The Results of a Water and Effluent Study carried out at Richard Coulbeck Limited in August 1997

Confidential Report No. CR128

October 1997

The Sea Fish Industry Authority

Seafish Technology

The Results of a Water and Effluent Study carried out at Richard Coulbeck Limited in August 1997

Confidential Report No. CR128

Authors: M. Archer
R. Watson

October 1997

SEAFISH

The Sea Fish Industry Authority

Seafish Technology

The Results of a Water and Effluent Study carried out at Richard Coulbeck Limited in August 1997

Confidential Report No. CR128

Authors: M. Archer
R. Watson

Summary

In the near future new environmental legislation will add greatly to the cost and difficulty of disposing of waste water, which will present a significant problem to the fish industry. Seafish has commissioned a number of water audits in fish processing companies, to look at water usage and effluent production, with a view to minimising both. This report is concerned with the audit of Richard Coulbeck Ltd.

Water is used throughout the factory, in a number of different processes but primarily in filleting and trimming operations, cleaning and defrosting. The total volume of water used during the 5 day week of the audit was 120m^3, generating approximately 100m^3 of effluent.

Sampling of the main drain leaving the factory was not possible. However, composite effluent samples taken throughout the factory indicate that the effluent for the overall site has a COD of 26,792 mg/l and TSS of 5,440 mg/l. When future full trade effluent charges are applied the cost of effluent disposal could increase from £0.18/m^3 to £11.87/m^3.

The main problem was the amount of high strength effluent generated by the dogfish preparation line ending up in the drain, as a result of poor bench and drain/catch basket design. Opportunities for minimising water use and effluent strength were identified, many of which may be carried out at little or no cost.

Table of Contents

Figures

1. Introduction

In the near future new environmental legislation will add greatly to the cost and difficulty of disposing of waste water, which will present a significant problem to the fish industry. Fish processing requires large volumes of water and similarly produces large volumes of effluent which can have a high level of organic contamination. Traditionally, the effluent in UK coastal regions where the fish processing industry largely remains, has been pumped out to sea at negligible cost but this will change as the Urban Wastewater Treatment Directive (91/271/EEC) demands that by the end of 2001 effluent must be treated before release into the sea.

In the future coastal businesses will be charged on the volume and strength of their effluent; the greater the quantity and the stronger the effluent, the higher the treatment costs. These new trade effluent charges will be calculated using the full Mogden formula which includes a component to meet the cost of the biological effluent treatment required to meet the strict standards set by the Directive. This will bring coastal companies into line with charges already faced by inland businesses.

In some areas the fish industry causes contamination far in excess of the human population and will, inevitably, pay the bulk of the sewerage costs in those areas. Alternatively the water industry may set very low consents to discharge to the public sewers and so the fish industry would have to take on the responsibility for treating its own effluent. These unavoidable increases in costs will ensure that waste management becomes an issue of major commercial importance to all and a survival issue for many.

To find solutions to these water and effluent problems, Seafish has been working with Yorkshire Enterprise Limited and technical consultants to carry out an ERDF funded project in the Humber region. With assistance from the Grimsby and Hull Fish Merchants Associations, 40 small to medium sized fish companies agreed to have a preliminary waste audit carried out in their premises. From the findings of these audits, 7 fish processing companies, representative of the diverse range of industry practices, were chosen. More detailed water audits have been carried out in these companies. The results will be used to develop comprehensive guidance documentation for industry, which will provide detailed advice on carrying out a water audit and how to minimise water use and reduce effluent strength.

This report is concerned with the audit of Richard Coulbeck Ltd. Water usage and the effluent produced were investigated and monitored within the factory. Areas for reducing water consumption and effluent strength are identified.

2. The Preliminary Review

A preliminary waste audit, carried out at the company on 6th March 1997, highlighted some general problems with water usage and effluent production in the process areas. In particular it was felt that the water consumption was too great for the type of process and was proving costly in terms of supply and disposal at over £27,000 per annum. The drainage system was also described as ineffective in terms of preventing solids from entering the main drain.

As a result of this initial waste audit the company installed water meters on all the water points in the main process room at a cost of approximately £2,000. This has led to a significant change in processing practices. Filleters are no longer allowed to use running hose pipes, instead water is bucketed into the filleting bench as and when required. No other change in practices were made as a result of the initial review.

3. The Company

Richard Coulbeck Limited has been based in Grimsby for 25 years and is now one of the largest dogfish processors in the world. The company has an annual turnover of between £10 and £15 million and employs 22 personnel. The Richard Coulbeck group comprises three companies which process a range of more specialised fish species including dogfish, redfish and mock halibut. Salmon and smoked fish are also processed.

3.1 Site Description

The audited site is situated on the North Quay of Grimsby. A plan of the factory is shown in Figure 1. The site consists of three main areas: the main process area where fish are filleted and packed, an ancillary despatch and delivery area which houses the chiller, ice plant and freezer, and an area occupied by another company within the group which primarily fillets and smokes fish.

The majority of the water usage and effluent production occurs in the main processing area, which houses nine filleting benches. Typically, six are used for dogfish preparation, including belly flap skinning, whilst the remaining three benches are used for whitefish.

Two skinning machines, also located in the main process area, are used to skin fillets when required, with a third machine kept on standby for busy periods or in case of breakdowns. Other processes carried out in the main area include washing and packing.

3.2 Factory Water Points and Drainage

A plan of the factory water points and drainage system is shown in Figure 2. Wall mounted taps are positioned around the factory and used to supply water for the individual processes. Most of the taps are timed release but are wired down, when in use, to enable a continuous flow of water.

The main factory drain originates from the canteen/toilets and runs underneath the factory and out into the main sewer. In the main processing area four drainage channels collect effluent from the factory floor. The effluent from each drainage channel runs through a catch basket, before emptying into the main central drain.

The drainage channels consist of 120 mm diameter steel pipe concreted into the floor, with 390 mm x 10 mm slots cut into the upper surface. In places the slot width increases to 40 mm.

