A GUIDE TO WATER AND WASTE-WATER MANAGEMENT IN THE POULTRY ABATTOIR INDUSTRY

A GUIDE TO WATER AND WASTE-WATER MANAGEMENT IN THE POULTRY ABATTOIR INDUSTRY

by

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FOREWORD

Abattoirs are generally large consumers of water and we must accept that, in the years to come, this resource is going to become more difficult to provide and certainly a lot more expensive.

One of the surprising facts to come from this research was the great variation in volumes of water used by different poultry abattoirs, even though all have to comply with the same meat hygiene regulations. This more than any other factor emphasises the scope for savings in our industry.

Another important aspect of the report deals with several simple techniques that can be used to reduce the pollutant load and hence the cost of treatment. If these methods are used together with effective treatment of the water, then it should be possible to recover a proportion of the water for reuse in certain areas which could go a long way to offsetting the cost of treatment.

As an industry we must thank the Water Research Commission for taking the lead in waste-water research and producing this guide which will, we hope, lead all poultry abattoirs to employ or further investigate these proposed conservation and treatment methods.

J CAWSON
SA POULTRY ASSOCIATION

PREFACE

This guide has been drawn up from work carried out during the course of a project entitled "Research on and an investigation into the use of physical/chemical techniques for water and waste-water management in the meat processing industry" (WRC Project No. 127). Detailed results from this project are available in a separate WRC Report No. 4/87/1 (Vol. 1 and 2).

Preparation of this guide was steered by an editorial committee, the members of which are thanked for their individual and collective contributions.

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SUMMARY

This guide characterises the status of water use and effluent generation, and identifies opportunities for improved water and waste-water management in the poultry abattoir industry in the RSA ("the Industry").

Over the period 1981 to 1991, broiler production by the Industry has more than doubled, from around 180 million birds per annum in 1980/81 to more than 360 million birds per annum in 1990/91. In 1989, poultry was found to account for approximately 40% by mass of all the meat (red and white) produced in the RSA. Because of the higher cost of red meat versus white meat, the increasing proportion of white meat is expected to continue and probably accelerate.

Poultry abattoirs are graded according to their maximum permissible throughput into five grades namely AP (> 10 000 birds/day) to EP (maximum 50 birds/day). AP-grade poultry abattoirs constitute only a small fraction (13%) by number of the total number (149) of abattoirs in the RSA but carry out the bulk of the production, namely more than 93% of the total number of broilers processed annually.

Specific water intake (SWI) values observed at poultry abattoirs show that the AP-grade abattoirs tend to be more water-efficient, with a mean SWI value of 17 ℓ/bird, compared with BP to EP grade abattoirs, with mean SWI values ranging from 20 to 25 ℓ/bird. Because of the high proportion of total production carried out by the AP-grade abattoirs, these abattoirs, however, are responsible for around 90% of the total water intake by the Industry. With regard to the breakdown of water use, processing (63%) and washdown of plant equipment (22%) account for 85% of the water used in AP-grade abattoirs. Target SWI values proposed are ultimately a maximum of 15 ℓ/bird for AP-grade abattoirs and 18 ℓ/bird for other grade abattoirs.

Opportunities for reducing water use and recommendations for improving water management are given in terms of water metering, processing areas, heating and cooling, and washdown of plant and equipment. Opportunities for reclaiming and recycling water are identified, and the potential for water saving in the Industry is indicated to be around 1 600 Mℓ/a, which is equivalent to 29% of current consumption by the Industry.

In large, modern, AP-grade abattoirs, the specific effluent volume (SEV) is typically around 15 ℓ/bird and the specific pollutant load (SPL) in terms of chemical oxygen demand (COD) is typically around 27 g COD/bird. The principal contributors to SEV and SPL are the operations carried out for evisceration (33% of SEV, 48% of COD SPL), washdown (22% of SEV, 35% of COD SPL) and scalding (17% of SEV, 11% of COD SPL). Nationally, pollutant loads estimated for the Industry are an effluent volume of 4 900 Mℓ/a and mass pollutant discharges of 10 255 t/a of COD, 2 450 t/a of SS and 4 970 t/a of TDS.

Target values for SEV and SPL are identified for AP-grade and other grade abattoirs. Opportunities for improved effluent management are identified in terms of specific actions the Industry can undertake in order to aim towards the target SEV and SPL values given.

Poultry abattoir effluents are generally discharged to municipal sewerage systems, and in order to meet applicable by-law quality requirements, on-site effluent pretreatment is generally required. Relevant aspects include improved housekeeping, gross solids handling, grease removal, screening, primary settling, effluent segregation, effluent balancing, chemical dosing and air flotation, as well as the potential for enhanced effluent treatment and water reclamation using membrane processes.

GLOSSARY

BROILERS

Chickens reared for slaughter, as opposed to chickens culled from laying stock.

DRESSED MASS

Mass of bird after removal of feathers, head, feet and viscera.

EFFLUENT

Liquid outflow from an industrial process operation.

EVISCERATION

Removal of organs (viscera) from a slaughtered bird.

RENDERING

Cooking of organic wastes followed by drying in order to produce a proteinaceous meal.

REVERSE OSMOSIS (RO)

In this context, the pressurisation of an effluent or waste water in order to force water molecules (or other molecules of a similar or smaller size) to pass from the solution through a semi-permeable membrane which will not pass larger molecules such as the majority of complex compounds.

SPECIFIC EFFLUENT VOLUME (SEV)

The effluent volume generated in a particular period divided by the number of birds slaughtered or used in production during the same period.

SPECIFIC POLLUTANT LOAD (SPL)

The pollutant mass load for a particular period (in terms of any particular pollutant parameter e.g. COD, FOG, TKN, etc.) arising from an abattoir unit process divided by the number of birds used in production during the same period.

SPECIFIC WATER INTAKE (SWI)

The water intake for a particular period divided by the number of birds used in production during the same period.

SPECIFIC WATER USE (SWU)

The quantity of water used in an abattoir unit process divided by the number of birds processed.

STUNNING

Mechanical, electrical or other means of ensuring that a live bird is made insensible in an approved humane manner before slaughtering.

TOTAL KJELDAHL NITROGEN (TKN)

The total of ammoniacal plus organic nitrogen as determined analytically according to standardised (e.g. SABS) laboratory test procedures.

ULTRAFILTRATION

The separation of large molecules or colloidal matter or solid particles by filtration through microporous membranes.

WASTE WATER

Final factory outflow i.e. sum of industrial process effluents.

WATER INTAKE

All water entering a premises from municipal and/or other sources e.g. boreholes, river intakes, etc.

ABBREVIATIONS

a	annum (year)
b	birds (broilers)
COD	chemical oxygen demand
DAF	dissolved air flotation
FOG	fats, oils and greases
NASWI	national average specific water intake
OA	oxygen absorbed
PV	permanganate value
RO	reverse osmosis
SEV	specific effluent volume
SPL	specific pollution load
SS	suspended solids
SWI	specific water intake
SWU	specific water use
t	tonnes
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TS	total solids
UF	ultrafiltration
σ	standard deviation
Σ	sum of

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The poultry abattoir industry in the RSA (hereinafter referred to as "the Industry") has been identified in previous and current studies [1, 2, 3, 4] as an industry which uses significant quantities of high-quality water for processing purposes. In the course of processing, a high proportion of this water is degraded directly to produce a strong organic effluent which the Industry has difficulty in disposing of adequately on a national basis. Large quantities of solid waste are also produced.

To address these problem areas, the Water Research Commission (WRC) has funded research to determine how water can be saved or utilized more effectively in the Industry, to develop appropriate technology for treatment of the effluents arising from the Industry, to co-ordinate such effluent treatment technology with the solid waste disposal situation in the Industry, and thereby to develop progressive water, waste-water effluent and solid waste management practices appropriate to the requirements of the Industry.

1.2 INTRODUCTION TO THE GUIDE

This guide has been drawn up for the primary purpose of transferring to the Industry the information obtained in the course of the project, to assist in enabling the opportunities for improved water and waste-water management to be translated into practice. A previous guide [5] deals in a similar fashion with the red meat abattoir industry.

The national poultry rearing and abattoir industry has in recent years showed an accelerating rate of growth. As shown in Figure 1.1, national broiler production has more than doubled since 1980, from around 180m birds/a in 1980/81 to over 350m birds/a in 1990/91. Currently, poultry accounts for approximately 40% [5] by mass of all meat (red and white) produced in the RSA.

This trend, i.e. a high rate of annual growth in the Industry, is by current indications set to continue in the foreseeable future. This has two important consequences in the context of this guide, firstly that the demand for improved water, waste-water and solid waste management in the Industry will grow in the future, and secondly that the statistics on national poultry production, water use, effluent generation and disposal, and solid waste generation and disposal will require updating in the future.

To address the first aspect, the Industry must continue to develop and implement the technology and management practices which will enable it to meet its growing requirements for supplies of high-quality water, and cost-effective handling, treatment and disposal of the waste waters and solid wastes generated. It is hoped that this guide will be an effective aid in assisting the Industry to attain these objections.

With regard to the second aspect, namely the regular updating of the statistics on national production, water use and the generation and disposal of effluent and solid waste by the Industry, *it is recommended that periodic surveys of the Industry be carried out* by means of a questionnaire such as that included in the guide (Appendix E), by liaison through the offices of the South African Poultry Association. Management in the Industry is urged to co-operate in this updating process, thereby extending the usefulness of the guide.

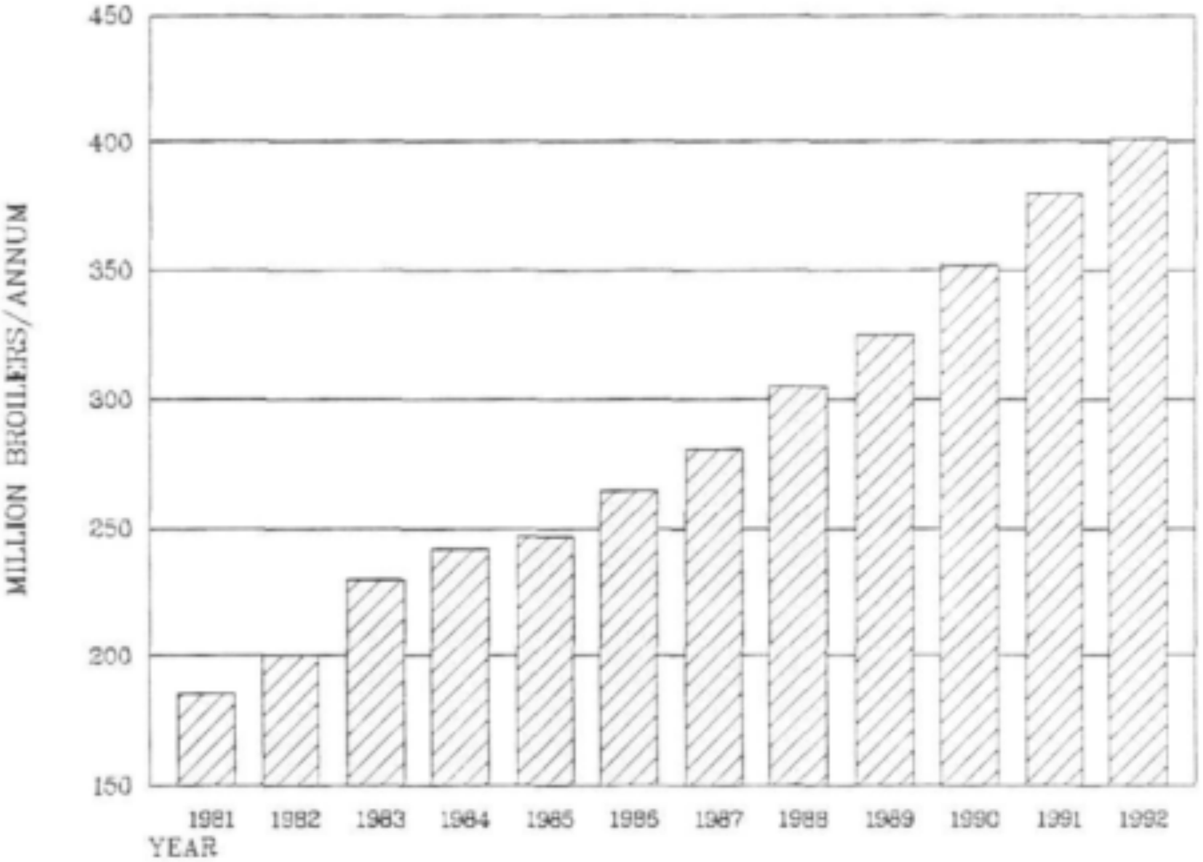


FIGURE 1.1 TREND IN NATIONAL POULTRY PRODUCTION SINCE 1980

CHAPTER 2

THE INDUSTRY

2.1 NATIONAL PRODUCTION

Currently (1989 data, [6]) it is estimated that national broiler production is around 350m birds/a, with an annual rate of increase in excess of approximately 7%. This figure does not include the much smaller numbers of birds culled from laying stocks, or other species (ducks, turkeys, etc), which are also slaughtered.

2.2 POULTRY ABATTOIR GRADING

Each poultry abattoir is graded according to its maximum throughput, and has to be approved by the Chief Meat Hygiene Officer. The grading system is shown in Table 2.1.

