 h<br>10 Apr. 80 | 296 | 167 | 0.56 | 73 | 77 | 5 | 4.32 | --- | 191 | 118 | 0.62 | 25 |
| Influent<br>1700 h-2400 h<br>10 Apr. 80 | 882 | 537 | 0.61 | --- | 412 | 62 | 5.23 | --- | 290 | 176 | 0.61 | --- |
| Effluent<br>1700 h-2400 h<br>10 Apr. 80 | 356 | 218 | 0.61 | 59 | 77 | 4 | 5.05 | --- | 251 | 147 | 0.59 | 16 |
| Influent<br>0900 h-1600 h<br>11 Apr. 80 | 1906 | 989 | 0.52 | --- | 976 | 381 | 4.82 | --- | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>11 Apr. 80 | 557 | 339 | 0.61 | 66 | 178 | 81 | 4.72 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>11 Apr. 80 | 819 | 456 | 0.56 | --- | 320 | 114 | 4.58 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>11 Apr. 80 | 329 | 166 | 0.50 | 64 | 64 | 7 | 4.80 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>14 Apr. 80 | 2119 | 1311 | 0.64 | --- | 912 | 186 | 5.30 | 28.4 | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>14 Apr. 80 | 1138 | 621 | 0.54 | 53 | 408 | 81 | 5.50 | 27.9 | ---- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>14 Apr. 80 | 982 | 526 | 0.54 | --- | 380 | 63 | 5.10 | 24.5 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>14 Apr. 80 | 523 | 289 | 0.55 | 45 | 188 | 14 | 5.05 | 27.1 | --- | --- | --- | --- |
| Influent<br>0800 h-1600 h<br>15 Apr. 80 | 1168 | 695 | 0.60 | --- | 456 | 57 | 5.40 | 21.2 | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>15 Apr. 80 | 702 | 387 | 0.55 | 44 | 262 | 34 | 5.30 | 16.1 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>15 Apr. 80 | 633 | 324 | 0.51 | --- | 254 | 36 | 4.85 | 17.8 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>15 Apr. 80 | 200 | 110 | 0.55 | 66 | 102 | 12 | 4.50 | 15.2 | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

|  |  |  |  |  |  |  |  |  | Soluble COD/BOD |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>16 Apr. 80 | 1011 | 605 | 0.60 | --- | 342 | 24 | 4.50 | --- | 360 | 214 | 0.59 | --- |
| Effluent<br>0900 h-1600 h<br>16 Apr. 80 | 339 | 221 | 0.65 | 63 | 68 | 8 | 4.64 | --- | 310 | 171 | 0.55 | 20 |
| Influent<br>1700 h-2400 h<br>16 Apr. 80 | 858 | 464 | 0.54 | --- | 316 | 40 | 4.30 | --- | 351 | 196 | 0.56 | --- |
| Effluent<br>1700 h-2400 h<br>16 Apr. 80 | 372 | 263 | 0.70 | 43 | 77 | 1 | 4.25 | --- | 332 | 183 | 0.55 | 7 |
| Influent<br>0800 h-1600 h<br>17 Apr. 80 | 1395 | 795 | 0.57 | --- | 572 | 71 | 4.58 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>17 Apr. 80 | 425 | 258 | 0.61 | 68 | 110 | 10 | 4.50 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>17 Apr. 80 | 845 | 468 | 0.55 | --- | 340 | 30 | 4.15 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>17 Apr. 80 | 448 | 254 | 0.57 | 46 | 100 | 6 | 4.13 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0900 h-1600 h<br>18 Apr. 80 | 1834 | 888 | 0.48 | --- | 640 | 102 | 4.39 | --- | 350 | 156 | 0.45 | --- |
| Effluent<br>0900 h-1600 h<br>18 Apr. 80 | 574 | 301 | 0.52 | 66 | 150 | 24 | 4.37 | --- | 296 | 141 | 0.48 | 10 |
| Influent<br>1700 h-2400 h<br>18 Apr. 80 | 1280 | 695 | 0.54 | --- | 452 | 149 | 4.20 | --- | 271 | 128 | 0.47 | --- |
| Effluent<br>1700 h-2400 h<br>18 Apr. 80 | 389 | 183 | 0.47 | 73 | 100 | 22 | 4.10 | --- | 261 | 128 | 0.49 | NIL |
| Influent<br>0800 h-1600 h<br>21 Apr. 80 | 1782 | 976 | 0.55 | --- | 680 | 132 | 4.01 | --- | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>21 Apr. 80 | 504 | 261 | 0.52 | 73 | 104 | 17 | 4.00 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>21 Apr. 80 | 992 | 460 | 0.46 | --- | 340 | 63 | 3.58 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>21 Apr. 80 | 426 | 234 | 0.55 | 49 | 82 | 10 | 3.89 | --- | --- | --- | --- | --- |

APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>22 Apr. 80 | 1228 | 625 | 0.51 | --- | 468 | 50 | 4.60 | 11.6 | --- | --- | --- | --- |
| Effluent<br>0800 h-1600 h<br>22 Apr. 80 | 324 | 163 | 0.50 | 74 | 44 | 3 | 4.55 | 10.4 | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>22 Apr. 80 | 856 | 432 | 0.50 | --- | 296 | 44 | 4.05 | 17.1 | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>22 Apr. 80 | 333 | 162 | 0.49 | 63 | 28 | 4 | 4.05 | 17.0 | --- | --- | --- | --- |
| Influent<br>0900 h-1600 h<br>23 Apr. 80 | 1173 | 601 | 0.51 | --- | 508 | 42 | 3.80 | 12.0 | 348 | 191 | 0.55 | --- |
| Effluent<br>0900 h-1600 h<br>23 Apr. 80 | 462 | 263 | 0.57 | 56 | 116 | 14 | 3.65 | 15.0 | 232 | 139 | 0.60 | 27.2 |
| Influent<br>1700 h-2400 h<br>23 Apr. 80 | 1061 | 591 | 0.56 | --- | 458 | 74 | 4.20 | 14.9 | 222 | 137 | 0.62 | --- |
| Effluent<br>1700 h-2400 h<br>23 Apr. 80 | 392 | 213 | 0.54 | 64 | 127 | 11 | 4.26 | 14.1 | 217 | 128 | 0.59 | 6.6 |

## APPENDIX III DATA FROM LCZ SAMPLING PROGRAM - 26 FEB. 80 TO 25 APRIL 80 (cont'd)

| | | | | | | | | | Soluble COD/BOD | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Point and Time | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction | TSS (mg/L) | Oil & Grease (mg/L) | pH | $NH_3N$ (mg/L) | COD (mg/L) | BOD (mg/L) | BOD/COD | % BOD Reduction |
| Influent<br>0800 h-1600 h<br>24 Apr. 80 | 904 | 498 | 0.55 | --- | 348 | 37 | 4.40 | --- | 236 | 209 | 0.88 | --- |
| Effluent<br>0800 h-1600 h<br>24 Apr. 80 | 252 | 149 | 0.59 | 70 | 37 | 7 | 4.39 | --- | 190 | 97 | 0.51 | --- |
| Influent<br>1700 h-2400 h<br>24 Apr. 80 | 817 | 460 | 0.56 | --- | 272 | 32 | 4.30 | --- | 227 | 110 | 0.48 | --- |
| Effluent<br>1700 h-2400 h<br>24 Apr. 80 | 248 | 157 | 0.63 | 66 | 48 | 3 | 4.38 | --- | 234 | 132 | 0.56 | --- |
| Influent<br>0900 h-1600 h<br>25 Apr. 80 | 923 | 478 | 0.52 | --- | 562 | 23 | 4.58 | --- | --- | --- | --- | --- |
| Effluent<br>0900 h-1600 h<br>25 Apr. 80 | 334 | 207 | 0.62 | 57 | 147 | 7 | 4.30 | --- | --- | --- | --- | --- |
| Influent<br>1700 h-2400 h<br>25 Apr. 80 | 760 | 418 | 0.55 | --- | 286 | 24 | 4.87 | --- | --- | --- | --- | --- |
| Effluent<br>1700 h-2400 h<br>25 Apr. 80 | 417 | 249 | 0.60 | 40 | 161 | 12 | 4.16 | --- | --- | --- | --- | --- |

## APPENDIX III ANALYSIS OF FLOAT SAMPLES - EXISTING BASIN

Moisture shown in percent by weight

| Sample Date | Time | Moisture |
|---|---|---|
| 3 March 80 | 0920 h | 65.58 |
| 5 March 80 | 0845 h | 59.43 |
| 7 March 80 | 0830 h | 57.94 |
| 10 March 80 | 0830 h | 65.46 |
| 12 March 80 | 0845 h | 60.73 |
| 14 March 80 | 0910 h | 63.82 |
| 17 March 80 | 0945 h | 61.32 |
| 19 March 80 | 0830 h | 57.65 |
| 21 March 80 | 0800 h | 47.57 |
| 26 March 80 | 0830 h | 52.42 |
| 28 March 80 | 0830 h | 15.91 |
| 31 March 80 | 0830 h | 64.04 |
| 2 April 80 | 0830 h | 62.60 |
| 7 April 80 | 0815 h | 41.47 |
| 9 April 80 | 0830 h | 50.16 |
| 11 April 80 | 0830 h | 33.26 |
| 14 April 80 | 0830 h | 65.75 |
| 16 April 80 | 0830 h | 35.48 |
| 18 April 80 | 0830 h | 24.19 |
| 21 April 80 | 0830 h | 59.93 |
| 23 April 80 | 0830 h | 31.54 |
| 25 April 80 | 0830 h | 32.88 |

Note: A good deal of free oil and fat was noticeable in nearly all samples.