The catch baskets are covered by either a cast iron grate with 300 mm x 20 mm slots or a solid cover. The baskets themselves are made from plastic buckets drilled with approximately twenty, 10 mm diameter holes for drainage. These are housed in concrete holders, which are significantly larger than the buckets themselves.

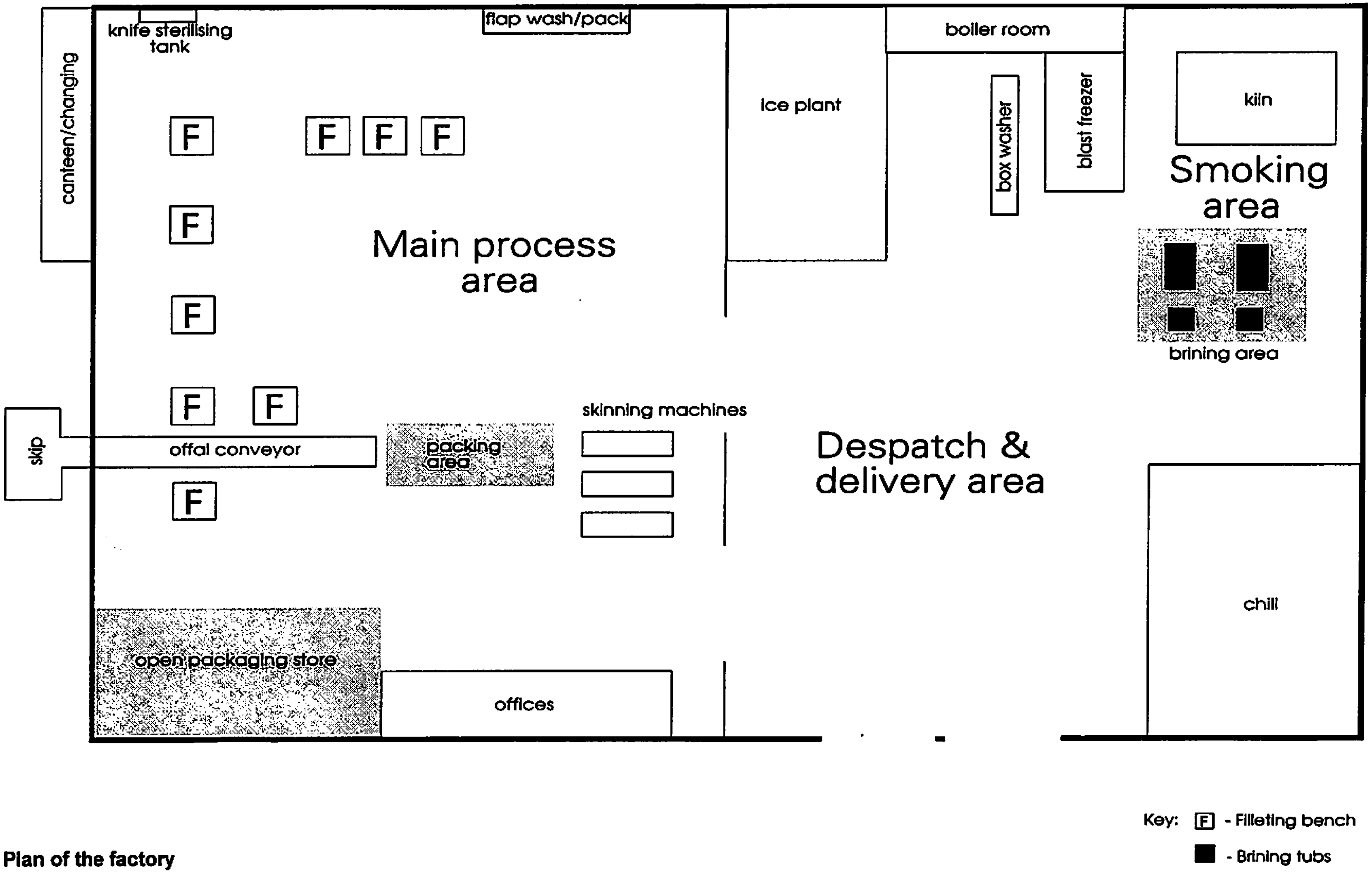

Figure 1 - Plan of the factory

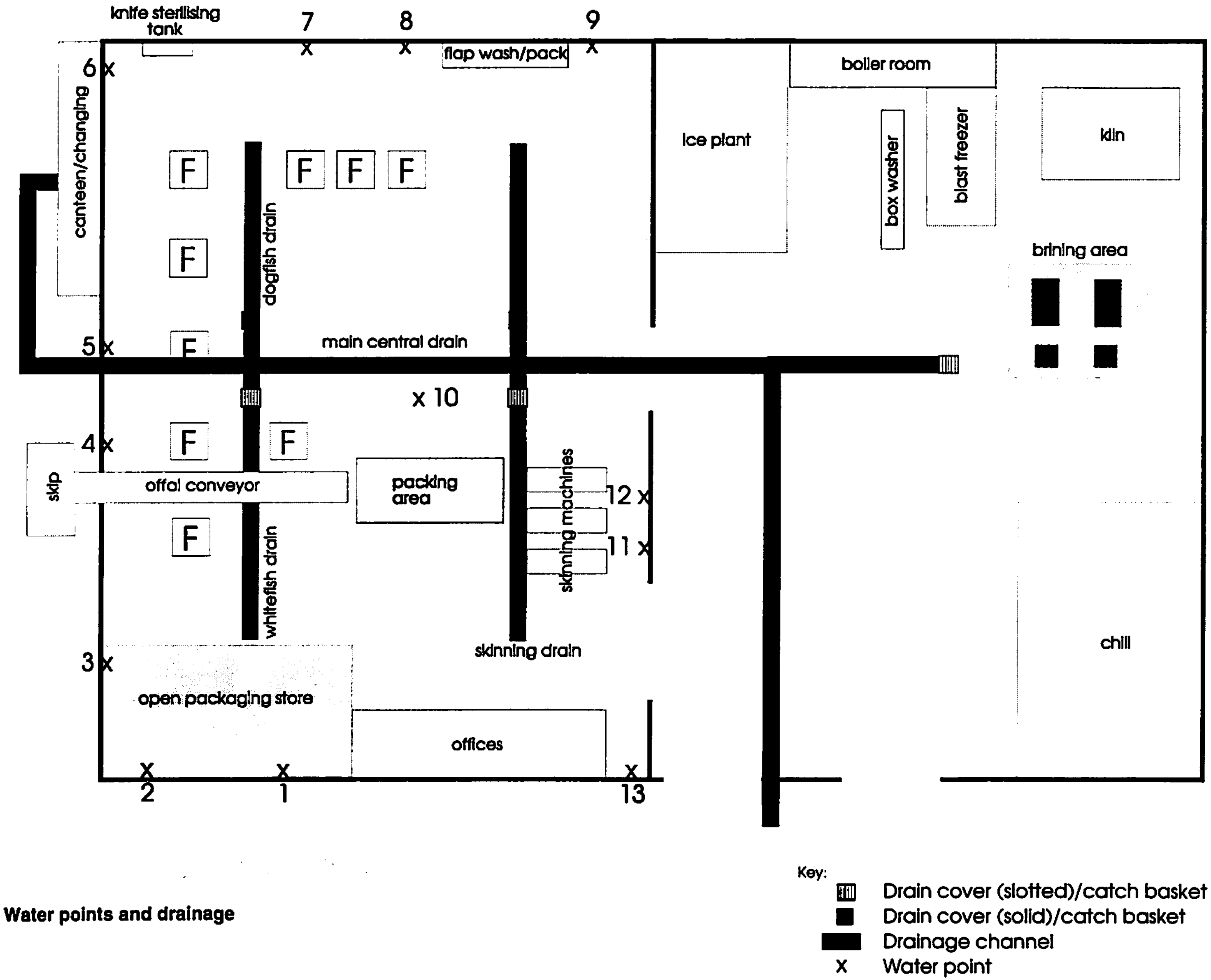

Figure 2 - Water points and drainage

4. The Audit Methodology

In order to investigate the use and contamination of water within the company 6 working days were spent on-site, observing the process and determining where water was used and effluent produced. General site information was obtained from factory personnel.

4.1 Measurement of Water Usage

The volume of water used in each main process was measured.

As the majority of the water points in the factory are individually metered, readings were taken immediately before the start of the working day and every 2 hours, until the end of the working day. Main site readings were also taken.

Two in-line flow meters with a 4-20mA output were installed in the water supplies to the skinning machines. A Squirrel data logger was used to record the flow rates at 1 minute intervals over a five day period. An in-line flow meter was also used to determine the flow rate of the water supply used for defrosting.

The water supply to the ice machine, which is not individually metered, was monitored using a Micronics Portaflow 300 ultrasonic, non-invasive meter, which logged the flow rate at 1 minute intervals, over a five day period.

4.2 Effluent Sampling and Analysis

The strength of the effluent produced by the different processes was determined by taking 1 litre samples. Spot samples were taken directly from equipment i.e. filleting tubs and the skinning machines, whilst an Epic automated effluent sampler was used to obtain composite samples (100 ml every 10 minutes) over a 6 hour period, from different areas of the factory drainage system. The samples of effluent were analysed by the Environment Agency, Laboratory, Leeds.

Samples were analysed for chemical oxygen demand (COD) and total suspended solids (TSS).

4.3 Calculating Trade Effluent Treatment Charges