TABLE 2.1 POULTRY ABATTOIR GRADING SYSTEM

Grade	Maximum daily slaughter allowed (birds/d)
AP	>10 000
BP	10 000
CP	800
DP	300
EP	50

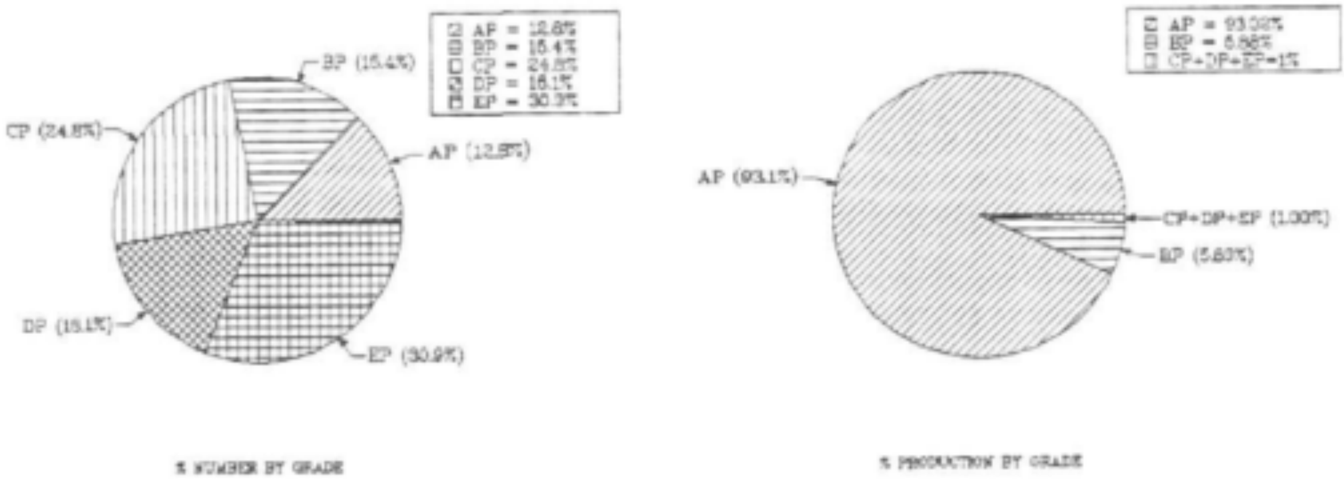
All poultry abattoirs in the RSA are privately owned. Table 2.2 shows the number of poultry abattoirs in each grade operating in 1989 [6] and the estimated grade-by-grade percentage breakdown of the total annual broiler slaughter.

The table highlights an important feature of the Industry, in that Grade AP abattoirs (19 total, constituting only 13% by number of the total number of poultry abattoirs in the RSA) are *nevertheless responsible for over 93% of the total poultry slaughter.* These AP-grade abattoirs, with production capacities ranging from around 3m birds/a (smallest) to 57m birds/a (largest) are highly intensive industrial operations, with a high localized demand for water supply, waste-water and solid waste disposal.

TABLE 2.2 POULTRY ABATTOIR GRADE-BY-GRADE DISTRIBUTION AND PRODUCTION (1988)

Grade	Number in RSA		Slaughter	
	Number	% of RSA total	m birds/a	% of RSA total
AP	19	12,8	303,68	93,02
BP	23	15,4	19,19	5,88
CP	37	24,8	2,29	0,70
DP	24	16,1	0,73	0,22
EP	46	30,9	0,57	0,18
Totals	149	100,0	326,46	100,0

Conversely, this may be compared with the large number of smaller abattoirs, particularly CP, DP and EP grades. Figure 2.1 illustrates relevant size distribution parameters for poultry abattoirs in the RSA (1989). The total national production by the BP to EP grades constitutes only around 7% of the annual national broiler production. Expressed alternatively, the total national production (3,59m birds/a) by CP DP and EP-grade poultry abattoirs (107 in number) is approximately equivalent to the annual production by the single smallest AP-grade abattoir (2,86m birds/a). Consequently, it may be expected that the water, waste-water and solid waste management requirements of the smaller abattoirs are significantly different to those at the larger (particularly AP-grade) abattoirs.



% NUMBER BY GRADE

% PRODUCTION BY GRADE

FIGURE 2.1 POULTRY ABATTOIR SIZE DISTRIBUTION (1988)

2.3 POULTRY ABATTOIR PROCESSING

Poultry slaughtering and processing may be considered as a series of unit operations, illustrated in block diagram form in Figure 2.2. The operations carried out at the various processing stages are described briefly below with special reference to water use and sources of effluent or solid wastes.

Reception of broilers at the live dock includes counting of the birds. At the live dock, the broilers are unloaded from the crates in which they arrive and are hung by their feet on the processing line shackles. Crates, and vehicles used for live bird transport, are washed in the reception area.

Stunning is carried out electrically in a stunning bath, where the live bird is made insensible in an approved humane manner before slaughtering. In kosher slaughtering, stunning is not practised, for religious reasons.

Bleeding is carried out over bleeding troughs where the throat is slit, the blood is collected and is then pumped or vacuum-drawn to a blood storage tank.

Scalding is carried out in either spray-type or dip-type scalding tanks. Scalding, as practised generally in the RSA, uses water at temperatures between 50°C and 60°C to remove feathers.

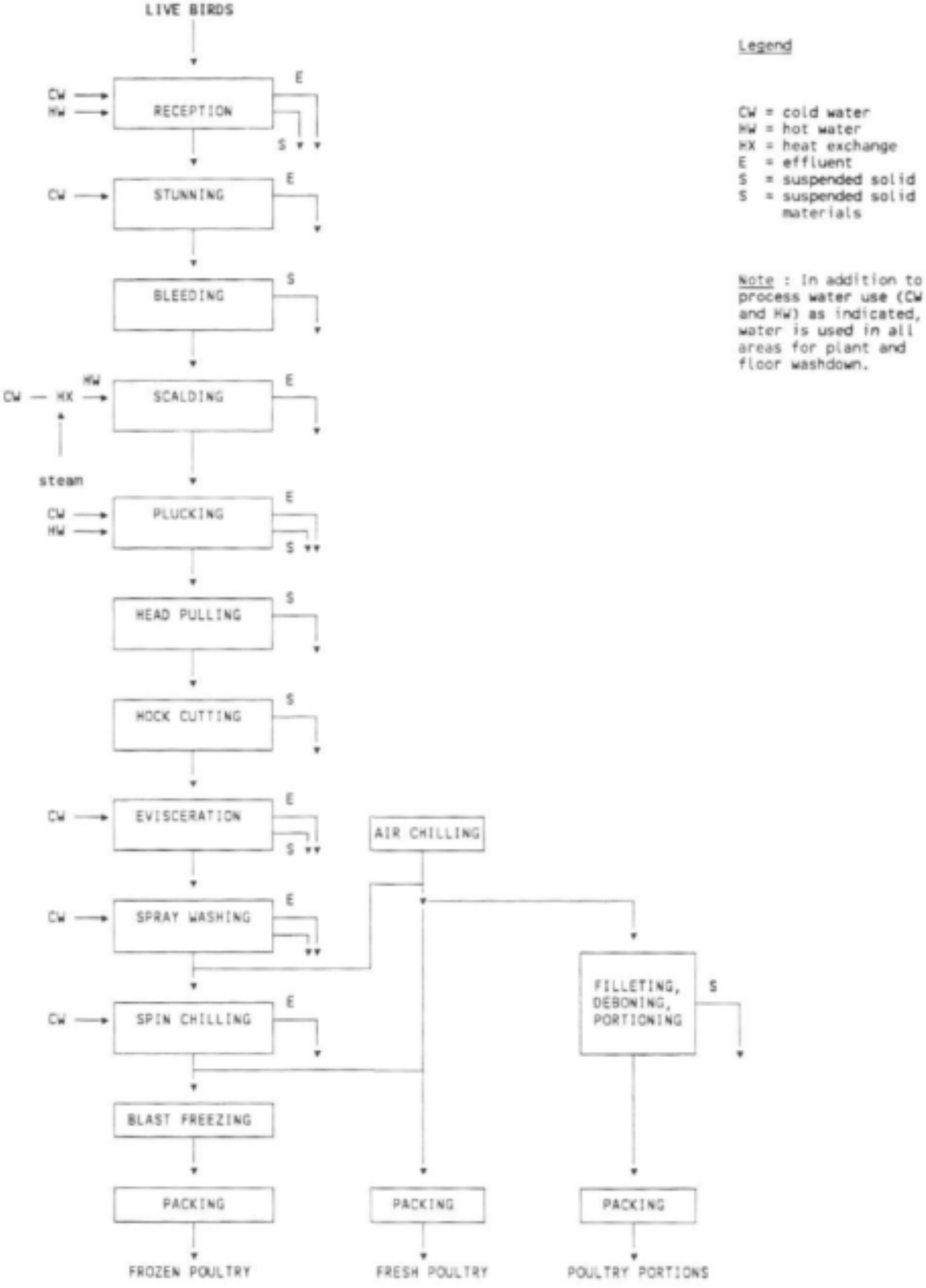
Plucking is carried out mechanically in several stages, with the birds being passed through pluckers with rotating rubber fingers and disks and high-pressure sprays. The plucked feathers are flumed away at high velocity to screens where the feathers are recovered and the flume water is recycled back as transport water. Dry transport systems are now also available on the market.

Head pulling is carried out mechanically while the birds remain hung from their feet. The heads fall onto mechanical conveying systems for forwarding to further processing or disposal.

Hock cutting releases the headless birds which fall from the conveyor onto a chute where they pass through a small hatchway from the "dirty" to the "clean" areas of the abattoir [8] for evisceration.

Evisceration is carried out, often in a separate room, after the birds have been hung by their shanks on a separate conveyor line and the vents have been cut. After passing inspection, at which point whole carcasses may be condemned, the viscera are removed either manually or automatically in carousel-type eviscerators. The viscera are then sorted into red offal (giblets i.e. neck, heart, liver, gizzard, lungs and kidney), edible rough offal (the washed digestive tract other than the gizzard) and inedible offal (the vent and reproductive organs of mature birds). Offal is transported from the evisceration area either by vacuum or by water fluming. Because hygiene considerations are very important at the evisceration stage in order to avoid microbiological contamination of the meat, water is used liberally for plant and area washdown.

Spray washing of eviscerated birds is carried out for purposes of hygiene and to remove loose particles.



Legend

CW = cold water
HW = hot water
HX = heat exchange
E = effluent
S = suspended solid
S = suspended solid materials

Note : In addition to process water use (CW and HW) as indicated, water is used in all areas for plant and floor washdown.

FIGURE 2.2 BLOCK DIAGRAM OF TYPICAL POULTRY ABATTOIR PROCESSING STEPS

Chilling of carcasses and giblets to a temperature of 10°C or lower is required [9] to be carried out immediately after evisceration. Spin chillers, where the birds are immersed in chilled water, are used to chill the birds to around 4°C, with a recommended water replacement rate of 1 ℓ/bird [10]. The mass gain by water absorption is limited by legislation to 8% by mass, with specified procedures for sampling and testing for the various abattoir grades. Poultry portions or whole birds that are to be sold fresh are air chilled, while birds to be sold as frozen pass through blast freezers. Chiller and freezer rooms are generally cooled by ammonia-based refrigeration systems, but defrosting of cooling coils is carried out either electrically or by water.

Filleting, deboning and portioning are carried out on a part of the product at some abattoirs. Additional solid wastes arise from these operations.

Plant and area washdown in all processing areas is carried out routinely during and after each processing shift, and is a major factor in the water, effluent and solid waste pattern at poultry abattoirs. In addition to the major processing plant items that are washed down, water is also used for sterilizing equipment, hand-wash basins, wash-sprays for aprons and other protective clothing, shackle washers, tray washers, crate washers and laundry purposes.

CHAPTER 3

WATER USE AND WATER MANAGEMENT

3.1 SPECIFIC WATER INTAKE

The Water Act (1956), Act 54 of 1956, as amended [II], contains important provisions affecting Industry. The more important relevant sections of the Act are summarised in Appendix A. Factory management should refer to the Act for amplification of this informal summary. In terms of gazetted regulations [9], a minimum water supply of 3 gallons/bird (13,6 ℓ/b) must be provided at poultry abattoirs.

With regard to actual water use at poultry abattoirs, the results of surveys carried out at a number of poultry abattoirs in the course of the investigation into the poultry industry [1,4] are summarised in Table 3.1 in terms of specific water intake (SWI), with mean values weighted in terms of slaughter (production).

TABLE 3.1 SUMMARY OF SWI VALUES OBSERVED AT POULTRY ABATTOIRS (1988)

Abattoir grade	Sample size	Slaughter (birds/day)			SWI(l/bird)			
		min	max	mean	min	max	mean	relative *
AP	8	20 370	174 900	66 439	15	20	17	1,00
BP	4	4 600	8 750	5 763	15	25	20	1,18
Other	5	140	460	328	20	30	25	1,47

* relative to mean SWI for AP-grade abattoirs.

Two principal conclusions may be drawn from the data in Table 3.1:

(i) The higher-grade (in particular AP-grade) abattoirs tend to be more water-efficient, i.e have lower SWI values, than the lower-grade abattoirs.

(ii) There is nevertheless a wide variation in SWI within each grade.

The relatively higher efficiency (in general) of water use at higher-grade and/or larger abattoirs is attributable to a number of factors. Firstly there is a benefit of size, with implications for a more sophisticated management structure, better monitoring and accounting for services such as water supply (partly because of the significant cost factor), a higher level of engineering services, etc. Secondly, at smaller abattoirs, water use for purposes not proportional to production throughput, such as plant start-up, tank filling, floor and equipment washdown, etc), is relatively more inefficient.

Conversely, it should be noted that efficiency of water use is generally higher when an abattoir is operating at full capacity. In view of the recent high demand for white (versus red) meat, most of the larger abattoirs have generally been operating at, close to, or, in some cases above, their design capacities. This factor is not as significant at smaller abattoirs, where operation is more often geared to local or immediate demand particularly where cold storage facilities are not available. Operation at small abattoirs is also often on a stop-basis, i.e the abattoir is closed down completely for a period of time, a situation which cannot be easily managed at larger abattoirs.

On a national basis, it is important to recognize that because of the high proportion of national production carried out by the larger (particularly AP-grade) abattoirs, these still account for most of the water used by the Industry. Paradoxically therefore, it is within the relatively more water-efficient larger abattoir group that significant water savings must be sought. This is illustrated in Table 3.2, which shows the estimated grade-by-grade distribution of water intake in the Industry, obtained by combining the mean SWI values (Table 3.1) with the corresponding 1988 production figures (Table 2.2) for the various grades of poultry abattoir.

TABLE 3.2 ESTIMATED GRADE-BY-GRADE NATIONAL WATER USE IN POULTRY ABATTOIRS (1988)

Grade	Slaughter (1988) birds/a	Mean SWI l/bird	Estimated water use	
			Ml/a	% of total
AP	303 680 000	17,0	5 163	91,6
BP	19 190 000	20,0	384	6,8
CP,DP,EP	3 590 000	25,0	90	1,6
Totals	326 456 000	17,3	5 637	100,0

From Table 3.2, AP-grade abattoirs account for over 90% of the estimated national water use by the Industry (5 637 Ml/a). The latter figure represents approximately 0,4% of the water used in the Republic of South Africa for all industrial purposes [12]. The estimated mean SWI for all poultry abattoirs is 17,3 ℓ/bird, but the variations in SWI shown in Table 3.1, both at different abattoirs in the same grade and also between different grades of abattoir, are also very significant. The variation in SWI at different abattoirs of the same grade and even with similar production throughput is most significant in the case of AP-grade abattoirs because of the large volumes of water involved. In the following section, a typical breakdown of the various uses to which water is put in poultry abattoirs is discussed.