## APPENDIX III ANALYSIS OF BOTTOM SLUDGE SAMPLES - EXISTING BASIN

Moisture shown in percent by weight

| Sample Date | Time | Moisture |
|---|---|---|
| 4 March 80 | 0930 h | 87.29 |
| 5 March 80 | 0930 h | 88.34 |
| 6 March 80 | 1230 h | 88.15 |
| 7 March 80 | 0950 h | 86.17 |
| 10 March 80 | 0930 h | 97.37 |
| 11 March 80 | 0945 h | 92.02 |
| 12 March 80 | 1045 h | 88.14 |
| 13 March 80 | 0930 h | 91.90 |
| 14 March 80 | 0930 h | 84.62 |
| 17 March 80 | 0945 h | 85.90 |
| 18 March 80 | 0930 h | 89.56 |
| 19 March 80 | 0930 h | 92.78 |
| 20 March 80 | 0945 h | 89.38 |
| 21 March 80 | 0930 h | 96.43 |
| 25 March 80 | 0930 h | 92.82 East pipe |
| 25 March 80 | 0930 h | 95.11 West pipe |
| 26 March 80 | 0930 h | 89.40 |
| 27 March 80 | 0945 h | 91.32 |
| 28 March 80 | 0930 h | 89.94 |
| 31 March 80 | 0930 h | 91.32 |
| 1 April 80 | 0930 h | 89.30 |
| 2 April 80 | 0930 h | 87.37 |
| 3 April 80 | 0930 h | 89.17 |
| 7 April 80 | 0930 h | 91.06 |
| 8 April 80 | 0930 h | 92.62 |
| 9 April 80 | 0930 h | 92.90 |
| 10 April 80 | 0930 h | 92.89 |
| 11 April 80 | 0930 h | 87.10 |
| 14 April 80 | 0930 h | 85.67 |
| 15 April 80 | 0930 h | 91.75 |
| 16 April 80 | 0930 h | 90.23 |
| 17 April 80 | 0930 h | 82.04 |
| 18 April 80 | 0930 h | 97.06 |
| 21 April 80 | 0930 h | 92.00 |
| 22 April 80 | 0930 h | 93.20 |
| 23 April 80 | 0930 h | 90.12 |
| 24 April 80 | 0930 h | 86.81 |
| 25 April 80 | 0930 h | 95.57 |

## APPENDIX III MOISTURE AND OIL AND GREASE ANALYSES - LCZ FLOAT SAMPLES

| Sample Date | Time | Temp. (°C) | pH | Moisture (%) | Oil & Grease (Freon Extractable) as % of dry solids |
|---|---|---|---|---|---|
| 3 March | 1855 h | -- | --- | | |
| | 2200 h | -- | --- | | |
| | 2325 h | -- | --- | 86.66 | 53.21 |
| 4 March | 1100 h | -- | --- | | |
| | 1430 h | -- | 4.8 | | |
| | 2225 h | -- | 4.4 | 91.70 | 54.15 |
| 5 March | 0840 h | 30 | 4.8 | | |
| | 2235 h | 35 | 4.8 | | |
| | 2325 h | 37 | 4.9 | 92.51 | 57.00 |
| 6 March | 1745 h | 32 | 4.7 | | |
| | 2205 h | 30 | 4.5 | | |
| | 2325 h | 28 | 4.3 | 93.09 | 31.00 |
| 7 March | 1025 h | 34 | 4.7 | | |
| | 1320 h | 27 | 4.7 | | |
| | 1510 h | 29 | 4.5 | 94.04 | 38.49 |
| 10 March | 1630 h | 30 | 4.4 | | |
| | 2000 h | 32 | 4.3 | | |
| | 2245 h | 32 | 4.3 | 91.96 | 68.09 |
| 11 March | 1245 h | 29 | 4.3 | | |
| | 1630 h | 28 | 4.6 | | |
| | 2330 h | 28 | 4.9 | 93.39 | 42.61 |
| 12 March | 1625 h | 30 | 4.4 | | |
| | 2130 h | 30 | 4.3 | | |
| | 2340 h | 29 | 4.3 | 93.82 | 54.71 |
| 13 March | 1014 h | 26 | 4.5 | | |
| | 1830 h | 29 | 4.7 | | |
| | 2330 h | 28 | 3.9 | 94.61 | 37.54 |
| 14 March | 1100 h | 21 | 4.0 | | |
| | 1830 h | 29 | 4.3 | | |
| | 2320 h | 29 | 4.7 | 93.64 | |
| 17 March | 1030 h | 19 | 4.4 | | |
| | 1820 h | 28 | 4.4 | | |
| | 2300 h | 31 | 4.4 | 94.30 | |

