The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation

Water Quality Improvement and Conservation Project

AUDIT REPORT:

Municipality of Greater Amman Slaughterhouse

Science Applications International Corp.

Water Quality Improvement and Conservation Project

Amman Chamber Of Industry

The Hashemite Kingdom Of Jordan

DAI

Development Alternatives, Inc.

USAID

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PREFACE/ACKNOWLEDGMENTS

This report is the result of a 4-week study/audit/evaluation of the Municipality of Greater Amman Slaughterhouse(MGAS), Jordan. The purpose of the study was to evaluate and identify potential pollution prevention/waste minimization and water conservation techniques which are appropriate. The executive summary on the following pages outlines the consultants findings and actions during the study/audit/evaluation.

Several individuals on the Water Quality Improvement and Conservation Project contributed to this report. Dr. Usama Mudallal of the Amman Chamber of Industry (Chamber); Engineer Rania Abdul Khaleq of the Ministry of Water and Irrigation (MWI); Mr. Hamed Abu Obeid, of the Water Authority of Jordan (WAJ); and Dr. Riyad Musa and Eng. Rafat Assi of the Royal Scientific Society of Amman; shared their knowledge with Mr. David Hair, of Science Application International Corp., Falls Church, VA, USA. These technical staff worked under the direction of Dr. Shawn R. Niaki, P.E., Pollution Prevention Program Director, of Harza Consulting Engineers and Scientists (Harza), Chicago, USA., who heads the WQIC component under which the study/audit/evaluation was housed. It is from their combined expertise that this report was possible.

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EXECUTIVE SUMMARY

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ntroduction

Inder Contract No. 278-0288-00-4026-00 with the United States Agency for International Development USAID), Development Alternatives, Inc. (DAI) is performing an Industrial Wastewater Discharge revention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components f the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program ; being performed by DAI with full coordination between the Jordanian Ministry of Water and rigation (MWI) and the Amman Chamber of Industry (Chamber).

his report provides the findings of the audit conducted at the Municipality of Greater Amman laughterhouse (MGAS) facility on September 17, 1994, and the results of the subsequent discharge ionitoring conducted by the audit team on September 24, 1994. The report provides recommendations or the development of a site-specific program that meets the specific needs and goals of the MGAS icility. Audit recommendations include both PP/WM techniques (e.g., water conservation techniques, ousekeeping practices, alternate waste disposal practices) and suggestions for PP/WM training for icility staff and follow-up studies to assess program successes.

rocess Overview

he MGAS facility provides red meat and poultry slaughtering services for the City of Amman, Jordan id its surrounding communities. The facility is owned and operated by the Municipality of Greater mman; however, the private sector plays an integral role in its operation. The MGAS facility receives ve animals for slaughter from producers in Jordan as well as other nearby nations, and receives eaned carcasses for inspection from slaughtering facilities in other countries. The facility charges oducers a set fee for the slaughtering services and does not own or sell any of the meat products that handles.

i order to meet the current demand for meat and poultry in the Amman area, planning has begun, and nd has been set aside, for a new, high-production facility. It is likely, however, that it will be several ears before this facility can be completed. The exiting facility, therefore, will continue its operation its current capacity for at least 5 years. Following the construction of the new facility, plans call for e existing plant to be upgraded and modernized and operated at a more moderate production rate.

he existing slaughterhouse facility is separated, both physically and operationally, into two separate oduction lines. One line is for the slaughter and processing of cattle and sheep (primarily lambs) and e other is for the slaughter and processing of poultry (chickens).

Sheep and Cattle Slaughtering and Processing Operations

The sheep (primarily lambs) and cattle operations at the slaughterhouse provide slaughtering and dressing services for live animals transported to the facility by truck, and inspection services for carcasses slaughtered at other facilities outside of Jordan. Some of the live animals slaughtered at the facility are raised in Jordan; however, most are imported live from other countries.

The sheep and cattle slaughtering operations at the MGAS facility follow the typical operations used by the industry, and include:

- Reception and lairage;
- Slaughtering and bleeding;
- Carcass dressing;
- Paunch manure recovery; and
- Chilling, storage and inspection.

This facility does not perform any rendering operations. Blood and other inedible by-products are sold to private sector facilities for further processing.

Poultry Slaughtering and Processing

The poultry facilities at the MGAS facility provide slaughtering and dressing services for live animals and inspection services for chickens killed and cleaned at other locations. All chickens are transported to the facility by truck.

The chicken slaughtering processes used at the MGAS facility follow the typical operations utilized by the industry and include:

- Reception;
- Slaughtering and bleeding;
- Defeathering;
- Eviscerating/Cleaning; and
- Chilling, storage and inspection.

This facility does not perform any rendering operations. Blood and other inedible by-products are sold to private sector facilities for further processing.

Ancillary Operations

In addition to the primary slaughterhouse operations, the MGAS facility also provides additional services including employee canteen and sanitary facilities, truck loading and unloading operations, laboratory facilities, and administrative offices. These operations, while not directly related to the slaughterhouse processes, are imperative for the proper functioning of the facility.

udit Process

he facility audit was conducted on September 17, 1994. The MGAS facility designated the facility's .aintenance engineer to accompany the audit team. The MGAS representative and the audit team .embers toured and inspected the facility starting at the sheep and cattle processing line operations and ›ntinuing through the poultry processing operation. Audit team members revisited the facility on ɜptember 24, 1994. During this visit several unanswered questions were resolved, and four samples wo composites and two grabs) were collected and sent for analyses at Water Authority of Jordan VAJ) laboratories in Amman.

udit Findings

'ater Use and Balance

'ater is used extensively throughout the MGAS facility for cleaning and sanitation requirements of the aughtering operation, and to a lesser extent for staff sanitary and hygiene needs. All water used by e facility is provided by the Water Authority of Jordan (WAJ). Total water use has reportedly been duced over the past few years with the average current consumption reported at approximately 700 ^{3} per day. The facility does not meter any water use for production operations, and has not developed timates of the water consumption rates for any of its unit processes.

ısed on process flow and water use information supplied to the audit team by the facility maintenance ıgineer, the unit processes of the sheep and cattle operation were estimated to consume approximately 3 percent of the total water used at the MGAS facility. The principal water consuming processes ere, carcass washing (16.3 percent of total MGAS consumption), viscera, and head and leg cleaning ›erations (11.3 percent), floor washings and domestic uses (10 percent) and slaughtering and bleeding ›erations (5 percent). In general the major water consuming devices included running hoses at various cations, continuously operated mechanical spray washers, and cleaning tank overflows.

ıe unit processes of the poultry operation were estimated to consume approximately 57 percent of the tal water used at the MGAS facility. The principal water consuming processes were chicken washing ıd chilling tanks (28.6 percent of the total water used by MGAS), scalding (7.1 percent), picking (7.1 :rcent), floor washings and other domestic uses (5 percent), chicken carcass spraying (4.3 percent), scera cleaning (4.3 percent), and rotary drum filter washing (0.7 percent). The major water ›nsuming devices included running hoses at various locations, continuously operated mechanical spray ashers, and cleaning/chilling tank overflows. In particular, the lack of water conservation techniques nployed in the design of the processes (e.g., counter current rinsing for the cleaning tanks) resulted unnecessary water consumption.

'ater consumed in ancillary operations included water used in canteen facilities for employees, boratory facilities, and domestic offices; however, the amount of water used in these operations was inimal compared to the major unit operations of poultry and cattle and sheep processing lines.

Wastewater Discharges

Results of previous monitoring performed at the MGAS facility varied widely. For example, the five day biochemical oxygen demand (BOD5) had been reported in the range of 1,485 to 13,800 kg/day, and total suspended solids (TSS) had been reported in the range of 1,309 to 7,500 kg/day. In order to reassess data from the previous studies, and to provide a "snapshot" of the discharge characteristics from the MGAS facility, the audit team collected samples from the facility's effluent lines and from specific unit processes.

Using the results of this monitoring, a total facility load was calculated based on the combined discharge from both sheep/cattle and poultry operations. The results compared well with those of the previous study performed by the World Bank, and indicated that the MGAS facility represented a population equivalent of approximately 45,000.

Sheep and Cattle Slaughtering

The monitoring conducted during the audit for the discharge from the sheep/cattle operation indicated that significant quantities of blood, solids, and manure were discharged by the MGAS facility. While the audit results were based on a single sample, the flows were lower than average, and the loadings from the MGAS facility are significantly higher than the averages presented in the literature. In particular, the TKN and P loadings from the MGAS sheep/cattle line are greater than even the highest values reported for the 24 plants sampled by the United States Environmental Protection Agency (USEPA), and the measured BOD5 loading was at the high end of the published range. This confirmed the general assessment of the audit team regarding excessive loss of blood, and other materials, to the sewer.

Poultry Slaughtering and Processing

The monitoring conducted during the audit for the discharge from the poultry operation indicated that significant quantities of blood, solids, and manure were discharged by the MGAS facility. While the audit results were based on a single sample, it was determined that while the flows are lower than average, the loadings from the MGAS facility are significantly higher than the averages presented in the literature. This confirmed the general assessment of the audit team regarding excessive loss of blood to the sewer.

Ancillary Operations

In addition to the wastestreams generated by the primary slaughterhouse operations at the MGAS facility, several additional wastestreams were identified from ancillary operations. These wastestreams were not found to be significant sources of the pollutants discharged by the facility.

ata Gaps

:veral important data gaps were identified during the audit of the MGAS facility. The identified data _ ıps included:

- Lack of Water Use Data
- Inconsistent Sampling Results
- Lack of Solid Waste Disposal Data
- Lack of Records Regarding Blood Disposal

ollution Prevention and Waste Minimization Opportunities

ıeep and Cattle Slaughtering and Processing

ıe principal wastes discharged to the sewer system, as observed during the audit, were blood, solids ncluding viscera, trimmings, and other debris), and paunch manure. Pollutant parameters typically sociated with these wastes include BOD5, COD, FOG, TSS, total dissolved solids (TDS), total jeldahl nitrogen (TKN), and phosphorus (P). Techniques identified during the audit to reduce the scharge of these pollutants include:

- Improved Blood Recovery Techniques
- Improved Solids Recovery Techniques
- Implementation of Paunch Manure Recovery

ɔultry Slaughtering and Processing

ıe principal wastes discharged to the sewer system from the poultry processing operations, as observed ırıng the audit, were blood, and solids, such as viscera, trimmings, and other debris. Pollutant ırameters typically associated with these wastes include BOD5, COD, FOG, TSS, TDS, TKN, and Techniques identified during the audit to reduce the discharge of these pollutants included the ·llowing.

- Improved Blood Recovery Techniques
- Improved Solids Recovery Techniques

'ater Conservation Opportunities

'hile water conservation is an important concern, the use of water at the MGAS facility must be aintained at a level to ensure sanitary conditions for meat and poultry handling. The hygienic ɔeration of the plant should in no way be compromised by any of the water conservation suggestions ·ovided in this report. The audit team is confident, however, that opportunities for significant water ;e reductions are available to the MGAS facility. Suggestions provided include water conservation ethods that can be easily implemented and that could result in an estimated water savings of 30 percent ır the sheep/cattle operation and 40 percent for the poultry operation.

Sheep and Cattle Slaughtering and Processing

Generally, water conservation opportunities identified for the sheep/cattle line related to use of "passive' water shutoff systems. These systems will significantly reduce water wasted to the sewer due tc continuously running hoses, taps left running, and mechanical washers that remain in operation whether or not animals are being processed. Specific techniques are provided in the recommendations section, below.

In addition to these specific opportunities, the MGAS facility could provide additional wet vacuums and dry solids removal techniques to reduce the use of water as a "broom" to rinse solids to the drain, and could optimize water use for all process operations.

Poultry Slaughtering and Processing

Techniques identified for the poultry processing line included "passive" water shutoff systems, counter current rinsing operations, and water reuse opportunities. These systems will significantly reduce water wasted to the sewer due to current operational practices. Specific techniques are provided in the recommendations section, below.

In addition to these specific opportunities, the MGAS facility could provide additional wet vacuums and dry solids removal techniques to minimize the use of water as a "broom" to rinse solids to the drain. Furthermore, MGAS could perform water use optimization evaluations for all process operations.

Water Conservation Policy

During the conduct of the site visit of the MGAS facility, the audit team determined that the facility did not have a written policy regarding water use practices. In addition, the water use records maintained for the facility were not sufficiently detailed to assess the quantities of water used for any of unit processes in the sheep/cattle or poultry operations. In order to begin any efforts to optimize water use practices, the MGAS facility could establish a written water conservation strategy that establishes and implements specific goals and objectives. The recommendations for such a policy are outlined in recommendations section below.

Conclusions and Recommendations

Based on the process evaluation and the assessment of PP/WM and water conservation opportunities conducted during the audit, the audit team identified the following conclusions and recommendations.

Conclusions

Based on the findings of the audit conducted on September 17, 1994, and subsequent visits, the audit team developed the following conclusions regarding the operation of the MGAS facility:

- The MGAS facility is the only slaughterhouse available for the City of Amman and its surrounding communities. As the only facility, it cannot be closed down for large scale maintenance or refitting of new equipment.

- The MGAS facility is operated at its maximum capacity and has limited space available for expansion or installation of large scale wastewater treatment facilities.

- The process operations and the discharges to the public sewer system at the MGAS facility are segregated (i.e., two sewer connections) for the sheep/cattle facility and the poultry facility. Sampling performed to evaluate the impact of the facility, therefore, will need to be performed on both of the discharge lines.

- The sheep slaughtering operation is more controlled than that for cattle due to the stunning of animals. However, blood recovery is less controlled due to the limited amount of time allowed for blood draining within the killing room.

- The cattle slaughtering operation is chaotic due to the lack of stunning prior to slaughter. Initial blood collection is made more difficult by this procedure.

- Continuously running hoses in sheep and cattle killing areas result in dilution of recovered blood. Continuously running hoses in other areas result in unnecessary loss of blood and solids to the sewer. Free running hoses are also a major source of unnecessary water consumption.

- Cattle carcasses were washed by the mechanical spray wash unit for approximately 15-20 seconds; however, the spray continued to run for 1-2 minutes before the next carcass was ready for washing. This procedure resulted in a significant waste of potable water.

- The paunch manure recovery room is the source of the most uncontrolled discharge of wastes observed at the MGAS facility. Procedures in this area resulted in the unrestricted flow of paunch contents to the sewer.

- The poultry slaughtering operation is more highly automated than the sheep/cattle operation, and practices result in more efficient recovery of blood and solids.

- The poultry line sticking operation results in unnecessary blood loss due to lack of stunning of chickens prior to sticking, and initial blood loss prior to beginning the blood collection channel.

- The final cleaning tanks for poultry were designed to operate in series, but were not used in this manner. Fresh water was added unnecessarily to both cleaning tanks and resulted in significant water consumption.

- Wet clean-up methods (e.g., hosing of blood and solids to sewer) is practiced widely at the MGAS facility. Dry cleaning methods would generally be more efficient and result in less wasted water.

13. Water conservation techniques identified for the sheep/cattle operation were projected to result i a water savings of approximately 30 percent. The breakdown of the water savings estimates i provided in Table 8.

14. Water conservation techniques identified for the poultry operation were projected to result in a water savings of approximately 40 percent. The breakdown of the water savings estimates is provided in Table 9.

Recommendations

Due to the limitations imposed by functioning as the only slaughterhouse for a population of over 2,000,000 people, PP/WM and water conservation opportunities implemented by the MGAS facility must be performed without a shutdown of the facility. The recommendations listed below are provided with these limitations in mind. While several of the options would require minor construction, all could be implementable under current operating conditions. Based on the PP/WM and water conservation opportunities identified and discussed in Sections 5 and 6 of this report, the audit team provides the following recommendations:

1. Sheep and Cattle Operation

The audit team identified several PP/WM and water conservation opportunities related to the sheep and cattle slaughtering operation at the MGAS facility. Based on these opportunities, the following recommendations are provided:

- Blood recovery should be maximized wherever possible. Techniques which should be adopted by the MGAS facility include:
  - Ensure that blood collection pits are fully accessible and that complete emptying of the pit is accomplished. If blood remains in pit overnight, it becomes difficult to remove, requiring additional water use, and will likely be wasted.
  - Blood collection in the killing room should be maximized by concentrating the bleeding operation to a more confined area.
  - Cattle should be stunned prior to the killing operation to allow bleeding to be performed more efficiently. This would also improve worker safety conditions.
  - Slaughtered sheep should be kept for longer detention times in the killing room to allow additional blood to drain into the blood collection pit.
  - Heads and legs should be allowed to drain more fully in the sheep or cattle killing room.
  - Two-way drains should be used in the killing rooms, and other high blood loss areas, to avoid dilution of recovered blood.
  - A system for additional blood recovery should be provided following removal of sheep from the killing room.
  - Additional blood recovery should be accomplished in the cleaning and dressing area by using wet vacuum units, or squeegees and pails, to collect spilled blood.

- Additional solids recovery should be performed in order to reduce water consumption, pollutant loadings to the sewer, and to recover additional usable by-products. The following specific actions should be considered:

- Manure from the sheep holding pen should be collected by dry methods (sweeping and shoveling) and recovered as fertilizer.
- A roof or cover should be constructed over the sheep holding pen to prevent manure from washing to the drain during a rain storm.
- Additional solids collection by sweeping, shoveling or wet vacuuming should be practiced throughout the killing and processing areas.
- Drain covers and screens should be maintained and/or replaced to prevent large solids from entering the sewer.
- The heads and legs workshop should be expanded to provide more efficient cleaning and processing operation.

- Paunch manure solids and liquids should be fully recovered and utilized. Suggestions for the operation of a paunch manure recovery system for the MGAS facility are provided below.
  - A collection pit for the collection and recovery of all liquid and solid paunch contents should by constructed. The recovered paunch contents should then be sent to a rendering operation for recovery. Alternatively, the MGAS facility could mix the recovered paunch contents with dry manure for distribution as fertilizer.
  - If complete recovery of paunch liquids and solids is not possible, screens housed in mobile drums for separation of solids and liquids should be used.

- All facility hoses should be fitted with hand operated nozzles.
- The facility should use of high pressure hoses (with nozzles) instead of the current low pressure system.
- Hand or foot operated valves should be installed on all taps, wash basins, and showers.
- Automatic on-off triggers should be installed on the mechanical carcass spray wash systems. Using an automated on-off system could reduce water use at the cattle wash operation by up to 70 percent.
- The facility should provide additional wet vacuums and dry solids removal techniques to minimize the use of water as a "broom" to rinse solids to the drain.
- MGAS should optimize water use for all process operations. Optimization should include slowly reducing water use at a given unit process until negative impacts are observed. Water use should then be maintained at the minimum effective flow rate.
- The use of water in the sheep holding pen, for washing purposes, should be minimized or eliminated.

. Poultry Processing Operation

'he audit team identified several PP/WM and water conservation opportunities related to the poultry laughtering operation at the MGAS facility. Based on these opportunities, the following ecommendations are provided:

- Blood recovery should be maximized wherever possible. Techniques which should be adopted by the MGAS facility include:
  - MGAS should perform stunning of chickens prior to killing operations to promote more efficient blood collection.
  - The blood collection channel should be extended and widened to provide additional blood collection immediately following sticking operations.

- The blood collection tubs should be replaced during the emptying process to prevent blood loss to the sewer.
- The chicken conveyor system should be extended to provide additional time for blood drainage. This could be accomplished by adding an additional loop within the killing room prior to the scalding tank. Benefits include additional blood recovery and less waste to the sewer.

- Recovered blood should be collected in a collection basin and rendered as a valuable by-product instead of mixing it with feathers.

- Opportunities were identified to increase the efficiency of the solids recovery and to reduce the loading of fine solids and soluble solid contaminants to the sewer. The MGAS facility should consider the following options:
  - A bar screen should be installed to remove large solids and whole chickens from the solids collection channel prior to the solids collection pit.
  - Additional solids collection by sweeping, shoveling or wet vacuuming should be practiced throughout the killing and processing areas. Use of low pressure hoses as a "broom" to wash solids to the drain should be eliminated.

- Passive water conservation systems should be used to reduce water wasted to the sewer due to continuously running hoses, taps left running, and mechanical washers that remain in operation whether or not animals are being processed. Opportunities available to the poultry operation include:

  - The MGAS facility should fit all hoses in the facility with hand operated nozzles.
  - The facility should use high pressure hoses (with nozzles) instead of the existing low pressure system.
  - Hand or foot operated valves should be installed on all taps, wash basins, and showers.
  - An automatic on-off trigger should be installed on the mechanical carcass spray wash system.
  - The facility should provide additional wet vacuums and dry solids removal techniques to minimize the use of water as a "broom" to rinse solids to the drain.
  - Oil and grease spills in the loading and unloading areas should be cleaned up using clay absorbent and removed as a solid waste rather than using a water washdown.
  - Water optimization should be practiced for all process operations.

- The MGAS facility should use a counter current rinsing technique for the poultry cleaning tanks. This would involve adding fresh water <u>only</u> to the secondary cleaning tank and plumbing the relatively clean water overflow from the secondary tank to the primary tank. Use of this technique is projected to reduce total water consumption in the poultry operation by 25 percent.
- The overflow water from cleaning tanks should be used to flush the solids collection trough in lieu of fresh water.

. Water Conservation Policy

'he MGAS facility should establish a written water conservation policy that establishes and implements ıe following minimum goals and objectives:

- Consideration of Water as a raw material for slaughterhouse operations. As such its uses should be evaluated and optimized to avoid waste.
- As a valued raw material, water use in the plant should be metered, or measured, at key locations, with records maintained to document water use practices over time.
- Water should be used only for purposes where no other suitable alternative exists. In particular, water should never be used as a "broom" to dispose of solid or semi-solid wastes. Dry cleaning methods should be implemented wherever possible.
- Employees should be made aware of the water conservation policy through training and incentives. Employee training should stress dry cleaning techniques, awareness that valves and nozzles should be closed when not in use, and that mechanical systems should be shut down during breaks.

1.0

INTRODUCTION

1.0 INTRODUCTION

'his report presents the findings of an audit conducted to evaluate the Pollution Prevention Waste /inimization (PP/WM) and water conservation opportunities for the Municipality of Greater Amman :laughterhouse (MGAS) facility located near Amman, Jordan. Additionally, this report provides ocumentation of the on-site evaluation of the facility's current operations, discusses water use and isposal practices, and provides recommendations for PP/WM opportunities. Additional information ncluding industry background, audit procedures, and an overview of the facility's operations, are rovided to support the audit findings and recommendations.

.1 BACKGROUND

Inder Contract No. 278-0288-00-4026-00 with the United States Agency for International Development USAID), Development Alternatives, Inc. (DAI) is performing an Industrial Wastewater Discharge revention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components f the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program ; being performed by DAI with full coordination between the Jordanian Ministry of Water and rrigation (MWI) and the Amman Chamber of Industry (Chamber).

'he IWDP will be performed in three phases. The first phase requires completion of ten PP/WM pportunity audits by DAI and its sub-contractors. The second phase requires completion of Feasibility tudies (FS) for four of the audited facilities. Finally, demonstration projects will be completed for two elected FS facilities.

arza Consulting Engineers and Scientists (Harza), Chicago, Illinois, USA, and Science Applications nternational Corporation (SAIC), Falls Church, Virginia, USA, have been retained as the ubcontractors to lead the audits. The Royal Scientific Society (RSS) of Jordan, was selected as the ocal consultant to assist the lead consultants in the audit site visits and report preparation. The PP/WM udit for the MGAS facility was conducted by the SAIC/RSS team.

ue to the scarcity of water in the Zarqa Basin, as well as the need to minimize the release of pollutants nto waters of the basin, it is in the best interest of industries to conserve water and implement effective P/WM practices. Companies practicing PP/WM and water conservation programs will more fficiently utilize scarce resources and minimize their impact on these resources. The hierarchy of P/WM and water conservation practices includes:

. Reduce waste generation

- Substitution of less polluting raw materials in product manufacture;
- Alteration of products manufactured to eliminate need for use of polluting materials;
- Replacement or upgrading of outdated or inefficient process equipment; and
- Development of employee training programs to ensure employees can efficiently manage raw materials and resources.

2. Reuse waste materials prior to disposal

- Reuse of uncontaminated raw materials and resources (including water);
- Reprocessing of previously discarded materials (e.g., off-spec materials, used materials); an
- On site recovery of reusable materials (e.g., used solvents, waste heat, scrap).

3. Recycle waste materials.
4. Treat wastes and dispose of residues.

The PP/WM audits conducted during this program will identify and evaluate available PP/WM and water conservation opportunities and will provide site specific recommendations to assist the study industry in developing a comprehensive water conservation and PP/WM strategy.

1.2 OBJECTIVES

The facility PP/WM audits are designed to assess the potential techniques for PP/WM and water conservation at the study facilities. The goal of each audit is to evaluate and identify all possible PP/WM, wastewater clean-up, and water conservation techniques that are appropriate for the study facility.

The specific objectives of this audit are as follows:

1. Review general industry background data and identify "state-of-the-art" wastewater management and processing practices.

2. Work on-site with industry representatives, MWI and the Chamber officials, and other interested groups to review current processing procedures and identify possible options for PP/WM and water conservation.

3. Prepare a report that evaluates possible PP/WM and water conservation alternatives and provides recommendations to the industry.

In order to complete the first objective, a comprehensive literature review was performed. This review included searches of the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC) repository (and its corresponding database PIES), on-line library catalog databases, pollution PP/WM bibliographical references, and personal contacts with pollution prevention specialists. The review resulted in the identification of numerous references with a range of very general to very specific PP/WM techniques. Source documents were assessed to determine their applicability to this project and categorized appropriately. The findings of the background document are included in Appendix F.

Following completion of the literature review, the audit team conducted the on-site audit of the MGAS facility. The audit was conducted with close consultation of industry representatives to ensure that they were aware of and supported proposed actions. Audit activities included the careful gathering of baseline water use and waste generation data, identification and assessment of potential PP/WM and water conservation options, and solicitation of ideas and proposals from management and production line staff.

.3 REPORT CONTENTS

'his report provides the findings of the audit conducted at the MGAS facility on September 17, 1994, nd the results of the subsequent discharge monitoring conducted by the audit team on September 24, 994. The report provides recommendations for the development of a site-specific program that meets ıe specific needs and goals of the MGAS facility. Audit recommendations include both PP/WM :chniques (e.g., water conservation techniques, housekeeping practices, alternate waste disposal ractices) and suggestions for PP/WM training for facility staff and follow-up studies to assess program ıccesses.

'he report is organized into eight sections that provide an overview of the slaughterhouse industry, as applies to the MGAS operation (Section 2), a description of the audit procedures and documentation Section 3), a description of the water use practices at the facility (Section 4), a description of the waste eneration activities at the facility (Section 5), a discussion of possible PP/WM opportunities (Section), the audit conclusions and recommendations (Section 7), and the suggested follow-up actions (Section).

everal appendices are also included in the report to provide supporting documentation and reference ıaterials. The appendices include a copy of the audit questionnaire (Appendix A), copies of ıformation provided by the MGAS facility (Appendix B), an overview of the regulations applicable to ıe MGAS discharge (Appendix C), photographs taken during the site visit (Appendix D), references ited in the report (Appendix E), and a copy of the text portion of the PP/WM Background Report repared prior to the audit visit (Appendix F).

2.0

PROCESS OVERVIEW

2.0 PROCESS OVERVIEW

'he slaughter and processing of meat for human consumption is an integral segment of the food rocessing industry in most countries. Depending on the size of the population and the area served by ıe slaughterhouse, a facility may handle anywhere from several animals to several thousands animals er day. In addition, depending on local demand, a slaughterhouse may handle one or several types f animal(s). This Section of the audit report provides a brief overview of typical slaughterhouse perations, as described in the literature, and provides a detailed overview of the process operations tilized by the MGAS facility.

.1 TYPICAL INDUSTRY PRACTICES

laughterhouse operations are conducted in nearly all countries of the world to supply their populations vith fresh meat products. Slaughterhouses range widely in size and complexity, however, their basic perations are quite similar. The following section provides a brief overview of the typical operational ractices used by the slaughterhouse industry, as described in the literature.

2.1.1 Sheep and Cattle Slaughtering and Processing

Sheep and cattle slaughtering operations range from small facilities, handling just a few animals per day, to modern, highly automated facilities that can process thousands of animals per day. The principal function of these facilities is to receive live animals as a raw material, and process these animals, under sanitary and humane conditions, to produce meat products. In addition to the principal meat products, a red meat slaughtering operation may also process edible and inedible meat by-products.

The functions of a modern slaughterhouse are described by Veall (1992) as follows:

- Reception and lairage;
- Slaughtering and bleeding;
- Carcass dressing;
- Edible by-products recovery and processing;
- Inedible by-products recovery and processing; and
- Chilling and storage of meat and by-products.

Regardless of the type of animal handled at a slaughterhouse, these general processes and functions remain the same.

2.1.2 Poultry Slaughtering and Processing

The operation of a poultry slaughtering and processing facility differs from facilities designed for larger animals in several ways. First, the number of animals handled at a poultry slaughterhouse is usually much higher than for large animals; often exceeding 10,000 animals per day. Because of this, the live animal reception and lairage facilities must be designed to accommodate the large

number of animals that will be processed. Second, the slaughtering process is generally mor highly automated in order to process the larger number animals. Additionally, the equipment use to process the large number of carcasses requires a higher degree of automation.

Processes commonly practiced at poultry slaughtering plant are described by Allwood and Colemai (1974) as follows:

- Receiving (reception and lairage);
- Slaughtering and bleeding;
- Defeathering;
- Eviscerating; and
- Chilling, packing and shipping.

Generally, the birds are slaughtered by severance of the jugular vein either mechanically or by hand. The feathers are then removed by a "scalding" process where high temperature water or steam is sprayed on the carcass, or the carcass is immersed in a tank of hot water. Feathers are then removed by a combination of mechanical and hand picking. Following feather removal, the carcass is eviscerated and edible by-products are removed for further handling. The head and lungs are also removed at this stage of processing, and the carcass is washed and prepared for chilling, packing and shipping.

2.2 PROCESS OPERATIONS AT THE MUNICIPALITY OF GREATER AMMAN SLAUGHTERHOUSE

The Municipality of Greater Amman Slaughterhouse (MGAS) provides red meat and poultry slaughtering services for the City of Amman, Jordan and its surrounding communities. The facility is owned and operated by the Municipality of Greater Amman; however, the private sector plays an integral role in its operation. The MGAS facility is operated to provide slaughtering services for livestock producers and to provide inspection and storage services for private sector butchers and supermarkets. In this capacity, the facility receives live animals for slaughter from producers in Jordan as well as other nearby nations, and receives cleaned carcasses for inspection from slaughtering facilities in other countries. All slaughtering operations are conducted as a service to producers and consumers. The facility charges producers a set fee for the slaughtering services and does not own or sell any of the meat products that it handles.

The MGAS facility began its sheep and cattle operation in 1972 and its poultry operation in 1976. In addition, the facility has been expanded in several phases since initial construction. The original facility was constructed to serve a population of approximately 250,000 in the Amman area; however, due to rapid population growth, the facility must now try to satisfy the meat and poultry demand of a population of over 2,000,000. Due to the excessive demands placed on the operation, the facility can provide slaughtering services for only about one third of the poultry consumed in the greater Amman area, with the remaining two thirds coming from private butcher shops. Since slaughtering operations in private shops cannot be evaluated by veterinary authorities, there is potential for unsanitary conditions at these locations.

n order to meet the current demand for meat and poultry in the Amman area, planning has begun, and and has been set aside, for a new, high-production facility. It is likely, however, that it will be several ears before this facility can be completed. The exiting facility, therefore, will continue its operation t its current capacity for at least 5 years. Following the construction of the new facility, plans call for he existing plant to be upgraded and modernized and operated at a more moderate production rate.

The existing slaughterhouse facility is separated, both physically and operationally, into two separate production lines. One line is for the slaughter and processing of cattle and sheep (primarily lambs) and he other is for the slaughter and processing of poultry (chickens). A diagram of the facility layout is provided in Figure 1. The remainder of this Section describes the processes used at this site. Where water is used as an integral part of a unit process, it is described in this Section; however, a more detailed discussion of water use and disposal practices is provided in Section 4.

2.2.1 Sheep and Cattle Slaughtering and Processing Operations

The sheep (primarily lambs) and cattle operations at the slaughterhouse provide slaughtering and dressing services for live animals transported to the facility by truck, and inspection services for carcasses slaughtered at other facilities outside of Jordan. Some of the live animals slaughtered at the facility are raised in Jordan; however, most are imported live from other countries.

The MGAS facility performs sheep and cattle slaughtering operations ten (10) hours per day, five (5) days per week. These operations are conducted during the day while distribution to producers (farmers) and consumers (butchers and retailers) takes place during the night. The current average levels of production for sheep and cattle, as reported by the facility engineer, are provided in Table 1.

The sheep and cattle slaughtering operations at the MGAS facility follow the typical operations described in Section 2.1, above. These processes include:

- Reception and lairage;
- Slaughtering and bleeding;
- Carcass dressing;
- Paunch manure recovery; and
- Chilling, storage and inspection.

This facility does not perform any rendering operations. Blood and other inedible by-products are sold to private sector facilities for further processing. A process flow diagram for the sheep and cattle operation is provided in Figure 2.

<u>Reception and Lairage</u>

Reception and lairage at the facility consist of a series of covered pens and stalls. Sheep and cattle are transported to the facility during the afternoon and evening and are housed in the pens for inspection. Animals are normally held in these pens for 10 - 12 hours. Just prior to the killing operation, sheep are held in a small uncovered pen (approximately 10m x 6m) for several minutes [Photo 1]. Sheep enter the killing area from the holding pen while cattle enter the killing area directly from the pens.

Slaughtering and Bleeding

Following inspection, animals are separated for slaughtering operations designed for either sheep or cattle. While the slaughtering operations are animal-specific, the carcass dressing processes generally occur in one large room. Only the killing and bleeding operations are separated in two different rooms for the different types of animals.

From the holding pen, the sheep enter the killing room in groups of about 20. Two men capture a sheep and another man uses an electric stunner to incapacitate the animal. Once stunned, the sheep is placed on a conveyor belt and its head is manually removed. Blood from this operation enters a stainless steel channel that drains to a "blood collection pit" at one end of the room [Photo 2]. As the sheep progresses along the conveyor, its legs are also removed. The heads and legs are placed in wheelbarrows and taken to a nearby building for further processing (described below). At the end of the killing room conveyor belt, the sheep are hung by their legs on an overhead conveyor system. Once attached to this conveyor, the sheep are immediately moved to the carcass dressing area [Photo 3]. All skinning, evisceration and cutting takes place in this main processing area.