3.2 BREAKDOWN OF SPECIFIC WATER INTAKE AT POULTRY ABATTOIRS

From water surveys carried out at a number of poultry abattoirs, an indicative breakdown of water use for various purposes is shown in Table 3.3 in terms of percentage and specific water use (SWU, where Σ SWU = SWI).

TABLE 3.3 BREAKDOWN OF WATER USE IN POULTRY ABATTOIRS* (1988)

Activity	Operations	% of total	Typical SWU l/bird
Processing	Hanging, stunning, bleeding Scalding, plucking Evisceration, spray washing Spin chilling	1 17 33 12	0,2 2,9 5,6 2,0
Subtotals processing		63	10,7
Utilities	Cooling and refrigeration Boilers	7 1	1,2 0,2
Subtotals utilities		8	1,4
Services	Floor and equipment washdown Crate washing Truck washing	17 2 3	2,9 0,3 0,5
Subtotals services		22	3,7
Subtotals by-products rendering		5	0,9
Subtotals domestic (ablutions, etc)		2	0,3
Overall SWI	Overall abattoir operation	100	17,0

* for a "typical large AP-grade abattoir"

Overall, processing (63%) and washdown of plant and equipment (22%) account for 85% of the water used in poultry abattoirs. The largest single use is in viscera fluming and washing (33% of total water use). Feather transport water is normally screened and then recycled back to the feather transport flume. Fresh water is continuously added for scalding and plucking.

The mean SWU values in Table 3.3 are based on an overall SWI value of 16,0 l/bird, which is the mean SWI value observed for AP-grade abattoirs. In practice many AP-grade abattoirs and most lower-grade abattoirs operate at higher overall SWI values. Target SWI values appropriate to the various abattoir grades and recommendations for improved water management to achieve lower SWI values are given in the following sections.

3.3 TARGET SPECIFIC WATER INTAKE VALUES FOR THE INDUSTRY

Within each grade of poultry abattoir there is a relatively wide spread in SWI values at different abattoirs. The SWI values are strongly affected by (but not normally distributed with respect to) abattoir throughput. This indicates the effect of other factors such as efficiency of water management, utilization of capacity, start-up demands, etc. Such factors can also affect the SWI value at any particular abattoir on a day-to-day basis.

Because of their predominance in terms of production and water use (see Table 3.2), AP-grade abattoirs are here considered separately from the other grades of abattoir in respect of appropriate SWI target values. Proposed first-stage and second-stage SWI targets are given in Table 3.4 for AP-grade and other grades of poultry abattoir respectively.

Realistic phase 1 targets proposed are the current mean SWI values. Abattoirs with SWI values higher than the relevant phase 1 target should aim initially at reducing their water use to the phase 1 levels. This would result in the mean SWI values being lowered, thus providing phase 2 targets. In the following section, opportunities and recommendations for reducing water use in poultry abattoirs are identified.

TABLE 3.4 TARGET SWI VALUES FOR POULTRY ABATTOIRS

Grade	Production (birds/d)	Target SWI (l/bird)	
		phase 1	phase 2
A	>10 000	17,0	15,0
Other	<10 000	24,0	18,0

3.4 OPPORTUNITIES FOR REDUCING WATER USE

Poultry abattoirs rely to a large extent on the use of good quality water for processing purposes and the maintenance of hygiene standards. The variations in SWI observed between different poultry abattoirs indicate that significant opportunities exist for reducing water use.

While the means of improving water use management are generally applicable to all grades and sizes of poultry abattoir, it should be noted that, because of the large proportion of the national water use by the Industry taken up by AP-grade abattoirs, it is in these abattoirs that a significant impact on national water use by the Industry can and should be made. This must be achieved even though the AP-grade abattoirs are on average, as a group, relatively more water-efficient than smaller abattoirs.

Most of the water intake in poultry abattoirs is used non- consumptively on a once-through basis, and the industrial effluent volume generated is thus affected directly by reducing the water intake. Treatment and disposal of the liquid effluent generated is a major concern for the Industry, in terms of the acceptability of the effluent to the receiving authority and the effluent discharge costs attracted. Reducing water use thus has the important additional benefit of an almost proportional reduction in the quantity of effluent to be disposed of, although the quality might deteriorate.

Opportunities and recommendations for improving water management and reducing water use in all grades of poultry abattoir include the following:

Water metering

(a) All water intakes, whether from mains supplies or other sources, should be metered and all water intakes should be routinely recorded either manually or automatically.

(b) Mains water intakes should be pressure-regulated.

(c) Water use in individual processing areas should be metered using water meters which are properly selected, installed and maintained.

(d) All water meters should be calibrated routinely.

(e) Management should ensure that water meters are not only installed, read and monitored, but also that the results obtained are used constructively on a routine basis, for example by calculating SWI values for the abattoir and SWU values for individually-metered processing areas, drawing up water balances to account properly for all water intakes, identifying and correcting anomalous or excessive water uses, checking for leaks or open valves leading to wastage of water after hours, training of staff to appreciate the need for and importance of water conservation, etc.

(f) Staff should be trained to appreciate the need for, and importance of, water conservation and this should be coupled with performance incentives.

Processing areas

(a) Brooms should be used to sweep up loose dirt and feathers in the reception area with routine washdowns only once or twice per shift as appropriate.

(b) Water-efficient, custom-designed equipment should be employed for washing vehicles and crates.

(c) Pneumatic systems for feather transport after defeathering should be considered.

(d) Dry removal and transport of viscera from poultry carcasses should be employed where practicable.

(e) Product-washing sprays should be automatically linked to process-line operation (using solenoid valves for example) so that the sprays switch off when the line stops.

(f) Overflows from spin chillers should be properly set and controlled so as to provide optimum water use and energy conservation.

(g) All hoses should be fitted with self-closing nozzles to eliminate wastage when not in use.

Heating and cooling

(a) At large abattoirs employing both a refrigeration and heating plant, considerable energy savings can be achieved by judicious heat exchange.

(b) Defrosting of blast freezer and cold storage rooms should be carried out electrically or by hot gas rather than by water.

(c) Where water is used for coil defrosting, the defrosting water plus melt water could be recycled to cooling towers or evaporative condensers in the refrigeration circuit.

(d) Hot water systems should be optimised to effect energy and water savings. Historically, boilers and mixing valve systems have been used to provide hot water at the various temperatures required. A more energy-efficient alternative is to heat water to typically 45°C by heat exchange for use in hand-wash basins etc., and to then calorify the water as required at higher temperatures either directly in an electrical geyser or indirectly by heat exchange with pressurised steam or hot water circuits.

(e) In general, steam should be used in coils with condensate return facilities; live steam use should be limited to essential applications only.

(f) Steam losses from steam lines should be eliminated to conserve both energy and water.

(g) Evaporative cooling towers and condensers should be fitted with demisters to minimize windage and drift losses.

Washdown

(a) Cold water should be used initially to clean surfaces soiled primarily with blood, e.g. in the slaughter area, as the use of hot water causes congealing of the blood which makes cleaning more difficult and results in unnecessary water use.

(b) The quantity of washdown water required to clean most areas can be substantially reduced if dry-brushing or squeegeeing techniques are employed initially to collect gross solids. The solids collected should be disposed of to solid waste handling facilities rather than flushed to drain.

(c) High-pressure/low-volume rather than high-volume/low-pressure cleaning systems should be used wherever possible to achieve the standard of cleanliness required. A separate water circuit should preferably be used to supply the high-pressure cleaning system, and water use for this purpose should be monitored and controlled.

(d) Where dedicated ring mains are provided for general washdown by hoses, consideration should be given to installing master valves which are opened by timing devices or shift supervisors only at the prescribed routine washdown times.

(e) All hoses should be fitted with positive self-closing nozzles to eliminate unattended sluicing as is frequently observed. Where the hoses are in frequent use, pistol grips should be fitted. For areas of infrequent use, "dead man control" nozzles are preferable. Instructions forbidding the jamming open or disconnection of self-closing nozzles should be strictly enforced. Devices are available for mixing a water jet and a compressed air stream close to the nozzles of hand-held sprays, thereby producing a more effective cleaning action without using additional water.

3.5 OPPORTUNITIES FOR WATER RECLAMATION AND RECYCLE

Two areas where water should be routinely recovered and recycled wherever possible in all abattoirs are, firstly, that uncontaminated condensates should be returned to boiler plants (reducing boiler make-up requirements and associated chemical dosing costs) and, secondly, that where feathers are flumed, the transport water should be screened and recycled.

Effluent treatment trials using membrane systems have demonstrated that reclaimed water of a quality acceptable for re-use in several selected areas of abattoir operation can be produced. The reclaimed water should be chlorinated before re-use as required. Abattoir operations in which reclaimed water could initially be considered for re-use are those where potable-quality water is not required according to regulations, for example truck and live bird crate washing (15%), some floor and yard washing (say 7%) and gardening (say 1%). Around 23% of the water requirement at a poultry abattoir could thus be derived from reclamation.

Essential requirements that should be met in all cases where water reclamation is practised are that the chemical and microbiological quality of the reclaimed water should be maintained at the required standards, the approval of the Chief Meat Hygiene Officer (and other authorities concerned) should be obtained, and back-up water supplies should be provided in case of failure or below-specification performance of the water reclamation plant.

Implementation of water reclamation is particularly relevant for poultry abattoirs in areas short of water where available water supplies cannot meet abattoir expansion requirements. In developing water re-use systems, all the cost items involved should be taken into account at the design stage. Examples are the provision of back-up supplies, separate reticulation systems, quality monitoring procedures, etc.

3.6 POTENTIAL FOR WATER SAVING IN THE INDUSTRY

Implementation of the measures outlined for reducing water use at poultry abattoirs will result in a significant reduction in the overall water intake required by the Industry. If the target SWI values given in Table 3.4 are achieved, the national water saving in the Industry would be approximately as shown in Table 3.5 below (1988 base date).

TABLE 3.5. POTENTIAL FOR WATER SAVING IN THE INDUSTRY

Grade	Production(1) (m birds/a)	Current water(1) intake (Ml/a)	Possible (reduced)(2) water intake (Ml/a)	Water saving	
				Ml/a	%
AP	304	4 864	3 648	1216	25
Other	22	704	308	396	56
Totals	326	5 568	3 956	1612	29

Notes: 1. Based on current annual slaughter and mean SWI values (Table 3.2).
2. Assuming current annual slaughter but at phase 2 target values (Table 3.4).

A total of 1612 Mℓ/a of water, equivalent to 29% of current consumption, could thus be saved by the Industry by implementing measures to reduce water use. At abattoirs where water reclamation and reuse are feasible, additional reductions in water would be achieved, thus lowering the national water demand by the Industry still further.

CHAPTER 4

EFFLUENT GENERATION AND MANAGEMENT

4.1 POLLUTANT SOURCES IN POULTRY ABATTOIRS

The principal sources of organic pollution in poultry abattoirs are the evisceration, scalding and washdown operations, as shown in Table 4.1 in terms of specific effluent volume (SEV) and chemical oxygen demand specific pollutant load (COD SPL).

This breakdown is for a large, modern, AP-grade poultry abattoir where blood is efficiently collected and feather transport water is screened and recycled. In the evisceration operation, the organic pollutant load arises from both product sprays and the transport water used to flume away inedible offal after screening.

TABLE 4.1 SOURCES OF ORGANIC POLLUTION IN POULTRY ABATTOIRS

Operation	SEV		COD SPL	
	l/bird	% of total	g/bird	% of total
Scalding	2,5	17	3,0	11
Evisceration	5,0	33	13,0	48
Washdown	3,3	22	9,5	35
Miscellaneous	4,2	28	1,5	6
Totals	15,0	100	27,0	100

At abattoirs where dry methods are used for feather and inedible offal transport, the SEV and COD SPL values would be distributed differently, with washdown contributing up to 60% of the total organic load.

4.2 SPECIFIC POLLUTANT LOADS (SPL)

Most of the water intake at poultry abattoirs is used non-consumptively for processing and washdown purposes, and large volumes of high-strength organic waste are produced. The results of water and effluent surveys carried out at poultry abattoirs of different sizes in the RSA are given in Table 4.2, showing the range in effluent quantity and quality data observed.

The data show that the volume of effluent generated is closely related to the water intake, with a mean value of 88% of the water intake being returned as industrial effluent. The effluent quality shows a much wider variation between different abattoirs, as shown by the high standard deviation (σ) values. Table 4.3 expresses the results obtained in terms of specific parameters.

TABLE 4.2 EFFLUENT QUANTITY AND QUALITY DATA

Data point	Production	Water intake (WI)	Effluent discharge		Effluent quality			
					pH	COD	SS	TDS
	birds/month	m^3/month	m^3/month	% of WI		mg/l	mg/l/	mg/l
1	440 000	8 380	7 350	88	10,1	2 584	314	2 040
2	601 000	9 020	8 100	90	6,9	1 300	220	997
3	645 600	12 300	10 460	85	8,0	1 264	283	668
4	986 000	20 430	17 980	88	6,8	891	615	332
5	1 900 000	37 970	33 800	89	6,6	1 643	315	438
6	3 100 000	35 000	29 900	85	5,9	698	106	800
7	3 777 100	60 520	57 050	94	6,3	4 744	1240	1 310
Mean	1 635 671	26 231	23 520	88	7,2	1 875	442	940
σ	-	-	-	-	1,3	1 300	356	543

TABLE 4.3 SPECIFIC POLLUTANT LOADS AT POULTRY ABATTOIRS

Data point	Production (birds/month)	SWI (l/bird)	SEV (l/bird)	SPL (g/bird)		
				COD	SS	TDS
1	440 000	19,0	16,7	43,2	5,2	34,1
2	601 000	15,0	13,5	17,6	3,0	13,5
3	645 600	19,1	16,2	20,5	4,6	10,8
4	986 000	20,7	18,2	16,2	11,2	6,0
5	1 900 000	20,0	17,8	29,2	5,7	7,8
6	3 100 000	11,3	9,6	6,7	1,0	7,7
7	3 777 100	16,0	15,1	71,6	18,7	19,8
Mean	1 635 671	17,4	15,3	29,3	7,0	14,2
σ	-	3,1	2,8	20,3	5,6	9,2

As can be seen from Table 4.3, there is relatively little variation in SWI (l/bird) between smaller and larger AP-grade abattoirs. SPL and SEV values (in terms of COD, SS and TDS) vary more widely, with no simple correlation to abattoir size (production). The low SPL and SEV values for Data Point 6 in Table 4.3 can be attributed to differences in processing at this abattoir. Assuming the production-weighted mean values as being reasonably representative of the Industry, Table 4.4 shows the estimated volumetric and mass pollutant loads generated by the Industry at the 1988 production level.