The COD and TSS values of the effluent were used to estimate the future costs when the effluent will have to be treated. Costs were calculated by the Mogden formula using the 1997 Anglian Water charging rates for treating trade effluent.

Mogden formula:

$$C = R + V + [B \frac{O_t}{O_s}] + [S \frac{S_t}{S_s}]$$

C	=	Cost pence/m^3
R	=	Reception charge = 11.42 pence/m^3
V	=	Preliminary treatment charge = 21.34 pence/m^3
B	=	Biological treatment charge = 17.63 pence/m^3
S	=	Suspended solids charge = 8.38 pence/m^3
O_t	=	Mean organic strength of the trade effluent (COD mg/l)
O_s	=	Mean regional organic strength of domestic sewage = 456 mg/l (COD)
S_t	=	Total suspended solids (TSS) of effluent sample (mg/l)
S_s	=	Mean regional strength of settleable solids in domestic sewage = 383 mg/l

5. Overall Water Usage and Effluent Production

This section gives an overview of water use and effluent production. Over the 5 day period of the audit, 11.9 tonnes of dogfish and 1.8 tonnes of whitefish were produced. The individual processes are discussed in detail in Section 6.

5.1 Water Usage

Water is used throughout the factory for a number of different processes. Each water point can be related to a main processing activity. The location of the water points within the main process area is shown in Figure 2. The water point numbering system is that used by the company. The water consumption at each metered water point, and for each main process, over the week of the audit is shown in Table 1.

Table 1 - Water points in relation to main processing activities and the water usage during the audit

Water point	Processing activities in week of audit	Water usage in 5 day week of audit (m^3)
1	unused	--
2	unused	--
3	whitefish filleting	9.44
4	whitefish filleting	7.61
5	dogfish preparation, cleaning	21.35
6	dogfish preparation	4.69
7	belly flap processing	3.78
8	belly flap processing	13.86
9	unused	--
10	defrosting, cleaning	12.46
11	skinning	7.54
12	skinning	1.72
13	box washing/rinsing, cleaning	7.81
	Total	90.26

The total volume of water used on-site over the week of the audit was $120m^3$. Approximately 25% of the water usage is unmetered by the company. This is primarily used in: the smoking area, ice production, the box washer and power washers and in non-processing areas, such as the kitchens and toilets.