## APPENDIX III MOISTURE AND OIL AND GREASE ANALYSES - LCZ FLOAT SAMPLES (cont'd)

| Sample Date | Time | Temp. (°C) | pH | Moisture (%) | Oil & Grease (Freon Extractable) as % of dry solids |
|---|---|---|---|---|---|
| 18 March | 1625 h | 31 | 4.5 | | |
| | 2025 h | 32 | 4.6 | | |
| | 2340 h | 31 | 4.4 | 94.56 | |
| 19 March | 1120 h | 26 | 4.6 | | |
| | 1930 h | 29 | 4.7 | | |
| | 2325 h | 29 | 4.3 | 92.26 | |
| 20 March | 1130 h | 28 | 4.9 | | |
| | 1925 h | 29 | 4.5 | | |
| | 2315 h | 28 | 4.9 | 80.36 | |
| 21 March | 2330 h | 24 | 4.7 | | |
| | 1830 h | 29 | 4.8 | 93.68 | |
| 24 March | 1745 h | 30 | 4.5 | | |
| | 2400 h | 27 | 4.7 | 93.33 | |
| 25 March | 1200 h | 28 | 5.0 | | |
| | 1830 h | 28 | 4.3 | | |
| | 2315 h | 29 | 4.6 | 92.65 | |
| 26 March | 1030 h | 29 | 3.9 | | |
| | 2045 h | 35 | 5.2 | | |
| | 2330 h | 31 | --- | 93.68 | |
| 27 March | 1820 h | 27 | 4.7 | | |
| | 2330 h | 30 | 4.5 | 94.01 | |
| 28 March | 1120 h | 24 | 5.7 | | |
| | 1820 h | 32 | 4.2 | | |
| | 2400 h | 28 | 3.8 | 92.40 | |
| 31 March | 1520 h | 30 | 4.0 | 93.78 | |
| | 2145 h | 32 | 3.9 | | |
| | 2350 h | 30 | 4.0 | | |
| 1 April | 1200 h | 28 | 4.1 | 94.40 | |
| | 1820 h | 29 | 4.2 | | |
| | 2345 h | 28 | 4.1 | | |
| 2 April | 1115 h | 26 | 3.9 | 93.43 | |
| | 1700 h | 29 | 4.2 | | |
| | 2320 h | 28 | 4.1 | | |

APPENDIX III MOISTURE AND OIL AND GREASE ANALYSES - LCZ FLOAT SAMPLES (cont'd)

| Sample Date | Time | Temp. (°C) | pH | Moisture (%) | Oil & Grease (Freon Extractable) as % of dry solids |
|---|---|---|---|---|---|
| 3 April | 1410 h | 31 | 3.8 | 94.54 | |
| | 1910 h | 31 | 4.9 | | |
| | 2320 h | 27 | 4.8 | | |
| 7 April | 1430 h | 30 | 4.6 | 91.00 | |
| | 2315 h | 30 | 3.9 | | |
| 8 April | 1215 h | 29 | 4.5 | 93.21 | |
| | 1850 h | 29 | 4.3 | | |
| | 2340 h | 29 | 4.3 | | |
| 9 April | 1230 h | 29 | 4.5 | 94.25 | |
| | 1910 h | 33 | 4.6 | | |
| | 2320 h | 30 | 4.8 | | |
| 10 April | 1220 h | 29 | 4.6 | 93.70 | |
| | 1820 h | 31 | 5.3 | | |
| | 2320 h | 28 | 5.3 | | |
| 11 April | 1220 h | 30 | 4.8 | 89.31 | |
| | 1845 h | 32 | 5.3 | | |
| | 2300 h | 28 | 4.6 | | |
| 14 April | 1700 h | 32 | 5.4 | 94.07 | |
| | 2200 h | 32 | 4.7 | | |
| | 2345 h | 31 | 4.5 | | |
| 15 April | 1415 h | 29 | 5.3 | 94.41 | |
| | 2020 h | 30 | 6.4 | | |
| | 2315 h | 28 | 4.5 | | |
| 16 April | 1330 h | 29 | 4.6 | 93.16 | |
| | 2015 h | 33 | 4.7 | | |
| | 2320 h | 31 | 4.5 | | |
| 17 April | 1320 h | 31 | 4.6 | 92.13 | |
| | 1930 h | 33 | 4.3 | | |
| | 2320 h | 33 | 4.6 | | |
| 18 April | 1300 h | 29 | 4.6 | 90.36 | |
| | 1850 h | 28 | 4.5 | | |
| | 2315 h | 28 | 4.4 | | |