TABLE 4.4 ESTIMATED NATIONAL POLLUTANT LOADS FROM THE INDUSTRY*

Grade	Production		Effluent volume		Effluent pollutant loads					
					COD		SS		TDS	
	m birds/a	%	Ml/a	%	t/a	%	t/a	%	t/a	%
AP	304	93	4 280	87	9 565	93	2 128	87	4 317	87
Other	22	7	620	13	690	7	322	13	653	13
Totals	326	100	4 900	100	10 255	100	2 450	100	4 970	100

* Based on 1988 production level of 326 m birds/a and mean SEV and SPL values from Table 4.3 as being representative of the Industry.

From Table 4.4 it is clear that, because the AP-grade abattoirs as a group carry out such a large portion (>93%) of the Industry production, their contribution to the effluent pollutant loads generated in the Industry is similarly also very large. It is predicted within the Industry [6] that future trends are for an increased number of large AP-grade abattoirs.

The pollutant mass loadings and concentrations in abattoir effluents vary considerably through the course of a working day. Peak values generally arise during the main general washdown periods, which are usually on a once-per-shift basis.

At many of the larger poultry abattoirs, further protein recovery from the effluent is practised. The wide variations in effluent flow rate and quality necessitate the use of on-site balancing to smooth out the load passed on to further waste-water treatment facilities. Where abattoir effluents are discharged to municipal sewers, and preferential tariffs are offered for balanced night-time discharge of industrial effluents, on-site balancing can substantially reduce the effluent discharge account. Such on-site balancing facilities must, however, be properly designed to take account *inter alia* of health requirements, odour control, grease removal, solids accumulation, etc.

4.3 TARGET SPECIFIC POLLUTANT LOAD (SPL) VALUES FOR THE INDUSTRY

In view of the large variations in SPL (COD, SS and TDS) observed at different abattoirs, it is apparent that significant improvements can be achieved. This applies particularly to abattoirs with SPL values considerably higher than the mean values observed, which are obviously appropriate targets as shown in Table 4.5.

TABLE 4.5 TARGET POLLUTANT LOADS FOR POULTRY ABATTOIRS

Grade	SEV (l/bird)	SPL (g/bird)	
		COD	SS
AP	14	30	7
Other	20	45	10

As with reductions in water use, it is in the AP-grade abattoirs that a significant impact on reducing the national pollutant load in the Industry must be made, because of the major contribution these large abattoirs make to the total waste water discharged by the Industry (Table 4.4).

4.4 OPPORTUNITIES FOR IMPROVED EFFLUENT MANAGEMENT

To minimize effluent volumes and improve effluent quality from poultry abattoirs, it is essential to reduce the losses of pollutant materials to drain. Opportunities for improving effluent management include the following:

(a) Water use should be minimized to reduce effluent volumes; even if measures taken in parallel to reduce pollutant mass loads still result in an increase in concentration of the waste water to some extent, handling and treatment of the waste water is facilitated. This is particularly relevant where protein recovery by treatment of the waste water is practised.

(b) Solid wastes should be prevented from entering the drainage system wherever possible, and should be disposed of by appropriate solid waste handling routes (see Sections 3.4 and 6.3).

(c) Blood (6-8% of poultry body mass) should be efficiently collected with a minimum of loss to drain. To indicate the importance of efficient blood collection, the loss to drain of blood from a single bird represents a COD load of 21g, which is of the same order as the target COD SPL value for the entire processing operation for a bird.

(d) Scalding tank overflows should be controlled and scalding tank sludges should be collected for disposal rather than flushed to drain.

(e) Where fluming is employed for feather transport, the flume water should be screened and recycled.

(f) Viscera transport water constitutes the single largest contributor to the overall COD load in poultry abattoirs, and should be reduced or eliminated entirely by the institution of alternative transport systems.

(g) All abattoir effluents should be screened, either as they arise at the various processing stages and/or when combined in the final effluent, to recover gross solids larger than about 0,5 mm.

(h) Abattoirs with rendering plants should recover all suitable available materials for rendering; careful collection of recoverable materials leads to a rendered product of greater consistency in addition to the extra revenue gained.

(i) Care should be taken to ensure that rendering plant cookers are not overcharged, which can lead to the overflow of very strong effluents (25 000 mg COD/ℓ or higher) from the condensers under such circumstances.

CHAPTER 5

EFFLUENT TREATMENT AND DISPOSAL

5.1 ROUTES FOR EFFLUENT DISPOSAL

Generally, poultry abattoir effluents are discharged to municipal sewerage systems. In some cases, on-site effluent treatment is practised and the treated effluent is disposed of to irrigation. Discharge to watercourses after treatment is generally impracticable because of the very high degree of treatment (95-98% removal) required to meet the General Standard (Appendix A).

Quality limits and tariffs for the discharge of industrial effluents to various municipalities are given in Appendix B [14]. Some difficulty is usually experienced by poultry abattoirs in consistently meeting the required quality limits, particularly in terms of suspended solids and fats, oils and greases. Because of the high organic strength of untreated poultry abattoir effluent, the discharge cost attracted is in any event correspondingly high.

Because of these considerations, a degree of on-site pre-treatment is desirable and/or necessary even when good water and effluent management has been implemented to reduce the volume and concentration of the abattoir final effluent. Figure 5.1 shows in outline the possible treatment processes that can be considered to achieve the various targets proposed.

5.2 ABATTOIR HOUSEKEEPING

Attention to good housekeeping, i.e. reducing the losses of highly pollutant materials to drain, can considerably alleviate the final effluent treatment and disposal problem to be handled. Opportunities for reducing water use (thereby reducing effluent volumes) and improving effluent management have been identified in Sections 3.4 and 4.4 respectively. Management teams at poultry abattoirs should implement these measures as the essential first step towards optimizing effluent management in the Industry.

5.3 GROSS SOLIDS HANDLING

Large solids as observed in poultry abattoir systems can cause blockages of drains, pumps, valves, and control equipment, and should under no circumstances be allowed to enter the drainage system.

Suitably designed screens or grates should be placed at all drain inlets where gross solids can arise. The screens or grates should preferably have a self-cleaning action in normal operation but should not be readily removable unless under adequate supervision, otherwise the solids accumulated tend to be dumped back into the drain system. The solid materials collected should be binned and removed for rendering or other processing/disposal as appropriate.

5.4 GREASE REMOVAL

Concentrations of fats, oils and greases (FOG) in abattoir effluents can range up to several thousand mg/ℓ. FOG tend to float and cause problems in collection sumps (clogging of level control float mechanisms, etc) and at screening plants (blinding of screen surfaces, etc).

Grease traps with suitable grease removal facilities should be installed on-line upstream of major collection sumps, pump installations, balancing tanks, etc., to reduce the problem of grease removal from large volumes of effluent or plant items. Various grease trap designs are favoured by the larger municipalities, who are pleased to advise on design, installation and operation. Typical designs for general application are also available [15].

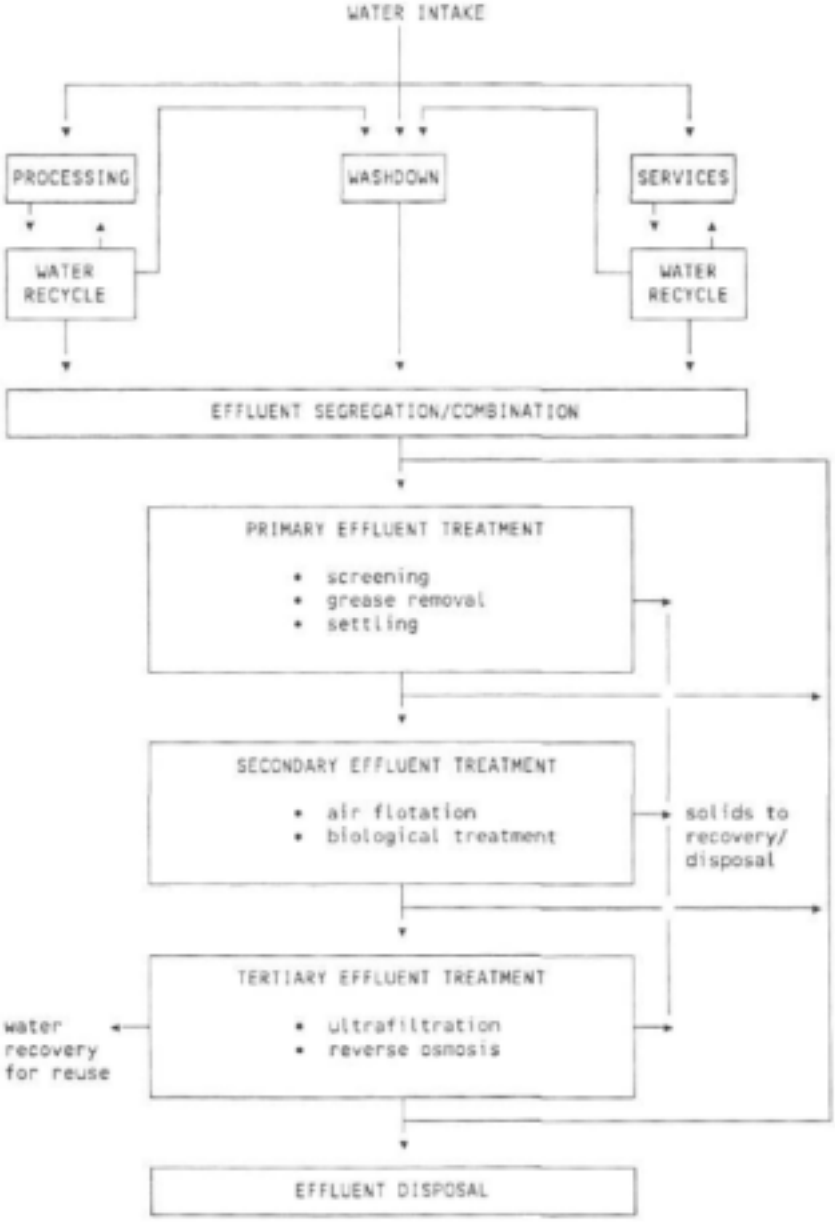


FIGURE 5.1. EFFLUENT TREATMENT ROUTES FOR POULTRY ABATTOIRS

5.5 SCREENING

Screening processes are widely used in poultry abattoirs to recover feathers and gross solids from waste waters, and are eminently suited to this purpose. Types in existing use include coarse mesh (1 to 10 mm apertures), perforated drum, tangential wedgewire (static and rotary) and vibrating screens.

Coarse screens are suitable mainly for preventing the entry of large solids into drainage systems. Finer screens, and in particular tangential wedgewire (static or rotary) screens, which have generally proved to be the most effective design, can retain much smaller particles (< 0,5mm) which can substantially reduce the suspended solids and settleable solids concentrations in abattoir effluents. The efficiency of solids removal in any particular application will depend on the size distribution and nature of the solids in the effluent to be screened. Loading rates should in all cases be maintained at or below the supplier's recommended levels, and appropriate performance guarantees should be obtained from suppliers.

In addition to performance (efficiency of solids removal), the other major factor to be considered in screen selection is the ease of cleaning, with self-cleaning types being preferable. Cleaning requirements can also affect water use. An example is a comparison between static and rotary tangential wedgewire screens, which have generally similar performance efficiencies. Despite their higher unit cost, the rotary type might be preferred in view of their more positive self-cleaning action and more efficient (lower water use) cleaning afforded by fixed inside and/or outside sprays operated by timers.

5.6 PRIMARY SETTLING

At some poultry abattoirs, primary settling is used successfully to reduce the suspended (settleable) solids content of the wastewater before further treatment and discharge to sewer. For effective management of such settling facilities, adequate provision must be made for removal of the settled solids/sludge, fats and other floating scum, and odour control. If variable-level settling tanks are used, a measure of effluent flow balancing and surge control may also be accomplished at this stage of the overall effluent treatment process.

Primary settling tanks may be either circular (radial-flow) or rectangular (horizontal-flow) in design, and would usually be made of concrete. Depending on the concentration, size and nature of the influent suspended solids, treatment efficiencies would be typically 30 to 60% removal of solids at reasonable hydraulic loading rates typically less than 1 $m^3/m^2.h$, corresponding to a hydraulic retention time of 2 h or longer.

5.7 EFFLUENT SEGREGATION

Three general types of effluent arise at poultry abattoirs, namely abattoir processing effluents, domestic sewage and other industrial effluents such as from workshops. These three types of effluent must be kept separate. The following comments apply to handling of the abattoir processing effluents only.

Two general approaches to effluent handling may be considered, namely either segregating individual effluents for appropriate treatment based on their strength/volume characteristics or, alternatively, combining all the effluents generated into a single stream for treatment. In poultry abattoirs, because of the very high pollutant potential of some effluent sources (for example blood wash-waters from the slaughtering area), the first approach is generally recommended.

Advantages are that contamination is treated close to the source, the capacity of end-of-line effluent treatment plants is effectively increased, the recovery of by-product materials is facilitated and the potential for water re-use via closed-loop or recycle systems is enhanced.

In order to cater properly for segregating effluents, provision should ideally be made at the abattoir planning stage for suitable drainage systems. Even in existing abattoirs, however, cost-effective arrangements can often be made to intercept particular effluents at source, either for recovery of additional materials from a high-concentration source or for recycle and re-use of low-concentration effluents.