It was calculated that approximately 1.14m^3 was used to produce 1 tonne of dogfish products, whilst 9.47m^3 of water was required to produce 1 tonne of white fish fillets (including daily clean downs, but excluding dogfish belly flap processing and white fish skinning).

5.2 Effluent Production

Due to the main drain carrying both domestic and trade effluent it was impossible to obtain an overall sample of process effluent for the site. Therefore the composite samples from the trade effluent drains inside the factory have to be used as an indicator of the strength of the effluent leaving the site. The source, strength and estimated future costs of the main effluent streams generated in the factory are shown in Table 2. Unfortunately, some of the samples were lost by the Environment Agency when sent for analysis. The future trade effluent charges can be compared to the current charge of £0.18/m^3.

Table 2 The main effluent streams within the factory

Source	Strength		Mogden calculated trade effluent charges (per m^3)	Volume produced in week of audit (m^3)	Mogden calculated trade effluent charges for the 5 day week of the audit
	COD (mg/l)	TSS (mg/l)			
Composite from whitefish filleting drain	--	--	unable to calculate	17.05	unable to calculate
Composite from dogfish preparation drain	49,700	10,000	£21.73	26.00	£565.00
Composite from skinning drain	7,460	1,150	£3.46	9.26	£32.07

Key:
-- Samples lost by EA

Based on the strength of effluent taken from different areas of the factory and knowledge of white fish processing from similar factories, the overall effluent sample for the site is estimated to have a COD of 26,792mg/l and TSS of 5,440mg/l. When future Mogden calculated trade effluent charges are applied the cost of disposing of this strength effluent would increase from £0.18 /m^3 to £11.87 /m^3.

6. The Main Operations

6.1 The Filleting Area

The main types of operations carried out are: dogfish preparation (skinning, gutting and trimming including belly flap preparation), and white fish filleting.

All nine filleting benches are of a traditional design with a central tub separating two cutting boards, allowing a pair of filleters to work facing each other. Two large 434 litre galvanised benches are used, whilst the rest are the more modern stainless steel, 134 litre bench units.

6.1.1 Water Usage

Dogfish skinning, gutting and trimming is carried out without the use of water.

Both whitefish filleting and dogfish belly flap trimming use water, which is generally bucketed into the filleting benches as and when required (water use approximately 1 l/m). However, when filleters believe that they are not being observed hoses are placed into the filleting tubs and left running continuously (26 l/m), see Figure 3.

Figure 3 - Filleters using a continuously running hosepipe

6.1.2 Effluent Production

During dogfish preparation a significant proportion of the guts fall onto the floor, see Figure 4. The average amount of waste ending up on the floor was determined to be 7% (by weight) of the dogfish processed. Two small fish boxes are sometimes placed under the benches to catch the falling waste. In effect, the ends of the boxes catch only a small proportion of the material, most of which drains out of the box through the drainage holes.

Figure 4 - The waste produced during dogfish preparation

The waste material from dogfish preparation consists of approximately 50% soft solids, greater than 20 mm in size, such as liver, yolk sacks and baby dogfish and 50% viscous slime resulting from burst yolk sacks, liquid gut tissue, blood and ice etc. The viscous fluid tends to pool round the bench and slowly flows towards the nearest drain, whilst the soft solids remain around the feet of the filleters, being constantly broken up underfoot. Samples of effluent were taken from a catch tray underneath one of the benches. The average COD was calculated to be 529,133mg/l. It was not possible to obtain a figure for TSS due to the nature of the samples.

During dogfish preparation the guts and trimmings are thrown into the offal bins but a significant amount misses the bin and ends up on the floor. Much of this material is washed or brushed into the drain.

Composite effluent samples were taken from the drain adjacent to the dogfish filleting area. The COD was 49,700 mg/l and the TSS was 10,000 mg/l.

During whitefish filleting and dogfish belly flap skinning, small pieces of fish and trimmings remain in the water in the filleting bench. When the bench drain plug is removed these empty into a catch basket (aperture size 10 mm). A proportion of these small pieces of fish are washed through the mesh of the catch basket onto the floor. A significant amount of trimmings which are thrown towards the offal bins miss and fall onto the floor. These are then washed or brushed into the drain.

Effluent samples were taken directly from the whitefish filleting and belly flap skinning benches. The cod and haddock filleting effluent had a COD of 1380mg/l and TSS of 312mg/l, whereas redfish filleting effluent had a COD of 3,200mg/l and TSS of 522mg/l. The dogfish belly flap skinning effluent had a COD of 42,000mg/l and

TSS of 4,070mg/l. Composite effluent samples were taken from the drain adjacent to the whitefish filleting area, however, these were lost by the Environment Agency.

6.1.3 Conclusions and Recommendations

The current method of dogfish preparation produces a significant volume of very high strength effluent. Calculations indicate that future trade effluent charges associated with this process could increase from the present cost of £0.18/m^3 to £21/m^3 based on the current strength of the effluent stream taken from the drain adjacent to this area. To keep future Mogden calculated trade effluent charges to a minimum this effluent must be prevented from entering the drainage system.

The dogfish filleting benches should be modified so that the dogfish guts are caught before they fall onto the floor. A simple offal tray could be used, see Figure 5. Education is also required to ensure filleters put offal into the fishmeal bin rather than it ending up on the floor.