Cattle enter the killing room directly from the lairage in groups of about 5 animals. Two men capture and physically restrain the unsedated animal while another man severs its jugular vein with a knife. Blood from the animal spills to the blood collection channel and into a blood collection pit at the end of the killing room. After the initial bleeding (1 to 2 minutes) the carcass is dragged toward the rear of the room where the head and legs are manually removed and deposited in a pile outside the killing room. As additional cattle are processed, the heads and legs are intermittently transported by wheelbarrow to a nearby building for further processing (described below). In contrast to the sheep killing operation, the cattle remain in the killing room for approximately 5 minutes while the hides are removed. At the end of the killing room, the slaughtered and skinned carcass is hung on an overhead conveyor system and transported to the carcass dressing area. All evisceration and cutting operations occur in this room.

Carcass Dressing

Sheep carcasses enter the main cleaning and dressing area from the sheep killing room and skins are immediately removed. Following the skinning, the carcass is opened and its organs and paunch are removed, by hand, in several steps. The edible organs are removed for inspection, cleaning and storage and the paunch is removed by wheelbarrow and taken to the paunch manure recovery area (described below). The carcass continues along the processing line and inedible materials are trimmed by hand. The larger trimmings are collected for rendering. After the carcass has been opened, but just before the edible organs are removed, the dressed and trimmed carcass passes through a mechanical spray washer (5 - 10 second duration)[Photo 5]. This washer removes loose debris, blood and spilled paunch and also begins the chilling process.

Cattle carcasses (hides removed) enter the main cleaning and dressing area from the cattle killing room on the overhead conveyor. The carcass is immediately opened and the organs and paunch are removed, by hand, in several steps. As with sheep dressing, the paunch is removed for paunch manure recovery and the edible organs are removed for inspection, cleaning and storage. Some trimming also occurs in this area. Following these processes, the carcass is split into two halves

by a manually operated chainsaw [Photo 7]. The hanging sides of cattle then pass through a mechanical washer (15 - 20 second duration) to remove remaining debris and to begin the chilling process [Photo 8].

The only cleaning and dressing activities not performed in the main processing area are those involving the heads and legs of both sheep and cattle [Photo 9]. The heads and legs are processed in a workshop located approximately 15 meters from the sheep and cattle slaughterhouse building. The heads and legs are immersed in scalding water for hair removal and the edible parts are recovered and cleaned. The cleaned paunches from the paunch manure recovery room is also processed in this workshop. The paunches are transported to the workshop by wheelbarrow where they are mixed with calcium hydroxide [$Ca(OH)_2$] for bleaching.

Paunch Manure Recovery

The paunches from both cattle and sheep are transported to the paunch manure recovery room from the carcass dressing area. The paunches are placed on one of two tables in the room and are split open by hand [Photo 10]. The paunch manure (partially digested feed and stomach contents) spill on to the floor in this room and, as liquids drain into an open channel, a small portion of the thickened paunch manure is recovered for use as fertilizer [Photos 11,12]. Literature indicates that the paunch contents are approximately 27 kg/paunch for cattle, 2.7 kg/paunch for sheep, and 1.7 kg/paunch for lambs. The cleaned paunches are transported to the workshop for bleaching.

Chilling, Storage and Inspection

After the carcasses have been eviscerated, trimmed, and cleaned, they are transported by the overhead conveyor to the chilling units. The meat is aged in these units for approximately 12 to 24 hours prior to final inspection and distribution. Following removal from the chillers, the meat enters the final inspection and distribution area. At this point, the meat is given a final inspection, stamped according to regulations, and distributed to the waiting customers [Photo 13].

2.2.2 Poultry Slaughtering and Processing

The poultry facilities at the MGAS facility provide slaughtering and dressing services for live animals and inspection services for chickens killed and cleaned at other locations. All chickens are transported to the facility by truck.

The MGAS facility performs chicken slaughtering operations ten (10) hours per day, five (5) days per week. The slaughtering operations are conducted during the day while receipt from producers (farmers), and distribution to consumers (butchers and retailers), takes place during the night. The current average levels of production for the poultry line, as reported by the facility engineer, are provided in Table 2.

The chicken slaughtering processes used at the MGAS facility follow the typical operations described in Section 2.2, above. These processes include:

- Reception;
- Slaughtering and bleeding;
- Defeathering;
- Eviscerating/Cleaning; and
- Chilling, storage and inspection.

This facility does not perform any rendering operations. Blood and other inedible by-products are sold to private sector facilities for further processing. A process flow diagram for the poultry processing operation is provided in Figure 3.

Reception

Chickens are transported to the MGAS facility each day by truck. The facility does not have storage facilities for live chickens; thus, the animals remain in plastic delivery crates until time for slaughtering. During hot weather, the crated chickens are intermittently sprayed with water to keep them from suffering heat stroke as they await the slaughtering process. The crates are removed from the delivery trucks, as needed, and placed on a conveyor belt through a doorway in the side of the slaughterhouse [Photo 14].

Slaughtering and Bleeding

At the end of the conveyor belt (approximately 15 meters), the chickens are removed from the crates and hung by their feet on an overhead mechanical conveyor [Photo 16]. Within approximately five meters of the hanging, two men severe the jugular veins of the unsedated birds. Blood is captured in a stainless steel channel below the hanging chickens, and is collected in a plastic tub on the killing room floor [Photo 17]. As the tub fills with blood, it is removed and mixed with the waste feathers on a waiting truck [Photo 18].

Defeathering

Following the bleeding process, the chicken carcasses are immersed in the scalding tank to loosen feathers [Photo 20]. The water in the scalding tank is kept at approximately 60°C by recirculating the water through a heat exchanger. Water is added to the tank to keep it from becoming over contaminated with blood and solids.

The carcasses, still suspended from the overhead conveyor, are removed from the scalding tank and moved through a mechanical defeathering device [Photo 21]. As feathers are removed, a continuous water spray is used to wash feathers to the open channel on the floor of the defeathering room and into a collection pit in an adjacent room.

As the carcasses emerge from the final defeathering unit, the heads are removed by a mechanical head puller. The heads drop to the open channel directly below the conveyor and are washed to the collection pit for recovery.

The open wastewater channel flows through the defeathering room, under a wall, and enters the collection pit [Photo 25]. This contents of the pit (feathers, heads, organs, and other solids) are pumped to a rotary drum filter where feathers, heads, and large solids are removed from the

wastestream [Photo 26]. The recovered feathers, heads, and solids from the rotary drum filter, along with recovered blood (in tubs) and dry swept solids, are loaded on a waiting truck for off-site rendering.

Eviscerating/Cleaning

Following head removal, the chicken carcasses are carried by the conveyor through a hole in the wall to the evisceration and cleaning area. As the carcasses enter this room, a small saw removes their feet and the chicken carcasses fall into a collection bin. The chickens are then re-hung and continue through the evisceration and cleaning operation [Photo 22].

As the chickens pass along the evisceration line, all remaining feathers are removed, the carcasses are opened, and the edible and inedible viscera are removed. All processes are performed manually. Following evisceration, the carcasses pass through a mechanical spray washer, for preliminary cleaning prior to the final cleaning/chilling units [Photo 23].

The final cleaning operation is performed in two open tanks placed end to end in the processing area [Photo 24]. As the chickens emerge from the mechanical washer, they are picked from the conveyor and thrown in the cleaning tanks. Mechanical mixers gently agitate the carcasses to remove loose debris and blood. A belt conveyor operates between the two tanks to remove chickens from the primary tank and place them in the secondary tank.

Chilling, Storage and Inspection.

The final stages of the operation require the chilling, storage and inspection of the cleaned and dressed chickens. Initial chilling begins in two open cleaning tanks described above. Chickens are removed by hand from the cleaning/chilling tanks and are hung on racks for inspection and storage in refrigerated chillers.

2.2.3 Ancillary Operations

In addition to the primary slaughterhouse operations, the MGAS facility also provides additional services including employee canteen and sanitary facilities, truck loading and unloading operations, laboratory facilities, and administrative offices. These operations, while not directly related to the slaughterhouse processes, are imperative for the proper functioning of the facility.

Employee canteens and sanitary facilities are available for both the sheep/cattle and the poultry operations. Sanitary facilities include washrooms for showers for employees. All employees working in the killing and eviscerating areas are required by MGAS rules to take showers following their shifts.

The truck loading and unloading operations are located throughout the sheep/cattle and poultry slaughterhouse areas. The large numbers of animals brought to the MGAS facility for slaughter, and delivered to consumers following processing, require hundreds of trucks per day to use these facilities.

The MGAS laboratory provides physical, chemical and biological inspection services for mea poultry and fish delivered to the slaughterhouse. The laboratory is currently housed in a relativel small space, but will soon be moving to a larger office.

Administrative offices are located in two buildings on site and conduct the recordkeeping management and other administrative activities.

3.0

AUDIT PROCESS

11A

3.0 AUDIT PROCESS

'he site visit to the MGAS facility was conducted on September 17, 1994. This visit was conducted) evaluate process operations, identify PP/WM and water conservation opportunities, and solicit input :om facility staff. The audit was coordinated through the MWI and the Chamber. This section escribes the preparation and conduct of the audit.

.1 AUDIT COORDINATION

'he Chamber informed the MGAS facility about the intent and schedule of the audit prior to the site 'isit. An audit questionnaire, specifically developed for this PP/WM project (Appendix A), was ncluded with the request, and MGAS staff were asked to complete the questionnaire prior to the audit. 'he MGAS facility was also requested to furnish an overall flow balance, process flow diagram, and 'acility layout. This information, where available, was furnished to the audit team during the site visit.

3.2 PP/WM BACKGROUND MATERIALS

.n order to review general industry background data and identify " state-of-the-art " processing and waste management practices pertinent to PP/WM, a comprehensive literature review was performed by he Lead American Consultant prior to his visit to Jordan. The review included searches of the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC) repository, on-line library catalogue databases, review of PP/WM bibliographical references, and personal contacts with pollution prevention specialists.

3.3 PRE-INSPECTION MEETING

The MGAS facility audit, including the pre-inspection meeting, was conducted on September 17, 1994. The initial audit team consisted of the following personnel:

Dr. Usama Mudallal	Amman Chamber of Industry
Mr. Mohamad Lafi	Water Authority of Jordan
Dr. Shawn Niaki	Program Director, DAI (Harza)
Mr. David Hair	Lead American Consultant (SAIC)
Dr. Riyad Musa	Local Consultant (RSS)
Mr. Rafat Assi	Local Consultant (RSS)

The representatives for the MGAS facility included:

Dr. Othman Kilani	MGAS Director
Dr. Mohammed Khaled	Poultry Operations Manager
Mr. Sami Najdawi	Maintenance Engineer
Dr. Na'eem Mustafa	Laboratory Director

The pre-inspection meeting was held at the MGAS facility on September 17, 1994. The intent of th meeting was to inform the facility staff about the conduct and the objective of the audit, and t familiarize the audit team with the MGAS process as it related to the fresh water utilization, wastewate generation, treatment and disposal, water recycle and reuse and the overall water management at th facility. The audit team explained to the MGAS facility staff the purpose of the audit and facility staf furnished the audit team the following:

- A slaughterhouse plan containing cross-sections and drainage;
- A poultry slaughterhouse plan; and
- A plan of the slaughterhall of the MGAS facility.

Copies of these materials are included in the Appendix B of this report.

3.4 AUDIT

The facility audit was conducted on September 17, 1994. The MGAS facility designated the facility's maintenance engineer to accompany the audit team. The MGAS representative and the audit team members toured and inspected the facility starting at the sheep and cattle processing line operations, and following the process through lairage, killing, carcass dressing and washing, paunch manure recovery, chilling, storage, and inspection. The tour also included the workshop used for cleaning the cattle and sheep heads and legs.

The poultry processing operations which included: reception, hanging and killing, scalding, defeathering, evisceration, washing, and chilling were also observed. During portion of the audit, Dr. Mohammed Khaled, manager of the poultry processing operation, joined the audit team.

Upon completion of the facility tour, the audit team and facility representatives continued discussions regarding overall water usage and wastewater management practices currently employed. The audit team requested that the technical manager provide additional water use and disposal data, and he kindly agreed to provide estimates.

Mr. David Hair, Dr. Riyad Musa, and Ms. Rania Abdul Khaleq (Ministry of Water and Irrigation) visited the facility again on September 24, 1994. During this visit several unanswered questions were resolved. In addition, four samples (two composites and two grabs) were collected and sent for analyses at Water Authority of Jordan (WAJ) laboratories in Amman. The two composite samples were collected from the two major processing lines (sheep/cattle and poultry), while the grab samples were taken from specific unit processes within the facility.

3.5 POST-INSPECTION MEETING

Following the data gathering effort, the audit team met with the MGAS representatives to discuss data gaps and the team's preliminary impressions regarding PP/WM and water conservation opportunities. The facility staff were responsive to the team's suggestions and agreed to help with any additional data gathering requests.

4.0

AUDIT FINDINGS

4.0 AUDIT FINDINGS

ıe principal focus of the audit site visit was to evaluate the water use and waste disposal practices at ɜ MGAS facility and to identify opportunities for PP/WM and water conservation. The findings of ɜ audit team regarding water use and waste disposal practices are provided in this section.

1 WATER USE AND BALANCE

'ater is used extensively throughout the MGAS facility for cleaning and sanitation requirements of the ıughtering operation, and to a lesser extent for staff sanitary and hygiene needs. All water used by e facility is provided by the Water Authority of Jordan (WAJ).

ıe facility's water supply enters the plant through two flow metered connections. One connection ırves the sheep and cattle slaughtering operation, and the other serves the chicken slaughtering ɔeration. Total water use has reportedly been reduced over the past few years with the average current ɔnsumption reported at approximately 700 m^3 per day. The facility does not meter any water use for ·oduction operations, and has not developed estimates of the water consumption rates for any of its ıit processes.

'uring the audit, the audit team utilized process diagrams of the sheep/cattle and poultry slaughtering ɔerations to discuss water usage rates with the facility engineer. From these discussions, water use ɜtimates were established for each of the unit operations based on the known daily total water use for ıe facility.

4.1.1 Sheep and Cattle Slaughtering and Processing

Based on process flow and water use information supplied to the audit team by the facility maintenance engineer, a process flow diagram and water balance was developed for the sheep and cattle operation. This diagram is presented in Figure 2. Based on the flow information presented in this figure, the unit processes of the sheep and cattle operation were estimated to consume approximately 43 percent of the total water used at the MGAS facility.

According to the maintenance engineer there were four major water consuming sources. These sources included the following processes:

- Slaughtering and Bleeding;
- Carcass Washing;
- Viscera, Head and Leg Cleaning Workshop; and
- Floor Washings, Domestic Uses.

The principal water consuming processes were, carcass washing (16.3 percent of total MGAS consumption), viscera, and head and leg cleaning operations (11.3 percent), floor washings and domestic uses (10 percent) and slaughtering and bleeding operations (5 percent). A breakdown of these relative water uses is provided in Table 3.

In general the major water consuming devices included running hoses at various locations continuously operated mechanical spray washers, and cleaning tank overflows. The specific water use and disposal practices in the sheep and cattle operation are described in Section 4.2.1.

4.1.2 Poultry Slaughtering and Processing

Based on process flow and water use information supplied to the audit team by the facility maintenance engineer, a process flow diagram and water balance was developed for the poultry operation. This diagram is presented in Figure 3. Based on the flow information presented in this figure, the unit processes of the poultry operation were estimated to consume approximately 57 percent of the total water used at the MGAS facility.

According to the maintenance engineer, there were six major water consuming processes. These processes were:

- Scalding;
- Picking;
- Carcass Spraying;
- Washing and Chilling Tanks;
- Floor Washings, Domestic uses; and
- Viscera Cleaning.

The principal water consuming processes were chicken washing and chilling tanks (28.6 percent of the total water used by MGAS), scalding (7.1 percent), picking (7.1 percent), floor washings and other domestic uses (5 percent), chicken carcass spraying (4.3 percent), viscera cleaning (4.3 percent), and rotary drum filter washing (0.7 percent). A breakdown of the relative water uses is presented in Table 4.

In general the major water consuming devices included running hoses at various locations, continuously operated mechanical spray washers, and cleaning/chilling tank overflows. In particular, the lack of water conservation techniques employed in the design of the processes (e.g., counter current rinsing for the cleaning tanks) resulted in unnecessary water consumption. The specific water use and disposal practices in the poultry operation are described in Section 4.2.2.

4.1.3 Ancillary Operations

Water consumed in these operations included water used in canteen facilities for employees, laboratory facilities, and domestic offices. The amount of water used in these operations was minimal compared to the major unit operations of poultry and cattle and sheep processing lines. Additionally, the canteen operation used a separate water connection independent from the main supply system.

4.2 WASTEWATER DISCHARGES

As indicated in Section 4.1, the MGAS facility uses water extensively throughout its operation. The water uses are primarily for cleaning and sanitation purposes, and nearly all water used is discharged to the sewer system. Only a trace amount of the water used leaves the facility with the final meat products. This section of the report describes the wastewater discharges observed at the facility during the audit of September 17, 1994 and presents the results of effluent monitoring performed by the audit team on September 24, 1994.

Previous monitoring had been performed at the MGAS facility by WAJ, and by the World Bank study in 1993; however, the results had varied widely. For example, the five-day biochemical oxygen demand (BOD5) had been reported in the range of 1,485 to 13,800 kg/day, and total suspended solids (TSS) had been reported in the range of 1,309 to 7,500 kg/day. Due to the widely divergent values, the total load estimated for the facility was unclear.

In order to reassess data from the previous studies, and to provide a "snapshot" of the discharge characteristics from the MGAS facility, several members of the audit team returned to the MGAS facility to collect samples from the facility's effluent lines and from specific unit processes. The sewer lines at the MGAS facility were configured such that there is a separate line collecting wastewater from the sheep/cattle operation, and from the poultry operation, and these lines connect to the public sewer system at different points. To properly characterize the total discharge, two composite samples were taken from the discharges from the two major production lines. The composites consisted of four aliquots collected and combined at 15 minute intervals over a one hour period. In addition, grab samples were collected from the discharge channel in the sheep/cattle paunch manure recovery room and from the discharge from the rotary drum filter in the poultry operation. The results of this monitoring are provided in Table 5.

Using the results presented in Table 5, a total facility load was calculated based on the combined discharge from both sheep/cattle and poultry operations. The results compared well with those of the previous study performed by the World Bank, and indicated that the MGAS facility represented a population equivalent of approximately 45,000.

A discussion of the monitoring results as they apply to the sheep/cattle and poultry processing operations is provided in Sections 4.2.1 and 4.2.2, below.

4.2.1 Sheep and Cattle Slaughtering

A tour of the entire sheep and cattle slaughtering operation was provided by the slaughterhouse maintenance engineer. The audit team observed each of the unit processes at the facility while they were in operation and noted water use and wastewater discharge practices. A summary of the wastewater discharge practices observed for each of the major processing areas is described below.

The monitoring conducted during the audit for the discharge from the sheep/cattle operation indicated that significant quantities of blood, solids, and manure were discharged by the MGAS facility. Table 6 presents a comparison of the monitoring results determined during this audit to literature values for similar operations in the United States and the United Kingdom. While the

audit results were based on a single sample, it can be seen that while the flows are lower than average, the loadings from the MGAS facility are significantly higher than the averages presented in the literature. In particular, the TKN and P loadings from the MGAS sheep/cattle line are greater than even the highest values reported for the 24 plants sampled by the United States Environmental Protection Agency (USEPA), and the measured BOD5 loading was at the high end of the published range. This confirmed the general assessment of the audit team regarding excessive loss of blood, and other materials, to the sewer. .

Reception and Lairage

The first area visited was the lairage area where incoming sheep and cattle are received and held for inspection. Manure from the lairage area was reportedly collected by dry methods for use as fertilizer; thus, water was not used here and no wastewater discharges were observed.

As animals were prepared for slaughter, they were placed in an un-roofed holding pen (10m x 6m) for 5 - 10 minutes. An open floor drain was present in the center of the holding pen to which all manure in the area was washed. A fresh water hose was available on one side of the holding pen and was observed to be running continuously during the audit team visit [Photo 1]. While a drain cover was in place, it did not prevent any solids or manure from reaching the sewer. During the second site visit, an individual was observed in the holding pen manually removing solids that had clogged the drain.

Slaughtering and Bleeding

From the lairage area, the audit team proceeded to the sheep killing room. Operations in the sheep killing room were observed to be somewhat chaotic. While most blood was collected in the blood collection channel, a significant amount was also spilled on the floor. To remove the blood, a fresh water hose was left continuously running on the killing room floor and spilled blood was washed to the blood collection pit. Occasionally, the hose was also used to wash blood down the steel channel to the collection pit.

Adjacent to the sheep killing room was the cattle killing room. Cattle entered the killing room one at a time, were knocked to the floor, and the jugular vein was severed. This process was also observed to be somewhat chaotic; however, the majority of the initial blood loss was observed flowing to the blood collection pit. As the carcass was dragged through the remainder of the killing room, a moderate amount of blood continued to drain to the floor. Water was used extensively in this area to wash the spilled blood to the blood collection pit.
The carcass's head, legs, and hide were also removed in the killing room, but were immediately stored in the adjacent processing area. The heads and legs continued to discharge a moderate amount of blood which was washed directly to the sewer.

In both killing rooms, the major contaminant was observed to be spilled blood. However, the plumbing in the killing rooms was reported to be completely separated from the sewer system, with all discharges flowing to the blood collection pit.

Carcass Dressing

While the slaughtering operations were animal-specific, the dressing operations took place in one room; thus, the water and wastes from sheep and cattle were commingled. Only the killing areas were observed to have separate collection systems to recover blood.

As the sheep were hung on the overhead conveyor and entered the dressing area from the killing room, a significant dragout of blood was observed [Photo 4]. This was due, primarily, to the lack of time provided for the blood to drain to the blood collection system within the killing room. In particular, as soon as the carcass was hung by its rear legs on the overhead conveyor, the remaining blood drained by gravity to the floor of the killing room and through the doorway to the dressing and cleaning room. A fresh water hose was used to rinse this spilled blood directly to the floor drain and sewer.

Upon entering the processing room, the sheep carcasses were immediately skinned by hand. The carcass and skin were rinsed by a fresh water hose during the skinning process. The rinsing hose was observed to run continuously at this location. All cuttings and blood drippings were washed to the floor drains. Because the cattle hides are removed in the killing room, there was no corresponding discharge from that process.

From the skinning operation, sheep were shifted by the overhead conveyor to the evisceration area. The carcass was manually opened and the edible and inedible organs were removed by wheelbarrow for cleaning and storage [Photo 6]. The paunch was also removed for paunch manure recovery. Finally, excess fat and inedible materials were trimmed from the carcass. During these operations, smaller cuttings, blood drippings, spilled paunch and other debris were washed to the floor drains. A significant amount of water was used in the dressing area for these clean-up activities.

The dressed and trimmed carcasses were passed through a mechanical spray washer to remove loose debris and to begin the chilling process. The mechanical sprayer was constructed of a small diameter pipe with holes drilled at regular intervals. The washer operated continuously, and all blood, fat, and other debris was washed to floor drains [Photo 5].

The cattle carcasses also entered the dressing and cleaning area on an overhead conveyor system. As noted above, the cattle were skinned in the killing room; thus, less blood was observed to be carried over to the processing area. Once in the dressing and cleaning area, the carcass was opened and the edible and inedible organs and paunch were removed by wheelbarrow. Water was used extensively in this area to remove small cuttings, blood drippings, spilled paunch manure, and loose debris.

Prior to the washing step, cattle carcasses were split from neck to tail with a chainsaw. The chainsaw contained a water spray system to rinse bone chips and other debris away from the carcass and to cool the saw and meat [Photo 7]. Water from the saw was collected by the floor drains.

Following the carcass splitting operation, a mechanical washer similar to that used for the sheep operation was also used for cattle washing. The cattle carcass washer was operated continuously; however, the sides of cattle passed through the washer at intervals of 2-5 minutes. All washwater from the processing area entered the floor drains.

After viewing the processing area, the audit team visited the head and leg processing operation located in an adjacent building. Water was used extensively in this workshop for scalding and cleaning sheep and cattle heads, and for processing the legs, edible organs, and recovered paunch. Several continuously running hoses were observed in the cleaning area [Photo 9]. In addition, the mixing of the paunch with calcium hydroxide was performed by foot in shallow drums. This resulted in significant spillage of the paunch residue/lime mixture to the floor and subsequently to the drain.

Paunch Manure Recovery

The paunch manure recovery room was also visited during the audit. The paunches were delivered to the room in wheelbarrows, placed on a cutting table and split. As the paunch was split open, the paunch manure (partially digested stomach contents) spilled on the floor of the room [Photo 10]. The liquid portion of the manure ran into an open channel on the floor and subsequently to an open drain to the sewer [Photos 11,12]. The wastestream carried significant quantities of solids and high-strength organic liquid wastes directly to the sewer. No screens or filters were used to prevent this material from reaching the open floor channel; thus, significant amounts of the paunch manure entered the wastestream directly.

During the monitoring conducted following the initial site visit, a grab sample was collected from the discharge channel outside the paunch manure recovery room. This sample location was well outside the area where the paunch was spilled and contained both paunch contents and water used to rinse paunch material to the sewer. The results, presented in Table 5, indicated that the BOD5 of this wastestream was 5,225 mg/l and had a TSS concentration of 19,777 mg/l. This wastestream entered the facility sewer system without further screening or treatment.

Chilling, Storage and Inspection

Very little water and wastes were observed during the team's visit to the chilling, storage and inspection area. During chilling, the washed meat generated a small amount of wastewater as it dripped to the floor; however, it did not appear to be heavily contaminated. The chilling room floor was also reportedly washed on regular basis. The inspection area was also generally dry; however, the floors were reportedly cleaned each evening. Since little blood or debris was observed in these areas, neither of the cleaning wastestreams should generate significant loads.

4.2.2 Poultry Slaughtering and Processing

Following the tour of the sheep and cattle slaughtering facility, the audit team moved to the chicken slaughtering operation. The tour of this operation was led by the facility maintenance engineer and the manager of the chicken processing operation. The audit team observed each of the unit

processes while they were in operation and noted water use and wastewater discharge practices. A summary of the wastewater discharge practices observed for each of the major processing areas is described below.

The monitoring conducted during the audit for the discharge from the poultry operation indicated that significant quantities of blood, solids, and manure were discharged by the MGAS facility. Table 7 presents a comparison of the monitoring results determined during this audit to literature values for similar operations published in the World Environment Center (WEC) report. While the audit results were based on a single sample, it can be seen that while the flows are lower than average, the loadings from the MGAS facility are significantly higher than the averages presented in the literature. This confirmed the general assessment of the audit team regarding excessive loss of blood to the sewer.

Reception

The crates containing the live chickens were removed from the delivery trucks and placed on a conveyor belt through a doorway in the side of the slaughterhouse. The only wastewater generated in the holding area was from the spraying of live chickens for cooling. This cooling spray occurred outside of the slaughterhouse in the truck unloading area and did not generate an internal wastestream at the facility.

As crates were placed on the conveyor, bird droppings collected on the floor near the doorway and were washed to an open floor drain directly under the conveyor belt [Photo 15]. A continuously running fresh water hose was observed laying on the floor near the drain, but was not attended while the audit team was present. Some feathers and solid wastes also collected in the conveyor belt area and were removed by dry sweeping. After chickens were removed from the crates, the crates were stacked on the receiving room floor and rinsed by hose. A mechanical crate washer was also present at this location but was not in operation during the initial or follow-up site visits. All wastes from this area flowed to open floor drains.

Slaughtering and Bleeding

After the chickens were removed from the crates and hung by their feet on the overhead conveyor, the manual sticking occurred. Since the birds were not stunned prior to sticking, they became highly agitated and caused a large amount of blood to be sprayed to the walls and floor of the killing area, as well as to the feathers of the chickens. This initial blood loss occurred prior to reaching the blood collection channel. Blood not lost in the first few meters following the slaughtering process was captured in a stainless steel channel below the hanging chickens [Photo 17]. The blood channel continued for approximately 15 meters to a point where the blood flowed through a drain in the channel into a plastic tub on the killing room floor. As the tub filled with blood, it was removed and mixed with the waste feathers on a waiting truck [Photo 18]. While the tub was removed for dumping, the blood channel continued to discharge blood to the floor [Photo 19]. Hoses in the area were used to wash this spilled blood down the floor drains.

Defeathering

Wastewater was generated during the defeathering operation from several sources including scalding, mechanical defeathering and floor washing. The primary source was observed to be the scalding tank overflow. Water was added to the tank to keep it from becoming over contaminated with blood and solids and overflowed continuously to an open channel on the floor directly below the scalding tank. Much of the blood contamination of the scalding water appeared to be related to the blood remaining on the feathers following the manual killing operation [Photo 20]. Some water was also lost from this tank due to the dragout of water on the birds as they were removed for defeathering.

For the mechanical feather removal, a continuous water spray was used to wash feathers to the open channel on the floor of the defeathering room [Photo 21]. In addition, the floors were rinsed to wash solids and feathers to the collection channel.

The collection channel flowed through the scalding and defeathering room, under a wall, and entered the solids collection pit. As the channel entered the solids recovery room, several men were observed "filtering" large solids from the channel using their feet and hands. Solids including large chicken parts and whole chickens were then removed from the channel for rendering. Everything not filtered at this point entered the solids collection pit [Photo 25].

The contents of the pit were pumped to a rotary drum filter where a majority of the feathers, heads and other large solids are removed from the wastestream [Photo 26]. Filtrate from the drum was then discharged to an open drain on the floor of the solids recovery room [Photo 27]. The recovered feathers, heads, and viscera, along with recovered blood (in tubs) and dry swept solids, were mixed together on a waiting truck for off-site rendering.

A grab sample of the filtrate from the rotary drum filter was collected during the subsequent monitoring effort [Photo 28]. The results of the analyses, presented in Table 5, indicated that this wastestream exhibited wastewater characteristics nearly identical to the total discharge from the poultry processing operation. Characteristics included high concentrations of BOD5, chemical oxygen demand (COD), and fat, oil, and grease (FOG), with moderate concentrations of total and dissolved solids. These results were consistent with the wastes observed to be present in this discharge, namely blood, fats and fecal matter.

Eviscerating/Cleaning

As the viscera were removed, water was used extensively to dispose of intestine contents, wash edible organs, and remove trimming wastes. Large solid wastes from the evisceration line were collected and placed with feathers for rendering; however, most trimmings and smaller solids were swept into the open solids collection channel directly under the conveyor. Most of the parts cleaning operations were performed in small, static basins. The water in the basins was kept fresh by constantly adding make-up water and allowing the excess to overflow. Water from this line was also collected in the open solids collection channel directly below the conveyor, and flowed back to the solids collection pit.

Following evisceration, the carcasses passed through a mechanical spray washer. This washer was constructed of a small diameter pipe with holes drilled at regular intervals. The washer was observed to run continuously [Photo 23]. The wastewater generated by the washer collected on the floor and flowed partly to floor drains (sewer) and partly to the collection channel leading to the rotary drum filter.

The final cleaning operation was performed in two open tanks placed end-to-end in the processing area [Photo 24]. As the chickens emerged from the spray washer, they were picked from the conveyor and thrown in the cleaning tanks. A belt conveyor operated between the two tanks to remove chickens from the primary tank and place them in the secondary tank. Water flowed continuously into each tank and overflowed from each tank to the floor drains. This operation resulted in the sewering of significant quantities of only slightly contaminated water.

While the configuration of the tanks and equipment clearly indicated that they were designed to be operated in series, the operation observed during the audit indicated that the tanks were used in parallel (i.e., chickens were placed in and removed from either tank) even though the belt conveyor was in operation between the two tanks. In addition, there was no recirculation of water within the tanks from the secondary washer to the primary washer.

Chilling, Storage and Inspection.

The final stages of the operation were the chilling, storage and inspection of the cleaned and dressed chickens. Initial chilling began in the two open cleaning tanks described above. Chickens were removed from the cleaning tanks and hung on racks for inspection and storage in refrigerated chillers. During this process, some water was spilled to the floor due to dragout and drainage from the cleaning/chilling tanks. This water did not appear to be highly contaminated and entered the sewer through floor drains.

4.2.3 Ancillary Operations

In addition to the wastestreams generated by the primary slaughterhouse operations at the MGAS facility, several additional wastestreams were identified from ancillary operations. Facility operations that produced wastewater included the canteen and sanitary facilities for employees, truck loading and unloading operations, laboratory facilities, and administrative offices.

Employee canteens and sanitary facilities were present for both the sheep/cattle and the poultry operations. Sanitary facilities included washrooms and showers for employees. All employees working in the killing and eviscerating areas were required by MGAS rules to take showers following their shifts. The canteen, washroom and showering facilities were not investigated during the audit, but were assumed to generate a relatively low strength wastestream.

Truck loading and unloading operations were observed throughout the sheep/cattle and poultry slaughterhouse areas. The large numbers of animals loaded and unloaded daily required hundreds of trucks to enter and leave the MGAS facility. Puddles of oil and grease were seen in the loading and unloading areas throughout the facility and would likely be washed to the storm sewer during a rain event.

The MGAS laboratory provided physical, chemical and biological inspection services for meat, poultry and fish delivered to the slaughterhouse. The laboratory was quite small and would not likely generate a significant wastestream.

4.3 AIR EMISSIONS AND SOLID WASTES

The MGAS facility generated primarily liquid wastes that were discharged to the municipal sewer system. Air emissions from the facility consisted of hydrocarbon and particulate emissions from the boiler operation, and odors generated from live animal and slaughterhouse wastes. Neither of these emissions were considered significant. Solid wastes generated by the facility, however, were of some concern due to both volume and potential hazard to human health.

The majority of the solids generated at the MGAS facility, such as trimmings, feathers, and manure, were recovered and sent to local renderers. However, some solid wastes were generated at the MGAS facility in the form of whole animals, meat, and edible and inedible viscera that were rejected due to contamination, disease, or quality concerns. The facility maintenance engineer reported that no records were kept to quantify the amount of solids generated; however, he estimated that approximately three containers, with a capacity of 9 m^3 each, were required each day to remove the waste solids. The engineer also reported that while renderers would accept some of the solids, the majority were removed to a landfill located in Ruseifa.