5.8 EFFLUENT BALANCING

Effluent balancing is useful when effluent treatment is carried out on site, to equalize the flow and concentration of the effluent presented to the treatment plant. Gross solids and grease should be removed upstream of the balancing tank. The balancing tank should nevertheless be provided with suitable facilities for odour control and removal of bottom sludges and floating material which will inevitably accumulate to some extent, even with proper hydraulic design and mechanical mixing (where appropriate).

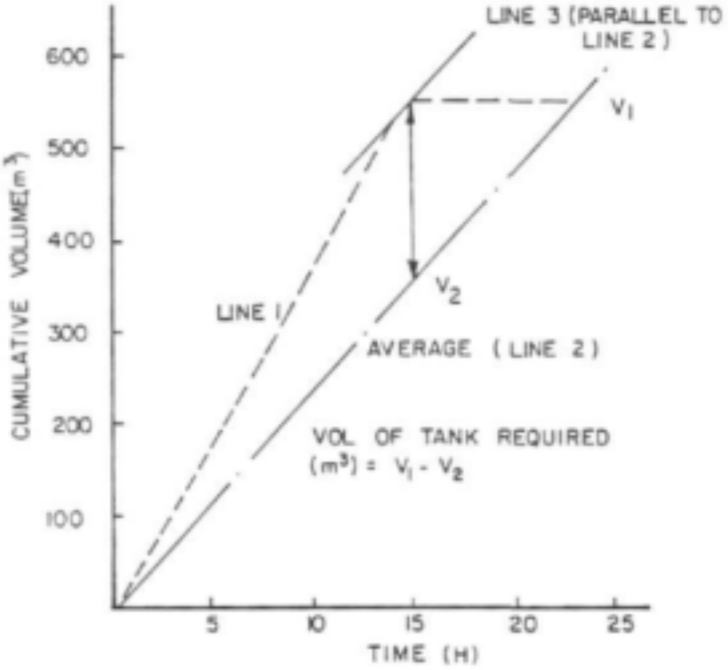
The advantages of effluent balancing depend on the application and include:

(a) buffer storage to contain extraordinary effluent discharge occurrences;

(b) balancing and equalization of the effluent flow and quality passed on to on-site treatment works, sewerage reticulation systems and off-site treatment works.

Several municipalities have recognised the advantages afforded to centralized sewerage systems by on-site balancing. At least one municipality offers financial inducements (reduced effluent discharge tariffs) to industry to install balancing/storage facilities which discharge during off-peak periods, usually overnight. The main general requirements are that the balancing facility should be to an approved design, that the flow discharged off-peak should be reasonably even and that the discharge to sewer be metered and recorded. In return, a substantial reduction in the effluent discharge tariff is offered for that portion of the effluent which is discharged in accordance with these requirements.

Figure 5.2 illustrates a simple graphical method for determining the tank volume required for balancing any particular effluent flow pattern over a 24-h period.



Method:

1. Plot cumulative effluent volume (V_1) over 24 h (Line 1).
2. Construct line giving average equivalent flow rate (Line 2).
3. Construct tangent to Line 1 parallel to Line 2 (Line 3).
4. The balancing tank volume required to discharge effluent evenly at the average equivalent flow rate is given by the vertical scaled difference between Lines 2 and 3 (ie $V_1 - V_2$).

FIGURE 5.2 GRAPHICAL METHOD FOR DETERMINING REQUIRED BALANCING TANK VOLUME

5.9 CHEMICAL DOSING

Poultry effluents contain significant quantities of dissolved and colloidal proteins which can be precipitated by acidic coagulants for subsequent removal by air flotation or filtration processes. After rendering and drying to around 10% moisture, the recovered solids can be sold as carcass meal for animal feed.

In practice, dosing trials must be conducted on the particular effluent concerned to determine the best and most cost-effective choice of chemical, dosage and pH.

From chemical dosing trials carried out, the most effective coagulants are ferric chloride ($FeCl_3$) and sodium hexametaphosphate (HMP). For HMP dosing, sulphuric acid dosing is required to lower the pH to around pH4. Table 5.1 gives indicative chemical dosing requirements for effective COD removal/SS precipitation.

TABLE 5.1: INDICATIVE CHEMICAL DOSING FOR POULTRY ABATTOIR EFFLUENT

Parameter	Range
pH to be achieved	4,0 - 5,5
Chemical dosage (mg/l)	150 - 200
g COD reduction/g chemical	10,6 - 12,7
g SS precipitated/g chemical	7,7 - 9,1

5.10 AIR FLOTATION

Air flotation has been proven in practice to be an effective method for recovering primary and secondary (chemically precipitated) solids from poultry abattoir effluents. Since the recovered sludge is high in protein and fat content, the additional revenue gained by rendering the recovered sludge can offset the effluent treatment costs or result in a net profit.

In air flotation processes, fine air bubbles are admixed with chemically dosed effluent to create solids/air conglomerates which are buoyant and rise to the surface in the flotation tank where they are mechanically scraped or sucked off. The most efficient system for producing the fine air bubbles is usually by dissolving air in liquid under a pressure of several hundred kPa (dissolved air flotation, (DAF)). Good results have also been obtained, particularly on proteinaceous effluents which have a tendency to foam when agitated, by inducing air mechanically by means of a variety of devices. Conservative design criteria to achieve a COD reduction in the range 60 to 70% are given in Table 5.2.

TABLE 5.2 : INDICATIVE DESIGN PARAMETERS FOR AIR FLOTATION SYSTEMS

Parameter	Units	Value
Hydraulic surface loading rate	$m^3/m^2.h$	1,5
Solids surface loading rate	kg $SS/m^2.h$	2 to 4
Air: solids ratio	g air/g SS	0,02

Depending *inter alia* on the effectiveness of upstream housekeeping practices and the concentration therefore of solid materials and blood in the abattoir waste water, chemical dosing and air flotation can recover > 10 g of additional solids per bird (dry mass basis) from abattoir final effluents. The float sludges can be recovered at a quality suitable for rendering to carcass meal (> 50% m/m protein, < 15% m/m fat, [13]). The moisture content of the recovered float sludge is, however, high (typically 95% m/m), and must be reduced to 10% m/m for sale as carcass meal [13].

5.11 AREAS FOR FURTHER RESEARCH

Grease and fat removal from poultry abattoir effluents is often not carried out effectively. A wide range of potential processes for improving this area of abattoir effluent treatment can be considered, and further research into appropriate technology for this purpose is indicated.

A second area identified for further research is the use of membrane technology for treatment of poultry abattoir effluents, recovery of additional saleable by-products and recovery of water for reuse. Membrane processes that can be considered include cross-flow microfiltration, ultrafiltration and reverse osmosis. Preliminary pilot-scale studies on the use of ultrafiltration and reverse osmosis have been carried out by the WRC [1].

CHAPTER 6

SOLID WASTE MANAGEMENT

6.1 GENERAL

Efficient management of solid wastes arising from poultry processing is a very important part of the overall management requirement in the Industry, since this impacts not only directly on disposal costs for unused solid wastes but also on the concentration of organic material in the liquid effluent, discharge costs thereof, and ultimately the net profitability per unit of production in the abattoir.

As detailed subsequently, birds are received at a chicken abattoir with a live mass of 1,5 to 2,0 kg/bird, and, after processing, are sold "dressed" at 1,2-1,6 kg/bird. The mass of solid waste available for processing to other products i.e. not for human consumption, is thus around 0,2 to 0,4 kg/bird.

Solid waste materials from sizeable poultry abattoirs are usually collected and rendered to meal for animal feeds, either on site or by sale to specialist animal feed meal producers. Where the rendering is carried out on site, the meal yield is sometimes supplemented by protein recovery from the abattoir liquid effluent, and/or solid waste materials from hatcheries and growing houses.

6.2 SOLID WASTES AND BY-PRODUCTS GENERATED IN THE INDUSTRY

In the poultry industry, there is a close connection between the rearing and slaughtering operations. The solid wastes generated fall into the following categories.

(a) hatchery wastes (egg shells, bedding, dead chicks);
(b) growing house mortalities (whole birds);
(c) dead-on-arrivals at abattoir (whole birds);
(d) feathers;
(e) inedible offal;
(f) blood;
(g) rejects, returns and condemned products (dressed whole birds or portions).

Some events, eg. mass farm mortalities, are sporadic and are difficult to estimate accurately on an industry basis. However, these items account for only around 7% of the total solid waste generated in the Industry. Table 6.1 gives a breakdown of the quantities of solid wastes arising in the other areas indicated, along with the usual disposal route associated with each waste material.

On average, the yield of by-products meal produced by rendering the materials indicated in Table 6.1 is around 25% after drying the meal to 8% moisture. The Industry thus has the potential for producing around 23 000 t/a of meal containing around 70% protein, 8% fat and 10% moisture.

TABLE 6.1 SOLID WASTE MATERIALS FROM POULTRY PROCESSING

Waste material	Disposal route	Specific mass (kg/bird)	Industry total* (t/a)
Processing wastes			
Feathers	Rendering	0,030	9 780
Inedible offal	Rendering	0,150	48 900
Blood	Rendering	0,030	9 780
Rejects, returns, etc	Rendering	0,015	4 890
Other waste			
Hatchery wastes	Rendering	0,030	9 780
Dead-on-arrivals	Rendering	0,030	9 780
Totals	-	0,295	92 910

* Based on 1988 production of 326 m birds/a

6.3 OPPORTUNITIES FOR IMPROVED SOLID WASTE MANAGEMENT

Areas in which solid waste collection, handling and processing can be enhanced to reduce solid waste and liquid effluent disposal costs, and to increase the profitable recovery of saleable by-products, include the following:

(a) Solid wastes falling to the floor in abattoirs should be dry-swept for collection and forwarding to by-products recovery plants before the area is washed down to drain; this facilitates by-product recovery and reduces the quantity of solid matter entering the final effluent.

(b) Birds should be bled completely over suitably designed bleeding troughs from where all blood should be scrupulously collected for processing; smaller abattoirs should partially process blood to a stable condition for forwarding to regionalized facilities for further processing wherever possible.

(c) Rendering plants operated in the poultry processing industry differ from those in red meat abattoirs in that only one product is generally produced. Feathers, blood and meaty materials are batched into the cookers according to a routine recipe designed to produce a uniform product. Additional attention should thus be given to the recovery of the various raw materials to ensure a consistent supply.

(d) Rendering plant design and operations should be integrated into the overall abattoir operation so that waste heat recovered from the rendering plant can be utilised efficiently to produce hot water according to abattoir demand. This requires careful design of the cooker complex with regard to the number of batch cookers, unit capacities and batch cycle times.

(e) An improved rendered meal quality, with an enhanced amino acid spectrum, can be achieved if the feathers are hydrolysed first at high pressure/temperature before adding the pre-coagulated blood once the high-temperature part of the cooking cycle has been completed.

(f) In general the approach to solid waste disposal in the poultry processing industry is reasonably well advanced. Scope, however, exists for more detailed evaluation of the different types of product that can be produced.

6.4 AREAS FOR FURTHER RESEARCH

Implementation of the various recommendations of Section 6.3 to improve basic solids handling and disposal procedures in the abattoir is a necessary first step toward rationalising this aspect of the Industry. Once this is accomplished, or in parallel as a development for the future, closer attention should be given to improved utilisation of the various raw materials available to yield products of enhanced value. Areas of further research for improved utilization of solid materials from the poultry processing industry are as follows:

(a) The disposal or recycling of poultry litter warrants further study. Litter from laying hens has been successfully converted to animal feed by drying, but economic methods of odour suppression are required. Broiler litter has a much lower potential nutritional value.

(b) Implementation of more efficient methods for the hydrolysing of feathers should be considered. Methods of minimising the formation of heat-retarding "skins" on the internal walls of rendering plant cookers are available. This phenomenon is most evident when a high proportion of feathers is cooked, while the problem is alleviated if hatchery wastes and/or protein sludges recovered from effluent are included in the cooker charge.

(c) Rendering plant operation should be studied and optimised so that high-protein materials such as blood can be processed at lower temperatures to avoid excessive degradation of the amino acid spectrum. The production of separate meals (feather, blood and meat) rather than a single mixed meal should be investigated to optimise batch processing times and product value. If separate meals are to be produced, methods of fat expression are required if dead birds and other meat materials are rendered separately from feathers, which soak up the fat during mixed meal production.

(d) The use of enzymatic hydrolyzation of feathers as an alternative to high-pressure/high-temperature hydrolyzation should be further researched to give higher-quality product yields.

(e) Effective control of utilization of the solid waste materials from hatcheries are very important to the Industry, and further attention should be given to this aspect.

6.5 ODOUR CONTROL IN ABATTOIR RENDERING PLANTS

In the development and implementation of odour control facilities for abattoir rendering plants, the impact of scrubbers and condensers on water use and effluent generation should be taken into account. Water use for such purposes should be metered and recycled in closed-loop systems with appropriate blow-down facilities. Chemical use (eg. caustic soda) should be carefully monitored, recovered and recycled with a minimum discharge to drain. Care should be taken to ensure that chemical discharges to municipal sewerage systems remain within the relevant permissible quality limits.

The Atmospheric Pollution Prevention Act [16] was amended in 1987 to include "animal reduction processes" such as abattoir rendering plants. All such processes must be registered in terms of the Act, with the issue of a registration certificate being dependent on the Chief Air Pollution Control Officer being satisfied that "best practicable means are being adopted for preventing or reducing to a minimum the escape into the atmosphere of noxious or offensive gases".

The Department of National Health and Population Development has identified three measures which can be implemented to reduce air pollution and to improve odour control from plants producing meal from animal matter namely :

(a) Direct-fired driers should be eliminated in favour of indirect-fired driers with a consequent reduction in the volume of contaminated vapour produced.

(b) Suitable scrubbing and/or condensing systems should be installed to reduce potentially odoriferous discharges to atmosphere.

(c) Non-condensibles from scrubbing/condensing systems should be incinerated in boiler plants or dedicated afterburners, or treated alternatively, for example chemically or by absorption in earth/compost systems.

CHAPTER 7

IMPLEMENTATION OF IMPROVED WATER AND WASTE-WATER MANAGEMENT

Water and waste-water management should be developed progressively, by first carrying out basic housekeeping measures to reduce water use (SWI) values and effluent generation (SPL values), and then implementing, as appropriate, further processes for effluent treatment, water recovery and by-products recovery.