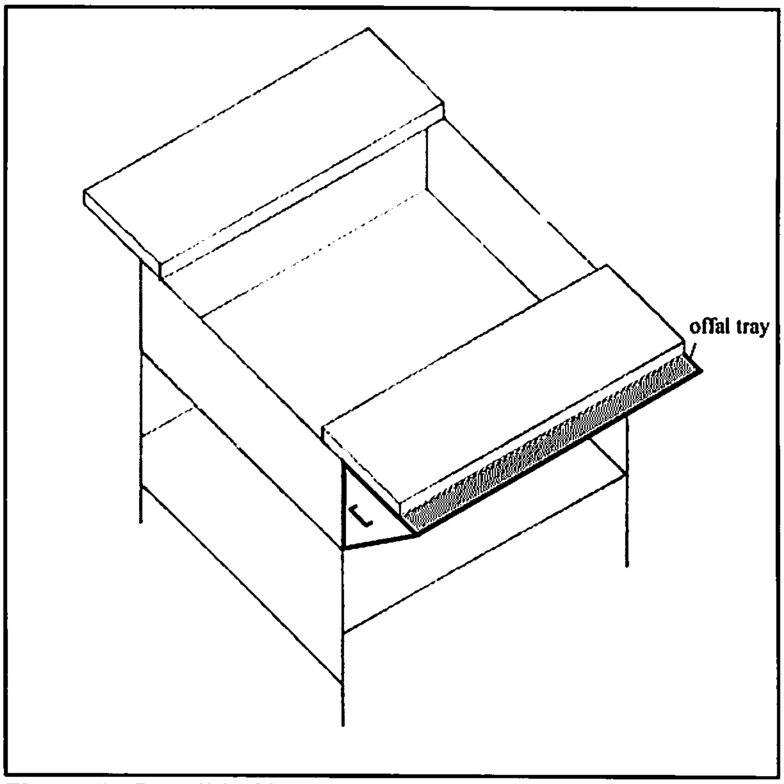

Figure 5 - Possible filleting bench modification

White fish filleting and belly flap trimming and skinning also add a significant contribution to the strength of effluent entering the drain. The future Mogden calculated charges for the effluent taken from the cod and haddock filleting bench is £0.93 /m^3 and £1.68 /m^3 for the effluent taken from the redfish filleting bench. Charges for the effluent taken from the belly flap skinning benches are calculated to be £17.50/m^3.

It is important to control the use of continually flowing hose pipes into filleting benches. A running hose will use approximately 25 times more water than bucketing. It is also likely that a fast flowing hose will stir up and resuspend the organic material which settles at the bottom of the filleting tub, which is likely to make the effluent as strong as when less water is used.

The continuous flow of water from the hoses into filleting tubs could be prevented by shortening the length of the hoses. Alternatively, running hoses could be used with a greatly reduced flow. This can be achieved by fitting flow regulators (approximate cost £10 each excluding installation).

It is important that a watertight bung is fitted in the tubs. Water continually washing through the catch basket underneath the bench drain must be avoided, as it can wash out fine solids and organic material, which may significantly add to the strength of the effluent entering the drain.

Clean water supply to a filleting bench is essential to maintain hygiene but the traditional tub type benches are wasteful in water usage. It is undesirable to leave fish soaking in water and particularly to wash fillets in that same water. Alternative systems are available in which the fish is washed/deiced separately prior to filleting and a controllable water spray is used on the filleting bench to maintain cleanliness and wash the fillets.

6.2 Skinning Machines

The two skinning machines in daily use are manufactured by different companies, one by Varlet (model number V778) and the other by Arenco (model number CUS80). Both are connected to metered water points by flexible hoses. The water supply is turned on and off when required, by either a manually operated valve on the main supply or on the machine itself. Each machine is set up to handle different types of fish.

When the machines are in operation, the waste water and fish skins exit from a waste chute located underneath each skinning mechanism. The skins are collected in catch baskets which are placed on the floor underneath each machine. These are emptied periodically, but mainly when full. The waste water washes through the skins in the catch basket before draining away into the main drainage system.

6.2.1 Water Usage

The results obtained from the data logger show that both skinning machines are used every day, for different periods depending on the particular orders for that day. The Varlet is used most frequently, as more catfish and mock halibut are processed than cod. Between $1m^3$ and $2m^3$ of water was used every day throughout the audit by the Varlet, which was generally used for between 1 and 2 hours, in total, each day. The Arenco was generally used between 30 minutes and one hour in total each day, using less than $0.4m^3$ each day. Over the five days, the skinning machines used a total of $9.26m^3$ of water.

The flow rate of water into the Arenco ranged from 3-31 litres per minute and averaged at 9 l/m. The Varlet flow rates ranged from 3-35 l/m and averaged at 15 l/m. The fluctuations in flow rates, for both machines, are consistent with water being used in other areas of the factory at the same time and affecting pressure.

Water was seen to be wasted in the skinning process, by personnel leaving the water supply turned on when the skinner was not in use.

To determine whether skinning could be carried out using less water without affecting the efficiency (yield) a basic trial was undertaken on the Varlet machine, with mock halibut.

The average flow rate to this machine was 15 l/m. Fish were skinned using flow rates of 15 l/m, 12 l/m and 8 l/m. At each flow rate boxes of fillets were weighed before and after skinning to estimate the yield in order to determine the relative success of the reductions in flow rates. The average yield at the flow rate of 15 l/m was 93%. At the flow rate of 12 l/m the yield was 91%. At 8 l/m the average yield was 90%. At both the 15 l/m and 12 l/m flow rates, excess water was retained on the fillets and in the boxes. This was not evident at the lower flow rate of 8 l/m.

6.2.2 Effluent Production

Effluent is produced as a result of the skinning process. As the water washes through the skins in the catch basket small pieces of solid material are washed out and either deposited on the floor or flow into the drain, see Figure 6. Effluent samples from both the initial waste water and after it washed through the catch basket were taken. The results are shown in Table 3.

Figure 6 - Solid material is washed out of the catch basket by the action of the water

Table 3 - The results of the effluent samples taken from the skinning machine

Fish Species	Flow rate l/m	Sample point	Strength COD (mg/l)	Strength TSS (mg/l)
Mock halibut	15	pre-catch basket	132	50
		post catch basket	1935	1178
Catfish	15	pre-catch basket	1035	328
		post catch basket	4575	nd

Key:
nd - no data

A composite effluent sample, taken from the drain adjacent to the skinning machines, was found to have a COD of 1460 mg/l and TSS of 1150 mg/l.