## APPENDIX III MOISTURE AND OIL AND GREASE ANALYSES - LCZ FLOAT SAMPLES (cont'd)

| Sample Date | Time | Temp. (°C) | pH | Moisture (%) | Oil & Grease (Freon Extractable) as % of dry solids |
|---|---|---|---|---|---|
| 21 April | 1920 h | 33 | 4.3 | 91.46 | |
| | 2320 h | 29 | 4.0 | | |
| 22 April | 1345 h | 29 | 4.9 | 93.15 | |
| | 1950 h | 34 | 4.6 | | |
| | 2330 h | 32 | 4.7 | | |
| 23 April | 1315 h | 30 | 8.5* | 90.54 | |
| | 1915 h | 32 | 4.7 | | |
| | 2315 h | 30 | 4.4 | | |
| 24 April | 1350 h | 33 | 4.7 | 93.40 | |
| | 2020 h | 35 | 5.0 | | |
| | 2350 h | 29 | 4.4 | | |
| 25 April | 1330 h | 29 | 5.0 | 93.06 | |
| | 1950 h | 34 | 4.7 | | |
| | 0020 h | 27 | 4.3 | | |

* Reported from plant - possibly in error; probably should read 4.5

# APPENDIX IV

## OPERATING COSTS AND RETURN ON INVESTMENT CALCULATIONS

# APPENDIX IV OPERATING COSTS AND RETURN ON INVESTMENT CALCULATIONS

## 1) Estimated By-product Recovery from Operation of LCZ.*

Meat Meal (APF or Cracklings)

| | |
|---|---|
| Annual average yield 1977, 1978, 1979 | 22.62 kg/head |
| Average head processed per day | 600 |
| Total daily production APF, 22.62 x 600 = | 13 573 kg |
| Average yield 1980 | 24.68 kg/head |
| Average head processed per day | 600 |
| Total daily production APF, 24.68 x 600 = | 14 809 kg |

Increase in daily production, 14 809 - 13 573 = 1 236 kg

Inedible Tallow

Swift data shows a substantial increase in inedible tallow recovery during 1979 due to in-house improvements. Therefore 1979 is assumed to be the base year and the increase in recovery from the LCZ is the increase in 1980 over the 1979 figure.

Based on processing 600 head per day this increase in recovery is 1 309 kg/d.

Increase in Revenue

| | |
|---|---|
| Price for APF | $ 0.330/kg |
| Price for inedible tallow | 0.506/kg |
| AFP revenue, 1 235 x 0.330 | 407.55 |
| Inedible tallow revenue, 1 309 x 0.506 | 662.35 |
| Total increase in revenue per day | $ 1 069.90 |

## 2) Daily LCZ Operating Costs

Chemical Usage

| | | |
|---|---|---|
| Polymer | 1.18 kg @ $6.64 | 7.84 |
| Acid | 27.00 kg @ $1.06 | 28.62 |
| Caustic | 27.00 kg @ $1.63 | 44.01 |
| | | $ 80.47 |
| Electrical Costs | | $ 33.00 |

---

* Yield figures supplied by Swift Canadian Ltd.

### Wastewater Labour

| | | |
|---|---|---|
| Operator | $ 84.24 | |
| Cleaning Unit - once per month, 2 men, $252.72, pro-rated on basis of 20 days per month - daily | 12.64 | |
| | $ 96.88 | $ 96.88 |

### Rendering Labour

| | |
|---|---|
| LCZ requires approximately 3 hours additional labor @ $7.50 per hour | $ 22.50 |

### Maintenance

Cost of replacing electrodes -
Total number of electrodes 500,
Estimated life 5-6 years,
Cost per unit $100 - $150,
Assume life of 5 years and
replacement cost of $150.

Replacement cost of 500
electrodes in five years
is 500 x 150 = $75 000.00

Cost per year = $15 000.00

| | | |
|---|---|---|
| Assuming a 250-day operating year, cost per day is | $ 60.00 | |
| Allowing $60.00 per day for labour for replacements and for escalation in electrode cost | 60.00 | |
| | $120.00 | $ 120.00 |

Steam costs for rendering -

Cost of steam at Lethbridge is $2.69 per 1 000 lb ($5.92 per 1 000 kg).

Approximately 10 455 kg steam is required to render 6 818 kg wet skimmings.

Case 1 - Assume additional daily yield of 2 545 kg dry weight (total cracks and inedible tallow).