In practice, each abattoir case must be individually assessed to determine the most beneficial and cost-effective overall strategy for water, waste-water and solid waste handling. Some of the site-specific factors that affect the choice of direction to take are:

- the cost of water;
- *the route(s) available for the disposal of industrial effluent;*
- the relative costs of industrial effluent disposal by alternative routes;
- the cost-effectiveness of on-site solid waste processing;
- the availability nearby of facilities for solid waste processing;
- local transport costs;
- the availability of space on site for effluent treatment facilities;
- local civil (structural) costs e.g. for reinforced concrete balancing tanks;
- labour costs for operating effluent treatment facilities.

Because of the variation in these (and other) factors nationally, representative costs cannot be assigned to "typical" situations. Some guidelines for applying the guide to particular abattoir situations in practice are:

- In the absence of sufficient data on water use for a particular abattoir, the grade-average figures given in Chapter 3 may be used without serious error [water intake (m^3/a) = SWI (ℓ/bird) x production (birds/a)/1 000].
- Different SWI and SPL targets are appropriate for different grades of abattoir, as shown in Tables 3.4 and 4.5 respectively.

- COD and SS are used as the main parameters for effluent strength and treatment efficiency in the design examples given. Other parameters, e.g. FOG, are usually more sporadic in terms of their concentration profiles in effluents. In some cases, e.g. membrane processes, FOG removal is for practical purposes 100% complete irrespective of the FOG level in the feed.

- The degree of waste-water treatment that is required or that is cost-effectively justified depends on the waste-water disposal route. Where discharge is to a local authority or watercourse, the appropriate discharge standards must be met. In addition, where a waste-water discharge tariff applies, the main criterion in terms of cost is usually organic strength, measured as COD, PV or OA. The on-site waste-water pre-treatment methods and technology employed should be selected appropriately to achieve the required discharge quality standard and/or cost saving.

As an indication of the strategic planning required to formulate, implement and maintain a comprehensive and effective water and waste-water management plan, some of the major considerations are illustrated in Figure 7.1.

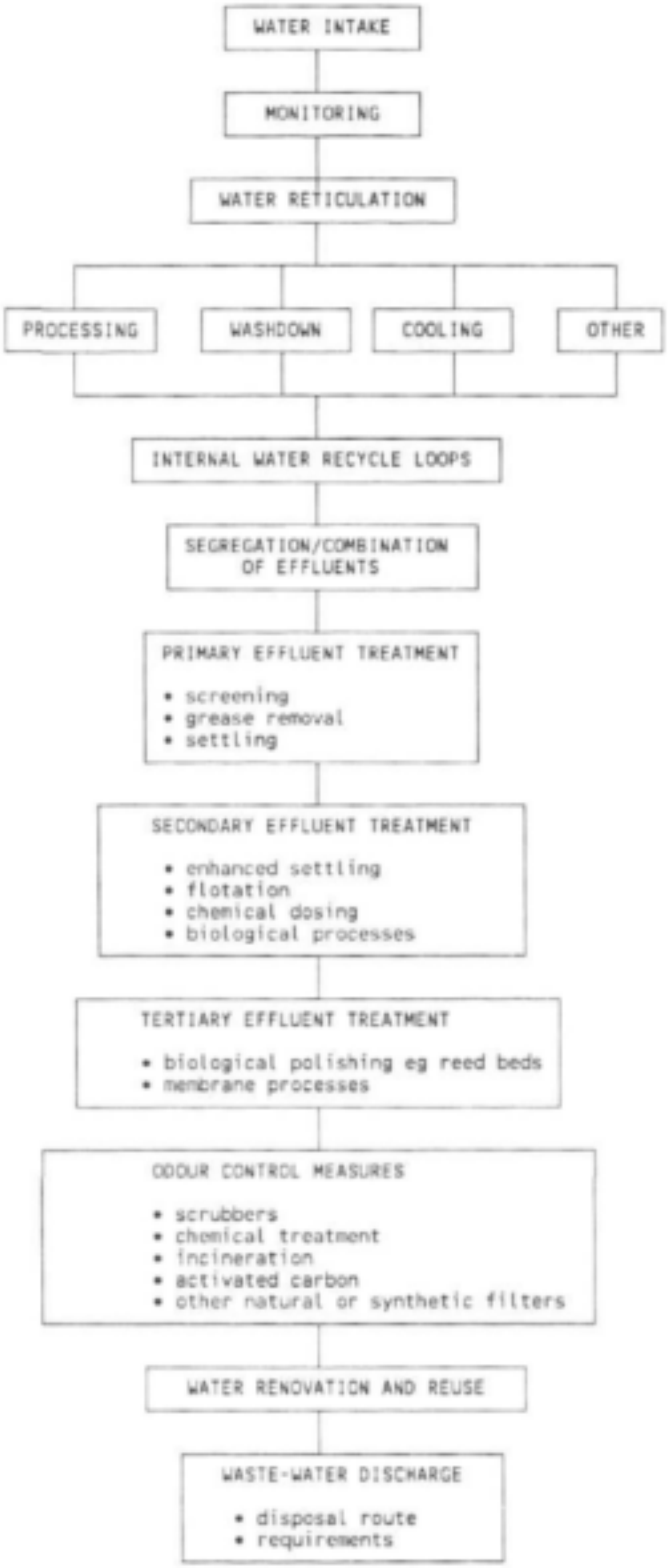


FIGURE 7.1 IMPLEMENTATION OF IMPROVED WATER AND WASTE-WATER MANAGEMENT

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APPENDIX A

THE WATER ACT (1956), ACT 54 OF 1956, AS AMENDED

The Water Act (1956) Act 54 of 1956, was amended in 1984 by the Water Amendment Act (1984), Act 96 of 1984. This Act contains important changes which affect all industrial operations. Factory management should obtain and read a copy of the Act. The more important provisions are as follows:

(a) The definition of the industrial use of water has been expanded to include the use of water for feedlots and fish farming.

(b) Section 12, governing the quantity of water used above that for which a Section 12 permit is needed, has been changed so that any plant using more than 150 m^3/d of any water including private borehole supplies or sea water, is now required to apply for a permit under this section of the Act.

(c) The Minister may terminate or reduce the supply of water from a Government Water Works or direct any supplier of water to an industry to terminate or reduce such supply until the industry complies with the requirement of the Act.

(d) Section 21 requires that any person using water, including sea water, for industrial purposes shall purify or otherwise treat the water so used and any effluent arising therefrom in accordance with such requirements as the Minister may prescribe from time to time, after consultation with the SABS. The person using water for industrial use must, amongst other provisions, furnish the Director-General in writing with such particulars regarding such use and the disposal of the purified or treated water, including water recovered from any effluent, as may be prescribed by regulation under Section 26.

(e) Section 22 (1) states that any person who has control over land on which anything was or is done which involved or involves a substance capable of causing water pollution, whether such substance is a solid, liquid, vapour or gas or a combination thereof, shall take such steps as may be prescribed by regulation under Section 26 in order to prevent:

(i) any public or private water on or under that land, including rain water which falls on or flows over or penetrates such land, from being polluted by that substance, or if that water has already been polluted, from being further polluted by that substance; and

(ii) any public or private water on or under any other land, or the sea, from being polluted, or if that water has already been polluted, from being further polluted, by water referred to in paragraph (a) of the Act which became polluted in the circumstances described in that paragraph.

(f) The Director-General may authorise any person in writing to enter upon any land referred to under Section 22 (1) or (2), or on which water is used for industrial purposes, or any of the steps referred to in Section 21 (1) are carried out, and to conduct on such land such investigation as the Director-General may determine.

(g) Section 26 states that the Minister may make regulations relating to:

- (i) any matter which under this Act is required to be prescribed by regulation under this Section;
- (ii) the prevention of wastage or pollution of public water and private water, including underground water, of pollution of sea water, and of damage to the environment caused by water;
- (iii) the information to be furnished to the Director-General in connection with the operations of any mine or industrial undertaking in so far as such operations affect a matter to which this Act relates, and the persons by whom such information is to be furnished;
- (iv) the information to be furnished to the Director-General in connection with water used for industrial purposes and in connection with the purification, treatment or disposal of water so used and effluent produced by or resulting from such use, and the persons by whom such information is to be furnished;
- (v) the manner and place of disposal of water used for industrial purposes and effluent arising therefrom, and the requirements to be complied with in connection with such disposal;
- (vi) the use or reuse for any purpose of water used for industrial purposes and effluent;
- (vii) the registration of sites or portions of sites where water used for industrial purposes or effluent containing poisonous matter is disposed of, and the control over and the disposal of such sites or portions of such sites.

TABLE A.1 STANDARDS FOR EFFLUENT DISCHARGE IN TERMS OF THE SOUTH AFRICAN WATER ACT (1956), ACT 54 OF 1956, AS AMENDED

NB: (1) All units mg/ℓ unless specified otherwise.
(2) N.S. = Not specified

Parameter	General standard limits	Special standard (2) limits
Colour, odour, taste	Nil	Nil
pH	5,5 - 9,5	5,5 - 9,5
Dissolved oxygen (% saturation)(DO)	75	75
Temperature (°C)	35	25
Typical faecal coli (per 100 ml)	Nil	Nil
Chemical oxygen demand (COD)	75	30
Oxygen absorbed	10	5
Conductivity (mS/m)	250; 75 above intake	250; 15% above intake
Suspended solids	25	10
Sodium	90 above intake	90 above intake
Soap, oil and grease	2,5	Nil
Residual chlorine (as Cl)	0,1	Nil
Free and saline ammonia (as N)	10	1
Nitrate (as N)	N.S.	1,5
Arsenic (as As)	0,5	0,1
Boron (as B)	1,0	0,5
Chromium (total, as Cr)	0,5	0,05
Copper (as Cu)	1,0	0,02
Phenolics (as phenol)	0,1	0,01
Lead (as Pb)	0,1	0,1
Sulphides (as S)	1,0	0,05
Fluoride (as F)	1,0	1,0
Zinc	5,0	0,3
Soluble orthophosphate	N.S. (1)	1,0
Iron (as Fe)	N.S.	0,3
Manganese (as Mn)	0,4	0,1
Cyanides (as Cn)	0,5	0,5
Cadmium (as Cd)	0,05	0,05
Mercury (as Hg)	0,02	0,02
Selenium (as Se)	0,05	0,05
Hexavalent chromium (as Cr)	0,05	N.S.

(1) In terms of Government Notice No. 991 of 18 May 1984, effluents draining to certain sensitive areas must have soluble orthophosphate (as P) concentrations of less than 1,0 mg/ℓ.

(2) The Special Standard applies to certain selected rivers and catchments as specified in Schedule II of Government Notice No. 991 of 1984.

APPENDIX B

LOCAL AUTHORITY CONDITIONS FOR EFFLUENT DISCHARGE

TABLE B.1 MUNICIPAL ACCEPTANCE STANDARDS FOR INDUSTRIAL EFFLUENTS

PARAMETER	MUNICIPALITY					
	JOHANNESBURG	PRETORIA	CAPE TOWN	DURBAN	PIETER-MARITZBURG	PORT ELIZABETH
pH	6	6 - 10	5,5 - 12	6	6,5 - 9,5	6 - 12
Temperature (°C)	44	44	43	43	43,3	44
Chemical oxygen demand (COD)	N.S.	5 000	N.S.	N.S.	N.S.	N.S.
4 hour oxygen absorbed (OA)	1 400	200	N.S.	N.S.	N.S.	1 000
Total dissolved solids (TDS)	N.S.	2 000	N.S.	N.S.	5 000	N.S.
Inorganic TDS (TDIS)	N.S.	N.S.	1000/2000	N.S.	N.S.	N.S.
Conductivity (mS/m)	500	N.S.	N.S.	N.S.	N.S.	500
Suspended solids (SS)	2 000	600	N.S.	2 000	400	1 000
Organic SS	N.S.	N.S.	2 000	N.S.	N.S.	N.S.
Inorganic SS	N.S.	N.S.	500	N.S	N.S.	N.S.
Fats, oil & greases	N.S.	N.S.	400	50	50	400
Ether-soluble solids	500	500	N.S.	N.S.	N.S.	400
Tar products	N.S.	60	60	60	250	50
Caustic alkalinity ($CaCO_3$)	2 000	N.S.	N.S.	N.S.	N.S.	1 000
Sodium (Na)	N.S.	N.S.	N.S.	N.S.	1 000	N.S.
Sulphate (SO_4)	1 800	300	500	200	250	1 500
Sulphides (S)	50	25	50	50	25	5
Chlorides (Cl)						
Fluorides (F)	5	N.S.	N.S.	N.S.	5	5
Cyanide (as HCN)	20	10	20	20	10	20
Formaldehyde (HCHO)	50	50	N.S.	N.S.	N.S.	50
Sugars, starches (as sucrose)	1 500	N.S.	1 500	1 500	250	1 000
Free chloride (Cl)	100	100	N.S.	N.S.	5	100
Iron (Fe)	20	5		N.S.	N.S.	20
Chromium (Cr)	20 Total	5		50	20	20 Total
Copper (Cu)	20 not to	5		50	25	20 not to
Nickel (Ni)	20 exceed	5		50	25	20 exceed
Zinc (Zn)	20 50	5		50	25	20 50
Cadmium (Cd)	20	5 Total	Total	50	25	20
		not to	not to			
		exceed	exceed			
Arsenic (As)	5	5 20	30	N.S.	25	5
Lead (Pb)	5 Total	5		N.S.	5	5 Total
Selenium (as Se)	5 not to	5		N.S.	N.S.	5 no to
Mercury (Hg)	5 exceed	5		N.S.	N.S.	5 exceed
Boron (B)	5 20	5		N.S.	5	5 20
Calcium carbide	Nil	Nil	Nil	Nil	N.S.	N.S.
Yeast, molasses, solvents, mineral oils	N.S.	N.S.	N.S.	N.S.	Nil	N.S.

Notes: (1) All units mg/ℓ unless specified otherwise.
(2) N.S. = Not specified.

