Feasibility Study For A Bailing Plant

by

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Executive Summary:

Companies producing Fast Moving Consumer Goods (FMCG) are faced with great challenges when competing in such a demanding market. As the phrase Fast Moving Consumer Goods states, the movement of goods to the consumer must be as quick as possible, because of the high risk of contamination, which may lead to food poisoning. Best practices must therefore be applied in order to manage supply chains, transportation and inventory systems effectively.

Earlybird Farms, a company in this market, has an advantage over other competitors as the supplier of one of its main processes is a business entity, the well known Bailing Plant. The Bailing Plant supplies Earlybird Farms' broiler process with high quality bedding material, at a very competitive price. The quality of the bedding material has a major influence on the quality of the final product and therefore demands careful considerations when external factors impedes on the quality of the bedding material.

The location of the Bailing Plant is under consideration as its current lease agreement of the site is about to expire. A feasibility study is conducted in order to find an optimal solution for the plant's future facility plans from a set of alternatives without compromising the quality of its product. Engineering techniques and approaches are used throughout this project in search of the best solution.

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Chapter 1

Project Proposal:

1.1 Introduction and Background:

South Africa's poultry is mainly produced by a company named Astral Operations Limited, which consists of several divisions one of these divisions is Earlybird Farms. Earlybird Farms specializes in Fast Moving Consumer Goods (FMCG) and is well known for its wide variety of products produced at facilities in Standerton (in Mpumalanga), Olifantsfontein (in Gauteng) and Camperdown (in Kwazulu Natal). Products such as feed pre-mixes, complete feed, hatching eggs, day old chicks and broilers can be purchased under brands like Festive, Goldi, Super Star and Mountain Valley.

The focus of this project is only on the production of broilers, in the poultry-farming process:

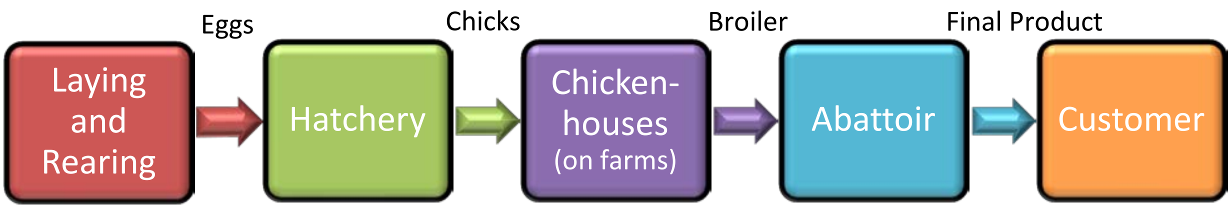


Figure 1 Poultry (broiler) process

Eggs are laid at the Laying and Rearing facility, then taken to the Hatchery where it is placed in a setter and then in a hatching-chamber for 21 days. The chicks are distributed to several chicken-houses, where they will be reared for 35 days. The broilers are then taken to the abattoir where they are slaughtered and processed to a final product, ready to be sent to customers.

As the company processes a total of 2.6 million broilers per week, it focuses primarily on safety and delivering a wide range of products to customers, on time and at a competitive price.

Earlybird Farms' broiler process is regarded as a leader in the market. The process' input cost is kept to a minimum since the Bailing Plant has a great impact on cost control. The Bailing Plant is a non-profit business subsidiary which supplies the chicken-houses with bedding material at the minimum cost. Bedding material is an essential part of keeping chickens healthy. It serves as a blanket to keep them warm as well as to absorb moisture from the chicken manure. If the moisture is not absorbed, a rash may break out, leading to infection, which causes irritation, a deterioration in meat quality and a foul smell.

Thus, it is of great benefit to Earlybird Farms to buy high quality bedding material at a competitive price from a trusted company for its broiler production process.

1.2 Problem Statement:

Earlybird Farms is facing a challenge in terms of the Bailing Plant's future. The plant is currently operated from a foreign company's (Investec) property and this lease agreement is about to expire and the indication is that the rent is to be increased. Thus, a decision must be made as to the plant's next premises.

The original raw material supplier to the Bailing Plant was situated close to the plant, but closed down some time ago. The Bailing Plant then found a replacement, but it is situated 17.7km from the plant, which has a great effect on cost.