4.4 DATA GAPS

Several important data gaps were identified during the audit of the MGAS facility. The identified data gaps included:

- Lack of Water Use Data - Of particular concern was the lack of data regarding water use for both individual unit processes and the overall slaughterhouse facility. As noted in Section 4.1, the facility has a flow meter for total water use at the sheep/cattle and poultry operations; however, it had not monitored or developed accurate estimates for water use in various areas of the plant. An effort was made during the audit to generate rough estimates of process water use; however, these estimates were very general in nature, and were developed by the facility maintenance engineer based on his best judgement.

- Inconsistent Sampling Results - Monitoring for the facility had been conducted primarily by WAJ representatives, although additional studies had been performed by the World Bank Study in 1993. The sampling location used by WAJ was not clear and may or may not be reflective of the entire facility discharge. In addition, past monitoring results from WAJ and World Bank had ranged widely; thus, an accurate estimate of the total pollutant load from the facility was not possible.

- Lack of Solid Waste Disposal Data - During the audit the team also requested information regarding the quantities of solid waste generated, and the disposal site for these wastes. The MGAS staff provided very rough estimates of the average number of trucks per day used to remove solid wastes, but were not able to accurately characterize these wastes.

- Lack of Records Regarding Blood Disposal - The MGAS facility also did not maintain records regarding the ultimate disposition of the blood collected in the blood pits. Facility staff reported that all blood was removed for rendering; however, it was not clear that the volume of tankers used was sufficient to remove all of the blood generated.

5.0

POLLUTION PREVENTION AND WASTE MINIMIZATION OPPORTUNITIES

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION OPPORTUNITIES

The MGAS facility was selected for the PP/WM study due to its loading and impact on the As Samra Wastewater Treatment Plant. This treatment plant was designed to treat 35,750 kg/day of BOD5, 42,000 kg/day TSS, and a flow of 68,000 m^3/day. The As Samra Wastewater Treatment Plant is currently treating 56,144 kg/day BOD5, 55,944 kg/day TSS, and a flow of 124,321 m^3/day. Of this total, the MGAS facility was determined during this study to contribute 4.43 percent of the total BOD5, 2.74 percent of the total TSS and 0.56 percent of the total flow to the As Samra treatment plant.

The discharge from the MGAS facility to the public sewer system is governed by the Water Authority Law, Law Number 18, of 1988, Annex [B-4], which limits the discharge of pollutants to the sewer system. A comprehensive overview of these standards is provided in Appendix C. A comparison of these standards with the effluent data collected during this audit is provided in Table 5. This comparison indicates that the effluent from the MGAS facility is likely to exceed the applicable standards. Previous monitoring by WAJ (1993/1994) and the World Bank (1993) have also shown exceedances of these standards. It should be noted, however, that while the standards presented in Table 5 represent "daily average" values and the effluent monitoring performed for the audit was simply a one hour composite. A full 24 hour composite should be used for a more accurate comparison with the standards.

This audit has evaluated the MGAS facility operation and has identified opportunities to reduce loadings from the facility to the As Samra treatment plant. In addition, many of the PP/WM techniques described in this report will result in the recovery of additional marketable by-products by the MGAS facility.

While the literature defines "pollution prevention" as the elimination of pollution before it is created and 'waste minimization" as the reduction of the amount of waste generated, this report will use the terms nterchangeably. Regardless of the terminology, the PP/WM opportunities identified in this report will ocus on reducing the impact of the discharges from the MGAS facility on the operation of the As Samra treatment plant.

.1 SHEEP AND CATTLE SLAUGHTERING AND PROCESSING

he operating procedures and the wastewater generation practices for the sheep and cattle lines at the IGAS facility were described in sections 2 and 4 of this report. For the sheep and cattle slaughtering nd processing operations, the principal wastes discharged to the sewer system, as observed during the udit, were blood, solids (including viscera, trimmings, and other debris), and paunch manure. ollutant parameters typically associated with these wastes include BOD5, COD, FOG, TSS, total ssolved solids (TDS), total Kjeldahl nitrogen (TKN), and phosphorus (P).

uring the facility site visits, the audit team assessed waste generation practices, and noted opportunities r the application of PP/WM techniques that had been utilized by similar types of operations. This ction provides a discussion of the PP/WM opportunities identified by the audit team related to the GAS facility.

5.1.1 Blood Recovery

Literature sources report the total blood content of sheep (35 kg body weight) to be approximately 2.5 liters and cattle (500 kg body weight) to be approximately 35 liters. The principal source of BOD5, COD, TKN, and P from the MGAS facility, and slaughterhouses in general, is the incomplete collection of blood during killing and dressing, and its subsequent loss to the sewer. Blood loss should be minimized wherever possible, therefore, to reduce pollutant loadings. An efficient blood recovery system is also economically advantageous to the MGAS facility because the recovered blood can be sold to local rendering operations as a useful by-product.

During the audit, the blood recovery practices at the MGAS facility were evaluated. In both the sheep and cattle killing areas, collection channels carry the initial blood loss to a blood collection pit and all floor drains in these rooms reportedly drain directly to the blood collection pit. While most blood was collected in the killing area during the slaughtering operation, a significant amount of blood was lost to the sewer system during subsequent handling and processing operations.

During the audit, and during subsequent site visits, the blood recovery tanker was not observed. As the blood holding capacity of the pits is not sufficient to permit storage for long periods, it is imperative that MGAS ensure blood removal on a timely basis to prevent unnecessary discharge of pure blood to the sewer. The configuration of the pits also appeared to limit accessibility to the blood collection tankers. MGAS staff should ensure that the pits are fully accessible and that complete emptying of the pit is accomplished. Incomplete removal of blood would require subsequent cleaning and discharge of waste blood to the sewer.

The following suggestions are provided to promote more efficient blood recovery within the sheep and cattle slaughtering and dressing operation.

<u>Killing Room</u>

1. Blood collection in the killing room could be maximized by concentrating the bleeding operation to a more confined area, particularly in the cattle operation. This would minimize the need for washwater to rinse blood to the collection pit, and result in less dilution of the recovered blood. Stunning cattle prior to the killing operation would allow bleeding to be performed more efficiently, and would greatly improve worker safety conditions.

2. Slaughtered sheep could be kept for longer detention times in the killing room to allow additional blood to drain into the blood collection pit. The current practice of hanging and immediately removing the carcass to the processing area results in a significant loss of blood to the sewer.

3. Heads and Legs, which are removed in the killing room, could be allowed to drain more fully in the sheep or cattle killing room. Current practice of storing these parts in the processing area allows significant amounts of blood to drain to the sewer.

4. The MGAS facility could employ two-way drains in killing room and other high blood loss areas to avoid dilution of blood for recovery. During killing operations the drains would lead directly to the blood pit; however, during clean-up operations, the drains would be opened to the sewer and the relatively clean washwater would not dilute collected blood.

Dressing and Cleaning Area

1. The MGAS facility could provide a system for additional blood recovery following removal of sheep from the killing room. As noted, significant dragout of blood was observed in the area immediately outside of the sheep killing room. MGAS could use two-way drains and/or a blood collection trough to collect blood dragout and return it to the blood collection pit.

2. Additional blood recovery could be accomplished in the cleaning and dressing area by using wet vacuum units, or squeegees and pails, to collect spilled blood. The collected blood would then be recovered in the blood collection pits.

5.1.2 Solids Recovery

The sheep and cattle processing operation at the MGAS facility also generated a significant quantity of waste solids. These solids were generated by dressing and cleaning operations such as viscera removal and trimming, as well as general maintenance activities such as pen cleaning and floor washing. A large percentage of these waste solids were observed to be washed directly to the floor drains within the production area.

While paunch manure recovery also generated waste solids, it is addressed as a separate section due to the unique nature of the operation. Based on the audit observations, the following PP/WM opportunities were identified.

1. Manure could be collected by dry methods (sweeping and shoveling) and recovered as fertilizer from the sheep holding pen. In addition, the holding pen should be covered to prevent manure from washing to the drain during a rain storm. Current practice in the holding pen is to wash manure solids directly to the sewer. This results in a high BOD5 and solids discharge, clogging of the facility sewer, and loss of a reusable by-product (manure).

2. Additional solids collection by sweeping, shoveling or wet vacuuming could be practiced throughout the killing and processing areas. Current practices of using low pressure hoses as a "broom" to wash solids to the drain results in significant pollutant discharges and the loss of renderable materials.

3. Drain covers and screens could be maintained and/or replaced to prevent large solids from entering the sewer. Several drain covers were observed to be missing or broken during the audit.

4. The heads and legs workshop could be expanded to provide more efficient cleaning and processing operations. Due to current overloaded operations, the cleaning and processing was performed in an extremely congested and chaotic area. Facilities were not available for proper

(dry) solids disposal; thus, the sewer was used for most wastes. Paunch bleaching operations were also conducted using make-shift basins and mixers. Spillage of lime and solids to the floor and drain were observed.

5.1.3 Paunch Manure Recovery

The paunch manure recovery practices at the MGAS facility were determined by the audit team as the most significant uncontrolled discharge of pollutants to the sewer system from the sheep and cattle slaughtering and processing operation. Paunch manure was dumped to the floor of the recovery room and allowed to flow in an unrestricted manner to an open channel leading to the sewer system. Paunch manure contains extremely high concentrations of BOD5 and TSS and contributed significantly to the overall pollutant load from the facility. Grab samples of the discharge from this process, collected during the audit, revealed a BOD5 concentration of 5,225 mg/l and a TSS concentration of 19,777 mg/l.

Literature sources indicate that paunch manure solids and liquids can, and should, be fully recovered and utilized. Several suggestions for the operation of a paunch manure recovery system for the MGAS facility are provided below.

1. The MGAS facility could construct a collection pit and collect all liquid and solid paunch contents. The recovered paunch contents could then be sent to a rendering operation for recovery. Alternatively, the MGAS facility could mix the recovered paunch contents with dry manure for distribution as fertilizer.

2. If complete recovery of paunch liquids and solids is not possible, the MGAS facility could use screens housed in mobile drums for separation of solids and liquids. Solids could be mixed with manure for fertilizer, and liquids could be evaporated or, as a last resort, discharged to the sewer.

5.2 POULTRY SLAUGHTERING AND PROCESSING

The operating procedures and the wastewater generation practices for poultry slaughtering and processing at the MGAS facility were described in sections 2 and 4 of this report. For the these operations, the principal wastes discharged to the sewer system, as observed during the audit, were blood, and solids such as viscera, trimmings, and other debris. Pollutant parameters typically associated with these wastes include BOD5, COD, FOG, TSS, TDS, TKN, and P.

During the site visits to the MGAS facility, the audit team assessed waste generation practices, and noted opportunities for the application of PP/WM techniques that had been utilized by similar types of operations. This section provides a discussion of the PP/WM opportunities identified by the audit team related to the MGAS facility.

5.2.1 Blood Recovery

As noted in the blood recovery discussion for the sheep and cattle operation, the principal source of oxygen demanding pollutants from a slaughterhouse is blood loss to the sewer. Blood loss should be minimized wherever possible, therefore, to minimize pollutant loadings. An efficient blood recovery system is also economically advantageous to the MGAS facility because the recovered blood can be sold as a useful by-product.

During the audit, the blood recovery practices employed in the chicken slaughtering operation at the MGAS facility were evaluated. While most blood was collected in the killing area during the slaughtering operation, a significant amount of blood was not collected during the initial bleeding due to inefficient operational practices. The following suggestions are provided to promote more efficient blood recovery within the poultry slaughtering and processing operation.

1. MGAS could perform stunning of chickens prior to killing operations to promote more efficient blood collection. Current operations involve the severance of the jugular vein of unsedated birds which results in uncontrolled initial blood loss. Stunning prior to sticking operations would allow controlled blood drainage to the blood collection trough and nearly eliminate blood contamination of feathers. Benefits include additional blood recovery and less contamination of scalding tank water by bloody feathers.

2. The blood collection channel could be extended and widened to provide additional blood collection immediately following sticking operations. Current practices involve the severance of the jugular vein several meters prior to the beginning of the blood collection channel; thus, initial blood loss is to the floor and walls. Benefits include additional blood recovery and less waste to the sewer.

3. Additional blood collection tubs could be used to prevent blood loss to the sewer. During the audit, it was observed that only one blood collection tub was used for blood recovery. When this tub was removed for emptying, a replacement was not provided. The lack of a collection tub resulted in the unrestricted discharge of blood to the floor and nearby floor drain. Benefits include additional blood recovery and less waste to the sewer.

4. The chicken conveyor system could be extended to provide additional time for blood drainage. This could be accomplished by adding an additional loop within the killing room prior to the scalding tank. Benefits include additional blood recovery and less waste to the sewer.

5. Recovered blood could be collected in a collection basin and rendered as a valuable by-product instead of mixing it with feathers. The blood tanker that is used to remove sheep and cattle blood could be used to remove the chicken blood for rendering. A collection pit or storage tank, however, would be required for this operation. Benefits include more efficient utilization of the valuable blood resource.

5.2.2 Solids Recovery

In general, the audit determined that most large solids generated by the poultry slaughtering and processing operations were recovered by the rotary drum filter and transported off-site for rendering. Several opportunities, however, were identified to increase the efficiency of the solids recovery operation, and to reduce the loading of fine solids, and soluble solid contaminants from reaching the wastestream and are provided below.

1. A bar screen could be installed to remove large solids and whole chickens from the solids collection channel prior to the solids collection pit. Currently, an individual is stationed full time at the terminus of the channel, and uses his hands or feet to block large solids. Benefits of a bar screen include, improved operation of pumps and of the rotary drum filter, and the freeing of staff for more efficient cleaning operations.

2. Additional solids collection by sweeping, shoveling or wet vacuuming could be practiced throughout the killing and processing areas. Current practices of using low pressure hoses as a "broom" to wash solids to the drain results in significant pollutant discharges and the loss of renderable materials.

5.3 ANCILLARY OPERATIONS

The ancillary operations at the MGAS facility were not observed to exert a significant pollutant load to the sewer system. One PP/WM opportunity, however, was identified by the audit team with respect to the cleanup of oil and grease spills at loading and unloading areas. Oil and grease puddles generated by trucking operations could be cleaned up using clay absorbent and discharged as a solid waste rather than using a water washdown.

6.0

WATER CONSERVATION OPPORTUNITIES

6.0 WATER CONSERVATION OPPORTUNITIES

Water conservation is an extremely important concern in the Zarqa Basin and throughout Jordan. The limited water resources require that businesses and industry view water as a valuable raw material and optimize its use. In order to optimize water use, business and industry should carefully monitor flows and uses within facility operations and develop a written strategy to coordinate water conservation activities.

While water conservation is an important concern, the use of water at the MGAS facility must be maintained at a level to ensure sanitary conditions for meat and poultry handling. The hygienic operation of the plant should in no way be compromised by any of the water conservation suggestions provided in this report. The audit team is confident, however, that opportunities for significant water use reductions are available to the MGAS facility. Suggestions provided in this section of the report provide water conservation methods that can be easily implemented and that could result in an estimated water savings of 30 percent for the sheep/cattle operation (see Table 8) and 40 percent for the poultry operation (see Table 9).

Additionally, it is possible for the MGAS facility to treat its wastewater using a combination of physical and biological treatment units in order to completely recycle its process wastestreams. Due to the significant costs involved in developing such a system, and the difficulty of producing an effluent of sufficient quality to meet the hygienic and sanitary needs of the slaughterhouse, this option is not developed in this report.

6.1 SHEEP AND CATTLE SLAUGHTERING AND PRCCESSING

Total water use in the sheep and cattle processing operation was estimated to be approximately 30 m^3 per hour during the 10 hours per day of operation. Figure 2 presents a breakdown of the water uses within this portion of the facility.

Table 6 provides a comparison of the flow at the MGAS facility versus values published in the literature for similar facilities in the United States (US) and the United Kingdom (UK). In comparison to these similar operations, the rate of water consumption at the MGAS facility is low. This lower water consumption rate is due part to the differing sanitation standards applied at the MGAS facility, compared to its US and UK counterparts, and because the literature data pre-dated implementation of the current PP/WM initiative in the US and UK.

While water use at the MGAS facility is relatively low, opportunities for additional conservation were identified during the audit. In general, each of the ideas presented below relate to "passive" water shutoff systems. These systems will significantly reduce water wasted to the sewer due to continuously running hoses, taps left running, and mechanical washers that remain in operation whether or not animals are being processed. A summary of the water savings that were projected for the various water conservation techniques is provided in Table 8. A description of the opportunities is provided below.

- The MGAS facility could fit all hoses in the facility with hand operated nozzles. During the audit, continuously running hoses were seen throughout the facility. A running hose will consume 30 liters of water per minute. Over the course of a ten hour work day, this equates to approximately 18,000 liters or 18 m^3. Placing nozzles on hoses will ensure that water is not consumed when it is needed. Assuming the MGAS sheep/cattle operation uses 6 continuously running hoses, and that nozzles would result in these hoses being shut off 3 hours during the 10 hour operating day, a savings of 3.2 m^3/hr, or 10.7 percent of the total sheep/cattle operation water consumption could be achieved.
- The use of water in the sheep holding pen could be eliminated. As indicated in 5.1.2, dry methods could be used to remove manure from the sheep holding pen. Assuming that the current practice results in the use of a hose open 50 percent of the operating day, this would result in a savings of 0.9 m^3/hr, or 3 percent of the sheep/cattle operation water consumption. (This water use practice was not indicated on the facility flow diagram by the maintenance engineer.)
- Use of high pressure hoses (with nozzles) instead of the current low pressure system would provide more efficient cleaning with less overall water use. Using a high pressure system. While it is anticipated that water consumption would be reduced, the amount of reduction will be dependent on the type of high-pressure system and the practices used by the system operator.
- Hand or foot operated valves installed on all taps, wash basins, and showers would remove the possibility of taps being left on when not in use. Several sink taps were observed running while not in use. Automatic shut of valves would significantly reduce this practice. Assuming that 6 taps are normally open for 2.5 hr/day, and that automatic shut-off valves would result in these taps being closed an additional 1 hr/day, a savings of 1.1 m^3/hr, or 3.6 percent of the total sheep/cattle operation water consumption could be achieved.
- An automatic on-off trigger could be installed on the mechanical carcass spray wash systems. Current practice involves the full time operation of these washers during the entire operating day. For the sheep processing line, this practice appeared to be warranted, as the flow of sheep carcasses was nearly continuous. For the cattle line, however, there was a significant lag time between carcasses being washed. During the audit, it appeared that cattle carcasses were in the wash for 15 - 20 seconds, followed by 1-2 minutes before the next carcass was ready for washing. Using an automated on-off system, therefore, would reduce water consumption at this operation by up to 70 percent and would reduce overall water consumption in the sheep/cattle operation by 11.7 percent.

In addition to these specific opportunities, the MGAS facility could provide additional wet vacuums and dry solids removal techniques to reduce the use of water as a "broom" to rinse solids to the drain, and could optimize water use for all process operations. Optimization could include slowly reducing water use at a given unit process until negative impacts are observed. Water use would then be maintained at the minimum effective flow rate.

6.2 POULTRY SLAUGHTERING AND PROCESSING

Total water use in the poultry processing operation was estimated to be approximately 40 m^3 per hour during the 10 hours per day of operation. Figure 3 presents a breakdown of the water uses within this portion of the facility.

6.3 ANCILLARY OPERATIONS

The ancillary operations at the MGAS facility were not observed to significantly affect water consumption. The only water conservation opportunity identified for these operations would be the installation of passive shutoff valves for all sinks and washbasins throughout the facility. Passive shutoff systems include hand and foot operated taps and hoses.

6.4 WATER CONSERVATION POLICY

During the conduct of the site visit of the MGAS facility, the audit team determined that the facility did not have a written policy regarding water use practices. In addition, the water use records maintained for the facility were not sufficiently detailed to assess the quantities of water used for any of unit processes in the sheep/cattle or poultry operations. In order to begin any efforts to optimize water use practices, the MGAS facility could establish a written water conservation strategy that establishes <u>and</u> implements the following minimum goals and objectives:

- Consideration of water as a raw material for slaughterhouse operations. As such its uses should be evaluated and optimized to avoid waste.
- As a valued raw material, water use in the plant should be metered, or measured, at key locations, with records maintained to document water use practices over time.
- Water should be used only for purposes where no other suitable alternative exists. In particular, water should never be used as a "broom" to dispose of solid or semi-solid wastes. Dry cleaning methods should be implemented wherever possible.
- Employees should be made aware of the water conservation policy through training and incentives. Employee training should stress dry cleaning techniques, awareness that valves and nozzles should be closed when not in use, and that mechanical systems should be shut down during breaks.

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7.0

CONCLUSIONS AND RECOMMENDATIONS

7.0 CONCLUSIONS AND RECOMMENDATIONS

The MGAS facility staff expressed a sincere concern regarding current wastewater generation and water consumption practices at their facility and was extremely helpful in providing access and information to the audit team. During the audit, and subsequent sampling visit, the audit team collected baseline information and performed an initial assessment of the opportunities for the application of PP/WM and water conservation techniques. The findings of the audit were presented in Sections 4, 5, and 6 of this report.

Based on the process evaluation and the assessment of PP/WM and water conservation opportunities conducted during the audit, the audit team identified the following conclusions and recommendations. The audit conclusions are provided in Section 7.1 and the recommendations for PP/WM and water conservation techniques are provided in Section 7.2.

7.1 CONCLUSIONS

Based on the findings of the audit conducted on September 17, 1994, and subsequent visits, the audit team developed the following conclusions regarding the operation of the MGAS facility:

1. The MGAS facility is the only slaughterhouse available for the City of Amman and its surrounding communities. As the only facility, it cannot be closed down for large scale maintenance or refitting of new equipment.

2. The MGAS facility is operated at its maximum capacity and has limited space available for expansion or installation of large scale wastewater treatment facilities.

3. The process operations and the discharges to the public sewer system at the MGAS facility are segregated (i.e., two sewer connections) for the sheep/cattle facility and the poultry facility. Sampling performed to evaluate the impact of the facility, therefore, will need to be performed on both of the discharge lines.

4. The sheep slaughtering operation is more controlled than that for cattle due to the stunning of animals. However, blood recovery is less controlled due to the limited amount of time allowed for blood draining within the killing room.

5. The cattle slaughtering operation is chaotic due to the lack of stunning prior to slaughter. Initial blood collection is made more difficult by this procedure.

6. Continuously running hoses in sheep and cattle killing areas result in dilution of recovered blood. Continuously running hoses in other areas result in unnecessary loss of blood and solids to the sewer. Free running hoses are also a major source of unnecessary water consumption.

7. Cattle carcasses were washed by the mechanical spray wash unit for approximately 15-20 seconds; however, the spray continued to run for 1-2 minutes before the next carcass was ready for washing. This procedure resulted in a significant waste of potable water.

8. The paunch manure recovery room is the source of the most uncontrolled discharge of wastes observed at the MGAS facility. Procedures in this area resulted in the unrestricted flow of paunch contents to the sewer.

9. The poultry slaughtering operation is more highly automated than the sheep/cattle operation, and practices result in more efficient recovery of blood and solids.

10. The poultry line sticking operation results in unnecessary blood loss due to lack of stunning of chickens prior to sticking, and initial blood loss prior to beginning the blood collection channel.

11. The final cleaning tanks for poultry were designed to operate in series, but were not used in this manner. Fresh water was added unnecessarily to both cleaning tanks and resulted in significant water consumption.

12. Wet clean-up methods (e.g., hosing of blood and solids to sewer) is practiced widely at the MGAS facility. Dry cleaning methods would generally be more efficient and result in less wasted water.

13. Water conservation techniques identified for the sheep/cattle operation were projected to result in a water savings of approximately 30 percent. The breakdown of the water savings estimates is provided in Table 8.

14. Water conservation techniques identified for the poultry operation were projected to result in a water savings of approximately 40 percent. The breakdown of the water savings estimates is provided in Table 9.

7.2 RECOMMENDATIONS

Due to the limitations imposed by functioning as the only slaughterhouse for a population of over 2,000,000 people, PP/WM and water conservation opportunities implemented by the MGAS facility must be performed without a shutdown of the facility. The recommendations listed below are provided with these limitations in mind. While several of the options would require minor construction, all could be implementable under current operating conditions. Based on the PP/WM and water conservation opportunities identified and discussed in Sections 5 and 6 of this report, the audit team provides the following recommendations:

1. <u>Sheep and Cattle Operation</u>

The audit team identified several PP/WM and water conservation opportunities related to the sheep and cattle slaughtering operation at the MGAS facility. Based on these opportunities, the following recommendations are provided:

- Blood recovery should be maximized wherever possible. Techniques which should be adopted by the MGAS facility include:

- Ensure that blood collection pits are fully accessible and that complete emptying of the pit is accomplished. If blood remains in pit overnight, it becomes difficult to remove, requiring additional water use, and will likely be wasted.
- Blood collection in the killing room should be maximized by concentrating the bleeding operation to a more confined area.
- Cattle should be stunned prior to the killing operation to allow bleeding to be performed more efficiently. This would also improve worker safety conditions.
- Slaughtered sheep should be kept for longer detention times in the killing room to allow additional blood to drain into the blood collection pit.
- Heads and legs should be allowed to drain more fully in the sheep or cattle killing room.
- Two-way drains should be used in the killing rooms, and other high blood loss areas, to avoid dilution of recovered blood.
- A system for additional blood recovery should be provided following removal of sheep from the killing room.
- Additional blood recovery should be accomplished in the cleaning and dressing area by using wet vacuum units, or squeegees and pails, to collect spilled blood.

- Additional solids recovery should be performed in order to reduce water consumption, pollutant loadings to the sewer, and to recover additional usable by-products. The following specific actions should be considered:
  - Manure from the sheep holding pen should be collected by dry methods (sweeping and shoveling) and recovered as fertilizer.
  - A roof or cover should be constructed over the sheep holding pen to prevent manure from washing to the drain during a rain storm.
  - Additional solids collection by sweeping, shoveling or wet vacuuming should be practiced throughout the killing and processing areas.
  - Drain covers and screens should be maintained and/or replaced to prevent large solids from entering the sewer.
  - The heads and legs workshop should be expanded to provide more efficient cleaning and processing operation.

- Paunch manure solids and liquids should be fully recovered and utilized. Suggestions for the operation of a paunch manure recovery system for the MGAS facility are provided below.
  - A collection pit for the collection and recovery of all liquid and solid paunch contents should by constructed. The recovered paunch contents should then be sent to a rendering operation for recovery. Alternatively, the MGAS facility could mix the recovered paunch contents with dry manure for distribution as fertilizer.
  - If complete recovery of paunch liquids and solids is not possible, screens housed in mobile drums for separation of solids and liquids should be used.

- All facility hoses should be fitted with hand operated nozzles.
- The facility should use of high pressure hoses (with nozzles) instead of the current low pressure system.
- Hand or foot operated valves should be installed on all taps, wash basins, and showers.
- Automatic on-off triggers should be installed on the mechanical carcass spray wash systems. Using an automated on-off system could reduce water use at the cattle wash operation by up to 70 percent.

- The facility should provide additional wet vacuums and dry solids removal techniques to minimize the use of water as a "broom" to rinse solids to the drain.
- MGAS should optimize water use for all process operations. Optimization should include slowly reducing water use at a given unit process until negative impacts are observed. Water use should then be maintained at the minimum effective flow rate.
- The use of water in the sheep holding pen, for washing purposes, should be minimized or eliminated.

2. Poultry Processing Operation

The audit team identified several PP/WM and water conservation opportunities related to the poultry slaughtering operation at the MGAS facility. Based on these opportunities, the following recommendations are provided:

- Blood recovery should be maximized wherever possible. Techniques which should be adopted by the MGAS facility include:
  - MGAS should perform stunning of chickens prior to killing operations to promote more efficient blood collection.
  - The blood collection channel should be extended and widened to provide additional blood collection immediately following sticking operations.
  - The blood collection tubs should be replaced during the emptying process to prevent blood loss to the sewer.
  - The chicken conveyor system should be extended to provide additional time for blood drainage. This could be accomplished by adding an additional loop within the killing room prior to the scalding tank. Benefits include additional blood recovery and less waste to the sewer.
  - Recovered blood should be collected in a collection basin and rendered as a valuable by-product instead of mixing it with feathers.

- Opportunities were identified to increase the efficiency of the solids recovery and to reduce the loading of fine solids and soluble solid contaminants to the sewer. The MGAS facility should consider the following options:
  - A bar screen should be installed to remove large solids and whole chickens from the solids collection channel prior to the solids collection pit.
  - Additional solids collection by sweeping, shoveling or wet vacuuming should be practiced throughout the killing and processing areas. Use of low pressure hoses as a "broom" to wash solids to the drain should be eliminated.

- Passive water conservation systems should be used to reduce water wasted to the sewer due to continuously running hoses, taps left running, and mechanical washers that remain in operation whether or not animals are being processed. Opportunities available to the poultry operation include:

  - The MGAS facility should fit all hoses in the facility with hand operated nozzles.

  - The facility should use high pressure hoses (with nozzles) instead of the existing low pressure system.

- Hand or foot operated valves should be installed on all taps, wash basins, and showers.
- An automatic on-off trigger should be installed on the mechanical carcass spray wash system.
- The facility should provide additional wet vacuums and dry solids removal techniques to minimize the use of water as a "broom" to rinse solids to the drain.
- Oil and grease spills in the loading and unloading areas should be cleaned up using clay absorbent and removed as a solid waste rather than using a water washdown.
- Water optimization should be practiced for all process operations.

- The MGAS facility should use a counter current rinsing technique for the poultry cleaning tanks. This would involve adding fresh water only to the secondary cleaning tank and plumbing the relatively clean water overflow from the secondary tank to the primary tank. Use of this technique is projected to reduce total water consumption in the poultry operation by 25 percent.
- The overflow water from cleaning tanks should be used to flush the solids collection trough in lieu of fresh water.

3. Water Conservation Policy

The MGAS facility should establish a written water conservation policy that establishes and implements the following minimum goals and objectives:

- Consideration of Water as a raw material for slaughterhouse operations. As such its uses should be evaluated and optimized to avoid waste.
- As a valued raw material, water use in the plant should be metered, or measured, at key locations, with records maintained to document water use practices over time.
- Water should be used only for purposes where no other suitable alternative exists. In particular, water should never be used as a "broom" to dispose of solid or semi-solid wastes. Dry cleaning methods should be implemented wherever possible.
- Employees should be made aware of the water conservation policy through training and incentives. Employee training should stress dry cleaning techniques, awareness that valves and nozzles should be closed when not in use, and that mechanical systems should be shut down during breaks.

8.0

FOLLOW-UP ACTIONS

8.0 FOLLOW-UP ACTIONS

To ensure the success of a PP/WM or water conservation project, a facility implementing specific actions must follow-up on these actions to ensure that the goals of the project are achieved. It is imperative, therefore, that the MGAS facility follow-up implementation of any of the recommendations of this report with activities such as increased monitoring of water use and disposal, ongoing maintenance and upkeep of new equipment, and conduct of periodic training and instruction for management and production line staff.

Increased monitoring of water use and disposal is particularly important for the MGAS facility due to the current lack of data in these areas. As part of its "Water Conservation Policy" the MGAS facility should begin routine monitoring of key water usage activities and wastewater discharge streams. This will assist the facility in more accurately targeting areas of concern, and will provide baseline data for overall plant performance. In addition, prior to initiating specific PP/WM activities, MGAS should evaluate the baseline characteristics of the wastestream (or water consumption activity) to be corrected. This baseline data can then be used to measure the initial success of the PP/WM or water conservation technique, and can also be used to ensure that the technique continues to perform successfully over time.

With respect to the PP/WM and water conservation techniques recommended in Section 7, the MGAS facility should follow-up on all of the elements that it determines are productive. Implementation of these recommendations will reduce water consumption, pollutant loadings, and will result in the recovery of additional by-products. In particular, the MGAS facility should follow-up on the following recommendations:

Sheep and Cattle Operation

1. The paunch manure recovery operation should be modified to collect all paunch contents. This will result in significant reductions in BOD5 and solids discharge to the sewer, and will result in additional recovery of paunch contents as a by-product.

2. The cattle spray washer should be fitted with an automatic shut-off valve to prevent wasting of water between carcasses. Installation of this valve is projected to save nearly 12 percent of the water consumed in the sheep/cattle operation.

Poultry Operation

1. The MGAS facility should perform stunning of chickens prior to the sticking operation and modify blood collection techniques to increase blood recovery. Stunning would result in lower blood loss to floor and chicken feathers, and modifications to the blood collection system, such as extending the collection channel and replacing the tub during dumping, would significantly decrease blood loss to the sewer.

2. The primary and secondary cleaning tanks should be operated in series with a counter current rinse. This operation can be easily refitted and is projected to save approximately 25 percent of the water consumed in the poultry operation.

General Facility Operation

1. General maintenance activities should be upgraded by providing additional cleaning tools such as wet vacuums, squeegees, and shovels. These tools would encourage dry cleaning techniques resulting in increased solids recovery and decreased water use.

2. Nozzles should be installed on all facility hoses to prevent unnecessary water consumption. Estimates provided in this report indicate that the use of nozzles could reduce total water consumption at the MGAS facility by approximately 10 percent.

3. Utilize water conservation equipment to the extent possible. Examples of water saving equipment include:

   - Flow Regulation Devices - When these devices are inserted into a water line, increasing pressure restricts flow to a constant rate.

   - Flow Shut-off Devices - The most useful devices are finger operated shut-off valves, or guns, connected to hoses. When finger pressure is released, water flow is stopped.

   - Nozzles - Nozzles use less water than drilled pipe sprayers. For faster, more efficient cleaning, a "vee" type nozzle is often recommended, as this nozzle forms a fan shaped chisel pointed spray.

   - Overflow Preventors - These devices are employed to prevent overflowing of containers, tanks, or reservoirs; thus, stopping waste of water or release of wastewater. Most of these devices are operated by float or electronic probe.

4. Eliminate spillage wherever possible. Where materials are not spilled, there is no need for cleaning or washwater use.