TABLE B.2 MUNICIPAL TARIFF FORMULAE FOR INDUSTRIAL EFFLUENT DISCHARGES (1991/1992 BASE DATE)

MUNICIPALITY	EFFLUENT TARIFF FORMULA(1)
Johannesburg	c/m^3 = 41 + COD x 0,75 x 71/700
Midrand	c/m^3 = 59 + 0,008 (COD - 700)
Pretoria	c/m^3 = 24,69 + COD x 35,24/950
Standerton	c/m^3 = 85
Durban	c/m^3 = 23,85 + PV x 3,78/30 + S x 7,55/9
Pietermaritzburg	c/m^3 = 44 + 0,031 (PV - 70)
Hammarsdale	c/m^3 = 120
Port Elizabeth	c/m^3 = 40,7 [(2PV - 160)/80 + (S - 10)/10] x 1/3
Worcester	c/m^3 = 20,97 + PV x 58,5 x 0,01

Notes :
(1) Excluding additional cost factors for metals, nutrients, etc and minimum charges (where applicable)
(2) PV = Permanganate value, mg/ℓ
(3) COD = Chemical oxygen demand, mg/ℓ
(4) S = Settleable solids, mg/ℓ

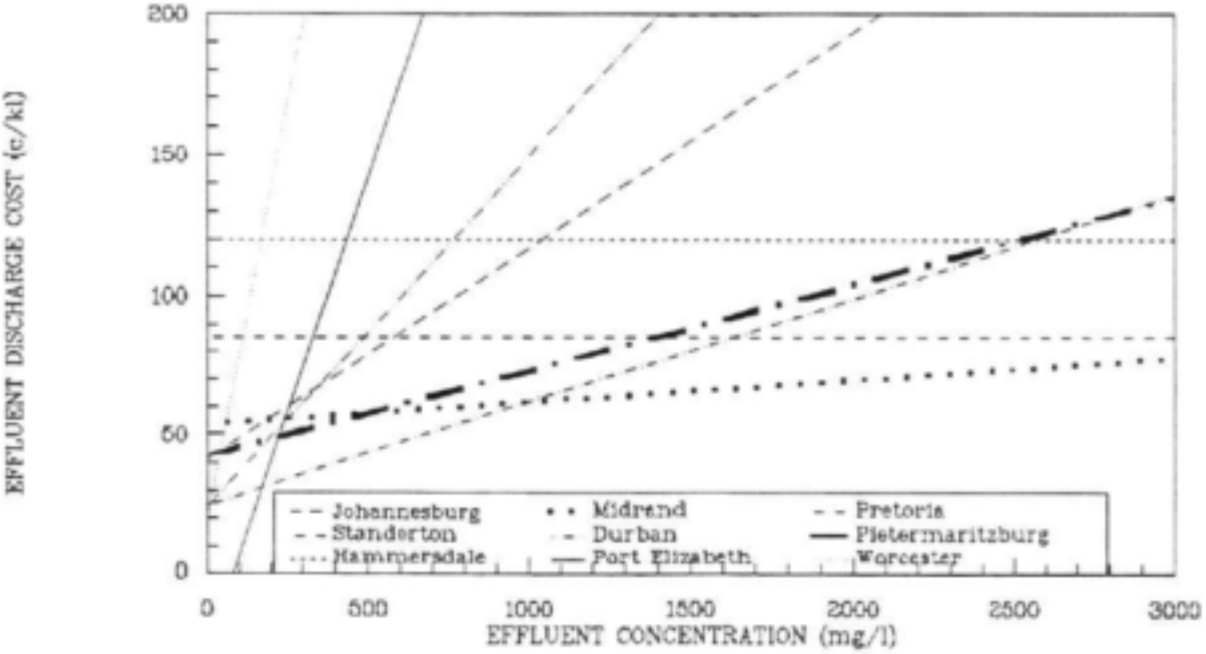


FIGURE B.1 COSTS OF DISCHARGING INDUSTRIAL EFFLUENTS TO MUNICIPAL SEWERS

APPENDIX C

FACTORY DRAINAGE GUIDELINES

C.1 GENERAL

These notes are intended as a general guide and reminder of factors to be considered and do not constitute a comprehensive specification.

C.2 PLANNING

During the construction stage of an abattoir it costs very little extra to design and install correct drainage systems. Alterations to drainage systems in an operative and completed abattoir are difficult and expensive, not only in terms of the actual costs of the modifications but also because of the resultant disruption.

Makers' drawings of equipment often label various outlets to drain, and do not differentiate between strong, weak, continuous or occasional flows. Effluent management requirements are also often poorly defined at the factory design stage. If incomplete data of this nature are given to an architect, structural engineer or contractor who has insufficient expertise in effluent treatment, a common drainage system is likely to result, with all discharges being mixed and interconnected without the necessary facilities to monitor, control and treat the various streams.

C.3 SEGREGATION OF EFFLUENT FLOWS

One of the fundamental requirements in factory design is to segregate effluent streams rationally, for example separating weak and strong streams and streams containing different types of pollutant.

Domestic sewage, for example from toilets and ablution facilities, must be kept completely separate from industrial effluents, otherwise on-site treatment of the latter can be made very difficult or impossible.

Complete segregation of storm water from industrial and domestic sewers is also essential. Storm-water discharge into industrial drains is unacceptable, as is any industrial discharge into a storm-water drain.

Major problems can arise with poorly designed storm-water drainage of open areas, for example where vehicles or containers drip pollutants on to a paved surface and where these accumulated pollutants are then washed into the storm-water drain either by rain, or deliberately by means of a hose.

It may prove necessary to combine the segregated streams (other than storm water) before they leave the site, for example to provide a single connection to a municipal sewer. Such a combining point should be located downstream of facilities installed for monitoring, controlling and treating the individual streams before they are combined.

C.4 BALANCING

Storage or balancing facilities can be very useful in a drainage system, as they smooth out the strength and flow-rate peaks.

Any treatment facility will operate better if it receives a stream which is more uniform in terms of composition and flow rate. The capital cost of the treatment facility can also be reduced if it is designed to handle average, rather than peak, conditions.

It is often possible to combine balancing with treatment, for example, separation of pollutants by settling and/or natural flotation.

If on-site effluent balancing is likely to be needed in the short or long term, provision must be made at the initial planning stage of the drainage design, otherwise future problems are likely to arise with regard to drain levels, site space for tanks and foundation restraints.

C.5 SCREENING

Screening is a relatively simple, inexpensive and effective treatment option. Wherever possible, screening out of solids should be incorporated before discharge of effluents to drain. This will minimise leaching of the dissolved substances into the effluents, problems of drain blockage and the suspended solids pollution load in the final effluent.

Screening should be carried out above ground wherever possible. Basket screens placed in sumps and catch pits require very close control and supervision if they are to be successful. "Cleaning" of such screens is often incorrectly carried out by removing the basket, emptying the contents down the drain, and by replacing the basket, thereby negating the purpose of the screen.

If it is necessary to screen liquid which is in an underground drain, the best solution is usually to incorporate a sump and to pump the liquid over a self-cleaning screen positioned above ground.

Cartridge type filters, especially those requiring manual cleaning or cartridge replacements, should be avoided in polluted effluent screening applications. Even relatively low suspended solids concentrations can block such a filter within a short time.

C.6 PUMPING

The most important design aspect of effluent pumping is that the pump must be able to handle the expected (and unexpected) solids in the effluent. The passages through the impeller must not be prone to blockage by stringy or similar substances, if these are present.

Where the flow rate is low, a small pump may appear suitable from the head/flow curve, but the overriding factor must be the solids handling capability, even if this implies an overdesigned pump from the flow point of view.

Pump material should be compatible with the fluids being handled. Factors to take into account include pH and temperature. It may, however, prove economically justifiable to install a pump with poorer corrosion resistance, and to accept ongoing replacement costs, rather than to use a pump made of very expensive material which will also wear out in time, rather than corrode.

In the case of large submersible pumps, provision must be made to lift them out of their sumps. The lowest permissible water level may have to be higher than the top of a submersible pump to ensure adequate cooling. This may severely reduce the usable capacity of a sump.

C.7 FLOOR DRAINAGE

Where hosing or spillage on floors is to flow naturally to a drainage point, a floor slope of 1 in 150 or steeper is usually necessary. The distance from any point to a drain should not be further than about 3 m, which implies drains at about 6 m centres.

The floor surface selected should not be slippery when wet or covered with product, but not so rough that it traps particulate matter and makes sweeping or squeezing difficult.

Low "bunds" or "humps" on the floor may be beneficial around areas where particularly strong or high-volume spillages occur, to segregate these discharges into one drain rather than another.

C.8 DRAINAGE PIPING

Drainage piping should not have a nominal bore of less than 100 mm, to permit cleaning and to minimize blocking. Pipes should, however, not be unnecessarily oversized, as this will facilitate settling out of solids. Pipes should be sized to accommodate peak flows, to prevent "backing up" and flooding of drain points.

The preferred slopes are 1 in 40 for 100 mm, 1 in 60 for 150 mm and 1 in 90 for 225 mm nominal borepipes. These slopes are slightly steeper than conventional building practice, in order to ensure adequate flow velocity to minimise settling out of solids.

Manholes must be provided wherever pipes change direction or join. The bottoms of the manholes should be "benched" to permit through-flow of solids. "Dead spaces" lower than pipes in manholes collect debris and are difficult to clean. Manholes deeper than about 500 mm must be sufficiently wide to permit a man to bend over during cleaning or rodding operations. Where gross solids are present in the effluent, it is worthwhile plastering the inside of manhole walls, to facilitate cleaning and to improve working conditions.

Drainage pipes, manhole walls and covers must be waterproof against the infiltration of ground or storm water, which can increase effluent volumes and treatment problems. Leakage from pipes and manholes into the ground must also be avoided.

Care should be taken in the choice of materials for effluent or drainage piping. Examples of potential problem areas are the use of PVC pipes for hot effluents. Note should be taken of the high thermal expansion coefficient of such pipework, (and the possible distortion resulting) and, on the other hand, corrosion problems in metal pipework.

APPENDIX D

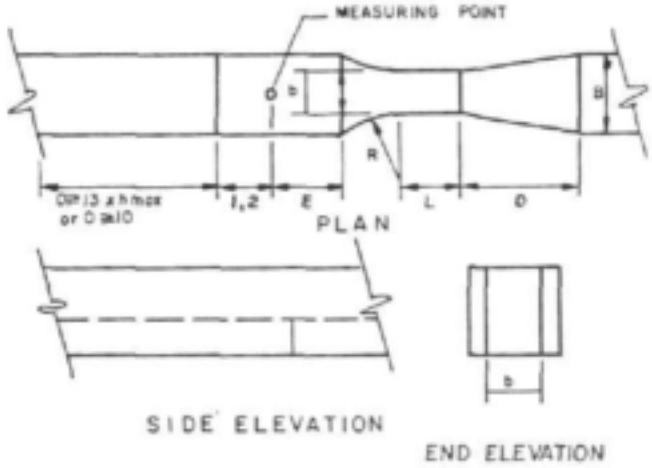
FLOW METERING EQUIPMENT

D.1 GENERAL

This section describes some of the types of equipment commonly used for flow measurement. In the future, the Department of Water Affairs will require metering of effluent flows before discharge.

D.2 FLUME METERS

The classical method of effluent flow monitoring is the flume and/or venturi. Various types of venturi flume exist for fitting into open channels. Figure D.1 provides the design of a flume suitable for widely varying flow rates. The flow rate is calculated from the equation given for Q(m^3/s), with the value of the terms being given by the geometrical dimensions of the flume installation (see Fig. D.1), measurement of the water depth, and the factors Ce (obtained from the formula) and Cv (obtained from Table D.1).



Notes:

(i) h max ≤ 3 x b
(ii) 5 cms ≥ h ≤ 180 cm
(iii) length of inlet section ≥ 120 cm + E
(iv) b/H ≤ 0,70
(v) h/b ≤ 3
(vi) E = 3 to 4 times h max.
(vii) max gradient at inlet section is 1:100

FIGURE D.1 FLUME METER

$$Q = \frac{2}{3} \times (2g/3)^{0,5} \times Cv \times Ce \times b \times (h)^{1,5} \qquad (m^3/s)$$

$$\text{The value of } Ce = \frac{b^{1,5}}{b + 0,004L} \times \frac{(h - 0,003L)^{1,5}}{h}$$

where Q = flow, m^3/s;
b = restriction width, m;
B = downstream channel width, mm;
E = distance of measuring point upstream of commencement of restriction;
Cv = velocity factor from table or by calculation;
Ce = outlet coefficient depending on friction losses; and
h = backup water height, mm.

TABLE D.1. VELOCITY FACTORS FOR DIFFERENT b/B RATIOS IN FLUME METERS

b/B	Cv	b/B	Cv	b/B	Cv	b/B	Cv
0,14	1,0022	0,30	1,0209	0,44	1,0476	0,58	1,0901
0,17	1,0051	0,32	1,0240	0,46	1,0526	0,60	1,0980
0,20	1,0091	0,34	1,0272	0,48	1,0579	0,62	1,1065
0,22	1,0110	0,36	1,0308	0,50	1,0635	0,64	1,1154
0,24	1,0132	0,38	1,0346	0,52	1,0695	0,66	1,1253
0,28	1,0181	0,42	1,0430	0,56	1,0829	0,70	1,1469

D.3 WEIRS

Among other methods of measuring effluent flow are weirs and the use of empirical equations. Weirs should, however, only be used where they will not become blocked with gross solids.

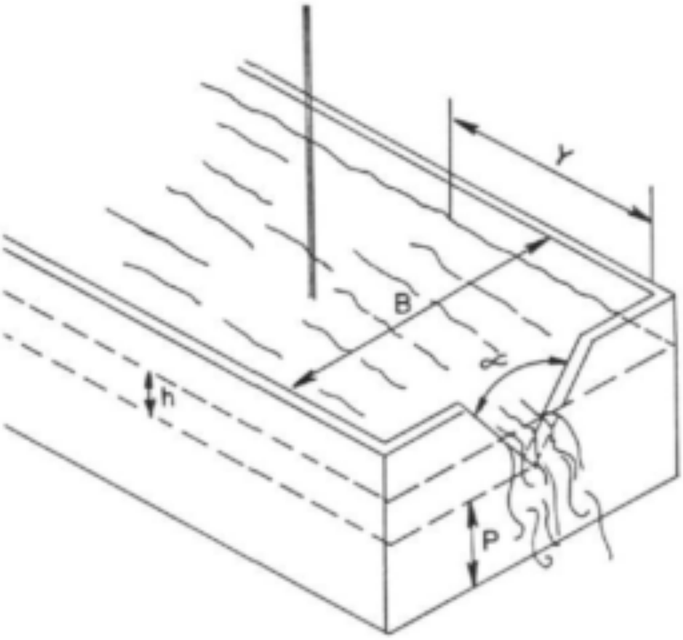
(a) V-notch weirs

Figure D.2 shows the general arrangement and formulae for calculating the flow over a weir. The general arrangement should be designed in accordance with the notes. The flow is calculated from the height of water above the weir apex when measured at the correct point. The V-shape results in a major change of level for a small increase in the rate of flow and it is therefore particularly suitable for highly varying rates of flow. The weirs can be made of replaceable sharp-edged metal plates.