The pending renewal of the lease agreement provided an opportunity to evaluate a premise for the Bailing Plant which will benefit the company in total, for example:

- Renew the present agreement
- Rent a facility at another location
- Build the company's own facility
- Close the plant down and buy bedding material from an outside supplier

The influencing factors emanating from these decisions are described below, but the evaluated factors will be described in the scope:

- Renew the agreement at the current premises
    - Monthly lease expense
    - Travelling distance among the new facility, sites and supplier
    - In – and outbound transportation cost
    - Current facility dimensions
    - Operating costs (overheads, production etc.)

- Relocate to another facility
    - Monthly lease expense
    - Travelling distance among the new facility, sites and supplier
    - In – and outbound transportation cost
    - Operating costs (overheads, production etc.)
    - Moving of equipment
    - Required facility dimensions

- Build a new facility
    - Real estate cost
    - Facility construction cost
    - Facility concrete floor cost
    - Operating costs (overheads, production etc.)
    - Moving of equipment
    - Travelling distance among the new facility, sites and supplier
    - Required facility dimensions
    - In – and outbound transportation cost

- Close the plant down
    - Equipment and machinery market value
    - Bedding material's purchasing price

The abovementioned factors must be investigated carefully, as the outcome of this project will influence Earlybird Farm's sustainability in the market.

1.3 Project Aim:

This project aims at finding an optimal solution regarding the premises of the Bailing Plant, while maintaining the quality of the final product and customer service levels.

The aim of the project is based upon:

- Identifying available alternatives for the premises of the Bailing Plant
- Detection of the applicable factors that will have an influence on the solution
- Investigating the implications of these factors of the alternatives

1.4 Project Scope:

For the purpose of this project, focus will only be on the Bailing Plant, at the Olifantsfontein sector, within Earlybird Farms, which plays a key role in the broiler process. The area of interest can be seen in the shaded part of figure 2. The activities that will be covered in the scope of this project are mainly:

- the transportation of raw material from the supplier to the identified plant (inbound transportation)
- distribution of the product to the chicken-houses (outbound transportation)
- Defining the plant size (area required) and the warehouses of the final product
- Production and establishment cost calculations to support the final decision

Other products produced by Earlybird Farms, activities of Standerton and Camperdown, as well as the remainder of the broiler process (the part in figure 2 without shading), are not included in this project.