Assuming 80% moisture, the total amount to render is

$$\frac{2\,545 \times 100}{20} = 12\,725 \text{ kg}$$

Steam required $\frac{12\,725}{6\,818} = 1.87 \times 10\,455 = 19\,513$ kg

Cost of steam/day $= \frac{19\,513 \times 5.93}{1\,000} = \$115.71$

Case 2 - Assume yield of 2 545 kg dry weight.

Assume 92% moisture (as determined during March - April run).

Total amount to render is

$$\frac{2\,545 \times 100}{8} = 31\,812 \text{ kg}$$

Steam required $\frac{31\,812}{6\,818} = 48\,782$ kg

Cost of steam per day $\frac{48\,782 \times 5.93}{1\,000} = \$289.28$

## 3) **Summary - Daily Costs and Revenue**

| Costs | | | Revenue | |
|---|---|---|---|---|
| Chemicals | | | APF | 407.55 |
| Polymer | 7.84 | | Tallow | 662.35 |
| Acid | 28.62 | | | 1 069.90 |
| Caustic | 44.01 | | | |
| | 80.47 | 80.47 | | |
| Electricity | | 33.00 | | |
| Labour | | | | |
| LCZ | 96.88 | | | |
| Rendering | 22.50 | | | |
| | 119.38 | 119.38 | | |

| | |
|---|---|
| Maintenance | 120.00 |
| | 352.85 |

Steam Costs

| Case 1<br>(80% moisture) | Case 2<br>(92% moisture) |
|---|---|
| 115.71 | 289.28 |
| 352.85 | 352.85 |
| 468.56 | 642.13 |

Difference between Case 1 and Case 2 = $173.57

### 4) Capital Costs and Return on Investment - Evaluation Factors and Assumptions

| | |
|---|---|
| Capital Expenditure: | $522 000 |
| Tax Depreciation*: | Double declining balance, 12-year tax life. |
| Book Depreciation*: | Straight line, 12-year life, $70 000 salvage value after 12 years. |
| Financing: | 10-year loan, at a 9.5% interest rate, repayment started in 1979 of $522 000. |
| Tax Rate: | 50% |
| Revenue*: | 267 475/year |
| Operating Costs*: | 117 140/year |

---

*Notes:

1) Book depreciation rate is 8.3%
2) Tax depreciation is twice book rate. Assume 17%.
3) Net revenue realized in 1980, one year after repayment of capital begins.
4) Both 'revenue' and 'operating costs' were determined based on the assumption that 80% moisture was attained in the float.

DEPRECIATION SCHEDULE

| Year | Undepreciated Capital Cost | Depreciation* |
|---|---|---|
| 1980 | $522 000 | $88 740 |
| 1981 | 433 260 | 73 654 |
| 1982 | 359 606 | 61 133 |
| 1983 | 298 473 | 50 740 |
| 1984 | 247 733 | 42 115 |
| 1985 | 205 618 | 34 955 |
| 1986 | 170 663 | 29 013 |
| 1987 | 141 650 | 24 081 |
| 1988 | 117 569 | 19 987 |
| 1989 | 97 582 | 16 589 |
| 1990 | 80 993 | 13 769 |
| 1991 | 67 224 | 11 428 |
| 1992 | 55 796 | -- |

* Declining balance @ 17% per annum.

## NOTES REGARDING DISCOUNTED RETURN ON INVESTMENT CALCULATIONS AND PROCEDURES - BASE CASE

### Assumptions

1) Total investment repayment started in 1979.
2) Net revenue not realized until 1980.
3) Net revenue is constant for the duration of the tax life, i.e., 12 years.
4) Salvage value at the end of 12 years is $70 000.

### Explanation of R.O.I. Calculations

1) Depreciation calculated at 17% on a double declining balance approach, (calculations shown in Depreciation Schedule).
2) Taxable profit is determined by subtracting the depreciation in column 3 from the net revenue in column 2.
3) After-tax profit is determined by multiplying taxable profit by tax factor (50%).
4) After-tax cash flow is the sum of the after-tax profit and the depreciation.
5) Present value or present worth is calculated by multiplying the after-tax cash flow by the present value factor at a given percentage, in this case 18% and 16%.
6) Return on Investment* is determined by summing the present values for the tax life period (12 years), including the present value of the salvage value, and comparing them to the initial investment. If equal, the appropriate R.O.I. has been determined for the given conditions.

---

*Notes: Initial Trial (18%)

- sum of present value < initial investment
- results in a negative net present value
- implies that R.O.I. is less than 18%

Second Trial (16%)

- sum of present value > initial investment
- results in a positive net present value
- implies that R.O.I. is greater than 16%
- exact determination can be determined by interpolation (arithmetic or graphic).

Actual R.O.I.