Where new equipment or processes are implemented to achieve a PP/WM or water conservation objective, the MGAS facility should provide ongoing maintenance and upkeep of this equipment. The success of any PP/WM project can be compromised if new equipment falls into disrepair, or if new processes are not correctly applied. Establishment of a long term maintenance schedule will help to ensure successful operation.

No PP/WM program will be successful if employees are not aware of the program goals and trained to effectively implement these goals. Employee training should include periodic refresher courses regarding the MGAS facilities PP/WM and water conservation policies and procedures and proper training in the use of new equipment or practices. Staff should also have the opportunity to provide input regarding additional PP/WM or water conservation activities and should be provided with incentives for program successes.

To ensure that MGAS management staff are kept updated on "state-of-the-art" technologies, the Ministry of Water and Irrigation and the Chamber of Industry should be consulted on a regular basis. Periodic site visits should be arranged for Ministry and Chamber staff so that they might provide additional input and suggestions.

TABLES

Table 1 - Current Production Rates for Sheep and Cattle Operations*

Animal	Number Killed (per day)	Average Live Weight (kg)	Live Weight Killed Per Day (kg)
Sheep	2,000	35	70,000
Cattle	150	500	75,000

* Values are based on information provided by MGAS staff in the questionnaire.

Table 2 - Current Production Rates for Poultry Processing Operation*

Animal	Number Killed (per day)	Average Live Weight (kg)	Live Weight Killed Per Day (kg)
Chickens	26,000	2.5	65,000

* Values are based on information provided by MGAS staff in the questionnaire.

Table 3 - Relative Water Uses for Processes in the Sheep and Cattle Operation[a]

Unit Operation	Water Consumption (m^3/hr)	Percent of Total Water Consumed by Sheep/Cattle Operation[b]	Percent of Total Water Consumed by the MGAS Facility[c]
Slaughtering and Bleeding	3.5	11.7	5
Carcass Washing	11.5	38.3	16.3
Viscera and Parts Cleaning	8	26.7	11.3
Washwater and Domestic	7	23.3	10
TOTAL	30	100	42.9

Based on facility flow diagram (Figure 2).
Total water consumption for the sheep/cattle operation was 30 m^3/hr.
Total water consumption for the MGAS facility was 70 m^3/hr.

Table 4 - Relative Water Uses for Processes in the Poultry Operation[a]

Unit Operation	Water Consumption (m^3/hr)	Percent of Total Water Consumed by the Poultry Operation[b]	Percent of Total Water Consumed by the MGAS Facility Total[c]
Scalding	5	12.5	7.1
Picking	5	12.5	7.1
Carcass Spraying	3	7.5	4.3
Carcass Washing and Chilling	20	50	28.6
Washwater and Domestic	3.5	8.8	5
Viscera and Parts Cleaning	3	7.5	4.3
Rotary Screen Cleaning	0.5	1.2	0.7
TOTAL	40	100	57.1

[a] Based on facility flow diagram (Figure 3).
[b] Total water consumption for the poultry operation was 40 m^3/hr.
[c] Total water consumption for the MGAS facility was 70 m^3/hr.

Table 5 - Comparison of MGAS Effluent Data[a] to Applicable Standards[b]

Parameter (mg/l)	Applicable Standards[c]	Sample Location			
		Sheep and Cattle Line	Poultry Processing Line	Rotary Drum Filter	Paunch Manure Recovery
BOD5	800	5,190	2,321	1,930	5,225
COD	2,100	7,161	3,600	3,155	10,225
FOG	50	0.6	243	231	0.4
TSS	1,100	3,966	857	996	19,777
TDS	NA	3,678	1,335	1,366	2,580
TKN	NA	646	161	179	571
P (total)	50	71.8	7	7.3	34
pH (SU)	5.5-9.5	7.5	6.8	6.8	6.7

Based on samples collected by audit team on September 24, 1994.
Jordanian Regulation for Disposal of Industrial and Commercial Wastewater to the Public Sewer System.
Standards are based on daily averages, while data reported were one-hour composites.

Table 6 - Water Use and Wastewater Discharge Characteristics of the MGAS Sheep and Cattle Operation Compared to US and UK Literature Values

Parameter	Audit Results[a]	USEPA 1974[b] Average Conc.	USEPA 1974[b] Ranges	WEC Report[c]
Flow (l/kg LWK)[d]	2.14	5.33	1.3 - 14.6	8.33
BOD5 (kg/1000kg LWK)[e]	11.12	6	1.5 - 14.3	8
TSS (kg/1000kg LWK)	8.5	5.6	0.6 - 12.9	-
FOG (kg/1000kg LWK)	0.0013	2.1	0.24 - 7.0	-
TKN (kg/1000kg LWK)	1.38	0.68	0.23 - 1.36	-
P (kg/1000kg LWK)	0.15	0.05	0.014 - .086	-

[a] Based on samples collected by audit team on September 24, 1994.
[b] USEPA Effluent Guidelines Development Document for the Red Meat Processing Industry.
[c] World Environment Center Report 1993.
[d] Liters per Kilogram Live Weight Killed.
[e] Kilograms per 1000 Kilograms Live Weight Killed.

'able 7 - **Water Use and Wastewater Discharge Characteristics of the MGAS Poultry Operation Compared to US and UK Literature Values**

Parameter	Audit Results[a]	WEC Report[b]
Flow (l/kg LWK)[c]	6.15	10.41
BOD5 (kg/1000kg LWK)[d]	14.3	12

[a] Based on samples collected by audit team on September 24, 1994.
[b] World Environment Center Report 1993.
[c] Liters per Kilogram Live Weight Killed.
[d] Kilograms per 1000 Kilograms Live Weight Killed.

Table 8 - Potential Water Savings for the MGAS Sheep and Cattle Operation[a]

Water Conservation Technique	Current Water Consumption (Estimated)	Projected Water Consumption (Estimated)	Decrease in Water Consumption	Percent Reduction in Total Water Use[b]
Nozzles on All Hoses	10.8	7.6	3.2	10.7
Dry Cleaning in Holding Pen	0.9	0.0	0.9	3.0
High Pressure Hoses	10.8	ND[c]	-	-
Hand or Foot Valves on Taps	2.7	1.6	1.1	3.6
Auto-shutoff for Spray Wash	5.0	1.5	3.5	11.7

[a] All units are m^3/hr unless otherwise noted.
[b] Percent reduction based on total water consumption for sheep/cattle operation (30 m^3/hr)
[c] Not Determined. Dependent on type of pressure system and operation.

Table 9 - Potential Water Savings for the MGAS Poultry Operation[a]

Water Conservation Technique	Current Water Consumption (Estimated)	Projected Water Consumption (Estimated)	Decrease in Water Consumption	Percent Reduction in Total Water Use[b]
Nozzles on All Hoses	10.8	7.6	3.2	8.0
High Pressure Hoses	10.8	ND[c]	-	-
Hand or Foot Valves on Taps	2.7	1.6	1.1	2.8
Auto-shutoff for Spray Wash	3.0	2.5	0.5	1.3
Counter Current Rinse	20.0	10.0	10.0	25.0
Cleaning Tank Water Reuse	1.8	0.0	1.8	4.5

ll units are m^3/hr unless otherwise noted.
ercent reduction based on total water consumption for poultry operations (40 m^3/hr)
ot Determined. Dependent on type of pressure system and operation.

FIGURES

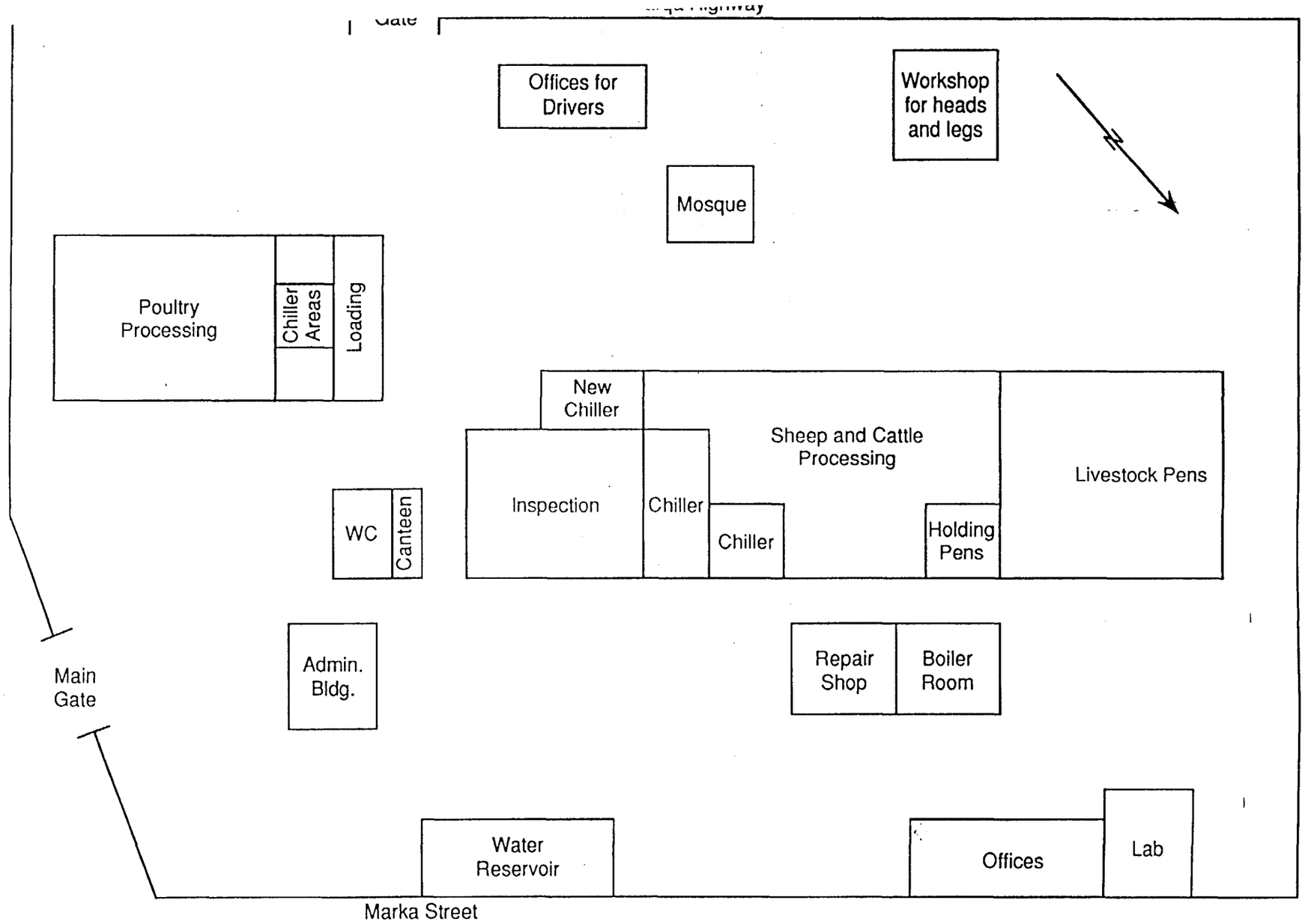


Figure 1. MGAS Facility Layout
Amman, Jordan

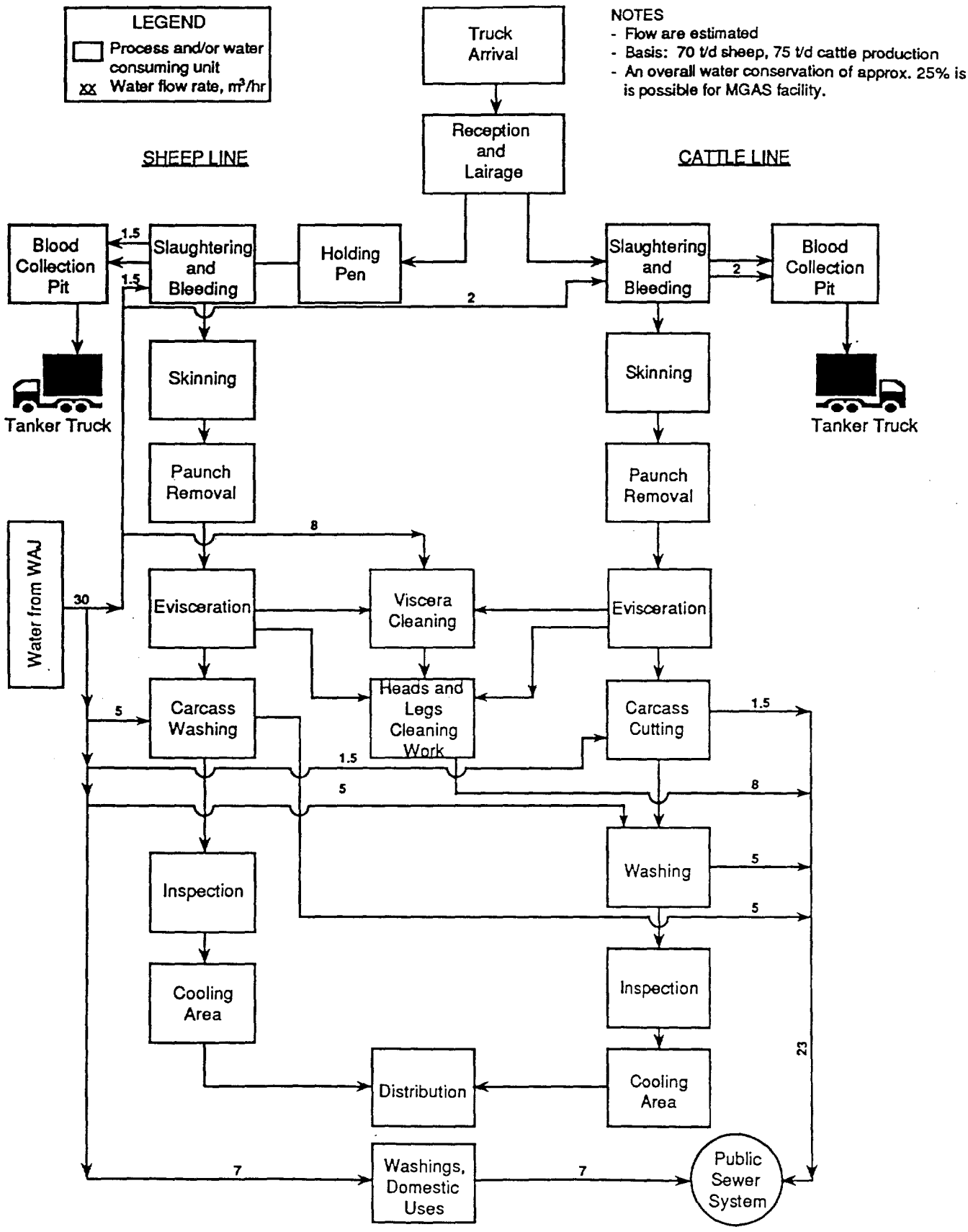


Figure 2. Process Diagram and Water Balance for the Sheep and Cattle Operation. MGAS, Amman, Jordan

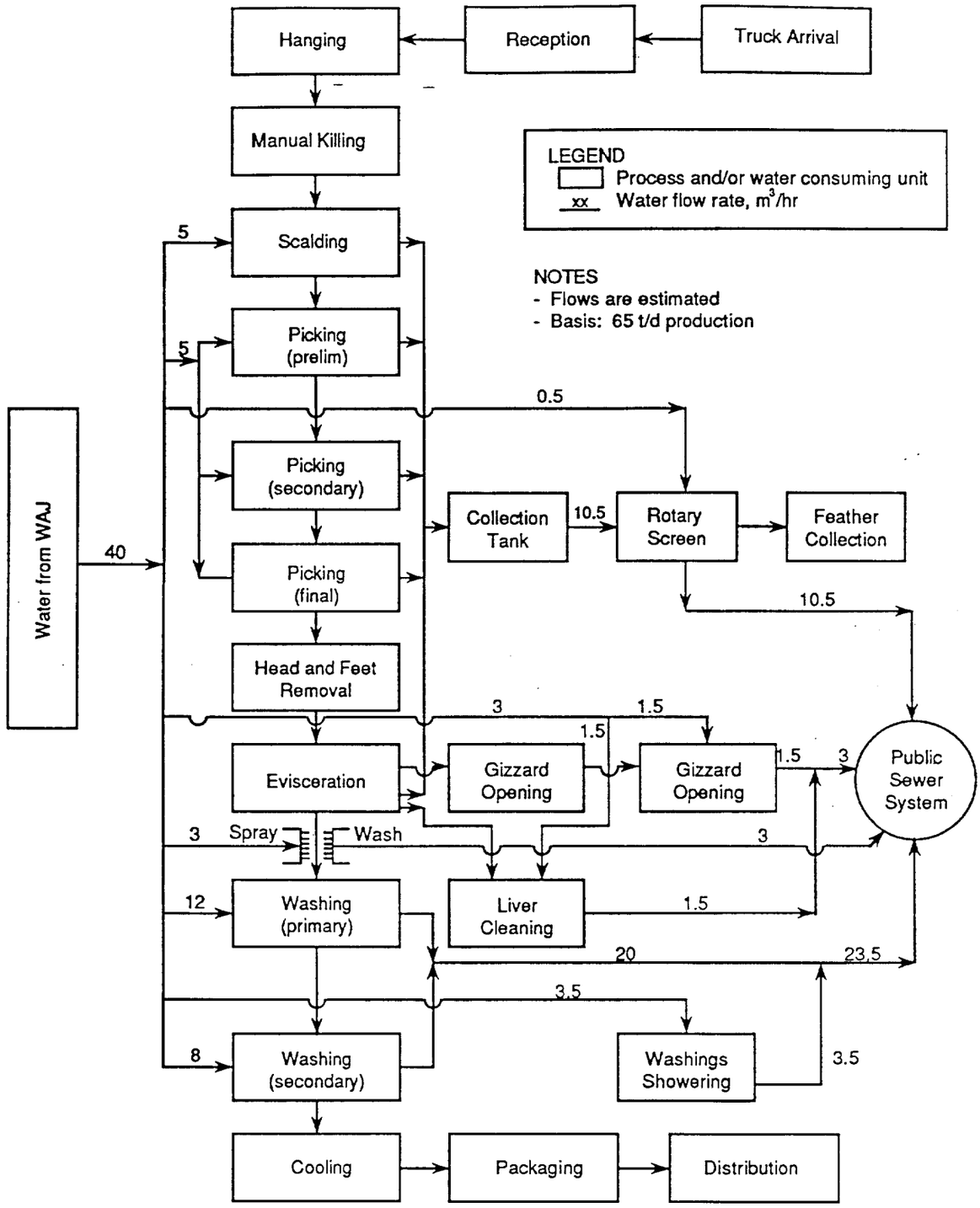


Figure 3. Process Diagram and Water Balance for the Poultry Operation MGAS, Amman, Jordan

Appendix A

Audit Questionnaire

WQICP WASTE MINIMIZATION AUDIT

Facility Name: The Municipality of Greater Amman Slaughterhouse (MGAS) Auditor/Firm: SAIC and RSS

Date: 9/17/1993

ATTACHMENT A

AUDIT QUESTIONAIRE

SITE DESCRIPTION

Facility Name: The Muinicipality of Greater Amman Slaughterhouse (MGAS)

Area: 20,000 m²

Address: Ain Ghazal Area, on Amman-Zarqa Highway.

Telephone: 891531

Major Products: Meat (Sheep (Lamb), Cattle, and Poultry), Other edible products

Production Rate: Animals Killed Per day: Sheep (Lamb): 2000, Cattle: 150, Chicken: 20,000

SIC Codes*: 2011, 2016

Major Sources of Wastewater Discharges:

1. Sheep and Cattle Processing line
2. Poultry Processing line

Major Processes:

1. Sheep and Cattle Process
   - Reception and Lairage
   - Slaughtering and bleeding
   - Carcass dressing
   - Paunch manure recovery
   - Chilling, storage and inspection.

2. Poultry Process
   - Reception
   - Slaughtering and bleeding
   - Defeathering
   - Eviscerating / Cleaning
   - Chilling, Storage, and inspection

Facility/Equipment Age: 22 years

* USA codes

WQICP WASTE MINIMIZATION AUDIT

Facility Name: The Municipality of Greater Amman Slaughterhouse

Auditor/Firm: SAIC and RSS

Date: 9/17/1994

PROCESS INFORMATION

Operation Type: -- Continuous -- Discrete
✓ Batch or Semi-Batch -- Other_____

Document	Complete? (Y/N)	Current? (Y/N)	Document Number
Process Flow Diagram	Y	Y	
Material/Energy Balance	N	N	
Design	N	N	
Operating	N	N	
Flow/Amount Measurements	N	N	
Stream			
Analyses/Assays	N	N	
Stream			
Plant Layout	Y	Y	
Process Description	Y	Y	
Operating Manuals	Y*	Y*	
Equipment List/Age	Y*	Y*	
Equipment Specifications	Y*	Y*	
Piping & Instrument Diagrams	Y*	Y*	
Plot and Elevation Plan(s)	Y*	Y*	
Environmental Audit Report	Y	Y	
Permit/Permit applications	Y	Y	
Raw Material Inventory Records	Y	Y	
Product Inventory Records	Y	Y	
Management method practiced for	N	N	
each wastewater stream	Y**	Y**	
Wastewater treatment facilities	N	N	
Waste management practice	Y**	Y**	
Ancillary facilities	Y	Y	
Annual cost for management of	N	N	
the wastewater discharge			
Photographic records	N	N	

* The Facility has it, but was not supplied to us.

** Connected to the public sewer network.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: The Municipality of Greater Amman Slaughterhouse (MGAS) Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INPUT MATERIALS SUMMARY

Material	DESCRIPTION[1] Stream No.	Stream No.	Stream No.
Name Live sheep, cattle, and Poultry. And chilled meat	N.A	N.A	N.A
Source/Supplier Bulgaria, Germany, Russia			
Component of Concern Meat			
Annual Consumption Rate N.K	N.K		
Overall			
Component(s) of Concern			
Purchase Price, $ per N.K	N.K		
Overall Annual Cost			
Delivery Mode[2] Trucks, Air, Ships			
Shipping Container Size & Type[3] N.K			
Storage Mode[4] Lairage for Live animals			
Transfer Mode[5] N.A			
Empty Container Disposal/Management			
Shelf Life N.A			
Supplier Would			
- accept expired material (Y/N) N			
- accept shipping containers (Y/N)			
Acceptable Substitute(s), if any NO*			
Alternate Supplier(s) Yes*			
Product Inventory Records Yes			

1. Stream number, if applicable, should correspond to those used on process flow diagram
2. e.g., pipeline, tank truck, etc.
3. e.g., drum, paper bag, tank, etc.
4. e.g., outdoor, warehouse, underground, aboveground, etc.
5. e.g., pump, forklift, conveyor, etc.
6. e.g., crush and dump, clean and recycle, return to supplier, etc.

N.A : not applicable

N.K : not known

* : Although these answers are contradictory, they still represent answers provided by MGAS personell.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 1 of 4)

1. Waste Stream Name/ID: Sheep and Cattle Processing Line Stream No. —

2. Waste Characterization (attach additional sheets with composition data, as necessary)

   --- Gas --- [Liquid] --- Solid --- Mixed phase

   Density kg/M³ ___/___ High Heating Value Cal/kg_____
   pH 7.5 Flash Point _____ % Water_____

3. Waste Leaves Process as:

   -- air emission -- [wastewater] -- solid waste

4. Occurrence:
   ✓ continuous
   -- discrete
   discharge triggered by -- chemical analysis_____
   -- other (describe)_____

   Type -- periodic_____length of period_____
   -- sporadic

5. Generation Rate:
   Annual _____ kg per year
   Maximum _____ kg per _____
   Average 30 m³/hr kg per _____
   Frequency _____ batches per _____
   Batch Size_____ average _____ range

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 2 of 4)

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? ---- Yes ---- [No]

Describe how the waste is generated.

This waste stream is generated from water used in the following processes:

- Slaughtering and bleeding
- Carcass washing and edible organ cleaning
- Washwater, and other domestic uses.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component, equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, venting losses, etc.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 3 of 4)

Waste Stream Sheep and Cattle Processing line

7. Management Method

Leaves site in --- bulk
--- 55 gal drum
--- other (describe) disposed into the Public Sewer system

Disposal Frequency Continuous

Applicable Standards/Regs "Jordanian Regulations for disposing industrial and commercial wastewater in the public Sewer System"

Managed --- onsite --- offsite
--- other (describe) disposed into the sewer system

Recycling -X- direct use/re-use
-X- energy recovery
-X- redistilled
-X- other (describe)

reclaimed material returned to site?

--- Yes --- [No] --- used by others

residue yield
residue disposal

Treatment -X- biological
-X- oxidation/reduction
-X- pH adjustment
-X- precipitation
-X- other (describe)

Final Disposition --- Dump
--- pond
--- other (describe) disposed into the sewer system

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 4 of 4)

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

cost as of* _____ (quarter and year)

Cost Element	Unit Price JD per ____	Reference/Source
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Taxes		
Total disposal Cost		

* Not applicable

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

WASTE STREAM INFORMATION

(one form for each stream)

Stream ID: 1

1. Streamname: Sheep and Cattle Processing line
(wastewater, waste oil, still bottoms, etc.)

2. Discharge Identification: Slaughtering and bleeding carcass cleaning, washings.
(Enter process or equipment from which stream is discharged)

3. Stream flow/quality:

minimum flow: _____ L/min
maximum flow: _____ L/min
average flow: 500 L/min

4. Is stream continuous orintermittent? Continuous

5. Which of following is the cause of the waste?

a. Process chemistry = (Reaction stoichiometry, kinetic, yield).
Describe: _____

b. Engineering Design (capacity, pressure, temperature limitations, etc.). Describe: Insufficient and Improper equipment, Pressure employed in the water lines is low.

c. Operations = (operating rates, order of addition, etc.) Describe: _____

d. Maintenance = (leaks, spills, corrosion, etc.)
Describe: presence of leaks, spills, and running hoses

6. Are the components of the waste stream a raw material (RM), product (P), useful byproduct (UPB), nonuseful byproduct (NBP), solvent (S), catalyst (C), or an impurity (I) in the raw material?

(Attach analysis records if possible)

Fill out attached Figure 1 for each waste stream

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

Component Name	Conc (mg/L)	Check One						
		RM	P	UBP	NBP	S	C	I

7. Waste stream characteristics -- pH: 7.5 TSS: 3966 TDS: 3678
Color: / Hardness: / Odor: / TOC: / Other: BOD_5: 5190
COD: 7161, FOG: 0.6, TKN: 646, P: 71.8, all units are in mg/L

8. Current disposition of the stream: into the public sewer system

9. Current effluent criteria and disposal limitation: Jordanian regulations governing disposition of commercial and industrial wastewater into the public sewer system.

10. Permits relevant to the waste stream disposition:

11. Current cost of disposal and/or treatment for this waste stream: N.A

2. If stream is currently being treated, list: No treatment.

a. Current treatment parameters (chemical consumption, treatment conditions, etc.):

b. Existing treatment equipment (identify, size and type of equipment): N.A

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS

Auditor/Firm: SAIC and RSS

Date: 9/17/1994

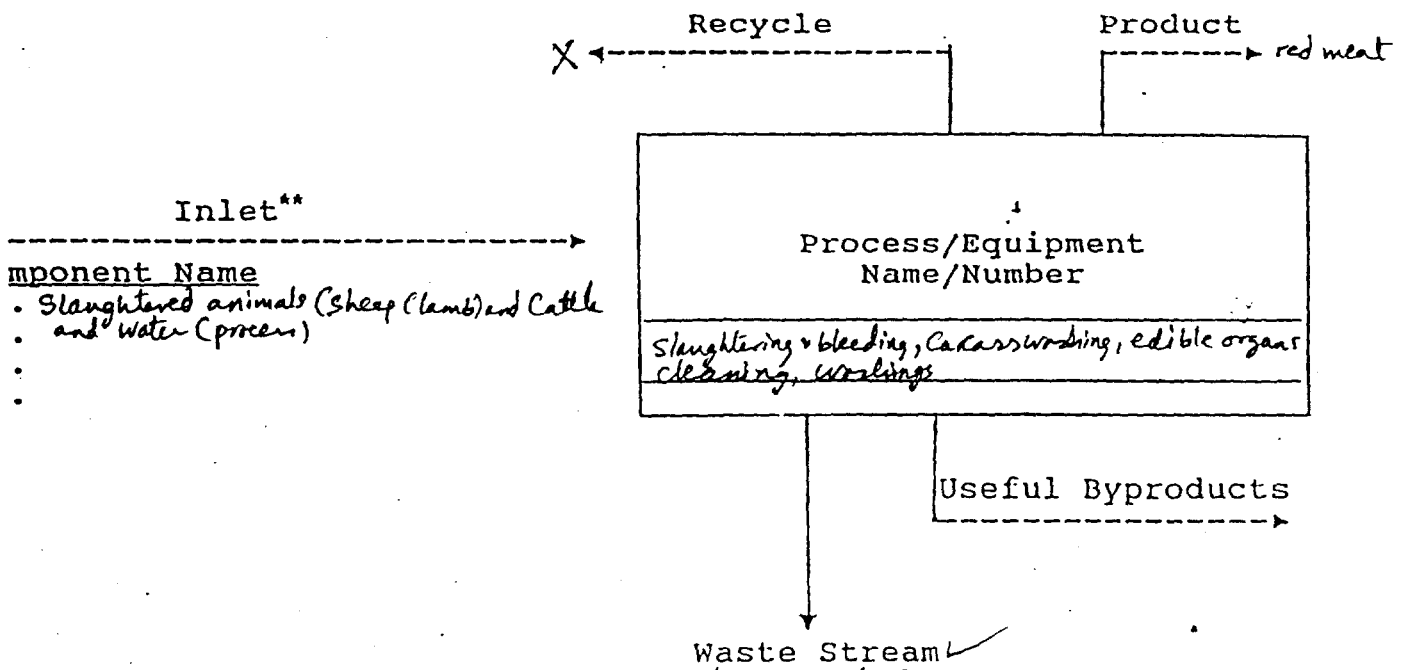
Other pertinent information: It is discussed indepth in Sections 5, 6 and 7

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS

Auditor/Firm: SAIC and RSS

Date: 9/17/1994



Waste Stream ✓
Sheep / Cattle Processing line

Name	(mg/L)
BOD_5	5190
COD	7161
FOG	0.6
TSS	3966
TDS	3678
TKN	646
P	71.8
PH	7.5

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 1 of 4)

1. Waste Stream Name/ID: Poultry Processing Line Stream No. _____

2. Waste Characterization (attach additional sheets with composition data, as necessary)

   --- Gas --- [Liquid] --- Solid --- Mixed phase

   Density kg/M³ ✓ High Heating Value Cal/kg _____
   pH 6-8 Flash Point _____ % Water _____

3. Waste Leaves Process as:

   -- air emission -- [wastewater] -- solid waste

4. Occurrence:
   - ✓ continuous
   - -- discrete
     discharge triggered by -- chemical analysis _____
     -- other (describe) _____

   Type -- periodic _____ length of period _____
   -- sporadic

5. Generation Rate:
   Annual _____ kg per year
   Maximum _____ kg per _____
   Average 40 m³/hr ~~kg per~~ _____
   Frequency _____ batches per _____
   Batch Size _____ average _____ range

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 2 of 4)

6. Waste Origins/Sources

Fill out this worksheet to identify the origin of the waste. If the waste is a mixture of waste streams, fill out a sheet for each of the individual waste streams.

Is the waste mixed with other wastes? ---- Yes ---- [No]

Describe how the waste is generated.

This waste stream is generated from water used in the following processes:

- Defeathering including Scalding
- Eviserating and carcass cleaning
- Washwater, and other domestic uses.

Example: Formation and removal of an undesirable compound, removal of an unconverted input material, depletion of a key component, equipment cleaning waste, obsolete input material, spoiled batch and production run, spill or leak cleanup, evaporative loss, venting losses, etc.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 3 of 4)

Waste Stream Poultry Processing line

7. Management Method

Leaves site in
--- bulk
--- 55 gal drum
--- other (describe) disposed into the public sewer system

Disposal Frequency Continuous

Applicable Standards/Regs "Regulations for disposing industrial and commercial wastewater in the public sewer system"

Managed
--- onsite --- offsite
--- other (describe) disposed into the public sewer system

Recycling
--X direct use/re-use
--X energy recovery
--X redistilled
--X other (describe)

reclaimed material returned to site?

--- Yes --- [No] --- used by others

residue yield
residue disposal

Treatment
--X biological
--X oxidation/reduction
--X pH adjustment
--X precipitation
--X other (describe)

Final Disposition
--- Dump
--- pond
--- other (describe) disposed into the public sewer system.

INDIVIDUAL WASTE STREAM CHARACTERIZATION

(page 4 of 4)

WQICP WASTE MINIMIZATION AUDIT

Facility Name: _____ Auditor/Firm: SAIC and RSS

Date: 9/17/1994

cost as of * _____ (quarter and year)

Cost Element	Unit Price JD per ____	Reference/Source
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Taxes		
Total disposal Cost		

* Not applicable.

WQICP WASTE MINIMIZATION AUDIT

Facility Name: _____ Auditor/Firm: _____

Date: _____

WASTE STREAM INFORMATION

(one form for each stream)

Stream ID: _____

1. Streamname: Poultry Processing Line
(wastewater, waste oil, still bottoms, etc.)

2. Discharge Identification: _____
(Enter process or equipment from which stream is discharged)

3. Stream flow/quality:
minimum flow: _____ L/min
maximum flow: _____ L/min
average flow: 666.6 L/min

4. Is stream continuous orintermittent? Continuous

5. Which of following is the cause of the waste?

a. Process chemistry = (Reaction stoichiometry, kinetic, yield).
Describe: _____

b. Engineering Design (capacity, pressure, temperature limitations, etc.). Describe: Tank overflows, no counter current washing employed.

c. Operations = (operating rates, order of addition, etc.) Describe: _____

d. Maintenance = (leaks, spills, corrosion, etc.)
Describe: presence of leaks, spills, and running hoses

6. Are the components of the waste stream a raw material (RM), product (P), useful byproduct (UPB), nonuseful byproduct (NBP), solvent (S), catalyst (C), or an impurity (I) in the raw material?