6.2.3 Conclusions and Recommendations

It is apparent that there is scope for reducing both water consumption and effluent production from the skinning process.

As the water pressure available to the skinning machines changes with the demands of other water users on the system, a flow regulator should be installed into the water supply to each machine to regulate the flow, which often exceeds the level required for efficient skinning. A flow regulator costs approximately £10 (excluding installation) and should have a relatively short payback period.

In addition to regulating the flow rate there appears to be scope for reducing the average flow rate to the Varlet. It is likely that the higher yield at 15 l/m was due to the water which was seen to be retained on the fillets and in the container. The boxes of fillets skinned at the lower flow rates did not visibly contain this water.

Reducing or stabilising the flow rate can result in water cost savings which may prove significant in future years. It may not be advisable to further reduce the flow rate to the Arenco as this already appears to be relatively low.

Calculations indicate that future effluent charges associated with skinning could increase from the present cost of £0.18 /m^3 to £3.46 /m^3, based on the strength of the composite sample taken from the drain adjacent to the skinning area.

The different strengths of the effluent samples indicate that the current practice of allowing water to wash over the skins in the catch basket adds to the effluent load, as the COD is significantly higher than the water which initially falls from the machine. As the water washes through the skins additional pieces of solid material are washed out with the water. This will have a significant effect on future effluent charges, which will be based on the actual strength of the effluent. Calculations indicate that the future effluent disposal costs of the initial water would be £0.39 per m^3, however, by allowing the water to pass through the skins this cost will increase to £1.33 per m^3, based on skinning fish at 15 l/m.

Simple measures could minimise the future costs associated with skinning effluent. Catch baskets should be emptied more frequently, if possible, after each use of the machine. A catch basket, with small drainage holes should be used to assist in preventing a large proportion of solid material from washing out of the basket. It is also important to ensure that the catch basket remains in place underneath the machine, in order to catch all the solid waste material.

Perhaps the best solution would be to prevent the waste water from washing over the fish skins in the catch basket. This would involve modifying the waste chute underneath each skinning machine in order to divert water away from the catch basket. This could be achieved by either diverter plates or a wedge wire chute.

Operators of this equipment should ensure that the water supply is switched off immediately after use, to reduce water use and minimise effluent production. Alternatively, an automatic valve to cut off the flow of water when the machine is not in use would be effective.

6.3 Defrosting

One of the main areas of water usage at the company is defrosting, particularly in winter, when up to five tonnes of frozen fish can be defrosted in water each night.

During the audit approximately 1 tonne of fish, in 50kg blocks, were defrosted in two ways: in air and in water. When defrosting in air the frozen blocks of fish are placed directly on to the floor. These are left overnight, for approximately 18 hours, at ambient temperatures.

The company usually defrosts fish in water by placing frozen blocks of fish, separated by wooden battens, into 660 litre, reusable insulated containers. During the audit, six 50 kg blocks were placed in each container. One container is then stacked on top of another, in a pair, and placed adjacent to a water point. Initially they are both filled with water, then a single hose pipe is then placed approximately 30cm into the top container. At a pre-arranged time in the evening the water supply is switched on and left to run continuously until the start of filleting the next day. As the top container overflows the water was observed to run down the sides of the containers, with little entering the bottom container.

The fish are taken out of the containers at the start of the following day and the water is emptied into the drain. If the fish are not defrosted they are returned to the container and left in water until fully thawed.

In order to estimate the effectiveness of the two defrosting methods the temperatures of a random selection of fish, defrosted in air or water, were taken at the start of the day's processing, when the fish is expected to be fully defrosted. The fish which were defrosted in air were all fully thawed, with temperatures ranging from 1°c to 12°c. The fish which were defrosted in water were not fully defrosted. There was a significant difference between the temperatures of the fish defrosted in the top container, which averaged -1°c, and the temperatures of the fish which were defrosted in the bottom container, which averaged -4°c.

6.3.1 Water Usage

The record of flow rates, obtained by the data logger, shows that the water supply was turned on at 4.30am and was left running continuously until 6.15 am, with a total usage of $3m^3$. The flow rate did not remain constant throughout this period, ranging from 17 l/m to 37 l/m, which is consistent with water being used elsewhere in the factory.

At the time of the audit defrosting in water was undertaken at only one water point but depending on the amount of fish which requires defrosting, up to all of the 13 metered water points can be used in any one night.

6.3.2 Effluent Production

As the fish defrost, slime and other contaminants become suspended in the water and eventually fall to the bottom of each container. It is estimated that approximately 5 kg of wet solid material is left at the bottom of each defrost container. This is also emptied into the drain.

An effluent sample was taken from the container in which the fish were defrosted in water. When analysed, this sample shows that the COD was 123 mg/l and the TSS was 33 mg/l, however, this was not a fully representative sample as a majority of the solid material had settled at the bottom of the container.

6.3.3 Conclusions and Recommendations

Overnight defrosting in air, at this time of year, is particularly effective for thawing fish, however, prolonged exposure to temperatures higher than 15°c should be avoided wherever possible.

In order to improve the hygiene and efficiency of the current method of defrosting fish in air, the blocks could be balanced on the top of reusable fish boxes. This will enable air to circulate around the whole block of fish, to assist defrosting. In addition, it will reduce the need for further handling the fish when defrosted, as they fall into the boxes rather than remain on the floor. When ambient temperatures allow, defrosting in air should be undertaken in preference to defrosting in water, in order to reduce costs.

The observed method of thawing fish in water was very inefficient. The success of this method of defrosting in water is reliant on the continual exchange of water in each container. In particular the container at the bottom of the stack suffered from a very poor exchange of water as a majority of the overflowing water from the top container drips straight onto the floor.

The efficiency of defrosting could be improved by giving each container its own supply of water, preferably with multiple inlets at the bottom of the container to ensure an effective flow around the fish. In winter the water could be heated somewhat using waste heat from the refrigeration system to speed up defrosting and reduce the amount of water used. However, care should be taken to ensure that the temperature of the fish does not exceed 4° C.