- interval between the sum of the present value at 18% and 16% is $39 679.
- the difference between the investment and the sum of the present value at 16% (net PV) is $12 480.
- the ratio of 12 480/39 679 = 0.31 or (0.31 x 2 = 0.62%)
- the actual R.O.I. is 16.62%; say 16.6%.

Payback Period

- determined from after-tax cash flow
- summing after-tax cash flow (cumulative) until a range about the initial investment is found yields between 4 and 5 years.
- by interpolating: interval year 4-5 $96 225
  interval year 4 total to
  initial investment $84 195
  ratio 84 195/96 225 = 0.90
  actual payback period is 4.9 years.

RETURN ON INVESTMENT CALCULATION TABLE - BASE CASE

| Year | 1 Investment | 2 Net Revenue | 3 Depreciation | 4 Taxable Profit | 5 After Tax Profit | 6 After Tax Cash Flow | 7 PV Factor @ 18% | 8 PV | 9 PV Factor @ 16% | 10 PV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | -522 000 | | | | | | 1.0 | -522 000 | 1.0 | -522 000 |
| 1980 | | 150 335 | 88 740 | 61 595 | 30 798 | 119 538 | .8474 | 101 297 | .8621 | 103 054 |
| 1981 | | 150 335 | 73 654 | 76 681 | 33 341 | 111 995 | .7182 | 80 435 | .7432 | 83 235 |
| 1982 | | 150 335 | 61 133 | 89 202 | 44 601 | 105 734 | .6086 | 64 350 | .6407 | 67 744 |
| 1983 | | 150 335 | 50 740 | 99 595 | 49 798 | 100 538 | .5158 | 51 858 | .5523 | 55 527 |
| 1984 | | 150 335 | 42 115 | 108 220 | 54 110 | 96 225 | .4371 | 42 060 | .4761 | 45 813 |
| 1985 | | 150 335 | 34 955 | 115 380 | 57 690 | 92 645 | .3704 | 34 316 | .4104 | 38 022 |
| 1986 | | 150 335 | 29 013 | 121 322 | 60 661 | 89 674 | .3139 | 28 149 | .3538 | 31 727 |
| 1987 | | 150 335 | 24 081 | 126 254 | 63 127 | 87 208 | .2660 | 23 197 | .3050 | 26 598 |
| 1988 | | 150 335 | 19 987 | 130 349 | 65 174 | 85 161 | .2255 | 19 204 | .2630 | 22 397 |
| 1989 | | 150 335 | 16 589 | 133 746 | 66 873 | 83 462 | .1911 | 15 950 | .2267 | 18 921 |
| 1990 | | 150 335 | 13 769 | 136 566 | 68 283 | 82 052 | .1619 | 13 284 | .1954 | 16 033 |
| 1991 | | 150 335 | 11 428 | 138 907 | 69 454 | 80 882 | .1372 | 11 097 | .1684 | 13 621 |
| 1991 | | 70 000 | | | | | .1372 | 9604 | .1684 | 11 788 |
| | | | | | | | | 494 801 | | 534 480 |
| | | | | | | | Net Present Value | -27 199 | | 12 480 |

## NOTES REGARDING RETURN ON INVESTMENT CALCULATIONS ASSUMING NON-PAYMENT OF SURCHARGES AS AN INCOME

1) In a manner similar to the previous calculations the additional value of $100 000/annum was added to the net revenue.
2) An initial R.O.I. of 25% was assumed.
3) Total present value was $575 939 which implies that the actual R.O.I. is greater than 25%.
4) Second trial R.O.I. of 35% was assumed.
5) Total present value was $434 827 which implies that the actual R.O.I. is less than 35%.
6) Actual R.O.I. is 28.8%.
7) Payback Period is 3.2 years.