(Attach analysis records if possible)

Fill out attached Figure 1 for each waste stream

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

Component Name	Conc (mg/L)	Check One						
		RM	P	UBP	NBP	S	C	I

7. Waste stream characteristics -- pH: 6.8 TSS: 857 TDS: 1335
Color: / Hardness: / Odor: / TOC: / Other: BOD_5: 2321
COD: 3600, FOG: 243, TKN: 161, P: 7

8. Current disposition of the stream: _____

9. Current effluent criteria and disposal limitation: Jordanian regulations governing disposition of commercial and industrial wastewater into the public sewer system.

10. Permits relevant to the waste stream disposition: _____

11. Current cost of disposal and/or treatment for this waste stream: N.A

12. If stream is currently being treated, list: No treatment

a. Current treatment parameters (chemical consumption, treatment conditions, etc.): _____

b. Existing treatment equipment (identify, size and type of equipment): N.A

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS

Auditor/Firm: SAIC and RSS

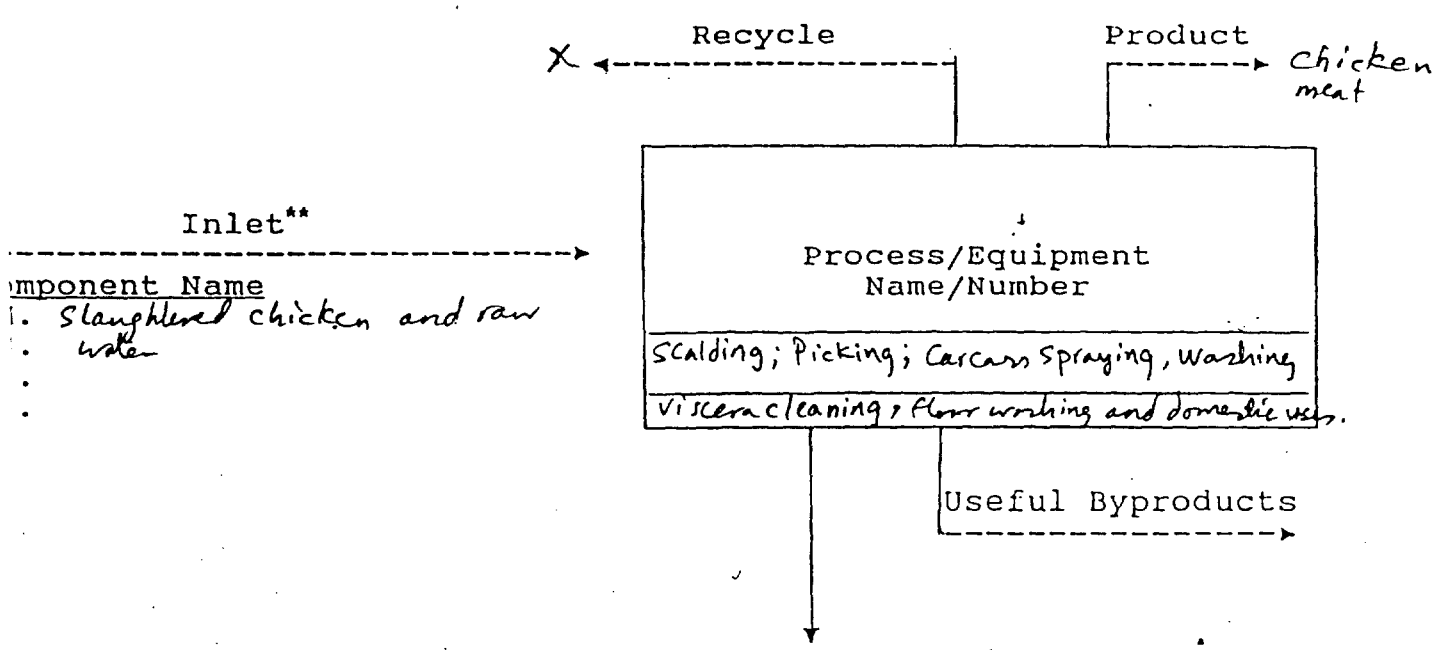
Date: 9/17/1994

Other pertinent information: More information is discussed in-depth in sections 5, 6, and 7

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC

Date: 9/17/1994



Waste Stream ✓ Poultry Processing Line

Name	(mg/L)
BOD_5	2321
COD	3600
FOG	243
TSS	857
TDS	1335
TKN	161
P	7
pH	6.8

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

WASTE STREAM SUMMARY

Component of Concerns		Stream No[1]		Stream No		Stream No	
Waste ID/Name		Sheep/Cattle line		Poultry line		✓	
Source/Origin		process		process			
Annual Generation Rate (units_____)		30 m³/hr		40 m³/hr		✓	
Overall							
Component(s) of Concern							
Cost of Disposal		✓		✓		✓	
Unit Cost (JD per _____)							
Overall (per Year)							
Method of Management[2]		Disposed into the sewer system		Disposed into the sewer system			
Priority Rating Criteria[3]*	W*	Rating (R)	R*W	Rating (R)	R*W	Rating (R)	R*W
Regulatory Compliance		N.A		N-A			
Treatment/Disposal Cost		N.A		N.A			
Waste Quantity Generated		30 m³/hr		40 m³/hr			
Waste Hazard		No		No			
Safety Hazard		No		No			
Minimization Potential		Yes		Yes			
Potential Byproduct Recovery		Yes		Yes			
Sum of Priority Ranking Scores							
Priority Rank							

1. Stream number, if applicable, should correspond to those used on process flow diagrams.
2. For example, sanitary dump, onsite recycle, dewatering, etc.
3. Rate each stream (W) in each category on a scale from 0 to 10.

OPTION DEVELOPMENT

Meeting Format (e.g., brainstorming, nominal group technique) _____

Meeting Coordinator _____

* Further investigation needed

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS Auditor/Firm: SAIC and RSS

Date: 9/17/1994

OPTION DEVELOPMENT *

Option Name: _____

Briefly describe the option _____

Waste Stream(s) Affected; _____

Input Material(s) Affected: _____

Product(s) Affected: _____

Indicate Type;--- Source Reduction
--- Equipment-Related Change
--- Personal/Procedure-Related Change
--- Material-Related Change

--- Recycling/Reuse
--- Onsite --- Material reused for original Purpose
--- Offsite --- Material used for lower-quality Purp.
--- Material sold
--- Material burned for heat recovery

* Suggested options are clearly discussed in the audit report (Ch. 6, 7, 8)

WQICP WASTE MINIMIZATION AUDIT

Facility Name: MGAS

Auditor/Firm: SAIC and RSS

Date: 9/17/1994

**OPTION EVALUATION BY*
WEIGHTED SUM METHOD**

* Not applicable

Appendix B

Information Provided by the MGAS Facility

Municipality Of Greater Amman

Amman - Slaughter Houses

==========

MR - Chairman

Distingush Guesls

Ladies and Gentlemen .

It is my pleasure to participate in this important seminar. On behalf of Amman Slughter Houses Director , I would like to thank the organizers for giving us this great apportunity to pointed out the important effects of Amman Slaughter Houses , concerning environmental pollution in Amman city .

Amman slaughter houses build on about [20 , 000] square meters on eastern part of Amman city , and started in service in 1979 at Eien - Ghazal area , it is the biggest one in Jordan and consist of two main abattoirs .

1] Cattle and sheep abattoir , build in acapacity , of about [4000] head of sheep and about [250] head of cattle daily).

To keep the biological pollution in a low level , we constructed a special hole in the area where bleeding of animals takes place , for collection of blood . And there is a system to segregate the blood from the waste - water .

Although there are many panels , constructed newly to carry the waste-water , with a system to separate and collect the solid - waste which is finally . removed by special containers , and send to private industries for rendering system .

Inspite of that , we reduced the consumption of water used for washing about [50 %] by using nozzles , and controlling the water - taps system during the period [1993 - 1994] .

Regarding to the edible offals , we prepared stainless steel sinks for cleaning and drainage system for segregating the Solid - waste from the waste - water .

2] Poultry abattoir , build on about [5000] square meter , a capacity of about [30,000] birds per day , and started on serivce in 1976 .

Regards to the recomendations submitted to us through the report of MR. Denker there are panels of stainless - steel , along the production line to collect as mush blood as possible from the birds .

during the processing , More over we repared the floor chillers , and we have the entention to remove the floor of abattoir to construct a new one , when we have a chance to stop the processing,because we can't stop the works when ever we want to keeping in mind its the only slaughter house in Amman .

Regarding the organic pollution , we do our best to reduce it to the Minimum level .

The following table shows the achevements in this regard : -

Year		Bods	
1991		18510	mg / liter
1992		7505	mg / =
1993		6739	mg / =
1994	June - Feb	2455	mg / =

MR. Chairman ,

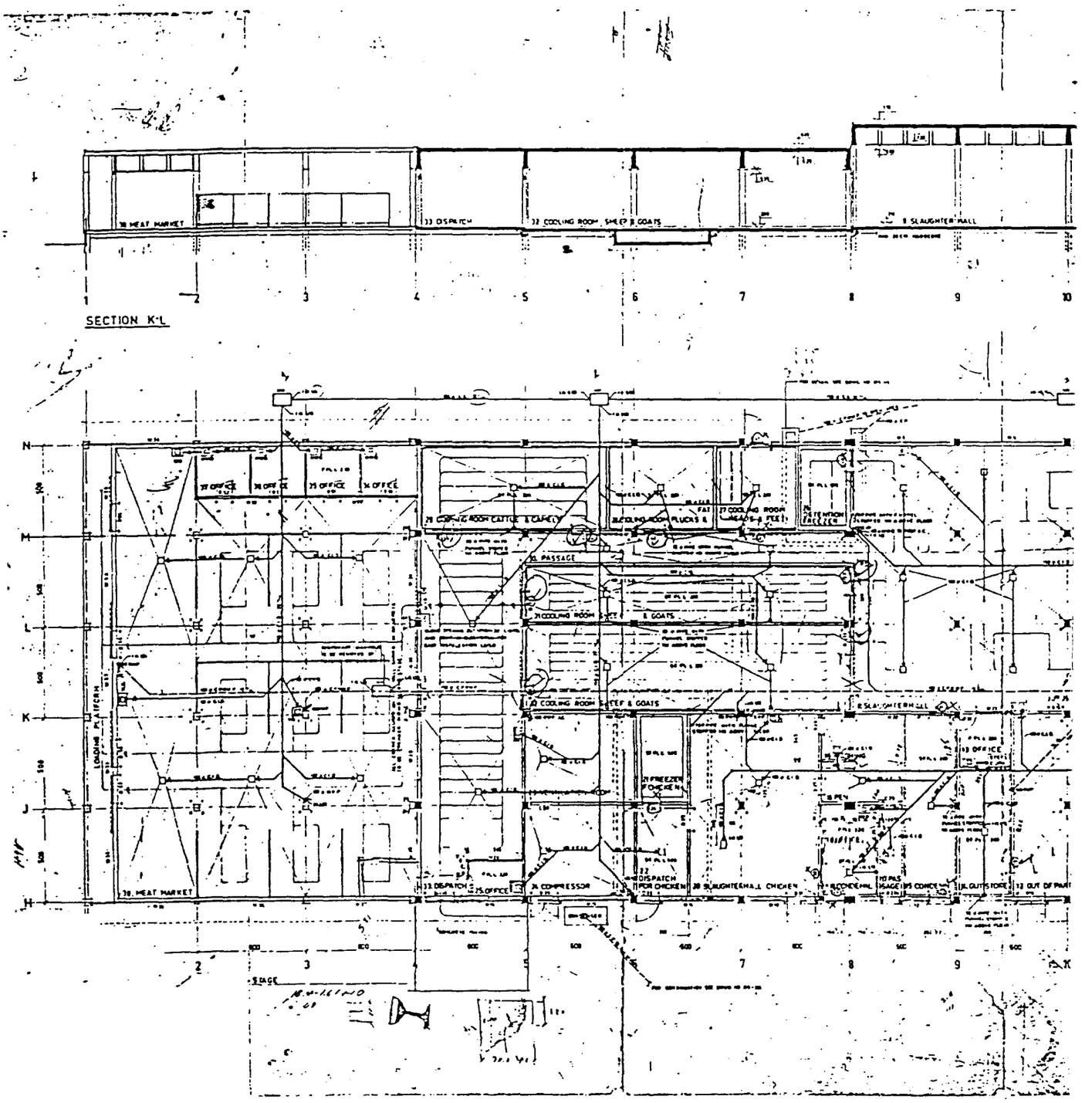
All these measures mentioned it was all ready in the plan of slaughter houses administration .

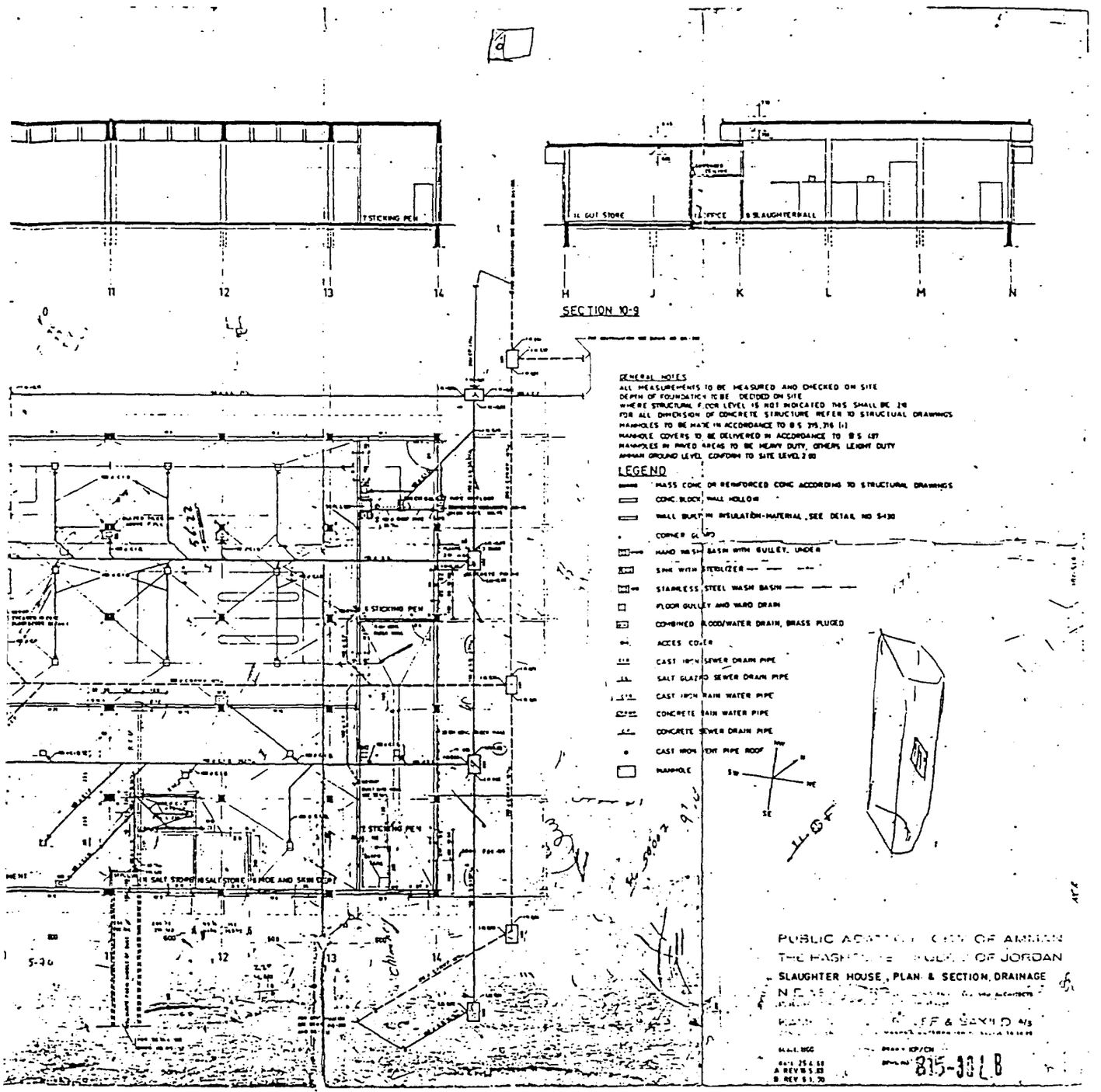
But due to our respect to the report submitted to us by MR. Denker and our keen interest to minimise the level of pollution , we completed most of the recomendations mentioned in the report .

Finally I would like to mention that , the municipality of greater Amman has plan to construct a new slaughter houses up to international standards , and the location will be in the eastern part of Amman city . And all the waste - water produced will be treated up to the Jordanian standard [202] .

Thanking you ,

Amman - Jordan
12 . 4 . 1994 .


SECTION K-L
30 MEAT MARKET
33 DISPATCH
32 COOLING ROOM, SHEEP & GOATS
8 SLAUGHTER HALL
1
2
3
4
5
6
7
8
9
10
N
M
L
K
J
H
37 OFFICE
36 OFFICE
35 OFFICE
34 OFFICE
29 COOLING ROOM CATTLE & CARCASS
31 COOLING ROOM PLUCKS & FAT
27 COOLING ROOM HEADS & FEET
26 RETENTION FREEZER
31 PASSAGE
31 COOLING ROOM SHEEP & GOATS
10 COOLING ROOM SHEEP & GOATS
8 SLAUGHTER HALL
LOADING PLATFORM
21 FREEZER FOR CHICKEN
33 OFFICE
30 MEAT MARKET
33 DISPATCH
35 OFFICE
24 COMPRESSOR
22 DISPATCH FROM CHICKEN
20 SLAUGHTER HALL CHICKEN
19 BOILER HAL
18 PLS USAGE
15 COOLING
14 OUTSTORE
13 OUT OF PART
STAGE


SECTION 10-9
GENERAL NOTES
ALL MEASUREMENTS TO BE MEASURED AND CHECKED ON SITE
DEPTH OF FOUNDATION TO BE DECIDED ON SITE
WHERE STRUCTURAL FLOOR LEVEL IS NOT INDICATED THIS SHALL BE 2.0
FOR ALL DIMENSION OF CONCRETE STRUCTURE REFER TO STRUCTUAL DRAWINGS
MANHOLES TO BE MADE IN ACCORDANCE TO B.S. 215, 216 (1)
MANHOLE COVERS TO BE DELIVERED IN ACCORDANCE TO B.S. 497
MANHOLES IN PAVED AREAS TO BE HEAVY DUTY, OTHERS LEIGHT DUTY
AMMAN GROUND LEVEL CONFORM TO SITE LEVEL 2.00
LEGEND
MASS CONC OR REINFORCED CONC ACCORDING TO STRUCTURAL DRAWINGS
CONC. BLOCK WALL HOLLOW
WALL BUILT IN INSULATION-MATERIAL, SEE DETAIL NO S-430
CORNER GUARD
HAND WASH BASIN WITH GULLEY, UNDER
SINK WITH STERILIZER
STAINLESS STEEL WASH BASIN
FLOOR GULLEY AND YARD DRAIN
COMBINED BLOOD/WATER DRAIN, BRASS PLUGED
ACCES COVER
CAST IRON SEWER DRAIN PIPE
SALT GLAZED SEWER DRAIN PIPE
CAST IRON RAIN WATER PIPE
CONCRETE RAIN WATER PIPE
CONCRETE SEWER DRAIN PIPE
CAST IRON VENT PIPE ROOF
MANHOLE
7 STICKING PEN
11 GUT STORE
12 OFFICE
8 SLAUGHTERHALL
5 STICKING PEN
2 STICKING PEN
10 SALT STORE
10 SALT STORE 16 HIDE AND SKIN DEP
11
12
13
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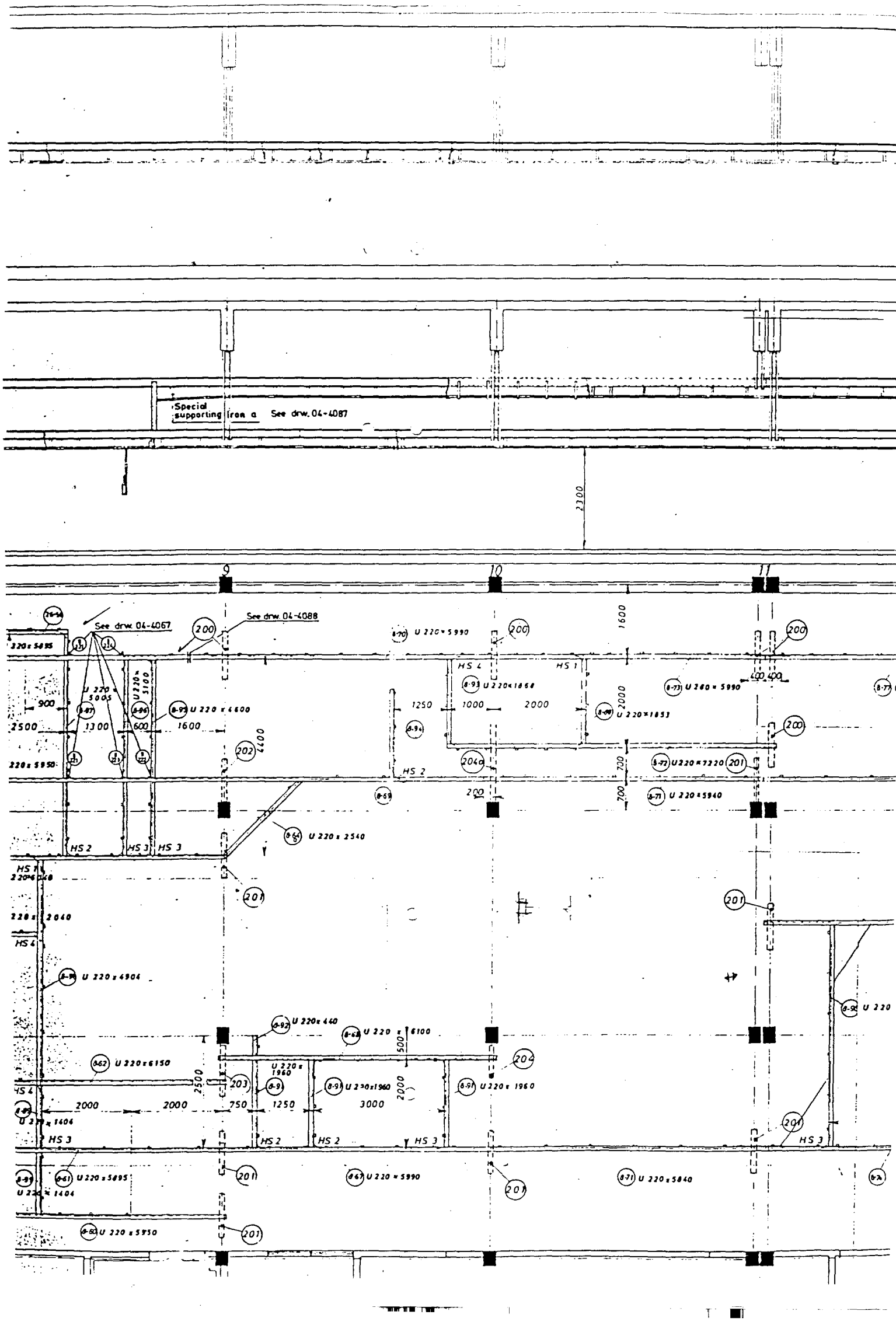
PUBLIC AC
CITY OF AMMAN
THE HASH
OF JORDAN
SLAUGHTER HOUSE, PLAN & SECTION, DRAINAGE
JEF & SEXILD A/S
815-301 B


Special supporting iron a
See drw. 04-4087
2300
9
10
11
See drw. 04-4067
See drw. 04-4088
200
U 220 x 5990
1600
HS 4
HS 1
U 220 x 1868
U 260 x 5990
400 400
U 220 x 1853
900
2500
1300
600
1600
U 220 x 4600
1250
1000
2000
202
4600
204a
HS 2
U 220 x 7220
201
700
200
U 220 x 5940
HS 3
U 220 x 2540
U 220 x 4904
U 220 x 440
U 220 x 6100
500
U 220 x 6150
2500
203
U 220 x 1960
204
2000
750
3000
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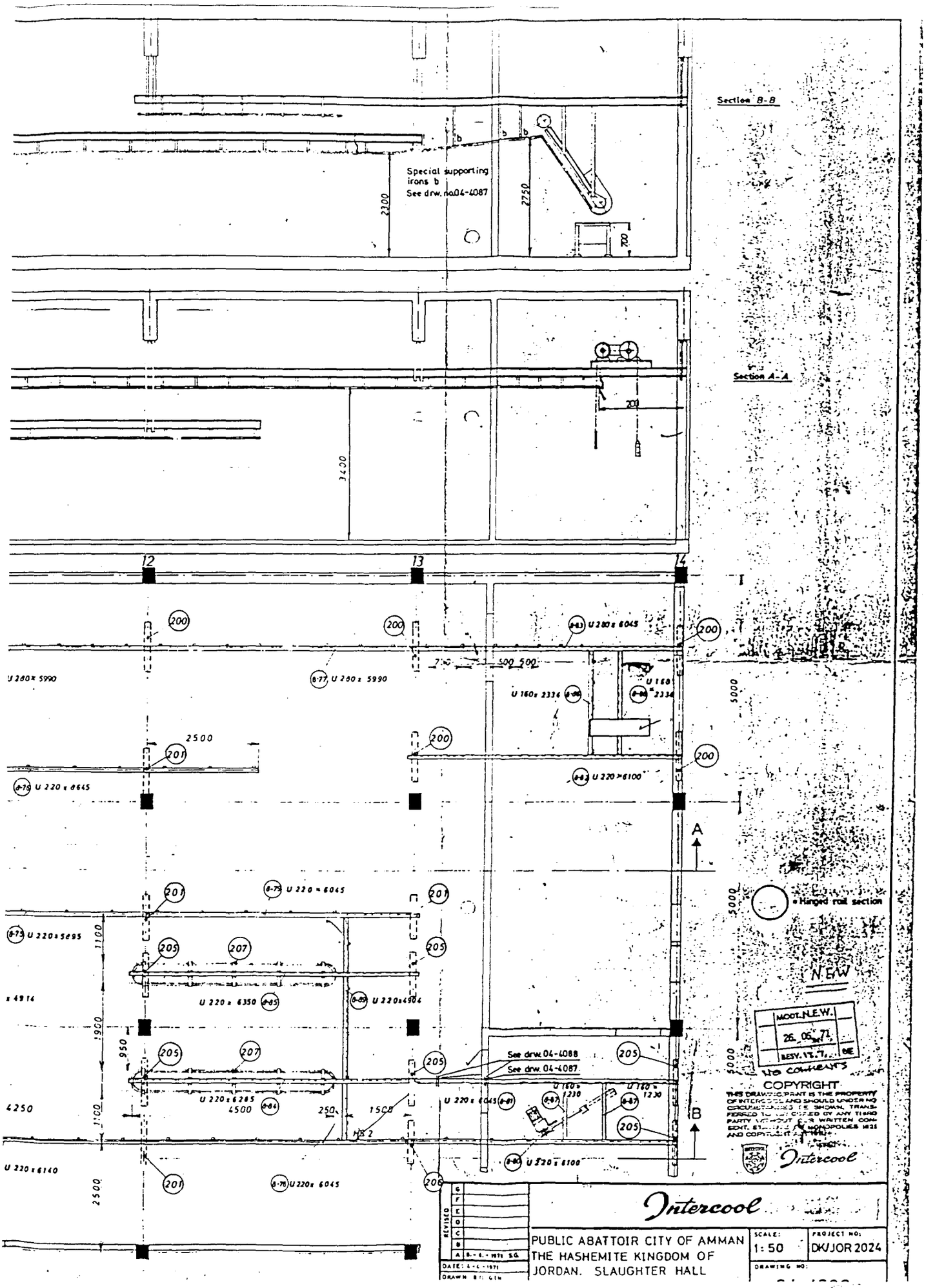
U 220 x 5895
U 220 x 5990
U 220 x 5840
U 220 x 5950


Section B-B
Special supporting irons b
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Section A-A
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14
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U 280 x 5990
U 280 x 6045
U 160 x 2336
U 220 x 6100
U 220 x 6045
U 220 x 5895
U 220 x 6350
U 220 x 4906
U 220 x 6285
U 220 x 6140
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500 500
5000
1100
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207
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See drw. 04-4087
U 160 x 1230
Hanged rail section
N.E.W
MOOT. N.E.W.
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NO COMMENTS
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Intercool
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DATE: 8-6-1971
DRAWN BY: GIN
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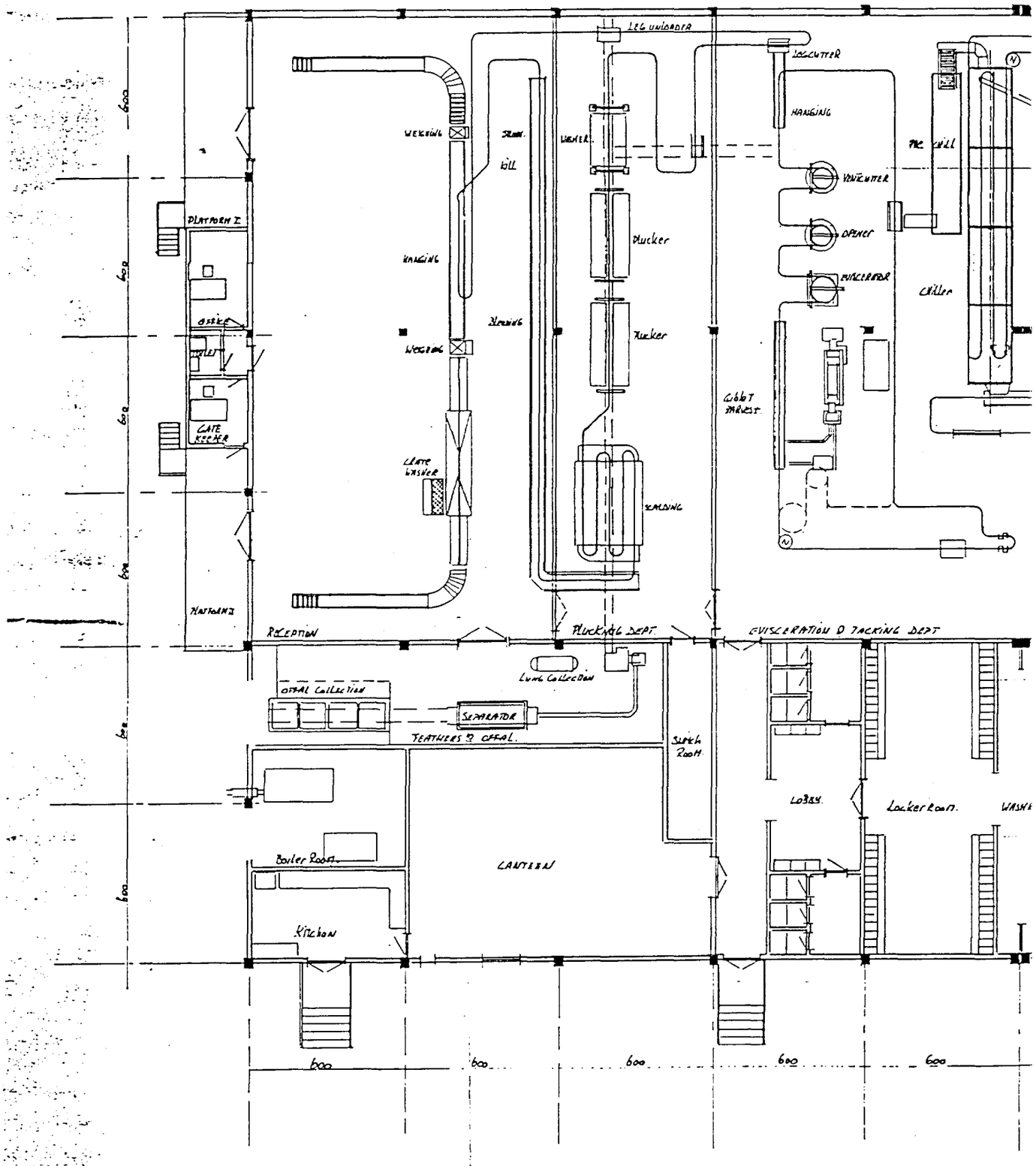
SCALE:
1: 50
PROJECT NO:
DK/JOR 2024
DRAWING NO: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OFFICE
TOILET
CRATE KEEPER
Plucker
Plucker
HANGING
WEIGHING
CRATE WASHER
SCALDING
CABLOT HARVEST
PLATFORM II
RECEPTION
PLUCKING DEPT
EVISCERATION & PACKING DEPT
LUNG COLLECTION
OFFAL COLLECTION
SEPARATOR
FEATHERS & OFFAL
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LOBBY
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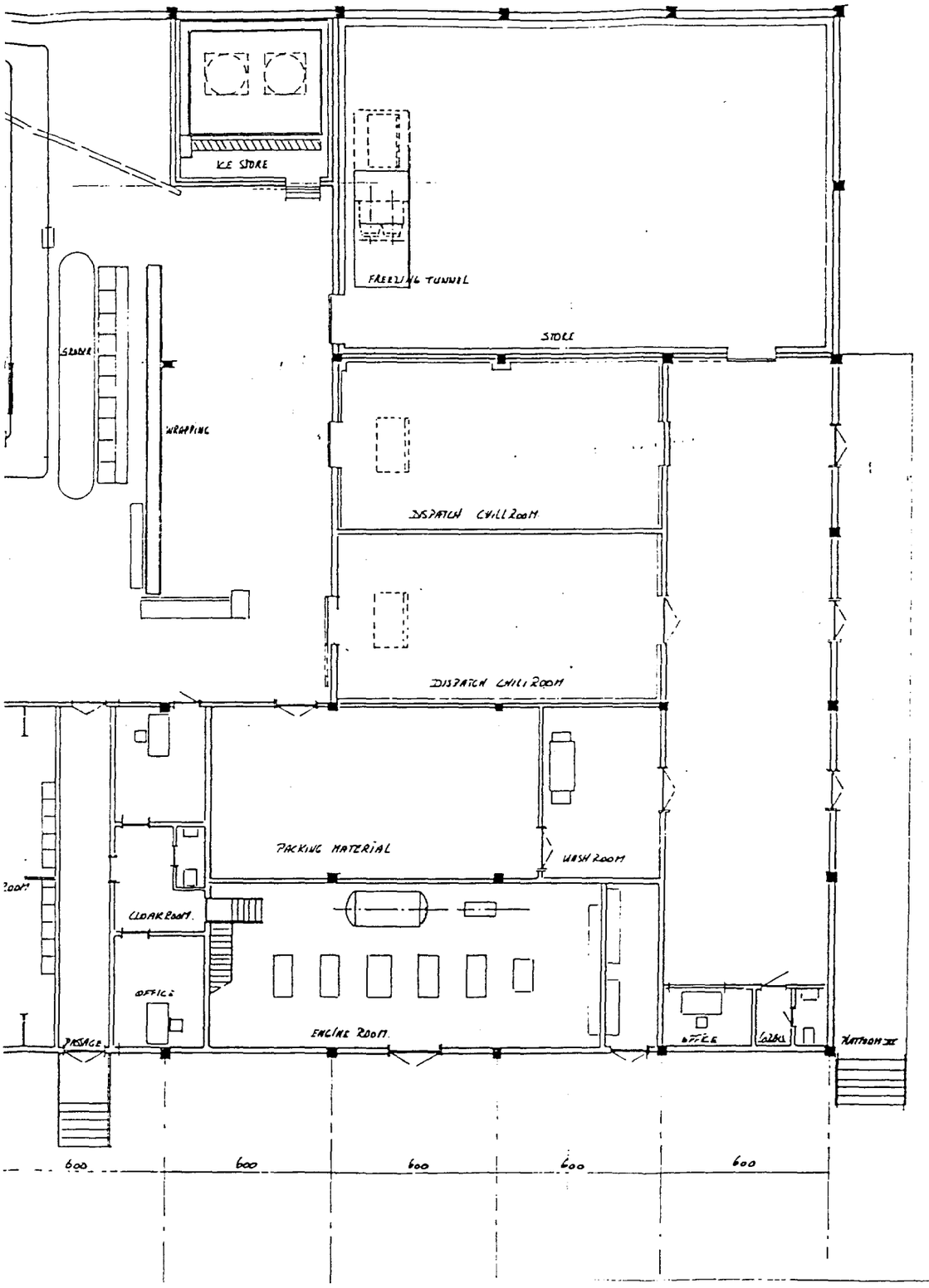

QTY	DESCRIPTION	MATERIAL
	BOILER PROCESSING PLANT CAP. 1000 bph.	