There are a range of other options available which could reduce both water consumption and costs, whilst effectively defrosting all the frozen supplies, but these would involve major capital expenditure i.e. specialist defrosting equipment. It is, however, worth considering the long-term cost effectiveness of the purchase of such equipment, against the current and future use of such large volumes of water, particularly when future disposal costs apply.

At current trade effluent charges the disposal of defrost water would cost £0.18/m^3, however, if future trade effluent charges applied this would increase to £0.38/m^3. The increased disposal charges mean that it will be important to try and minimise the volume of water used in defrosting.

6.4 Smoking Area

A separate company operating within the factory fillets and smokes a small quantity of cod, haddock and occasionally dogfish. The fillets are brined before being smoked in an Afos kiln. Two stainless steel tubs, each holding approximately 37 litres of undyed brine and 2 tubs holding approximately 150 litres each of coloured brine are used. These are filled and emptied twice per week and topped up when required.

6.4.1 Water Usage

The main water usage in this area is for filleting and brining. The water supply to this area is not metered, and being a separate company, it is not subject to the same controls that exist in the main process area i.e. a continuous supply of water to the filleting tub is maintained throughout the day, rather than the bucketing system.

As the volume of water used in this area is not individually metered there is no estimation of the volume of water used in filleting over the week of the audit. The water usage in brining was approximately 0.8m^3 per week.

6.4.2 Effluent Production

There is no catch basket underneath the drain plug of the filleting bench, which means small pieces of fish contained in the water fall onto the floor when the tub is drained. These are eventually washed into the drain.

Effluent samples of the brine were taken and sent for analysis. The average COD and TSS of the brine was found to be 8,360 mg/l and 1,644 mg/l, respectively.

6.4.3 Conclusions and Recommendations

It would be beneficial to limit the water usage of filleting in this area, by adopting the same controls which exist in the main process area, or by only turning the water supply on when necessary. The installation of a meter would also ensure that water usage can be properly monitored. A catch basket should be placed underneath the drain plug in order to catch the small pieces of fish which otherwise wash into the drain.

Sodium chloride (salt) can interfere with the COD test, giving values much higher than the true readings and will therefore make the effluent appear more costly to treat. Calculations estimate that this type of effluent could cost approximately £3.91/m^3 to treat in the future. Only the required volume of brine should be used at any one time. Excess brine would not only be costly in the terms of salt and colouring wasted, but also in the high effluent disposal costs. If possible, the brine should be filtered before being emptied into the drain, in order to remove any small pieces of fish.

6.5 Ice Production

A flake ice machine is used to supply ice for the site. The ice is fed into a 50m^3 storage bunker. When this is full a shut-off valve is activated and the water supply to the ice machine is stopped. Surplus ice is sold to other local businesses when required.

6.5.1 Water Usage

The maximum rate of water consumption was approximately 0.24m^3 per hour. Typical water consumption over a 24 hour period was 4.5m^3.

6.5.2 Conclusions and Recommendations

The ice produced on-site is generally packed and sent out with the fish. As it does not go down the drain, trade effluent charges should not be paid for the volume of water used in ice production.

Based on the amount of water used over the 24-hour period, it is calculated that approximately £200 per year could be saved by this means at current charges.

As ice consumption patterns may vary daily, a totaliser water meter should be fitted to the water input to the ice machine. The amount of water used over a longer period could then be determined accurately and the information used to try and claim an allowance from the landlord Associated British Ports (ABP), who in turn deal with Anglian Water. It will become particularly important to claim an allowance when future charges apply, as the increased costs of disposal will apply to the total volume of water used on-site.

6.6 Knife Sterilising Tank

At the end of the day knives and steels are placed in small stainless steel cylinders (3.3 litres) which are then filled with disinfectant. Currently, approximately 12 cylinders are used, and this may increase to 20 during busy periods. The solution of disinfectant is made up in a 270 litres (0.27m^3) stainless steel tub. The knife cylinders are filled by dipping and are then hung on the side of the tank overnight. The tank is generally emptied the following day.

6.6.1 Water Usage

Typically, approximately 200 litres (0.2m^3) of disinfectant solution is made up daily.

6.6.2 Conclusions and Recommendations

As only 40-66 litres/day of disinfectant is required, a significant amount is being wasted. The knife sterilising tank should be replaced with a smaller, wall mounted tank with suitable self closing tap for filling the sterilising cylinders. This modification would save approximately 75% of current water, effluent and disinfectant costs. Disinfection solutions could also be made up more accurately, resulting in consistently effective sterilisation.

6.7 Box Rinsing Containers

The reusable plastic boxes in which fish are delivered are used for holding fillets after filleting. Between the different uses the boxes are rinsed clean. Current practice involves filling a 660 litre container with water and, when required, boxes are rinsed in this water. Two of these box rinsing containers are used, one in the dogfish preparation area and one in the whitefish filleting area. At the end of the day the water from the containers is emptied into the drain. When emptied, a layer of wet solids at the bottom of each container is evident. This is also emptied into the drain.

6.7.1 Water Usage

At current consumption of approximately 0.6m^3 per container, per day, the total volume of water used in a week is approximately 6m^3.

6.7.2 Effluent Production

A sample of the water from both containers was taken and analysed. The effluent from the container in the whitefish area had a COD of 1540 mg/l and TSS of 1456 mg/l. The effluent from the container in the dogfish area had a COD of 859 mg/l and TSS of 316 mg/l.

6.7.3 Conclusions and Recommendations

The current disposal cost of this water is £0.18/m^3. The future costs of disposal as trade effluent are calculated to be £1.24 /m^3 for the container from the whitefish area and £0.73/m^3 for the container from the dogfish area.

The efficacy of this method of cleaning fish boxes for subsequent use with fillets is questionable. Scrubbing and the use of detergent, followed by rinsing with clean water, may be required to clean used fish boxes sufficiently for use with fillets. This may increase, rather than decrease, water use and effluent production. Preferably a different set of fillet boxes should be retained for use within the factory.