RETURN ON INVESTMENT CALCULATION TABLE - ASSUMING NON-PAYMENT OF SURCHARGE AS AN INCOME

| Year | 1 Investment | 2 Net Revenue | 3 Depreciation | 4 Taxable Profit | 5 After Tax Profit | 6 After Tax Cash Flow | 7 PV Factor @ 35% | 8 PV | 9 PV Factor @ 25% | 10 PV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | -522 000 | | | | | | 1.0 | -522 000 | 1.0 | -522 000 |
| 1980 | | 250 335 | 88 740 | 161 595 | 80 798 | 169 538 | 0.7407 | 125 577 | 0.8000 | 135 630 |
| 1981 | | 250 335 | 73 654 | 176 654 | 88 341 | 161 995 | 0.5487 | 88 887 | 0.6400 | 103 677 |
| 1982 | | 250 335 | 61 133 | 189 202 | 94 601 | 155 734 | 0.4064 | 63 290 | 0.5120 | 79 736 |
| 1983 | | 250 335 | 50 740 | 199 595 | 99 798 | 150 538 | 0.3011 | 45 327 | 0.4096 | 61 660 |
| 1984 | | 250 335 | 42 115 | 208 220 | 104 110 | 146 225 | 0.2230 | 32 608 | 0.3277 | 47 918 |
| 1985 | | 250 335 | 34 955 | 215 380 | 107 690 | 142 645 | 0.1652 | 23 565 | 0.2621 | 37 387 |
| 1986 | | 250 335 | 29 013 | 221 322 | 110 661 | 139 674 | 0.1224 | 17 096 | 0.2097 | 29 290 |
| 1987 | | 250 335 | 24 081 | 226 254 | 113 127 | 137 208 | 0.0906 | 12 431 | 0.1678 | 23 024 |
| 1988 | | 250 335 | 19 987 | 230 348 | 115 174 | 135 161 | 0.0671 | 9 069 | 0.1342 | 18 139 |
| 1989 | | 250 335 | 16 589 | 233 746 | 116 873 | 133 462 | 0.0497 | 6 633 | 0.1074 | 14 334 |
| 1990 | | 250 335 | 13 769 | 236 566 | 118 283 | 132 052 | 0.0368 | 4 860 | 0.0859 | 11 343 |
| 1991 | | 250 335 | 11 428 | 238 907 | 119 454 | 130 882 | 0.0273 | 3 573 | 0.0687 | 8 992 |
| 1991 | | 70 000 | | | | | 0.0273 | 1 911 | 0.0687 | 4 809 |
| | | | | | | | | 434 827 | | 575 939 |
| | | | | | | | Net Present Value | -87 173 | | 53 939 |

## NOTES REGARDING RETURN ON INVESTMENT CALCULATIONS USING ENVIRONMENT CANADA'S ACCELERATED CAPITAL COST ALLOWANCE (ACCA)

1) All evaluation factors and assumptions are the same as those in the first example, with one exception.
2) ACCA program allows 50% write-off of capital cost in each of the first two years.
3) All R.O.I. calculations are shown in table.
4) The major deviation comes in the taxable profit column, wherein the result of subtracting the depreciation from the net revenue is negative.
5) In a 50% tax bracket half of the taxable profit then becomes an after-tax profit as shown, which is added to the depreciation to yield the after-tax cash flow.
6) The initial trial at an assumed R.O.I. of 25% resulted in a negative net present value (NPV), i.e., actual percent return is lower.
7) The second trial at 20% had a positive NPV, i.e. the actual return is higher.
8) By interpolation the actual R.O.I. is 21.4%
9) Similarly the payback period is 3.5 years.

## SUMMARY OF R.O.I. CALCULATIONS

| | R.O.I. (%) | Payback Period (years) |
|---|---|---|
| Base Case | 16.6 | 4.9 |
| Surcharge Considered | 28.8 | 3.2 |
| ACCA (without surcharge) | 21.4 | 3.5 |

RETURN ON INVESTMENT CALCULATION TABLE - "ACCA"

| Year | 1 Investment | 2 Net Revenue | 3 Depreciation | 4 Taxable Profit | 5 After Tax Profit | 6 After Tax Cash Flow | 7 PV Factor @ 25% | 8 PV | 9 PV Factor @ 20% | 10 PV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | -522 000 | | | | | | 1.0 | -522 000 | 1.0 | -522 000 |
| 1980 | | 150 335 | 261 000 | -110 665 | -55 333 | 205 667 | .8000 | 164 534 | .8333 | 171 382 |
| 1981 | | 150 335 | 261 000 | -110 665 | -55 333 | 205 667 | .6400 | 131 627 | .6944 | 142 815 |
| 1982 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .5120 | 38 486 | .5787 | 43 500 |
| 1983 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .4096 | 30 789 | .4823 | 36 254 |
| 1984 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .3277 | 24 633 | .4019 | 30 210 |
| 1985 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .2621 | 19 702 | .3349 | 25 174 |
| 1986 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .2097 | 15 763 | .2791 | 20 979 |
| 1987 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .1678 | 12 613 | .2326 | 17 484 |
| 1988 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .1342 | 10 088 | .1938 | 14 568 |
| 1989 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .1074 | 8 073 | .1615 | 12 140 |
| 1990 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .0859 | 6 457 | .1346 | 10 118 |
| 1991 | | 150 335 | 261 000 | 150 335 | 75 168 | 75 168 | .0687 | 5 164 | .1122 | 8 434 |
| 1991 | | 70 000 | | | | | .0687 | 4 809 | .1122 | 7 854 |
| | | | | | | | Total | $472 738 | | $540 912 |
| | | | | | | | Net Present Value | -49 262 | | 18 912 |