MUNICIPALITY OF AMMAN.

DRAWN	DATE	SCALE
MB	21-7-99	1:100

ATLORGE

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Appendix C

Overview of the Regulations Applicable to the MGAS Discharge

APPLICABLE REGULATORY CRITERIA

Current Status of Environmental Regulations in Jordan:

In order to assess the Municipality of Greater Amman Slaughterhouse (MGAS) compliance with applicable Jordanian standards and regulations, it is of importance at this stage to present an overview of Jordan's environmental protection control laws, standards, and regulations. Interestingly, Jordan has no comprehensive law to control water, air, and soil pollution. However, a Jordanian Environment Act (JEA) was drafted two years ago to achieve the principle objectives mentioned in the National Environment Strategy (NES) for Jordan. JEA is currently awaiting approval from the Parliament.

In general, the nature of water pollution standards and regulations in Jordan vary according to sources. Industrial wastewater discharges are regulated by the Jordanian standard specification number 202 (Table C-1) adopted in 1981 by the Department of Standards and Specifications (DSS) and revised in 1990. Standard 202 regulates industrial wastewater discharges to rivers, wadis, groundwater, the sea, and reuse for irrigation. This standard covers 37 pollutant parameters and sets maximum allowable concentration limits of pollutants in the discharged industrial wastewater effluents. Moreover, the standard also contains narrative conditions to protect public health, aquatic life, worker health; and groundwater quality. The standard is not associated with a permitting mechanism and therefore is self-implementing.

Drinking water quality is regulated by the Jordanian standard number 286. Tables C-2a - C-2e present quantitative requirements of pertinent characteristics including physical, chemical , radiation , and health related issues. With regards to regulations related to the quality of treated domestic wastewater to be reused in irrigation, Jordan has neither standards nor guidelines. However, it is a common practice to use the Food and Agriculture Organization (FAO) and World Health Organization (WHO) Guidelines as a reference .Tables C-3 through C-5 are related to the quality of treated domestic wastewater effluents to be reused in irrigating agricultural crops. The remaining tables C-6 - C-12 present the tolerance and sensitivity of crops to salinity and other specific ions like Sodium, Boron and

Chloride. These are adapted from the FAO Guidelines (1985). Treated domestic wastewater is regulated by the Jordanian Standard 893 (Table C-13) adopted in

1994 by DSS. Discharge of Industrial and Commercial Wastewaters into the public sanitary Sewer System is regulated by the Water Authority Law, Law Number 18, of 1988, Annex (B-4). The regualations stipulated herein are presented in table C-14. Regarding air pollution, Jordan does not have any existing standards or regulations to control air pollution.

Regulations Applicable to the MGAS Discharges:

During the course of conducting an environmental pollution prevention/ waste minimization audit of the MGAS, the audit team identified two continually discharged effluents. These discharges are industrial wastewater effluents disposed into the public sanitary sewer system.

The first effluent corresponds to wastewater produced from the cattle andd sheep slaughtering and processing line. While, The second wastewater discharge, however, originates from the poultry slaughtering and processing line.

Pertinent Jordanian standards regulating disposition into the Public Sewer System are governed by the Jordanian regualtions presented in table C-14.

Results of analyses conducted for composite samples taken from these discharges show that most parameters of concern (e.g BOD5,TSS,FOG) exceed maximum allowable limits stipulated in the Jordanian regulations presented intable C-14

It is highly recommended that MGAS institutes a monitoring program in order to test for the quality of their wastewater effluents. This action, if adopted, will enable MGAS to be prepared when the new JEA will be passed.

Table C-1

Summary of requirements of Jordan Standard 202/1991 for disposal of industrial effluents.

Parameter	Maximum Allowable Limit, (mg/l)+			
	Disposal To			
	Wadis & Rivers	Sea	Groundwater Recharge	Reuse for Irrigation**
)D5	50M	-	50M	-
)D	150M	200	150M	-
)	1*	5*	1*	1*
)S	3000(1)	-	1500 (1)	2000 (2)
SS	50	-	-	100 (3)
I (su)	6.5-9.0	5.5-9.0	6.5-9.0	6.5-8.4
)lor (unit)	15	75	15	-
:	-	4	-	-
)G	5	10	Absent	5
ıenol	0.002	1	0.002	0.002
BAS	25		15	-
)3-N	12 (4)	-	12 (4)	30
H3	5	12	5	5
N	-	125	-	50
)4-P	15	-	-	-
	500	-	500	350 (3)
)4	500	-	500	400
	1.5	-	1.5	-
:O3	-	-	-	500
ı	-	-	400	-
g	-	-	-	-
ı	-	-	-	-
ıR	-	-	-	9
	5	-	0.3	5
	0.05	0.1	0.05	0.1
	1	-	1	1 (5)
	0.1	0.3	0.05	0.1
ı	2	0.1	2	0.2
	1	2	1	5
n	0.2	0.2	0.2	0.2
	0.2	0.02	0.1	0.2
	0.1	0.1	0.1	1
	0.02	0.02	0.05	0.02
l	0.01	0.07	0.02	0.01
ı	15	-	15	2
N	0.1	1	0.1	0.1
g	0.001	0.001	0.001	0.001
:C MPN/100ml		5000	-	-
'CC MPN/100ml	1000(6)	-	1000 (6)	1000 (6)
ematodes	< 1	-	-	< 1

All units are in mg/l except where noted.
Minimum value.
) Depends upon, type and quantity of crops, irrigation methods,soil type, climate & groundwater in the area concerned.
Undetermined.
) Monthly average.

tes:

TDS allowable limit is subject to the TDS concentration in the water supply and the water basin affectd.
Allowable limits of wastewater reuse determine the degree of restriction (none, slight to moderate, or severe).
Method of irrigation is determined by wastewater quality being used.
Nitrate concentrations allowed are determined by its concentrations in the affected water basin.
Could reach 3 mg/l.
Geometric mean.

Table C-2a
Jordanian Drinking Water Standards
A: Physical characterstics

Parameter	Permissible Limit	Max. allowable conc. in case no better source is available
Taste	aesthetically acceptable	-
Odor	aesthetically acceptable	-
Color	10 units	15 units
Turbidity	1 unit (JCU)	5 units
pH	6.5 < pH < 9	-
Temperature	8 - 25 c	-

Table C-2b

Jordanian Drinking Water Standards
B: Chemical Charecterstics

Parameter	Max. Allowable Conc. mg/l
Pb	0.05
Se	0.01
As	0.05
Cr	0.05
CN	0.1
Cd	0.005
Hg	0.001
Sb	0.01
Ag	0.01

Table C-2c
Jordanian Drinking Water Standards
C: Health related

Parameter	Permissible Limit mg/l	Max. allowable conc. in case no better source is avialable	Effects within max. allowable limits
TDS	500	1500	aesthetic
TH(CaCO3)	100	500	aesthetic
ABS	0.5	1	indicator
Al	0.2	0.3	aesthetic
Fe	0.3	1	aesthetic
Mn	0.1	0.2	aesthetic
Cu	1	1.5	aesthetic
Zn	5	15	aesthetic
Na	200	400	aesthetic
Ni	0.05	0.1	health
Cl	200	500	aesthetic
F	1	1.5	health
SO4	200	500	aesthetic
NO3	45	70	health

Table C-2d

Jordanian Drinking Water Standards
D: Radiation

Parameter	Maximum limit Bq/l
Alpha-emitters (except for Radon)	0.1
Beta-emitters	1

Table C-2e

Jordanian Drinking Water Standards
E: Organic pollutants*

Parameter	Max. Permissible Conc. mg/l
A) Chlorinted Hydrocarbons	
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
B) Chlorophenoxys	
2,4-D	0.1
2,4,5-TP (Trichlorophenoxy propionic acid)	0.01

* Other organic pollutants should not exceed the max. allowable limit set by WHO.

Table C-3

Guidelines for interpretations of water quality for irrigation (1)

Potential irrigation problems	Units	Degree of restriction on use: None	Slight to moderate	Severe
Salinity (affects crop water availability) (2)				
EC_w (or)	dS/m	< 0.7	0.7 - 3.0	> 3.0
TDS	mg/l	< 450	450 - 2000	> 2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using (EC_w and SAR together) (3)				
SAR = 0-3 and EC_w	=	> 0.7	0.7 - 0.2	< 0.2
= 3-6	=	> 1.2	1.2 - 0.3	< 0.3
= 6-12	=	> 1.9	1.9 - 0.5	< 0.5
= 12-20	=	> 2.9	2.9 - 1.3	< 1.3
= 20-40	=	> 5.0	5.0 - 2.9	< 2.9
Specific ion toxicity (affects sensitive crops)				
Sodium (Na) (4)				
Surface irrigation	SAR	< 3	3 - 9	> 9
Sprinkler irrigation	me/l	< 3	> 3	
Chloride (Cl) (4)				
Surface irrigation	me/l	< 4	4 - 10	> 10
Sprinkler irrigation	me/l	< 3	> 3	
Boron (B) (5)	mg/l	< 0.7	0.7 - 3.0	> 3.0
Trace elements (see table E4)				
Miscellaneous effects (affects susceptible crops)				
Nitrogen (NO3-N) (6)	mg/l	<5	5 - 30	> 30
Bicarbonate (HCO3) (Overhead sprinkling only)	me/l	< 1.5	1.5 - 8.5	> 8.5
pH			Normal range 6.5 - 8.4	

1. Adapted from University of California Committee of Consultants 1974
2. ECw means electrical conductivity, a measure of the water salinity, reported in deci-Siemens per metre at 25C° (dS/m) or in units millimhos per centimeter (mmhos/cm). Both are equivalent. TDS means total dissolved solids, reported in milligrams per liter (mg/L)
3. SAR means sodium adsorption ratio. SAR is sometimes reported by the symbol RNa. At a given SAR, infiltration rate increase as water salinity increases. Evaluate the potential infiltration problem by SAR as modified by ECw
4. For surface irrigation, most tree crops and woody plants are sensitive to sodium and chloride, use the values shown. Most annual crops are not sensitive. With overhead sprinkler irrigation and low humidity (<30 percent), sodium and chloride may be absorbed through the leaves of sensitive crops.
5. For boron tolerances, see Tables 16 and 17.
6. NO3-N means nitrate nitrogen reported in terms of elemental nitrogen (NH4-N and Organic-N should be included when wastewater is being tested)

Assumptions in the Guidelines

The water quality guidelines in Table 1 are intended to cover the wide range of conditions encountered in irrigated agriculture. Several basic assumptions have been used to define their range of usability. If the water is used under greatly different conditions, the guidelines may need to be adjusted. Wide deveations from the assumptions might result in wrong judgements on the usability of a particular water supply, especially if it is a borderline case. Where sufficient experience, field trials, research or observations are available, the guidelines may be modified to fit local conditions more closely.

The basic assumptions in the guidelines are:

Yield Potential: Full production capability of all crops, without the use of special practices, is assumed when the guidelines indicate no restrictions on use. A "restriction on use" indicates that there many be a limitation in choice of crop, or special management may be needed to maintain full production capability. A "restriction on use" does not indicate that the water is unsuitable for use.

Site Conditions: Soil texture ranges from sandy-loam to clay-loam with good internal drainage. The climate is semi-arid to arid and rainfall is low. Rainfall does not play a significant role in meeting crop water demand or leaching requirement. (In a monsoon climate or areas where precipitation is high for part or all of the year, the guideline restrictions are too severe. Under the higher rainfall situations, infiltrated water from rainfall is effective in meeting all or part of the leaching requirement.) Drainage is assumed to be good, with no uncontrolled shallow water table present within 2 metres of the surface

Methods and Timing of Irrigations: Normal surface or sprinkler irrigation methods are used. Water s applied infrequently, as needed, and the crop utilizes a considerable portion of the available stored soil-water (50 percent or more) before the next irrigation. At least 15 percent of the applied water percolates below the root zone (leaching fraction [LF] ≥ 15 percent). The guidelines are too restrictive for specialized irrigation methods, such as localized drip irrigation, which results in near daily or frequent irrigations, but are applicable for subsurface irrigation, if surface applied leaching satisfies the leaching requirements

Water Uptake by Crops: Different crops have different water uptake patterns, but all take water from wherever it is most readily available within the rooting depth. On average about 40 percent is assumed to be taken from the upper quarter of the rooting depth, 30 percent quarter, 20 percent from the third quarter, and 10 percent from the lowest quarter. Each irrigation leaches the upper root zone and maintains it at a relatively low salinity. Salinity increases with depth and is greatest in the lower part of the root zone. The average salinity of the soil-water is three times that of the applied water and is representative of the average root zone salinity to which the crop responds. These conditions result from a leaching fraction of 15-20 percent and irrigations that are timed to keep the crop adequately watered at all times.

Salts leached from the upper root zone accumulate to some extent in the lower part till a salt balance is achieved as salts are moved below the root zone by sufficient leaching. The higher salinity in the lower root zone becomes less important if adequate moisture is maintained in the upper, "more active" part of the root zone and adequate leaching is accomplished.

Restriction on Use: The "Restriction on Use" shown in Table 1 is divided into three degrees of severity: none, slight to moderate, and severe. The divisions are somewhat arbitrary since change occurs gradually and there is no clear-cut breakpoint. A change of 10 to 20 percent above or below a guideline value has little significance if considered in proper perspective with other factors affecting yield. Field studies, research trials and observations have led to these divisions, but management skill of the water user can alter them. Values shown are applicable under normal field conditions prevailing in most irrigated areas in the and and semi-arid regions of the world.

Table C-4
Recommended maximum concentrations of
trace elements in irrigation water (1)

Element	Recommended maximum concentration(2) (mg/L)	Remarks
Al (aluminium)	5.0	Can cause non-productivity in acid soils (pH < 5.5). but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
As (arsenic)	0.10	Toxicity to plants varies widely, ranging from 12 mg/L for Sudan grass to less than 0.05 mg/L for rice.
Be (beryllium)	0.10	Toxicity to plants varies widly, raning from 5 mg/L for kale to 0.5 mg/L for bush beans.
Cd (cadmium)	0.01	Toxic to beans beets and turnips at concentrations as low as 0.1 mg/l. in nutrient solutions. Conservative limits recommended due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans.
Co (cobalt)	0.05	Toxic to tomato plants at 0.1 mg/L in nutrient solution. Tends to be inactivated by neutral and alkaline soils.
Cr (chromium)	0.10	Not generally recognized as an essential growth element. Conservative limits recommended due to lack of knowledge on its toxicity to plants.
Cu (copper)	0.20	Toxic to a number of plants at 0.1-1.0 mg/L in nutrient solutions.
F (fluoride)	1.0	Inactivated by neutral and alkaline soils.
Fe (iron)	5.0	Not toxic to plants in aerated soils. but can contribute to soil acidification and loss of availability of essential phosphorus and molybdenum. Overhead sprinkling may result in unsightly deposits on plants, equipment and buildings.
Li (lithium)	2.5	Tolerated by most crops to 5 mg/L, mobile in soil. Toxic to citrus at low concentrations (<0.075 mg/L). Acts similarly to boron.
Mn (manganeses)	0.20	Toxic to a number of crops at a few-tenths to a few mg/L, but usually only in acid soils.
Mo (molybdenum	0.01	Not toxic to plants at normal concentrations in siol and water. Can be toxic to livestock if forage is grown in siols with high concentrations of available molybdenum.
Ni (nickel)	0.20	Toxic to a number of plants at 0.5-1.0mg/L; reduced toxicity at neutral or alkaline pH.
Pd (lead)	5.0	Can inhibit plant cell growth at very high concentrations.
Se (selenium)	0.02	Toxic to plants at concentrations as low as 0.025 mg/L and toxic to livestock if forage is grown in soils with relatively high levels of added selenium. An essential element to animals but in very low concentrations.
Sn (tin)		
Ti (titanium)		Effectively excluded by plants; specific tolerance unknown.
W (tungsten)		
V (vanadium)	0.1	Toxic to many plants at relatively low concentrations.
Zn (zinc)	2.0	Toxic to many plants atwidely varying concentrations, reduced toxicity at pH > 6.0 and in fine textured or organic soils.

1- Adapted from National Academy of Sciences (1972) and Pratt (1972).
2- The maximum concentration is based on a water application rate which is consistent with good irrigation practices (10000 m3/ha per years). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates lease than 10 000 m3/ha per year. The values given are for water used on a continuous basis at one site.

Source: FAO Guidelines, R.S. Ayers & D.w. Westcot (1985).

Table C-5

Recommended microbiological quality guidelines for wastewater use in agriculture (a)

Category	Reuse conditions	Exposed group	Intestinal nematodes (b) (arithmetic mean no. of eggs per litre (c))	Faecal coliforms (geometric mean no. per 100ml) (c)	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked. sports fields, public parks, (d)	Workers, Consumer, public	<1	< 1000 (d)	A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, Pasture and trees (e)	Workers	<1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation.

(a) In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly.

(b) Ascaris and Trichuris species and hookworms.

(c) During the irrigation period.

(d) A more stringent guideline (< 200 faecal coliforms per 100 ml) is appropriate for public lawns, such as hotel lawns. With which the public may come into direct contact.

(e) In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

Source: Scientific group on health aspects of use of treated wastewater for agricultural and aquaculture-W.H.O.- Geneva 18-23 Nov. 1987.

Table C-6

Chloride tolerance of some fruit crop cultivars and rootstocks.(a)

Crop	Rootstock or cultivar	Maximum permissible Cl in water without leaf injury (b),(c) (mg/L)
	Rootstocks	
Avocado (Persea americana)	West indian	180
	Guatemalan	145
	Mexican	110
Citrus (Citrus spp.)	Sunki mandarin, grapefruit	
	Cleopatra mandarin, Rangpur lime	600
	Sampson tangelo, rough lemon, sour orange, Ponkan mandarin	355
	Citrumelo 4475, trifolate orange, Cuban shaddock, Calamondin, Sweet orange, Savage citrange, Rusk citrange, Troyer citrange	250
Grape (Vitis spp.)	Salt Creek, 1613-3	960
	Dog ridge	710
Stone fruit (Prunus spp.)	Marianna	600
	Lovell, Shalil	250
	Yunman	180
	Cultivars	
Berries (Rubus spp.)	Boysenberry	250
	Olallie blackberry	250
	Indian Summer raspberry	110
Grape (Vitis spp.)	Thompson seedless, Perlette	460
	Cardinal, black rose	250
Strawberry (Fragaria spp.)	Lassen	180
	Shasta	110

(a) Data are adapted from Haas (13)

(b) For some crops, the concentrations given may exceed the overall salinity tolerance of that crop and cause some yield reduction before chloride ion toxicities. Values given are for the maximum concentration in the irrigation water. The values were derived from saturation extract data (ECe) by the following relationship : saturation extraction concentration = 1.5 water concentration.

(c) The maximum permissible values apply only to surface irrigated crops. Sprinkler irrigation may cause excessive leaf burn at values far below these, (see Table 3-10).

Source : FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table C-7

GUIDLINES FOR INTERPRETING LABORATORY DATA ON WATER SUITABILITY FOR GRAPES

Potential Irrigation Problem	Unita	Degree of Restriction on Use		
		None	Slight to Moderate	Severe2
Salinity[3] *(affects water availability to crops)*				
ECw	dS/m	< 1	1.0 - 2.7	> 2.7
Toxicity *(Specific ions which affect growth of crop)*				
Sodium (Na^+)[4]	me/l	< 20	-	-
Chloride (Cl^-)[4]	me/l	< 4	4 - 15	> 15
Boron (B)	mg/l	< 1	1 - 3	> 3
Miscellaneous				
Bicarbonate ($HCO3^-$)[5]	me/l	< 1.5	1.5 - 7.5	> 7.5
Nitrate-nitrogen (NO3-N)	mg/l	< 5	5 - 30	> 30

1. Adapted from Neja et al. 1978.
2. Special management practices and favorable soil conditions are required for successful production.
3. Assumes that rainfall and extra water applied owing to inefficiencies of normal irrigation will supply the crop need plus about 15 percent extra for salinity control.
4. With overhead sprinkler irrigation, sodium or chloride in excess of 3 me/l under extreme drying conditions may result in excessive leaf absorption, leaf burn and crop damage. If overhead sprinklers are used for cooling by frequent on-off cycling, damage may occur even at lower concentrations.
5. Bicarbonate (HCO3) in water applied by overhead sprinklers may cause white deposits on fruit and leaves which reduces market acceptability, but is not toxic to the plant.

Table C-8

PELATIVE SALT TOLERANCE OF VARIOUS CROPS AT GERMINATION[1]

Crop		50 percent Emergence reduction (ECe in dS/m)
Barley	*(Hordeum vulgare)*	16 - 24
Cotton	*(Gossypium hirsutum)*	15.5
Sugarbeet	*(Beta vulgaris)*	6 - 12.5
Sorghum	*(Sorghum bicolor)*	13
Safflower	*(Carthomus tinctorius)*	12.3
Wheat	*(Triticum aestivum)*	14 - 16
Beet, red	*(Beta vulgaris)*	13.8
Alfalfa	*(Medicago sativa)*	8.2 - 13.4
Tomato	*(Lycopersicon Lycopersicum)*	7.6
Rice	*(Oryza sativa)*	18
Cabbage	*(Brassica oleracea capitata)*	13
Muskmelon	*(Cucumis melo)*	10.4
Maize	*(Zea mays)*	21 - 24
Lettuce	*(Lactuca sativa)*	11.4
Onion	*(Allium cepa)*	5.6 - 7.5
Bean	*(Phaseolus vulgaris)*	8.0

1 Data taken from Maas (1984).

Table C-9

Relative boron tolerance of agricultural crops (1), (2)

Very Sensitive (<0.5 mg/L)

Lemon	*Citrus Limon*
Blackberry	*Rubus spp.*

Sensitive (0.5-0.75 mg/L)

Avocado	*Persea americana*
Grapefruit	*Citrus X paradisi*
Orange	*Citrus sinensis*
Apricot	*Prunus armeniaca*
Peach	*Prunus persica*
Cherry	*Prunus avium*
Plum	*Prunus domestica*
Persimmon	*Diospyros Kaki*
Fig, Kadota	*Ficus carica*
Grape	*Vitis vinifera*
Walnut	*Juglans regia*
Pecan	*Carya illnoiensis*
Cowpea	*Vigna unguiculata*
Onion	*Allium cepa*

Sensitive (0.75-1.0 mg/L)

Garlic	*Allium sativum*
Sweet potato	*Ipomoea batatas*
Wheat	*Triticum eastivum*
Barley	*Hordeum vulgare*
Sunflower	*Helianthus anratus*
Bean, mung	*Vigna radiata*
Sesame	*Sesamum indicum*
Lupine	*Lupinus hartwegii*
Strawberry	*Fragaria spp.*
Artichoke, Jerusalem	*Helianthus tuberosus*
Bean, Kidney	*Phaseolus vulgaris*
Bean, lima	*Phaseolus lunatus*
Groundnut/Peanut	*Arachis hypogaea*

Moderately Sensitive (1.0-2.0 mg/L)

Pepper, red	*Capsicum crucum*
Pea	*Pisum sativa*
Carrot	*Daucus carota*
Radish	*Raphanus sativus*
Potato	*Solanum tuberosum*
Cucumber	*Cucumis sativus*

Moderately Tolerant (2.0-4.0 mg/L)

Lettuce	*Lactuca sativa*
Cabbage	*Brassica oleracea capitata*
Celery	*Apium graveolens*
Turnip	*Brassica rapa*
Bluegrass, Kentucky	*Poa pratensis*
Oats	*Avena sativa*
Maize	*Zea mays*
Artichoke	*Cynara scolymus*
Tobacco	*Nicotiana tabacum*
Mustard	*Brassica juncea*
Clover, sweet	*Melilotus indica*
Squash	*Cucurbita pepo*
Muskmelon	*Cucumis melo*

Tolerant (4.0-6.0 mg/L)

Sorghum	*Sorghum bicolor*
Tomato	*Lycopersicon Lycopersicum*
Alfalfa	*Medicago sativa*
Vetch, purple	*Vicia benghalensis*
Parsley	*Petroselinum crispum*
Beet, red	*Beta vulgaris*
Sugarbeet	*Beta vulgaris*

Very Tolerant (6.0-15.0 mg/L)

Cotton	*Gossypium hirsutum*
Asparagus	*Asparagus officinalis*

(1) Data taken from Maas (1984)
(2) Maximum concentrations tolerated in soil-water without yield or vegetative growth reductions. Boron tolerances vary depending upon climate, soil conditions and crop varieties. Maximum concentrations in the irrigation water are approximately equal to these values or slightly less.

Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table C-10

Relative tolerance of selected crops to exchangeable sodium (1).

Sensitive (2)	Semi-tolerant(2)	Tolerant(2)
Avocado	Carrot	Alfalfa
(Persea americana)	*(Daucus carota)*	*(Medicago sativa)*
Deciduous Fruits	Clover, Ladino	Barley
Nuts	*(Trifolium repens)*	*(Hordeum vulgare)*
Bean, green	Dallisgrass	Beet, garden
(Phaseolus vulgaris)	*(Paspalum dilatatum)*	*(Beta vulgaris)*
Cotton *(at germination)*	Fescue, tall	Beet, sugar
(Gossypium hirsutum)	*(Festuca arundinacea)*	*(Beta vulgaris)*
Maize	Lettuce	Bermuda grass
(Zea mays)	*(Lactuca sativa)*	*(Cynodon dactylon)*
Peas	Bajara	Cotton
(Pisum sativum)	*(Pennisetum typhoides)*	*(cossypium hirsutum)*
Grapefruit	Sugarcane	Paragrass
(Citrus paradisi)	*(Saccharum officinarum)*	*(Brachicria mutica)*
Orange	Berseem	Rhodes grass
(Citrus sinensis)	*(Trifolium alexandrinum)*	*(Chloris gayana)*
Peach	Benji	Wheatgrass, crested
(Prunus persica)	*(Melilotus parviflora)*	*(Agropyron cristatum)*
Tangerine	Raya	Wheatgrass, fairway
(Citrus reticulata)	*(Brassica juncea)*	*(Agropyron cristatum)*
Mung	Oat	Wheatgrass, fairway tall
(Phaseolus aurus)	*(Avena sativa)*	*(Agropyron slongatum)*
Mash	Onion	Karnal grass
(Phaseolus mungo)	*(Allium cepa)*	*(Diplachra fusca)*
Lentil	Radish	
(Lens culinaris)	*(Raphanus sativus)*	
Groundnut *(peanut)*	Rice	
(Arachis hypogaea)	*(Oryza sativus)*	
Cram	Rye	
(Cicer arietirum)	*(Secale cereale)*	
Cowpeas	Ryegrass, Italian	
(Vigna sinensis)	*(Lolium multiflorum)*	
	Sorghum	
	(Sorghum vulgare)	
	Spinach	
	(Spinacia oleracea)	
	Tomato	
	(Lycopersicon esculentum)	
	Vetch	
	(Vicia sativa)	
	Wheat	
	(Triticum vulgare)	

Adapted from data of FAO-Unesco (1973); Pearson (1960); and Abrol (1982).
Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table C-11

LABORATORY DETERMINATIONS NEEDED TO EVALUATE COMMON IRRIGATION WATER QUALITY PROBLEMS

Water parameter	Symbol	Unit[1]	Usual range in irrigation water	
SALINITY				
Salt Content				
Electrical Conductivity	EC_w	dS/m	0 - 3	dS /m
(or)				
Total Dissolved Solids	TDS	mg/l	0 - 2000	mg/l
Cations and Anions				
Calcium	Ca^{++}	me/l	0 - 20	me/l
Magnesium	Mg^{++}	me/l	0 - 5	me/l
Sodium	Na^{+}	me/l	0 - 40	me/l
Carbonate	CO_3^{--}	me/l	0 - .1	me/l
Bicarbonate	HCO_3^{-}	me/l	0 - 10	me/l
Chloride	Cl^{-}	me/l	0 - 30	me/l
Sulphate	SO_4^{--}	me/l	0 - 20	me/l
NUTRIENTS[2]				
Nitrate - Nitrogen	NO_3 - N	mg/l	0 - 10	mg/l
Ammonium - Nitrogen	NH_4 - N	mg/l	0 - 5	mg/l
Phosphate - Phosphorus	PO_4 - P	mg/l	0 - 2	mg/l
Potassium	K^{+}	mg/l	0 - 2	mg/l
MISCELIANEOUS				
Boron	B	mg/l	0 - 2	mg/l
Acid / Basicity	pH	1 - 14	6.0 - 8.5	
Sodium Adsorption Ratio[3]	SAR	(me/1)[1,2]	0 - 15	

1. dS/m = desiSiemen/meter in S.I. units (equivalent to 1 mmho / cm - 1 millimmho / centimeter)
   mg/l = milligram per litre ~ parts per million (ppm).
   me/l = milliequivalent per litre (mg/l ÷ equivalent weight = me/l); in SI units, 1 me/l = 1 millimol / litre adjusted for electron charge.
2. NO_3-N means the laboratory will analyse for NO_3 but will report the NO_3 in terms of chemically equivalent nitrogen. Similarly, for NH_4-N, the laboratory will analyse for NH_4 but report in terms of chemically equivalent elemental nitrogen. The total nitrogen available to the plant will be the sum of the equivalen elemental nitrogen.
   The same reporting method is used for phosphorus.
3. SAR is calculated from the Na, Ca and Mg reported in me/l.