6.8 Cleaning

The main source of organic material on the floor comes from the dogfish filleting process. The floor around these filleting benches is cleaned down as necessary during the day, often before a break period. The majority of the solids are shovelled into the fish meal bin, however, a significant amount of waste is brushed and hosed down the drain, see Figure 7. During cleaning, the slot design of the drainage channels allows large solids, such as fish skins, dogfish livers, yolk sacks and baby dogfish to enter the drain. The catch baskets quickly block, causing effluent to overflow, carrying solids up to 40mm in size past the catch basket, into the main drain.

After the last of the dogfish have been prepared a final clean down is carried out. If necessary, a fork lift may be used to tip a 440 litre bin of water to rinse down the floor. Effluent cannot escape past the catch basket fast enough, resulting in large pools of effluent flooding the factory floor, which slowly drain away. The volume of water used in cleaning throughout the day is unknown.

Figure 7 - Large volumes of waste are hosed down the drain

From 9pm to 6am a night cleaner washes down and sanitises the factory floor and drains. Although this operation was not observed, it was calculated that an average of $3.6m^3$ of water was used per night.

6.8.1 Conclusions and Recommendations

All solids on the floor must be collected and shovelled into the fishmeal bin rather than being brushed into the drain which adds to the effluent load. The brushing action itself often breaks up the soft organic material, further increasing the strength of the effluent.

The design of the drainage channels allows personnel to wash or brush large solids down the drain. The drainage channels should be modified to form a smooth shallow channel with stainless steel 6mm punch plate or smaller aperture wedge wire covers. This type of drain cover should act like a high surface area catch basket preventing the majority of solids entering the drain. The design should incorporate a simple locking device, to ensure the drain covers cannot be lifted by general staff.

Catch baskets should also be redesigned with small aperture punch plate or wedge wire stainless steel to ensure a high surface area for filtration and a tight fit in the drain. Catch baskets should be emptied frequently, as effluent washing through a full catch basket picks up additional organic material, which can add significantly to the strength of the effluent.

6.9 Leaks and Wastage

An inspection of the pipe fittings and hoses around the premises showed that water was leaking out of the system. Each water point was monitored and a timed measurement of leaks at each relevant point was taken. The results are shown in Table 4.

Table 4 - An identification of leaking water points

Meter point	Source of leak	Volume wasted (l/m)	Volume wasted in week of audit (l)
1	mains line above	0.04	288
3	tap	0.15	59
4	tap and hosepipe	0.63	154
5	tap and hosepipe	3.75	2748
6	tap	1.00	175
7	hose connection and tap	0.72	102
12	hosepipe	2.50	342
	Total	8.79	3868

6.9.1 Conclusions and Recommendations

The cost of the water leaking from the system over a year, based on the period of the audit, amounts to approximately £152, including disposal.

It is advisable to remove all leaks and limit wastage in the premises, particularly when future charges apply. Regular maintenance of taps and installation of more durable hoses and hose clips would assist in preventing leaks occurring from these areas in the future. Personnel should be properly educated about the reasons behind the need for reducing water consumption i.e. with particular emphasis on continually rising costs.

7. Overall Conclusions and Recommendations

When Mogden calculated trade effluent charges are introduced, the company is likely to face a significant increase in effluent disposal costs. From the effluent samples taken within the factory the overall strength of effluent produced by the factory was estimated to have a COD of about 26,792mg/l and TSS of 5,440mg/l. This would result in effluent treatment charges increasing from the current £0.18/m^3 to £11.87/m^3. Fortunately many low cost or no cost changes in working practices can be implemented to reduce this cost.

- Dogfish processing results in a large volume of high strength effluent finding its way into the drains. The dogfish filleting bench could be easily modified to incorporate an offal tray to prevent waste falling onto the floor.

- Drain covers and catch baskets were found to be ineffective, allowing waste to easily enter the drain. Drain covers must be redesigned and replaced to prevent this problem. Effective covers and catch baskets are particularly important as the mixing of factory effluent with domestic waste prevents a final end of pipe treatment.

- The high strength effluent stream produced by the skinning machines could be significantly reduced by using a simple deflector to prevent water being washed through the skins collected in the catch basket.

It was calculated that 1.14m^3 of water was used to produce one tonne of dogfish product, whilst 9.47m^3 of water was required to produce one tonne of whitefish fillets (includes daily clean downs but excludes dogfish belly flap processing and whitefish skinning). In terms of whitefish processing, this compares favourably with other companies, although there is scope for improvement. It is not known how the water usage in dogfish preparation compares to other similar operations.

Reducing water use is equally as important as reducing effluent strength, as diluting strong effluent increases the volume of water used which also results in increased effluent charges.

- Improving the circulation and controlling the temperature of water used in defrosting could significantly improve the efficiency of the process, reducing the time taken and water used. During warmer months fish should be laid out on fish boxes. Defrosting could be achieved without using any water.

- The policy of no continually running hoses during filleting must be enforced by management practices or changes in equipment, such as timed or valved flow regulation, or by repositioning water points and hoses.

- Water is wasted in other areas including; leaking taps and pipework, knife sterilisation, box washing and in the skinning process. More stringent controls, or changes to equipment should also be introduced in these areas.

It is advisable to inform and educate staff about the future costs associated with effluent and water use. Water usage figures should be continually monitored. Staff should be involved and encouraged to identify further opportunities for making reductions in water use and effluent production. Any measures which change working practices must be properly managed to ensure staff do not revert back to old ways. It is advisable to monitor any changes in water consumption to ensure that they do not cause the strength of the effluent to increase.

Anglian Water have not formalised their plans for introducing the new trade effluent charges. However, they suggest that the latest implementation date would be sometime in the year 2000. With this in mind it is recommended that the company starts to introduce changes, with regards to reducing water usage and effluent production, as soon as possible in preparation for the inevitable increases in costs in 2000.