An arrangement is provided in Figure D.3 for a measuring box which can be installed in line at a suitable location in the effluent pipeline.

(b) Rectangular weirs

The general arrangement of a rectangular weir is shown in Figure D.4. This type of weir is best suited to relatively constant flows.



Measuring point 3 to 4 x h max

Notes:

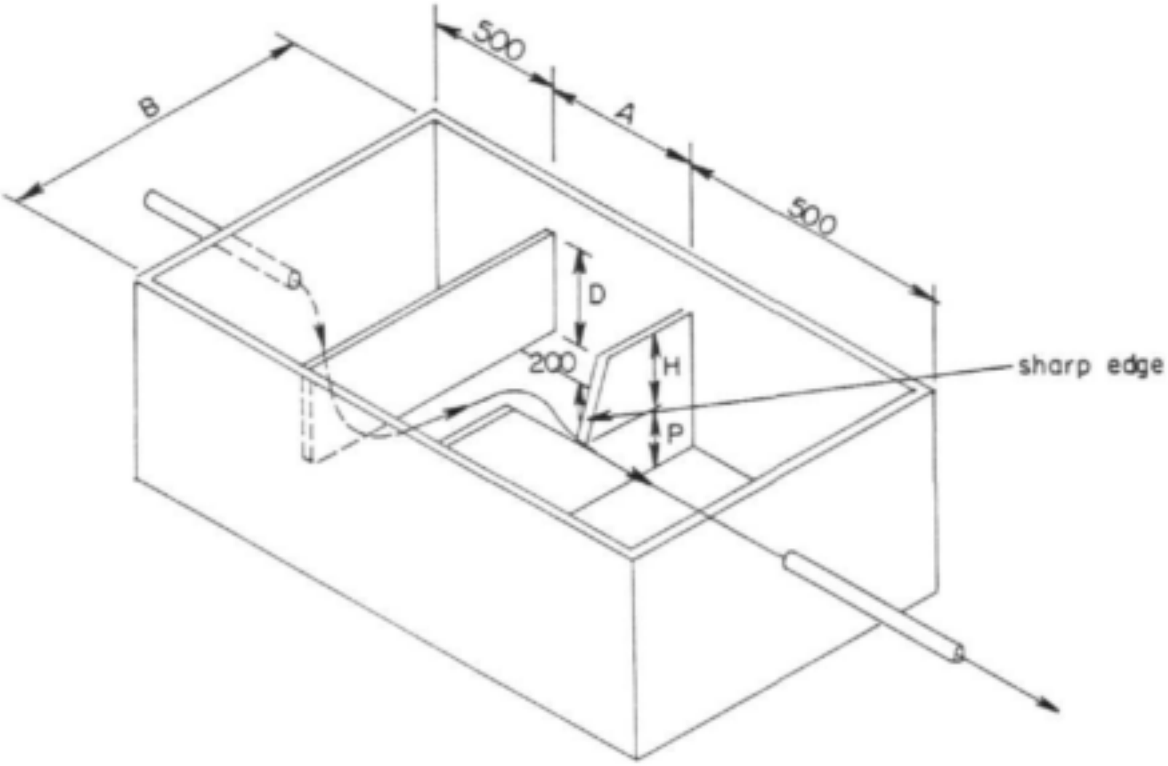
(i) minimum h = 5 cm
(ii) maximum h = 30 cm
(iii) opening angle α = 30° to 90°
(iv) measurement range 0,75 to 240 m^3/h
(v) notches to be sharp-edged
(vi) Y $\geq$ 1,5 m
(vii) B $\geq$ 80 cm
(viii) P $\geq$ 80 cm
(ix) $h/p \leq$ 45 cm
(x) $hB \leq 0{,}30$

FIGURE D.2 V-NOTCH WEIR

$$Q = \frac{g}{15} Ce \, (2g)^{0,5} \times \tan \frac{\alpha}{2} \, (h)^{2,5}$$

if $\alpha = 30$	$\alpha = 45$	$\alpha = 90$
$Q = 0{,}63 \ Ce \ h^{2,5}$	$Q = 0{,}98 \ Ce \ h^{2,5}$	$Q = 2{,}36 \ Ce \ h^{2,5}$

$Ce = 0{,}565 + 0{,}0087 \, (h)^{0,5}$
Q = flow, m^3/s
g = 9,81 m/s^2
h = metres



Notes:

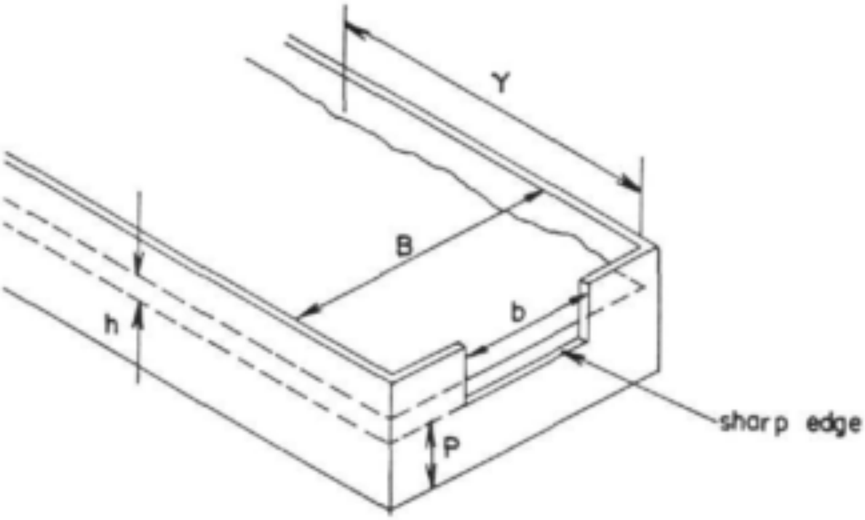
(i) A ≥ 1,5 m

(ii) B ≥ 0,8 m

(iii) P ≥ 0,45 m

(iv) H/B ≤ 0,3

FIGURE D.3 V-NOTCH WEIR MEASURING BOX



Measuring point 3 to 4 x h max

FIGURE D.4 RECTANGULAR WEIRS

$$Q = \frac{2}{3} \ (2g)^{0,5} \times Ce \times b \times (h)^{1,5}$$

or

$$Q = 2,09 \times Ce \times b \times h^{1,5}$$

where:

$C = 0,616 \ (1 - 0,1 \ h/b)$

flow $Q = m^3/s$

$g = 9,81 \ m/s^2$

both b & h in metres

Notes:

(i) suitable for relatively constant flow

(ii) overall height between 7,5 cm and 60 cm

(iii) base width $b \geq 2$ h max ≥ 30 cm

(iv) inlet length ≥ 10 to $13 \times$ h max

(v) width $B \geq 3b$

(vi) ratio $h/p \leq 0,50$

D.4 OTHER METHODS

If the drain or channel layout does not permit the installation of a flume or weir, empirical methods of flow estimation may be used. Examples include the co-ordinate method (for free discharges) and the California pipe method (for partially filled pipes).

D.5 ELECTRONIC METERS

If the above methods of flow measurement are not suitable, consideration may be given to the use of electromagnetic or ultrasonic meters.

Average flow in any conduit is equal to the cross-sectional area of the flow multiplied by its average velocity. Two measurements are needed; the liquid depth (width known by channel geometry) and the velocity.

D.6 ELECTROMAGNETIC METERS

A typical unit consists of an electromagnetic sensor head clipped to a pipe ring for insertion into the open end of a pipe, or to the base of a channel. This sensor head measures the velocity and is also equipped with a pipe conveying air to the sensor.

The air is allowed to bubble out at about 2 bubbles per second; the back pressure measured on a suitable gauge provides the depth data for the calculation. Portable units can be mounted in any desirable location within a factory or in the final effluent pipe or channel.

D.7 ULTRASONIC METERS

This type of meter is attached to two sensors mounted on the outside of a pipe.

The meter measures the instantaneous linear flow velocity. The internal cross-sectional area of the pipe must be measured or estimated. The volumetric flow can then be calculated.

Ultrasonic meters are simple to use but are expensive and are restricted to certain pipe materials and pipes in full flow. The wall thickness of the pipe must be known for accurate results, and scale or corrosion on the inside of the pipe can significantly affect the results obtained.

APPENDIX E

QUESTIONNAIRE FOR ANNUAL UPDATING OF NATIONAL WATER, WASTE-WATER AND SOLID WASTE STATISTICS FOR THE INDUSTRY

E.1 NOTES FOR COMPLETION OF QUESTIONNAIRE

(a) It is requested that the questionnaire be completed for the current calendar or financial year as stated in the covering letter.

(b) The aim of this brief questionnaire is to update annually the national water, waste-water and solid waste statistics for the Industry, thereby to provide a valid basis for assisting the Industry in progressively managing the problems faced in this context.

(c) All information received will be treated as strictly confidential. Please return completed questionnaires by the end of January of each year to the **Water Research Commission, PO Box 824, PRETORIA, 0001**.

(d) To obtain accurate updating of the national water, waste-water and solid waste situation for the Industry, a 100% response is aimed at. If any part of the questionnaire cannot be completed due to lack of information, please submit the semi-complete questionnaire in any event. If insufficient space is provided for completion of any part of the questionnaire, or if particular factors of relevance are not provided for, please append any additional notes or data as required.

(e) Your cooperation in assisting the Water Research Commission to continue monitoring and assisting the Industry with the management of its water, waste-water and solid waste problems is gratefully acknowledged.

E.2 GENERAL INFORMATION

Date : ....

Name of company : ....

Name of holding company : ....

Name of factory : ....

Factory street address : ....

.... Postal code : ....

Factory PO Box : ....

Contact person : .... Telephone : ....

Service authority : ....

Factory operation : ....

MONTH	NO. OF DAYS	NO. OF SHIFTS/DAY	DURATION OF SHIFT (H)	NO. OF EMPLOYEES ON SITE/24H
JANUARY				
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				

E.3 PRODUCTION

Production period : Start

SLAUGHTER (NUMBER OF BIRDS)			
MONTH	CHICKENS	OTHER*	TOTALS
JANUARY			
FEBRUARY			
MARCH			
APRIL			
MAY			
JUNE			
JULY			
AUGUST			
SEPTEMBER			
OCTOBER			
NOVEMBER			
DECEMBER			
TOTALS			

* Please specify species.

E.4 WATER INTAKE

MONTH	TOTAL WATER INTAKE (m^3)			
	MUNICIPAL	BOREHOLE	OTHER	TOTAL
JANUARY				
FEBRUARY				
MARCH				
APRIL				
MAY				
JUNE				
JULY				
AUGUST				
SEPTEMBER				
OCTOBER				
NOVEMBER				
DECEMBER				
TOTALS				

E.5 WATER USE

It is desired to break down, in overall terms, the total water intake in order to estimate the water use for processing, for factory and equipment washdown, for utilities (cooling towers, boiler plant, refrigeration plant, etc.) and for services (general washdown, vehicle and pallet washing, ablutions, laundry, etc.)

The information required will not be available to the same extent at different factories. It will assist, however, in compiling overall statistics for the Industry if reasonable estimates of the water use for particular aspects of factory operation are given where more precise information is not available. Where such estimates are given, i.e. the water flow concerned is not metered, the estimate should be identified by "(E)" following the figure. Carrying out this exercise will also assist management in identifying large water uses which are not adequately metered, so that consideration may be given to installing water meters for such purposes.

In completing the following table identifying the overall breakdown of water use in the factory, please photocopy the table as many times as required for the different species, and add additional relevant information or comments as appropriate.

BREAKDOWN OF WATER USE

Species

WATER USE CATEGORY	WATER USE (m^3/MONTH)												TOTALS FOR YEAR (m^3)
	J	F	M	A	M	J	J	A	S	O	N	D	
PROCESS													
WASHDOWN													
COOLING													
REFRIGERATION													
BOILERS													
ABLUTIONS													
LAUNDRY													
VEHICLE WASHING													
GARDEN													
OTHER (SPECIFY)													
TOTALS													

Note : Please photocopy and complete the above table for each species or principal product as fully as possible.

E.6 WASTE WATER

Disposal route for abattoir waste water . . . .

Estimated annual waste-water volume (m^3) . . . .

Waste-water analysis (year . . . .)

PARAMETER		J	F	M	A	M	J	J	A	S	O	N	D
Flow	m^3												
pH	min max mean												
COD	min max mean												
TS	min max mean												
SS	min max mean												
TDS	min max mean												
Other (specify)	min max mean												
Other (specify)	min max mean												
Other (specify)	min max mean												
Other (specify)	min max mean												

Notes for Table E.6

(a) COD = chemical oxygen demand (mg/ℓ), TS = total solids (mg/ℓ), SS = suspended solids (mg/ℓ), TDS = total dissolved solids (mg/ℓ), "other" parameters eg. TDIS (total dissolved inorganic solids), colour, etc. to be specified if analyses are not available.

(b) If more than one analysis is available per month, fill in "min" (lowest analysis for month), "max" (highest analysis for month), and "mean" (average of all analyses taken in a particular month).

(c) If analyses are taken less frequently than monthly, eg. if waste-water sampling and analysis are carried out by a local authority on a "four times per six-month" cycle, fill in the "min", "max" and "mean" figures as above and indicate the period covered by arrows across the table (typically Jan-Jun and Jul-Dec in the example cited).

Breakdown of annual waste-water volume : Please estimate, if possible, by the best means available, a breakdown of the annual waste-water volume. Monthly breakdown parameters are indicated in the following table.

PARAMETER	J	F	M	A	M	J	J	A	S	O	N	D
Flow m^3/month												
Min m^3/day												
Max m^3/day												
Mean m^3/day												