Table C-12

Crop tolerence and yield potential of selected crops as influenced by irrigation water salinity (EC_w) or soil salinity (ECe)

	Yield potential (2)									
	100%		90%		75%		50%		0% maximum(3)	
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw
Field crops										
Barley *(Hordeum Vulgare)* (4)	8.0	5.3	10	6.7	13	8.7	18	12	28	19
Cotton *(Gossypium hirsutum)*	7.7	5.1	9.6	6.4	13	8.4	17	12	27	18
Sugarbeet *(Beta vulgaris)* (5)	7.0	4.7	8.7	5.8	11	7.5	15	10	24	16
Sorghum *(Sorghum bicolor)*	6.8	4.5	7.4	5.0	8.4	5.6	9.9	6.7	13	8.7
Wheat *(Triticum aestivum)* (4), (6)	6.0	4.0	7.4	4.9	9.5	6.3	13	8.7	20	13
Wheat durum *(Triticum turgidum)*	5.7	3.8	7.6	5.0	10	6.9	15	10	24	16
Soyabean *(Glycine max)*	5.0	3.3	5.5	3.7	6.3	4.2	7.5	5.0	10	6.7
Cowpea *(Vigna unguiculata)*	4.9	3.3	5.7	3.8	7.0	4.7	9.1	6.0	13	8.8
Groundnut *(peanut)* *(Arachis hypogaea)*	3.2	2.1	3.5	2.4	4.1	2.7	4.9	3.3	6.6	4.4
Rice *(paddy)* *(Oriza sativa)*	3.0	2.0	3.8	2.6	5.1	3.4	7.2	4.8	11	7.6
Sugarcane (Saccharum officinarum)	1.7	1.1	3.4	2.3	5.9	4.0	10	6.8	19	12
Corn *(maize)* *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Flax *(Linum usitatissimum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Broadbean *(Vicia faba)*	1.5	1.1	2.6	1.8	4.2	2.0	6.8	4.5	12	8.0
Bean *(phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Vegetable crops										
Squash zucchini *(courgette)* *(Cucurbita pepo melopepo)*	4.7	3.1	5.8	3.8	7.4	4.9	10	6.7	15	10
Beet, red *(Beta vulgaris)*(5)	4.0	2.7	5.1	3.4	6.8	4.5	9.6	6.4	15	10
Squash, scallop *(Cucurbita pepo melopepo)*	3.2	2.1	3.8	2.6	4.8	3.2	6.3	4.2	9.4	6.3
Broccoli *(Brassica oleracea botrytis)*	2.8	1.9	3.9	2.6	5.5	3.7	8.2	5.5	14	9.1
Tomato *(Laycopersicon esculentum)*	2.5	1.7	3.5	2.3	5.0	3.4	7.6	5.0	13	8.4
Cucumber *(Cucumis sativus)*	2.5	1.7	3.3	2.2	4.4	2.9	6.3	4.2	10	6.8
Spinach *(Spinacia olerucea)*	2.0	1.3	3.3	2.2	5.3	3.5	8.6	57	15	10
Celery *(Apium graveolens)*	1.8	1.2	3.4	2.3	5.8	3.9	9.9	66	18	12
Cabbage *(Brassica oleracea capitata)*	1.8	1.2	2.8	1.9	4.4	2.9	7.0	4.6	12	8.1
Potato *(Solanum tuberosum)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Corn, sweet *(maize)* *(Zea mays)*	1.7	1.1	2.5	1.7	3.8	2.5	5.9	3.9	10	6.7
Sweet potato *(Impomoea batatas)*	1.5	1.0	2.4	1.6	3.8	2.5	6.0	4.0	11	7.1
Pepper *(Capsicum annuum)*	1.5	1.0	2.2	1.5	3.3	2.2	5.1	3.4	8.6	5.8
Lettuce *(Lactuca sativa)*	1.3	0.9	2.1	1.4	3.2	2.1	5.1	3.4	9.0	6.0
Radish *(Raphanus sativus)*	1.2	0.8	2.0	1.3	3.1	2.1	5.0	3.4	8.9	5.9
Onion *(Allium cepa)*	1.2	0.8	1.8	1.2	2.8	1.8	4.3	2.9	7.4	5.0
Carrot *(Daucus carota)*	1.0	0.7	1.7	1.1	2.8	1.9	4.6	3.0	8.1	5.4
Bean *(Phaseolus vulgaris)*	1.0	0.7	1.5	1.0	2.3	1.5	3.6	2.4	6.3	4.2
Turnip *(Phaseolus vulgaris)*	0.9	0.6	2.0	1.3	3.7	2.5	6.5	4.3	12	8.0
Forage crops										
Wheatgrass, tall *(Agropyron elongatum)*	7.5	5.0	9.9	6.6	13	9.0	19	13	31	21
Wheatgrass, fairway crested *(Agropyron oristatum)*	7.5	5.0	9.0	6.0	11	7.4	15	9.8	22	15
Bermuda grass *(Cynodon dactylon)* (7)	6.9	4.6	8.5	5.6	11	7.2	15	9.8	23	15
Barley *(forage)* *(Hordeum vulgare)* (4)	6.0	4.0	7.4	4.9	9.5	6.4	13	8.7	20	13
Ryegrass, perennial *(Lolium perenne)*	5.6	3.7	6.9	4.6	8.9	5.9	12	8.1	19	13
Trefoil, narrowleaf birdsfoot (8) *(Lotus corniculatus tenuifolium)*	5.0	3.3	6.0	4.0	7.5	5.0	10	6.7	15	10

Table C-12 Continued

	Yield potential									
	100%		90%		75%		50%		0%maximum (3)	
	ECe	ECw	ECe	ECw	ECe	ECw	ECe	ECw	Ece	ECw
Harding grass *(Phalaris tuberosa)*	4.6	3.1	5.9	3.9	7.9	5.3	11	7.4	18	12
Fescue, tall *(Festuca elatior)*	3.9	2.6	5.5	3.6	7.8	5.2	12	7.8	20	13
_Wheatgrass, standard crested *(Agropyron sibiricum)*	3.5	2.3	6.0	4.0	9.8	6.5	16	11	28	19
Vetch, common *(Vicia angustifolia)*	3.0	2.0	3.9	2.6	5.3	3.5	7.6	5.0	12	8.1
Sudan grass *(Sorghum sudanense)*	2.8	1.9	5.1	3.4	8.6	5.7	14	9.6	26	17
Wildrye, beardless *(Elymus truicoides)*	2.7	1.8	4.4	2.9	6.9	4.6	11	7.4	19	13
Cowpea *(forage)* *(Vigna unguiculata)*	2.5	1.7	3.4	2.3	4.8	3.2	7.1	4.8	12	7.8
Trefoil, big *(Lotus uliginosus)*	2.3	1.5	2.8	1.9	3.6	2.4	4.9	3.3	7.6	5.0
Sesbania *(Sesbania exaltata)*	2.3	1.5	3.7	2.5	5.9	3.9	9.4	6.3	17	11
Sphaerophysa *(Sphaerophysa salsula)*	2.2	1.5	3.6	2.4	5.8	3.8	9.3	6.2	16	11
Alfalfa *(Medicago sativa)*	2.0	1.3	3.4	2.2	5.4	3.6	8.8	5.9	16	10
Lovegrass *(Eragrostis sp.)* (9)	2.0	1.3	3.2	2.1	5.0	3.3	8.0	5.3	14	9.3
Corn *(forage)* *(maize)* *(Zea mays)*	1.8	1.2	3.2	2.1	5.2	3.5	8.6	5.7	15	10
Clover, berseem *(Trifolium alexundrinum)*	1.5	1.0	3.2	2.2	5.9	3.9	10	6.8	19	13
Orchard grass *(Dactylis glomerata)*	1.5	1.0	3.1	2.1	5.5	3.7	9.6	6.4	18	12
Foxtail, meadow *(Alopecurus pratenis)*	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Clover, red *(Trifolium pratense)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, alsika *(Trifolium hybridum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, ladino *(Trifolium repens)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
Clover, strawberry *(Trifolium fragiferum)*	1.5	1.0	2.3	1.6	3.6	2.4	5.7	3.8	9.8	6.6
_Fruit crops (10)										
Date palm *(Phoenix dactylifera)*	4.0	2.7	6.8	4.5	11	7.3	18	12	32	21
Grapefruit *(Citrus paradisi)* (11)	1.8	1.2	2.4	1.6	3.4	2.2	4.9	3.3	8.0	5.4
Orange *(Citrus sinensis)*	1.7	1.1	2.3	1.6	3.3	2.2	4.8	3.2	8.0	5.3
Peach *(Prunus persica)*	1.7	1.1	2.2	1.5	2.9	1.9	4.1	2.7	6.5	4.3
Apricot *(Prunus armeniaca)* (11)	1.6	1.1	2.0	1.3	2.6	1.8	3.7	2.5	5.8	3.8
Grape *(Vitus sp.)* (11)	1.5	1.0	2.5	1.7	4.1	2.7	6.7	4.5	12	7.9
Almond *(Prunus dulcis)* (11)	1.5	1.0	2.0	1.4	2.8	1.9	4.1	2.8	6.8	4.5
Plum, prune *(Prunus domestica)* (11)	1.5	1.0	2.1	1.4	2.9	1.9	4.3	2.9	7.1	4.7
Blackberry *(Rubus sp.)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Boysenberry *(Rubus ursinus)*	1.5	1.0	2.0	1.3	2.6	1.8	3.8	2.5	6.0	4.0
Strawberry *(Fragaria sp.)*	1.0	0.7	1.3	0.9	1.8	1.2	2.5	1.7	4.0	2.7

(1) Adapted from Maas and Hottman (1977) and Maas (1984). These data should only serve as a guide to relative tolerances among crops. Absolute tolerances vary depending upon climate, soil conditions and cultural practices. In gypsitcrous soils, plants will tolerate about 2ds/m higher soil salinity (ECe) than indicated but the water salinity (ECw) will remain the same as shown in this tabel.

(2) ECe means average root zone salinity as measured by electrical conductivity of the saturation extract of the soil, reported in decisiemens per meter (ds/m) at 25C. ECw means electical conductivity of the irrigation water in deci Siemens per meter (ds/m). The relationship between soil salinity and water salinity (ECe=1.5 ECw) assumes a 15-20 leaching fraction and a 40-30-20-10% water use pattern for the upper to lower quarters of the root zone.

(3) The zero yield potential or maximum ECe indicates the theoretical soil salinity (ECe) at which crop growth ceases.

(4) Barley and wheat are less tolerant during germination and seedling stage : ECe should not exceed 4 - 5 dS/m in the upper soil during this period.

(5) Beets are more sensitive during germination : ECe should not exceed 3 ds/m in the seedling area for garden beets and sugar beets.

(6) Semi-dwart, short cultivars may be less tolerant.

(7) Tolerance given is an average of several varieties : Suwannee and Coastal Bermuda grass are about 20% more tolerant, while common and Greenfield Bermuda grass are about 20% less tolerant.

(8) Broadleaf Birdsfoot Trefoil seems less tolerant than Narrowleaf Birdsfoot Trefoil.

(9) Tolerance given is an average for boer. Wilman, Sand and Weeping Lovegrass ; Lehman Lovegrass seems about 50% more tolerant.

(10) These data are applicable when rootstocks are used that do not accumulate Na^+ and Cl^- rapidly or when these ions do not predominate in the soil.

(11) Tolerance evaluation is based on tree growth and not on yeild.

Source: FAO Guidelines, R.S. Ayers & D.W. Westcot (1985).

Table C-13
Summary of requirements of Jordanian Standard 893/1994 for treated domestic wastewater.

Parameter	Maximum allowable limit (mg/L)*	
	Disposed to wadis, rivers, surface water bodies, and groundwater recharge	Reuse for irrigation
pH	6.5-9	6.5-9
Temperature change (C)	<3	-
D.O	31	-
TDS	3000	2000 (1)
TSS	50(3) / 200(4)	100 (1)
BOD5	50(3) / 50(4)	-
COD	150(3) / 150(4)	-
NH3	30	-
FOG	15	15
ABS	6	-
Cl2	0.5 (5)	-
Phenol	0.5	-
TFCC MPN/100mL	<1000	<1000 (6)
Intestinal nematodes	<1	<1 (6)

* All units are in mg/L except where noted.

(1) Depends on degree of restriction (none, slight to moderate, or severe).

(2) Depends on method of irrigation.

(3) Conventional wastewater treatment plants.

(4) Waste stabilization ponds.

(5) This is a minimum limit of residual chlorine and it should be linked with total faecal coliform count.

(6) FAO and WHO guidelines and their amendments should be taken into consideration.

Table C-14

Summary of Jordanian Regulations Governing Discharge of Industrial and Commercial Wastewater Into the Sanitary Sewer System.*

Parameter	Unit	Maximum Allowable Limit
pH	Su	5.5-9.5
BOD	mg/l	800
COD	mg/l	2100
TSS	mg/l	1100
P	mg/l	50
FOG	mg/l	50
MBAS	mg/l	26
Phenol	mg/l	10
Cr**	mg/l	5
Cu**	mg/l	4.5
Zn**	mg/l	15
Sn	mg/l	10
Be	mg/l	5
Ni**	mg/l	4
Cd**	mg/l	1
As	mg/l	5
Ba	mg/l	10
Pb**	mg/l	0.6
Mn	mg/l	10
Ag**	mg/l	1
B	mg/l	5
Hg**	mg/l	0.5
Fe	mg/l	50
S (as H_2S)	mg/l	10
Temp	°C	65
Chlorinated Solvents	mg/l	0

* Published in the Official Gazette, September 17, 1988

** The total concentration of all the double asterisked materials should not exceed 10 mg/l

It is not permitted to dispose any liquids or materials which have cyanides in a concentration which can produce 1 mg/l HCN or more

It is not permitted to dispose any radioactive material without written approval from WAJ.

Appendix D

Site Visit Photographs

Photo 1 - Sheep holding pen. Hose is being used to wash solids to an open drain.

Photo 2 - Blood collection trough in sheep killing room.

Photo 3 - Hanging of sheep on conveyor system in sheep killing room.

Photo 4 - Dragout of blood from sheep killing room. Blood is washed to an open drain.

Photo 5 - Mechanical sheep carcass washer.

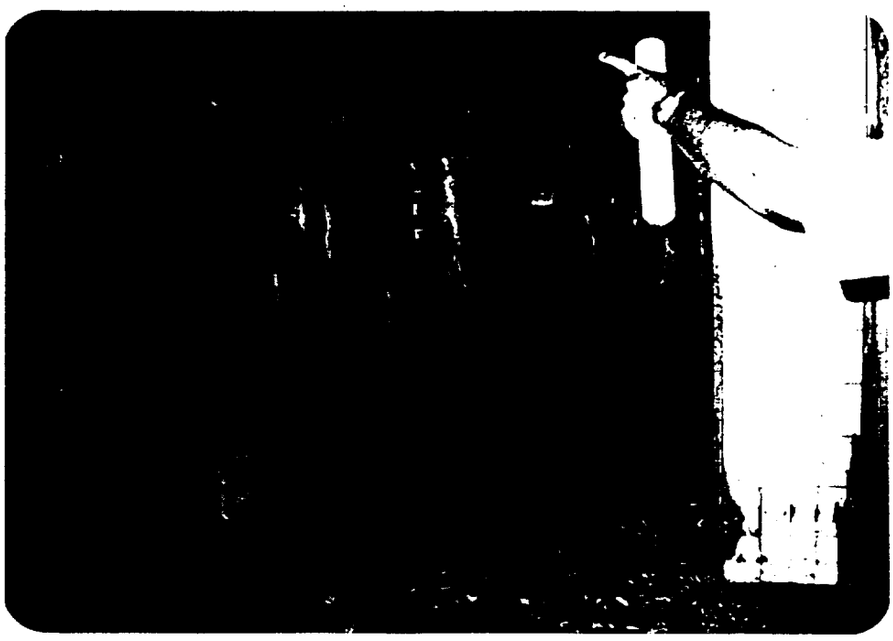

Photo 6 - Evisceration area with debris on floor.

Photo 7 - Cattle carcass splitting. Water spray on chainsaw.

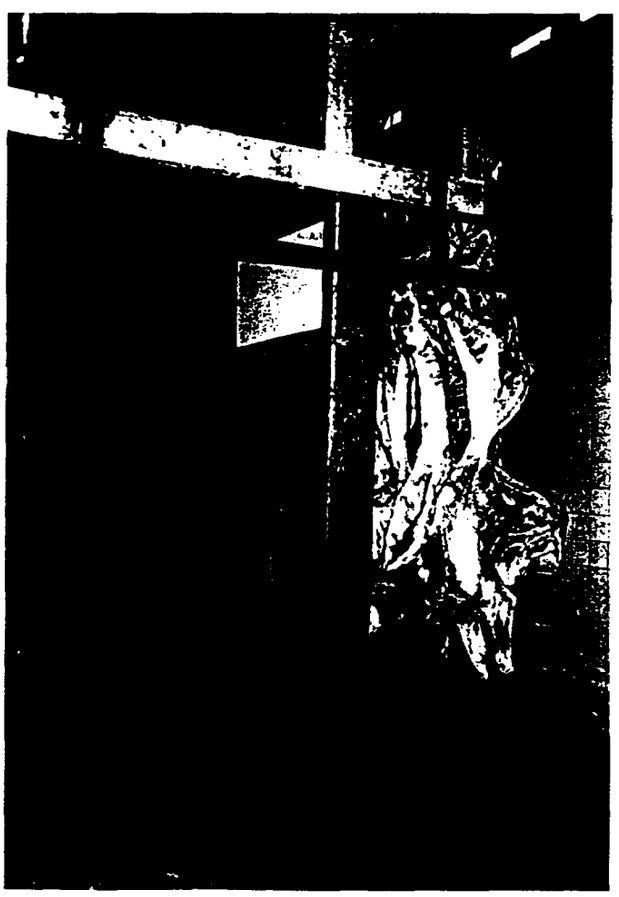

Photo 8 - Mechanical cattle carcass washer.

Photo 9 - Head and legs workshop. Hoses running in parts cleaning tanks.

Photo 10 - Paunch reception and cleaning area.

Photo 11 - Paunch contents spilled to floor.

Photo 12 - Running hose used to wash paunch contents to open channel drain.

Photo 13 - Sheep and cattle inspection and distribution area.

Photo 14 - Chicken reception area.

Photo 15 - Running hose used to wash debris to open floor drain.

Photo 16 - Chicken hanging and killing area.

Photo 17 - Blood collection trough in chicken killing area. Tub used to collect blood.

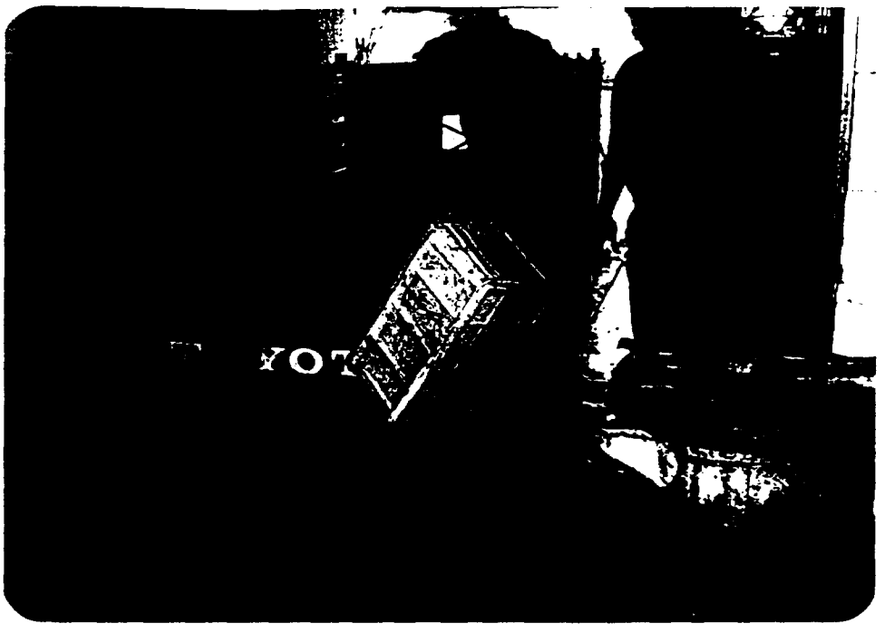

Photo 18 - Blood, feathers, and heads loaded to a waiting truck.

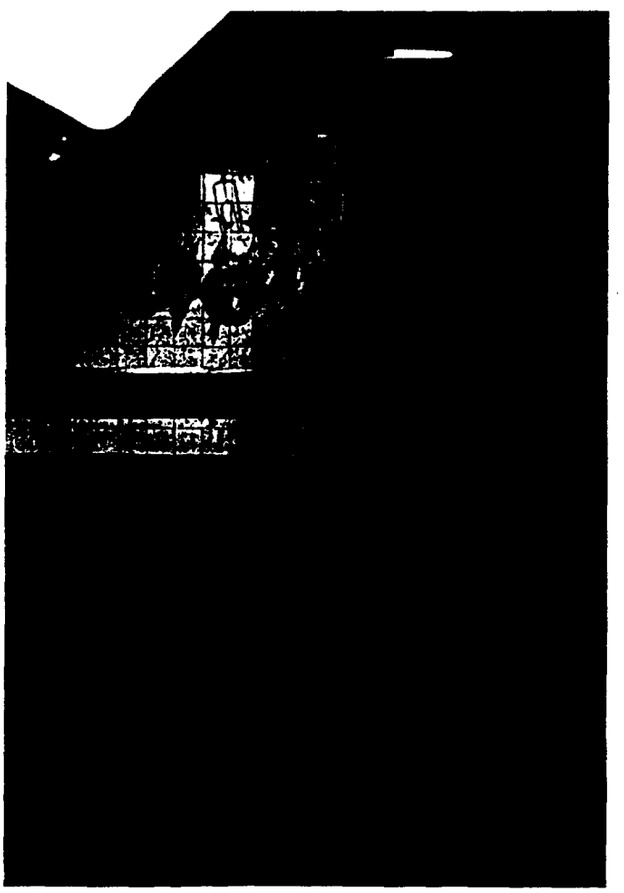

Photo 19 - Blood collection trough in chicken killing area discharging to floor and open floor drain while tub is removed.

Photo 20 - Chickens entering scalding tank.

Photo 21 - Mechanical defeathering process.

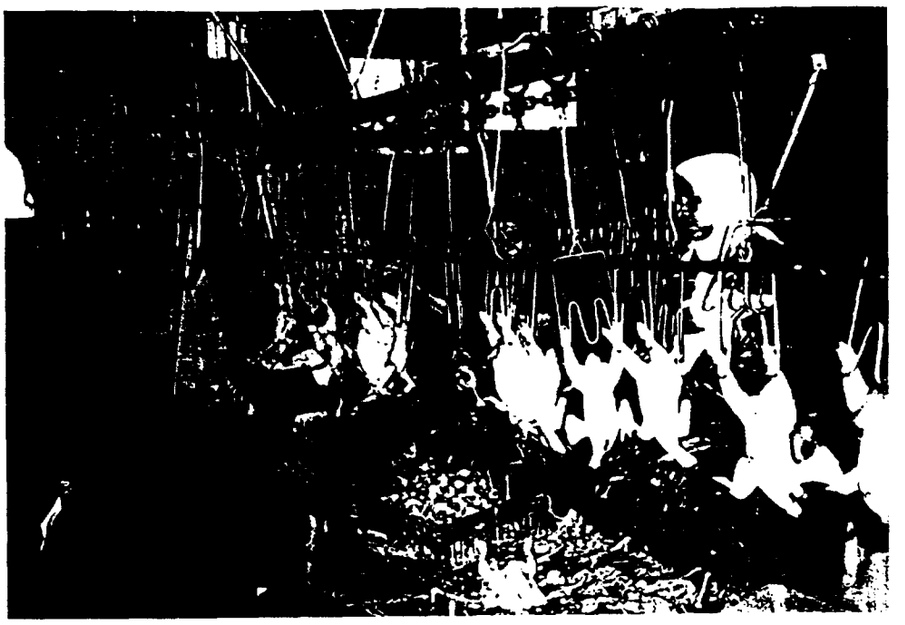

Photo 22 - Foot removal and evisceration process.

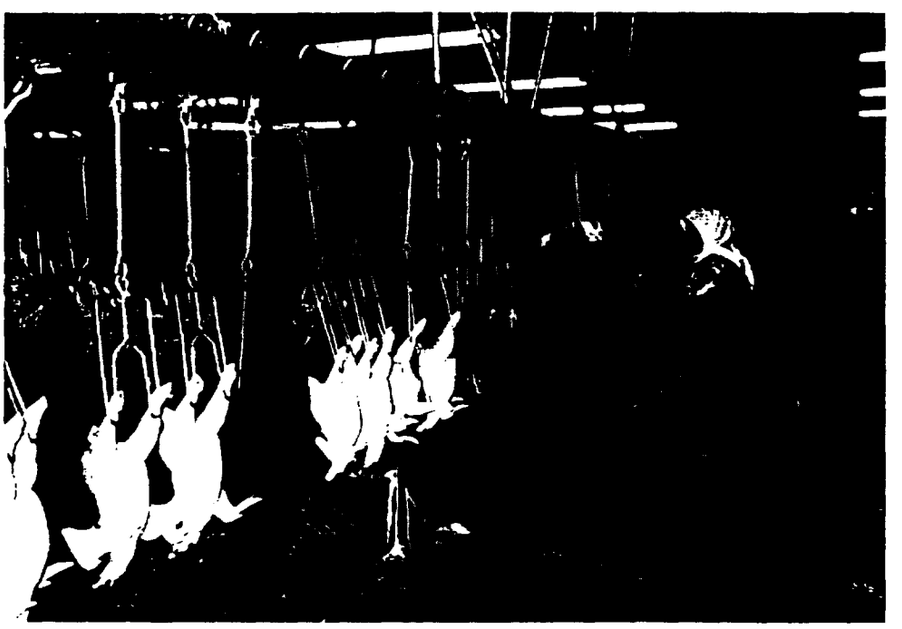

Photo 23 - Mechanical chicken carcass washer.

Photo 24. Final cleaning tanks in series. Water is added to both tanks.

Photo 25 - Chicken processing solids collection pit.

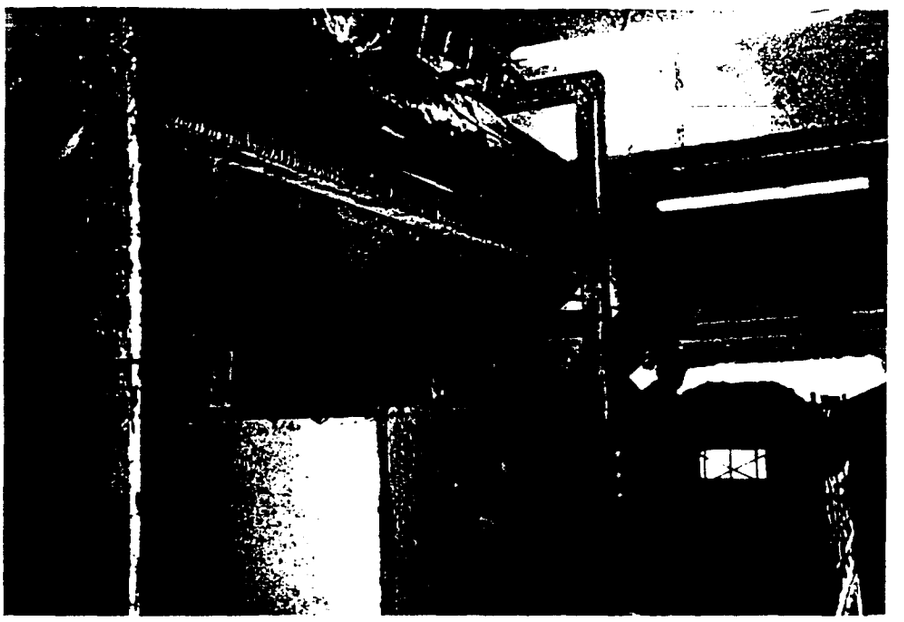

Photo 26 - Rotary drum filter in chicken processing area.

Photo 27 - Discharge from rotary drum filter to open floor drain (submerged).

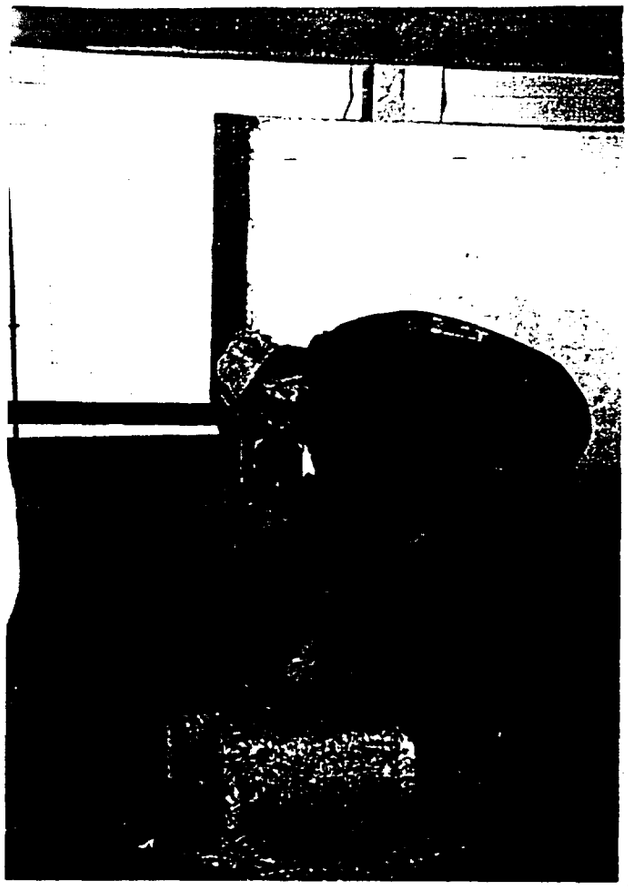

Photo 28 - Collection of grab sample from drum filter discharge.

Photo 29 - Collection of compsite sample from manhole serving the sheep/cattle processing area.

Appendix E

References

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Appendix F

PP/WM Background Report

Review of Pollution Prevention and Waste Minimization Techniques Used by the Meat and Poultry Processing Industry

FINAL REPORT

September 15, 1994

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United States Agency for International Development

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SAIC Project No. 01-0833-03-8167-100

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1.0 INTRODUCTION

1.1 Background

Under a contract with the United States Agency for International Development (USAID), Development Alternatives Incorporated (DAI) is performing an Industrial Wastewater Discharge Prevention (IWDP) Program in Amman, Jordan. The IWDP Program is one of the four components of the Water Quality Improvement and Conservation (WQIC) project funded by USAID. The Program is being performed by DAI with full coordination between the Jordanian Ministry of Water and Irrigation (MWI) and the Amman Chamber of Industry (Chamber).

The IWDP will be performed in three phases. The first phase requires completion of eight pollution prevention/waste minimization (PP/WM) opportunity audits by DAI and its sub-contractors. The second phase requires completion of Feasibility Studies (FS) for four of the audited facilities. Finally, demonstration projects will be completed for selected FS facilities.

Due to the high cost of waste treatment, as well as the need to minimize waste of raw materials and resources, it is in the best interest of businesses and industries to minimize their waste generating practices. Companies with effective PP/WM programs may well be the lowest-cost producers of goods due to their efficient practices. Waste management practices can include:

1. Reduce waste generation

   - Substitution of less hazardous raw materials in product manufacture
   - Alteration of products manufactured to eliminate need for hazardous materials use
   - Replacement or upgrading of outdated or inefficient process equipment
   - Development of employee training programs to ensure employees efficiently manage raw materials and resources.

2. Reuse waste materials prior to disposal

   - Reuse of uncontaminated raw materials and resources (including water)
   - Reprocessing of previously discarded materials (e.g., off-spec materials, used materials)
   - On site recovery of reusable materials (e.g., used solvents, waste heat, scrap).

3. Recycle waste materials

4. Treat wastes and dispose of residues.

The audits performed during this project will evaluate all available waste management alternatives and will provide site specific recommendations to assist the study industry in developing a comprehensive waste management strategy.

1.2 Objectives

The facility PP/WM audits are designed to assess the potential for pollution prevention and waste minimization at the study facilities. The goal of each audit is to evaluate and identify all possible PP/WM, wastewater clean-up, and water conservation techniques that are appropriate for the study facility. Audit documentation will consist of a background PP/WM assessment paper and an audit evaluation report. This document is intended to serve as the PP/WM background paper for the meat and poultry processing industrial sector.

The specific objectives of this audit are as follow:

1. Review general industry background data and identify "state-of-the-art" processing and waste management practices.

2. Work on-site with industry representatives, ministry officials, and other interested groups to review current processing procedures and identify possible PP/WM options.

3. Develop a report that evaluates all possible PP/WM alternatives and provides recommendations to the industry.

In order to complete the first objective, a comprehensive literature review was performed. This review included searches of the U.S. EPA Pollution Prevention Information Clearinghouse (PPIC) repository (and its corresponding database PIES), on-line library catalog databases, pollution PP/WM bibliographical references, and personal contacts with pollution prevention specialists. The review resulted in the identification of numerous references with a range of very general to very specific PP/WM techniques. Source documents were assessed to determine their applicability to this project and categorized appropriately. Documents pertinent to this project are included as Appendix A (Fact Sheets), Appendix B (Case Studies) and Appendix C (Bibliography).

Following completion of the literature review, the audit team will perform the on-site audit of the industrial facility. The audit will be performed with close consultation of industry representatives to ensure that they are aware of and support proposed actions. Audit activities will included the careful gathering of baseline water use and waste generation data, identification and assessment of potential PP/WM options, and solicitation of ideas and proposals from management and production line staff.

Finally, the audit findings will be summarized and option evaluated in the audit report. The audit will recommend the development of a site-specific program that meets the specific needs and goals of the audited facility. Audit recommendations will include both technical PP/WM recommendations (e.g., housekeeping practices, treatment options, etc.) and suggestions for PP/WM training for facility staff and follow-up studies to assess program successes.

2.0 INDUSTRIAL HISTORY

2.1 Red Meat and Poultry Slaughtering Industry in Jordan

The Ain Ghazel Slaughterhouse is the only facility in the City of Amman, Jordan that provides red meat and poultry slaughtering services. The facility is partly owned by the Greater Amman Municipality. A recent study evaluated process and operational characteristics of the Ain Ghazel facility and provided recommendations regarding the control of wastewater discharges. The information in this section of the report is summarized from this previous evaluation.

The Ain Ghazel facility was built in 1967 and has been expanded in several phases since that time. The buildings, equipment and facilities are relatively old and outdated. A replacement facility is under development in Marka, but will not be completed for several years. The Ain Ghazel facility, therefore, will likely continue its operation for at least 5 years.

The operations at the Ain Ghazel facility include two primary production lines. One line is for the slaughter and processing of cattle and sheep and the other is for the slaughter and processing of poultry (chickens). The production capacity reported for this facility is provided in Exhibit 2-1.

Exhibit 2-1 Production Capacity at the Ain Ghazel Slaughterhouse

Type of Animal	Number Killed (per day)	Live Weight Killed (tons/day)
Sheep	3000	90
Cattle	200	100
Chicken	30000	45

Due to import of meat from other foreign markets, the facility was not operating at capacity during the 1993 study. The actual production rates for the Ain Ghazel facility, recorded during the 1993 study, are provided in Exhibit 2-2.

Exhibit 2-2 Actual Production Rates During 1993 Facility Study

Type of Animal	Number Killed (per day)	Live Weight Killed (tons/day)
Sheep	1000	30
Cattle	30	15
Chicken	25000	38

The slaughtering and processing operations at this facility are consistent with those of the industry; however, due to the age of the facility and processing equipment, the level of automation is minimal, with many operations performed by hand. An overview of these processes is provided in Section 3 of this paper.

The water used at the Ain Ghazel facility is provided by the municipal supply system. The water consumption rates are reported as:

1. Sheep and Cattle Processing - 150 m^3/day
2. Poultry Processing - 480 m^3/day

This level of water consumption is low compared to industry averages reported for the United States; however, the previous study indicated that opportunities for water use minimization were apparent.

Wastewater generated by this facility is discharged to the sewer system for subsequent treatment at the municipal wastewater treatment facility. The discharge reportedly contains high levels of Biochemical Oxygen Demand (BOD) and suspended solids and is not in compliance with applicable discharge requirements. Wastewater flows are not routinely measured, but are assumed to be equivalent to the water consumption rate of 630 m^3/day. The facility also generates approximately 3 m^3/day of sanitary wastewater.

Previous studies indicate that the primary pollutants of concern for the facility are BOD, total suspended solids (TSS), fats, oils and grease (FOG), pH, and fecal coliform bacteria. This is consistent with typical slaughterhouse operations (see Section 4). The slaughtering operation is the source of the highest pollutant loadings, with blood contributing a high BOD load. Blood and paunch manure are reported as the primary sources of BOD and solids loadings. The arithmetic means for several parameters were developed from 30 samples collected during the previous study. The results of these analyses are provided in Exhibit 2-3.

Exhibit 2-3 Mean Pollutant Loadings from the Ain Ghazel Facility

Animal	Flow (m^3/day)	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)
Sheep/ Cattle	150	7.0	5600	8400	2135
Poultry	480	6.1	2350	5940	1620
Total	630	6.8	3120	5550	1750

The 1993 study of the facility recommended several PP/WM practices including development of better handling procedures for blood and paunch manure and proposed several end-of-pipe treatment technologies for control of discharges to the sewer system.

3.0 PROCESS OVERVIEW

3.1 Red Meat Slaughtering and Processing

The slaughter and processing of meat for human consumption is an integral segment of the food processing industry in most countries. Depending on the size of the population and the area served by the slaughterhouse, a facility may handle anywhere from several animals to several thousand animals per day. In addition, depending on local demand, a slaughterhouse may handle one or several types of animal. The functions of a modern slaughterhouse are described by Veall (1992) as follows:

- Reception and lairage
- Slaughtering and bleeding
- Dressing of animals
- Edible by-products recovery and processing
- Inedible by-products processing
- Storage of meat and by-products.

Regardless of the type of animal handled at a slaughterhouse, the general processes and functions remain the same. A diagram of the process flow in a typical slaughterhouse is shown in Exhibit 3-1.

3.2 Poultry Slaughtering and Processing

The operation of a poultry slaughtering and processing facility differs from facilities designed for larger animals in several ways. First, the number of animals handled at a poultry slaughterhouse is usually much higher than for large animals; often exceeding 10,000 animals per day. Because of this, the live animal reception and lairage facilities must be designed to accommodate the large number of animals that will be processed. Second, the slaughtering process is generally more highly automated in order to process the larger number animals. Additionally, the equipment used to process the large number of carcasses requires a higher degree of automation.

Processes commonly practiced at poultry slaughtering plant are described by Allwood and Coleman (1974) as follows:

- Receiving (reception and lairage)
- Slaughtering and bleeding
- Defeathering
- Eviscerating
- Chilling, packing and shipping.

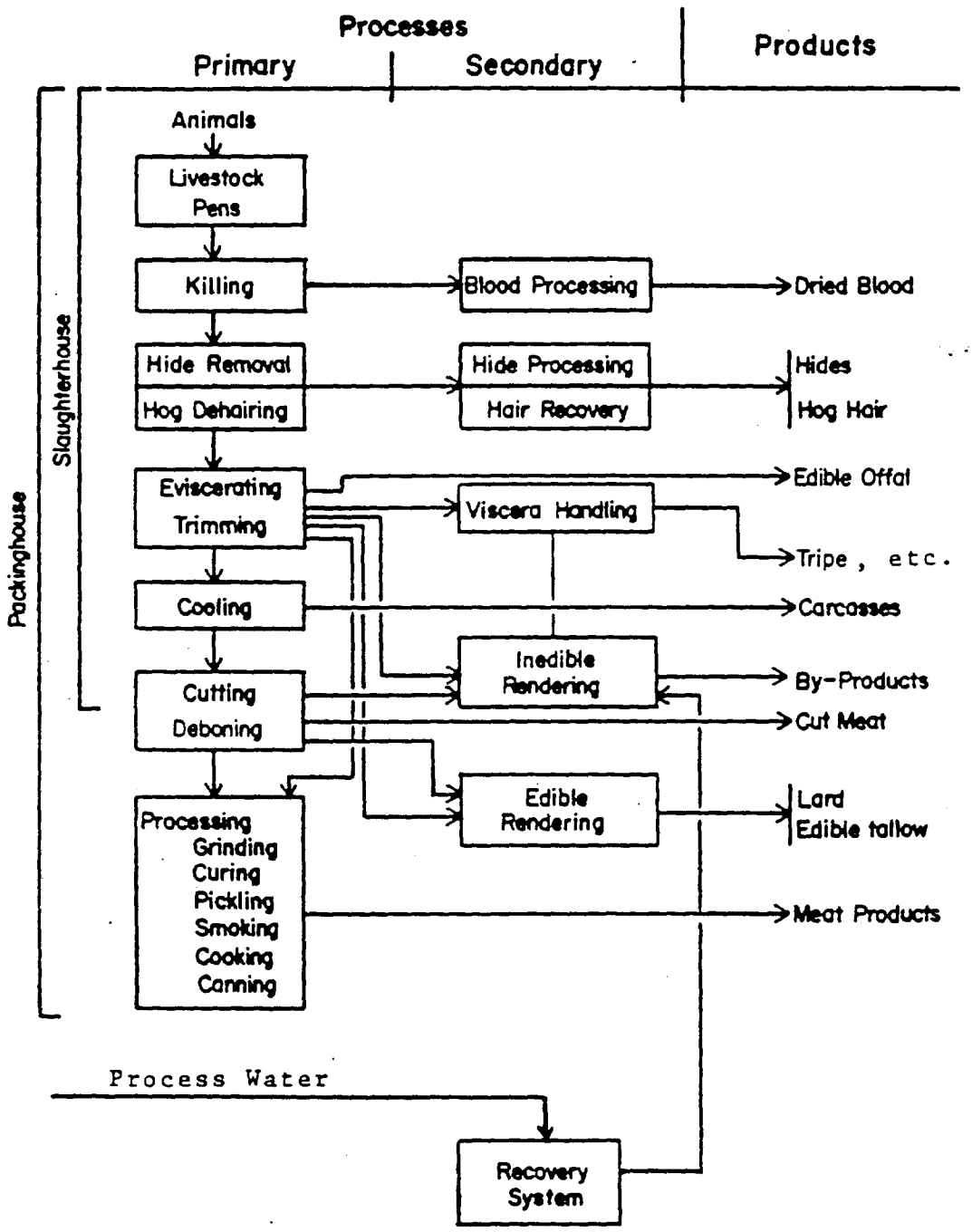

Exhibit 3-1 - Process Flow in a Typical Red Meat Slaughterhouse
(From: *Development Document for Red Meat Processing*, USEPA 1974a.)

Generally, the birds are slaughtered by severance of the jugular vein either mechanically or by hand. The feathers are then removed by a "scalding" process where high temperature water or steam is sprayed on the carcass, or the carcass is immersed in a tank of hot water. Feathers are then removed by a combination of mechanical and hand picking. Following feather removal, the carcass is eviscerated and edible by-products are removed for further handling. The head and lungs are also removed at this stage of processing, and the carcass is washed and prepared for chilling, packing and shipping. A flow diagram for a typical poultry processing facility is provided in Exhibit 3-2.

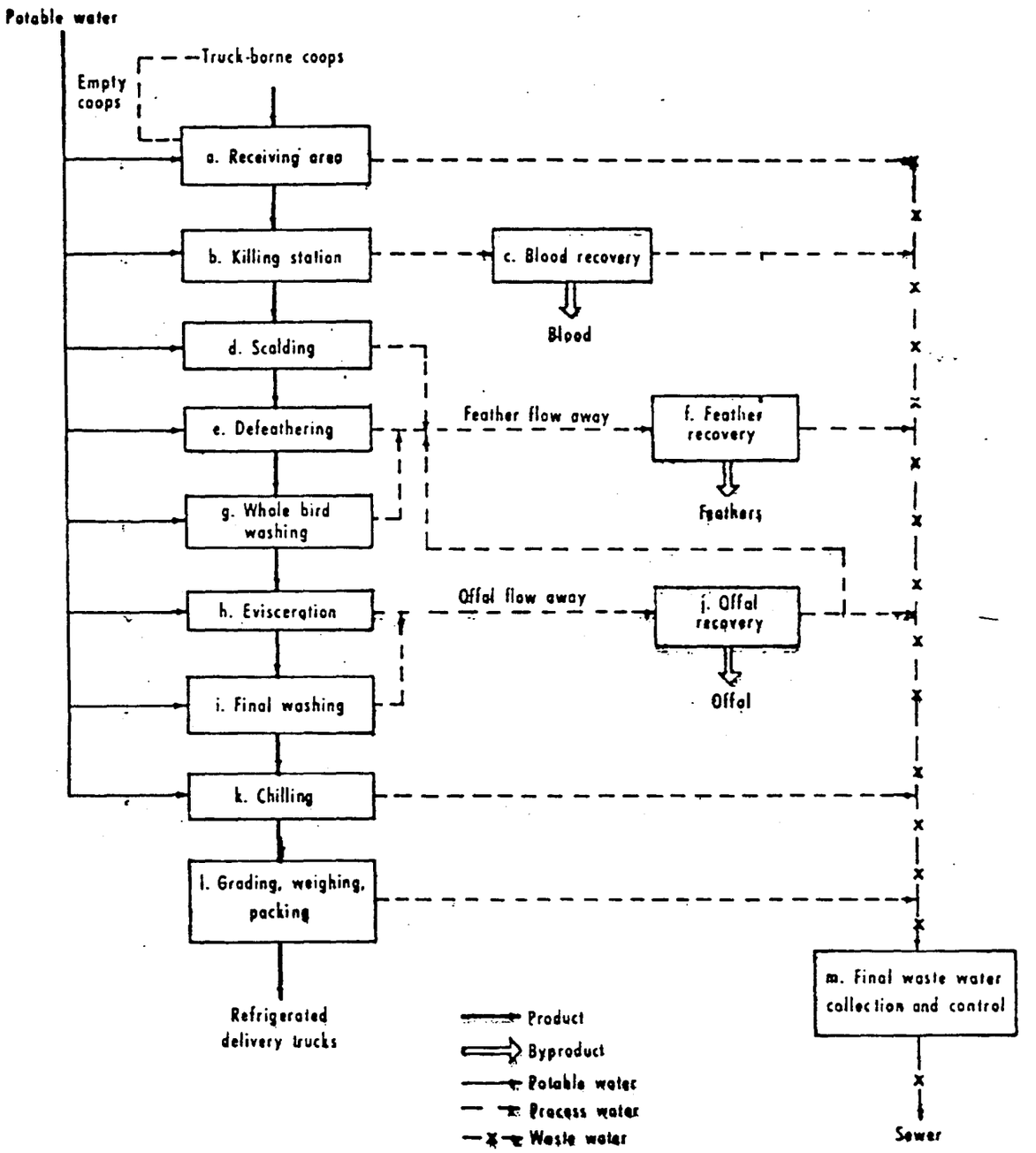

Exhibit 3-2 - Process Flow in a Typical Poultry Slaughterhouse
(From: *Economic Analysis for the Poultry Meat Processing Industry*, Allwood and Coleman 1974)

4.0 WATER USE AND WASTE GENERATION

4.1 Water Use in Meat and Poultry Slaughtering and Processing

Water is used extensively for cleaning and processing at facilities engaged in the slaughter and processing of both red meat and poultry. Several literature sources provided estimates of water flow requirements for typical meat and poultry processing facilities. The reported values are summarized in Exhibit 4-1.

Wastewater is generated in a slaughtering operation from the cleaning of products, and the removal of unwanted materials. Nearly all of the operations within a slaughterhouse generate some wastewater; however, the primary sources are the slaughtering floor (including bleeding processes), scalding and evisceration operations (poultry only), and paunch removal. Additionally, carcass washing, viscera and offal processing, and floor and equipment washing also require large volumes of water (USEPA 1974a., Veall 1992).

Exhibit 4-1 Water Use in the Meat and Poultry Slaughtering and Processing Industry

Reported Flow (liters/animal)	Industry Segment	Data Source
1000-1200	Cattle - Slaughter only	Veall 1992.
2000-2400	Cattle - Slaughter and by product processing	
2650 (1) 3690 (1)	Red Meat - Simple slaughterhouse Red Meat - Complex slaughterhouse	USEPA 1974a.
19-38	Poultry - Boiler production	McVaugh 1979.
32 40	Poultry - Slaughter and Evisceration Poultry - With further processing	Kerns and Holemo 1973

(1) Liters per 500 kg live weight killed

4.2 Waste Generation in the Meat and Poultry Slaughtering Industry

The primary pollutants of concern in the meat and poultry slaughtering industry, as reported in the literature (USEPA 1974a., Hrudey 1984., Cooper, et al. 1979), include the following:

- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Suspended Solids (TSS)
- Dissolved Solids (TDS)
- Fats, oils and greases (FOG)
- Nitrogen (ammonia, total Kjeldahl nitrogen)
- Phosphorus
- Chlorides
- pH
- Pathogenic organisms

Depending on the types of processes utilized by a given facility, the concentrations and loadings of these pollutants may vary widely.

The pollutants are introduced to the wastestream in the form of blood, paunch or rumen contents, fecal matter, washings and meat residues, fats and greases, feathers (poultry), and soil. The pollutants enter the wastestream through nearly all processes; however, the highest loads are reportedly introduced in the following areas:

- Slaughtering and bleeding - Blood, washings, fecal material
- Paunch or Rumen contents - Partially digested feed, manure, washings
- Floor and equipment washing - Blood, fecal material, meat residues, fats, feathers
- Carcass cleaning and preparation - blood, meat residues, fats, feathers
- Rendering - Fats, meat residues
- Edible and inedible by-products - Meat residues, fats, blood.

Water conservation and PP/WM activities should, therefore, focus on these production processes.

4.3 United States Effluent Guidelines

The United States Environmental Protection Agency (USEPA) has established numerical "effluent limitations" for several categories of the red meat slaughtering and processing industry. These limits, however, apply only to facilities that discharge treated effluent directly to a receiving water. Facilities that discharge wastewater to a municipal treatment plant are regulated directly by the local municipal government. There are no national effluent guidelines for the poultry slaughtering and processing industry.

The limitations established by USEPA are based on an evaluation of the "best available treatment (BAT)" for the types of wastes generated by the meat slaughtering and processing industry. USEPA gathered data on the performance of well operated treatment systems, statistically evaluated these data, and developed effluent limitations reflective of treatment system performance. Limitations are published in "production-based" format; thus, each facility will receive unique concentration-based limits depending on the production rate at the facility. Unique limitations are also developed for both a "daily maximum" (average over a calendar day), and a "monthly average" (average over a calendar month). A summary of limitations for selected meat processing industry categories is provided in Exhibit 4-2.

Exhibit 4-2 Selected USEPA Effluent Limitations

(All units are "kilograms per 1000 kilograms LWK" (Live Weight Killed) unless otherwise noted.)

Pollutant	Simple Slaughterhouse		Complex Slaughterhouse		High-Processing Packinghouse	
	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg.	Daily Max.	Monthly Avg.
BOD5	0.24	0.12	0.42	0.21	0.48	0.24
TSS	0.40	0.20	0.50	0.25	0.62	0.31
FOG	0.12	0.06	0.16	0.08	0.26	0.13
Fecal Coliform	400/100 ml max.	400/100 ml max.	400/100 ml max.	400/100 ml max.	400/100 ml max.	400/100 ml max.
pH	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0	6.0 - 9.0

[**Source:** *United States Code of Federal Regulations* (40 CFR Part 432)]

In addition to the numerical effluent guidelines for direct dischargers, USEPA has also established "general and specific prohibitions" that apply to all industrial facilities (including meat and poultry slaughterhouses) discharging to municipal wastewater treatment facilities. These prohibitions state that no industrial user of a municipal wastewater treatment plan can discharge any pollutant, or combination of pollutants that cause "Pass Through" or "Interference" at the treatment plant. In the context of the regulations, "Pass Through" and "Interference" are specifically defined, and refer to pollutants released at a flow rate or concentration that may upset biological treatment processes or that may pass through the treatment plant without sufficient treatment.

To implement the USEPA regulations, most municipal governments establish site-specific numerical limitations applicable to industries that are served by the sewer system. These limitations may be based on the treatment capacity of the municipal treatment plant, or on the technology available to industrial user to control its discharge. Facility specific limits are imposed and enforced by the municipality through discharge permits. In the United States permits issued to direct and indirect dischargers are enforceable by the Federal, State and local governments and private citizens.

5.0 POLLUTION PREVENTION AND WASTE MINIMIZATION

The types of pollutants introduced and wastewater flows generated by the meat and poultry processing industry are ideal candidates for PP/WM activities. In general, the wastes generated by this industry group are organic and non-hazardous; thus, they are more easily handled and reprocessed. Slaughterhouse wastes are often amenable to reuse or recycling in order to recover the nutrients, oils, or other by-products that remain in the organic material.

The high volumes of water used for cleaning and processing meat/poultry and their by-products can also be reused or recycled in many facilities. Water conservation has been practiced by many slaughterhouses, as well as other food processing facilities, and documented in successful case studies. Several of these are included in Appendix B of this report.

5.1 Water Conservation Techniques Used by the Meat and Poultry Slaughtering Industry

Studies have shown that as water use increases at a meat processing facility, its overall waste load increases (EPA 1974a., Hrudey, 1984). Where water is used indiscriminately, valuable recoverable product materials (e.g., meat by-products, blood, fats and greases) will be lost to the sewer. Efficient utilization of water at meat and poultry processing facilities should, therefore, result in lower costs for water consumption and waste disposal as well as increased revenue from reclaimed wastes. Water use minimization techniques have been successfully demonstrated in a number of facilities and have resulted in substantial cost savings. Several case studies which document these successes are provided in Appendix B of this report. In addition, Appendix A provides a variety of PP/WM fact sheets and guidance materials that may be useful in establishing a PP/WM program at food processing facilities.

To begin a successful water conservation program, plant management should establish specific goals for specific processes. The first step in the program requires an inventory of all water uses throughout the facility. This inventory should result in an overall plant water balance with all uses and routes of disposal accounted for. Management should them establish a plan to reduce water use by specific amounts in each segment of production. Hrudey (1984) proposes the establishment of in-plant controls based on the following premises:

- Downstream removal of pollutants is not as efficient as their initial exclusion from the sewer
- All drains should be equipped with threaded covers to discourage their removal. This will reduce the possibility of large solids being flushed with high volumes of water.

- Use of potable water should be justified, and quantities should be monitored and optimized.
- Non-potable water should be utilized wherever possible.
- Dry clean-up should be practiced where appropriate followed by controlled wet clean-up.

Literature sources describe water conservation methods applicable to slaughtering operations. The USEPA (1974a) suggests several methods for water use conservation. Several example of these practices are provided below:

- Replace drilled spray pipes with more efficient spray nozzles
- Replace washwater valves with hand, foot or knee operated squeeze valves
- Install foot pedal operated handwashing and drinking water sources
- Install spray washers or rinsers that operate on timers (set to reduce wash time)
- Replace water-based chillers with cryogenic (e.g., nitrogen) type coolers
- Use low volume, high pressure sprayers for cleaning operations
- Utilize low contamination wastestreams for lower quality needs

Several types of PP/WM techniques which demonstrate these water conservation are described in the literature. Specific case study examples and references are provided in Appendices B and C.

5.2 Waste Minimization Used by the Meat and Poultry Slaughtering Industry

Due to the nature of wastes generated by the meat and poultry slaughtering and processing industry (i.e., blood, meat residue, fats and greases, etc.), recovery and reuse techniques are widely practiced. A review of the literature identified many examples of recovery methods for both liquid and solid wastes generated by these types of operations.

The USEPA (1974a) suggests numerous PP/WM opportunities. A few examples of these techniques, applied to the processes and pollutant sources described in Section 3, are provided below. In addition, Exhibit 5-1 provides an overview of a waste reduction program suggested by USEPA for the red meat slaughtering and processing industry.

- Reception and Lairage: Pens should be covered and dry cleaned to minimize water use and contamination. Manure can be collected and used as fertilizer.

- Slaughtering and Bleeding: Blood should always be collected and used and should not be sewered. Water or steam are not necessary in the blood collection process. Blood should be cleaned from slaughter area using dry techniques. Blood water can be evaporated to concentrate proteins. Dried blood should be mixed with feed or manure and reused.

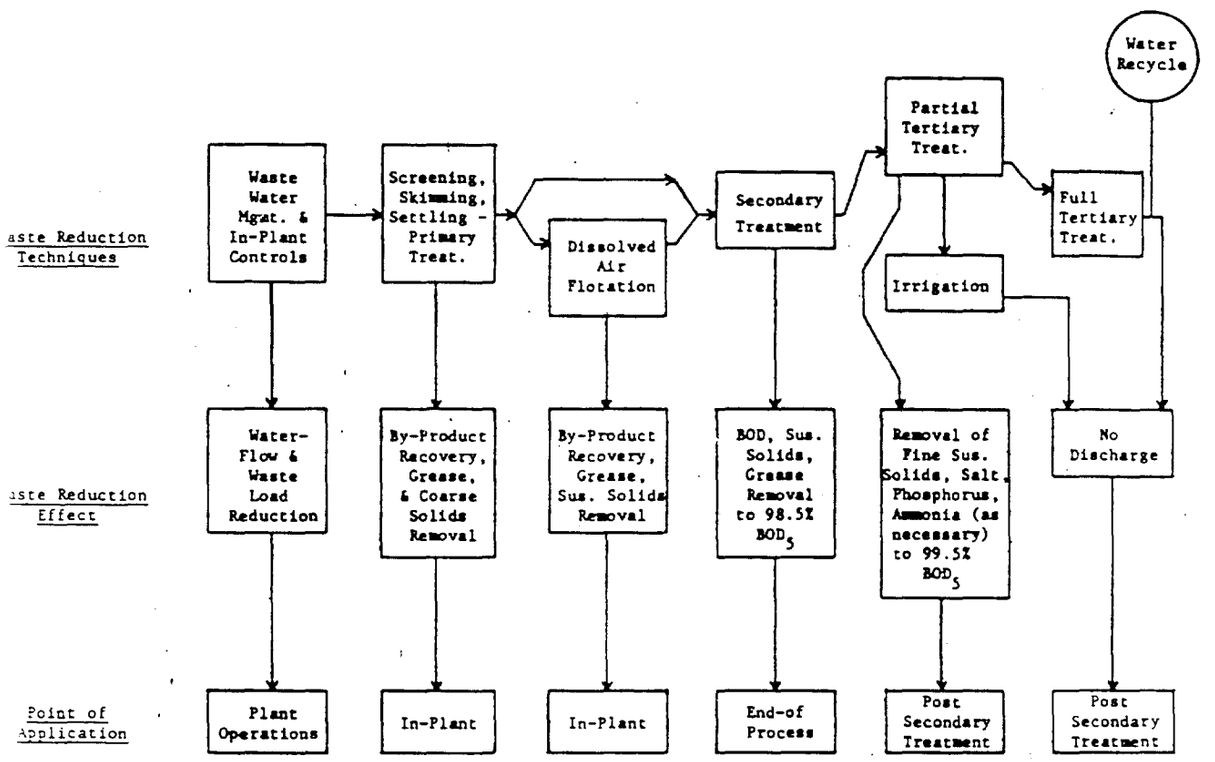

Exhibit 5-1 Suggested Meat Packing Industry Waste Reduction Program
(From: *Development Document for Red Meat Processing*, USEPA 1974a.)

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- Paunch/Rumen Removal: Water should not be used for initial dumping of paunch material. Dumped paunch should be collected and removed by dry methods followed by high pressure cleaning with minimal water use. Liquids screened from paunch should be evaporated or rendered, but not sewered.

- Scalding tanks (poultry): Collection screening, settling and reuse of this water should be considered. Slow drainage of the tank should be practiced to minimize shock loads the treatment system.

In addition to these PP/WP techniques, the literature is replete with examples potential uses for animal by-products. The Food and Agriculture Organization of the United Nations (FAO) has published guidance and bibliographical information on animal by-products utilization (FAO 1989 and FAO 1982). These documents describe many successful techniques currently being practiced by facilities throughout the world. Additional case studies and examples are provided in the selected case studies and references in Appendices B and C of this paper.

5.3 Treatment Technologies Used by the Meat and Poultry Slaughtering Industry

Slaughterhouse wastes are generally in the form of concentrated liquid wastewaters or solid organic wastes. The liquid wastes are typically discharged to a municipal sewer system, or are treated on-site and discharged to a receiving water. Solid wastes may be use directly as fertilizers, mixed with feed as a protein supplement, rendered for recovery of fats and greases, or landfilled as solid, non-hazardous wastes.

The liquid wastes generated by a slaughterhouse are characterized by high BOD, suspended solids, and dissolved solids. While the organic constituents of these wastewaters are readily biodegradable, and may be compatible with the treatment processes provided by municipal wastewater treatment plants, the wastestream may be of sufficiently high strength to cause upsets or "slug" loads to the treatment plant.

To prevent the discharge of an effluent that could cause shock loadings or slugs that can overload or upset the municipal wastewater treatment plant, several in-plant treatment options are available. These treatment processes can be categorized as either physical or biological systems. Chemical treatment of slaughterhouse wastes is not generally practiced, unless the facility wishes to remove dissolved solids, nutrients (nitrogen and phosphorus), or extract selected proteins for further processing. A schematic diagram of a wastewater treatment system at a red meat slaughterhouse, prior to sewering, is provided in Exhibit 5-2.

5.3.1 Physical Treatment Systems

Physical treatment processes at slaughterhouse facilities can include: flow and loading equalization basins; screens and filters; and, fat, oil and grease separation units. These processes and their applications are described below.

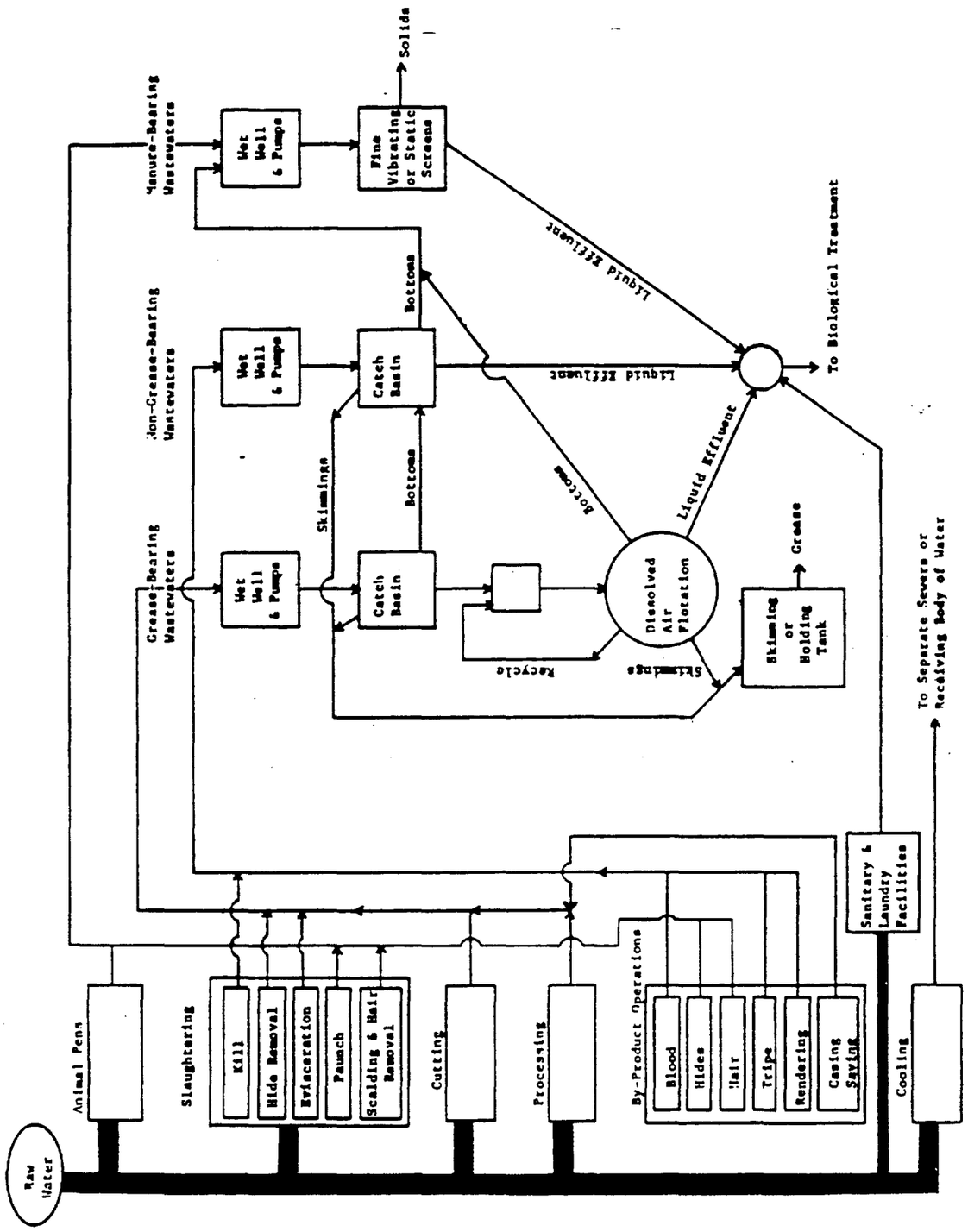

Exhibit 5-2 Integrated Treatment System at a Red Meat Slaughterhouse
(From: *Development Document for Red Meat Processing*, USEPA 1974a.)

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Flow Equalization:

Flow equalization is a relatively simple process that can yield substantial benefits with respect to mitigating shock loads to a municipal treatment plant. Equalization facilities consist of tanks and basins that hold flows from various processes, mix these wastestreams, and release a wastestream to the sewer at a relatively constant rate.

Equalization basins allow slaughterhouse facilities to combine high and low strength wastes and control the rate of discharge to their own treatment system, or a municipal sewer. This process reduces the potential for sporadic discharges of high strength wastewaters and allows the facility to release its wastestream under controlled conditions and during periods (such as late night) when the municipal treatment plant may more readily accommodate the additional loading. These systems are also attractive due to their low capital cost and minimal operation and maintenance requirements.

Screens and Filters:

A large percentage of the wastes generated at a slaughterhouse enter the wastestream in the form of solids. These wastes include meat cuttings, manure, feathers, and coalesced fats and greases. As these wastes are transferred through the sewer system, they tend to break down and release soluble organic matter to the wastestream. The soluble organic matter exerts a high BOD load and introduces nutrients to the wastestream that will have to be removed by the municipal treatment plant. The overall loading from these solids can be reduced, therefore, by removing them from the wastestream through screening and filtration prior to discharge the sewer.

Screens and filters can be installed in a slaughterhouse facility on individual process wastestreams or on the combined wastestream prior to sewering. In addition, screens can utilize a static, vibrating, or rotary design, depending on the characteristics of the solids to be removed. Screens can be used both as preliminary treatment to minimize loadings to subsequent biological systems, and to protect pumps and plumbing from damage caused by solids. As with equalization units, screens are simple to install and operate, and require low capital expenditures.

Fat, Oil and Grease Removal:

Fats, oils and greases (FOG) can be removed from the wastestream by a variety of methods including; catch basins, skimmers, and dissolved air floatation systems.

Catch basins are relatively simple units that trap large solids and floatable materials, but allow unrestricted flow to the wastestream. Trapped solids and floatables must be routinely removed from these systems to ensure their proper operation. Removal can be performed manually, or mechanically using a combination of skimmers, rakes and vacuum equipment.

Skimmers can be used to remove FOG where they are suspended in the wastestream. These systems allow and encourage the suspended FOG to coalesce on the surface of the separation unit where they can be removed by manually operated or mechanical skimmers.

Dissolved air floatation (DAF) units are highly effective in removing dispersed FOG from the wastestream. These units utilize fine air bubbles, which are produced by diffusers in the bottom of the separation tank, that promote the coalescing of the FOG as they ascend through the wastewater. The coalesced FOG is then removed by manually operated or mechanical skimmers.

The FOG removal systems described above each require a moderate capital expenditure and must be properly operated and maintained to ensure efficient pollutant removal. The advantages to these systems, however, can include significant reductions in difficult to remove contaminants, and the capture of animal FOG that can be rendered and recovered as a useful product.

5.3.2 Biological Treatment Systems

Because of the organic, biodegradable nature of the pollutants generated by slaughterhouses, a wide variety of biological treatment systems can be applied to these wastestreams. A brief description of anaerobic and aerobic treatment systems and their application to slaughterhouse wastestreams is provided below.

Anaerobic Treatment Systems:

Anaerobic lagoons are widely used by slaughterhouses to reduce organic loading prior to secondary treatment on-site or to discharge to the municipal sewer system. These systems can reportedly remove up to 95 percent of BOD and TSS and routinely achieve over 80 percent removal. Anaerobic lagoons are relatively simple to construct and operate and are less costly than other biological treatment systems. Problems associated with these systems include the potential for significant odor generation and high ammonia concentrations in the effluent.

Anaerobic contact systems are equally applicable to slaughterhouse facilities; however, they require significant expenditures for equipment and operation, and are not widely used. Their advantages include a high BOD removal rate in a short timeframe. Disadvantages include high cost and operational difficulties.

Aerobic Treatment Systems:

Aerobic treatment processes are generally used by the slaughterhouse industry as secondary treatment prior to direct discharge to a receiving water. The relatively high capital and operation and maintenance costs for these units generally preclude their use to pre-treat wastes prior to disposal to municipal sewers. Because the wastewater at the Ain Ghazel facility is discharged to the sewer system, a detailed description of these processes is not provided in this section. A list of the different types of aerobic processes that have been used by direct discharging slaughterhouse facilities, however, includes aerated lagoons, aerobic lagoons, activated sludge, trickling filters, and rotating biological contactors (RBC). A summary of the performance characteristics of each of these secondary treatment processes is provided in Exhibit 5-3, below.

Secondary Treatment System (number of systems used to determine averages)	Water Wasteload Reduction					
	Average Values			Exemplary Values		
	BOD_5	SS	Grease	BOD_5	SS	Grease
Anaerobic + Aerobic lagoon (22)	95.4	93.5	95.3	98.9	96.6	98.9
Anaerobic + aerated + Aerobic lagoon (3)	98.3	93.3	98.5	99.5	97.5	99.2
Anaerobic Contact Process + Aerobic lagoon (1)	98.5	96.0	99.0			
Extended Aeration + Aerobic lagoon (1)	96.0	86.0	98.0	96.0	86.0	98.0
Anaerobic lagoon + Rotating Biological contactor	98.5e	--				
Anaerobic lagoon + Extended Aeration + Aerobic lagoon	98e	93e	98e			
Anaerobic lagoon + Trickling filter (1)	97.5	94.0	96.0			
2-Stage Trickling filter (1)	95.5	95.0	98.0			
Aerated + Aerobic lagoon (1)	99.4	94.5	--	99.4	94.5	--
Anaerobic Contact (1)	96.9	97.1	95.8	96.9	97.1	95.8

e - estimated

Exhibit 5-3 Performance of Various Secondary Treatment Systems
(From: *Development Document for Red Meat Processing*, USEPA 1974a.)

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