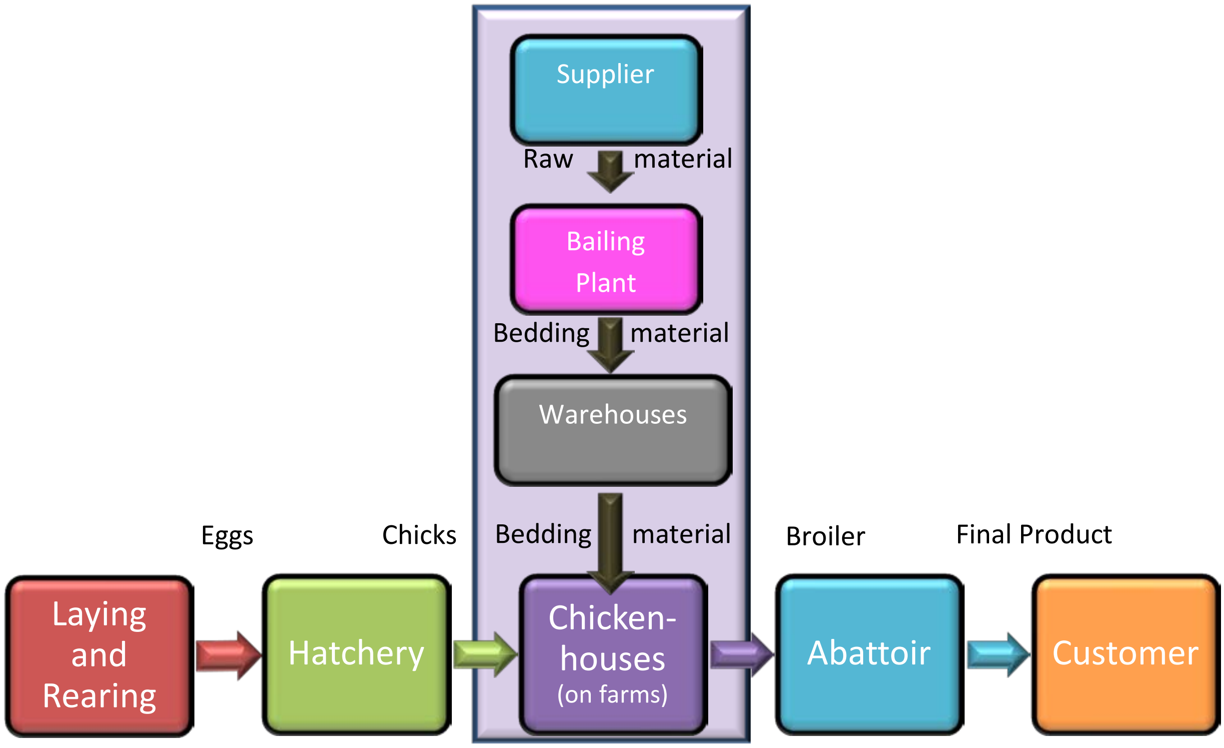


Figure 2 Project scope

The layout of the Bailing Plant and optimization of its processes are not within the scope of this project. Included in the scope of the overall project is to determine which alternative to select among the premises as stated in section 1.2, based on certain criteria, techniques and approaches.

The implementation of the solution found by this study is not included in the scope of this project.

1.5 Deliverables:

- Thorough summary of Bailing Plant's activities and process flow
- Comprehensive description of alternatives and applicable factors
- Documented cost structure
- Report on final solution and possible improvements

1.6 Project Plan

1.6.1 Activities and Tasks:

- Comprehensive analysis of the industry (research)
- Thorough analysis of the Bailing Plant's processes and activities
- Compile an extensive summary of the industry
- Compile an extensive summary of the Bailing Plant's activities and processes

- Identify possible alternatives for the plant's location
- Identify factors of interest for each alternative
- Complete an in-depth analysis for each alternative, making use of engineering techniques
- Prioritise factors regarding its influence on the solution
- Gather accurate data and information on these factors
- Execute required calculations
- Weigh the alternatives against each other
- Select the most feasible alternative
- Present the outcomes of the project to the board of Ealrybird Farms

1.6.2 Resources:

During the course of this project the following resources will be used:

- Earlybird Farms employees
- Bailing Plant employees
- Project leader (Ms Jozine Botha)
- Internet (as communication and research medium)
- Computer
- External companies (for quotations and information)
- Transportation to visit the required facilities and sites
- Stationary
- Research resources such as textbooks, journals, databases etc.
- Funds
- Time

1.6.3 Budget:

Expenses that the student expects to incur during the course of the project are:

Expenses:	Amount:
Traveling	R 400
Telephone	R 50
Internet	R 100
Stationary	R 50
Printing	R 150
Total	R 750

Table 1 Estimated budget

Chapter 2

Literature Study:

A sustainable solution for the Bailing Plant problem can only be found after the environment and market impact on Earlybird Farms of the proposed alternatives have been analysed with the aid of contemporary literature, which discusses different approaches, techniques and tools.

2.1 Facilities planning defined:

Technology is ever-changing and new competitive approaches are discovered and implemented on a regular basis. If a company does not adapt to new discoveries it will certainly loose its competitive edge as competitors will capture the market with advanced technology, management techniques and processes.

According to Tompkins[10] (Tompkins et al, 2010), facilities planning is a process that:

- Determines how a tangible fixed asset of an activity must contribute to meet a company's overall objective
- Designs a facility and determines its location
- Is a combination of art and science
- Can use engineering design processes to find a solution
- Should be seen as a life-cycle that is a continuous opportunity for enhancement
- Is one of the leading opportunities for cost reduction and improvement of productivity

Tompkins[10] (Tompkins et al, 2010) states that facilities planning is not only a science but a strategy, which plays a key role in the success of any supply chain analysis. When facilities are well planned the effectiveness of the supply chain will be improved and this can be accomplished by planning facilities that are:

- Flexible – When a facility can adapt as changes are made in the supply chain, without being transformed
- Modular – If a facility can collaborate with a variety of operating rates
- Upgradable – When a facility can incorporate upgrades in technology and systems
- Adaptable – Implications of variance in the use of a facility must be considered
- Selective operable – The importance of understanding each facility segment and how it functions
- Environmental and energy friendly – Taking on the process of leadership in energy and environmental design (LEED), an approach to the sustainability of site development, water savings, energy efficiency, material selection and indoor environmental quality (Tompkins et al, 2010)[10].

2.2 The importance of facilities planning:

According to Tompkins[10] (Tompkins et al, 2010), facilities planning is so important that its study field will continue to grow as it holds a great promise for increasing the rate of productivity improvement. Statistics have shown that 20% to 50% of manufacturing operating expenses is assigned to material handling, but by the improvement of the facilities plan it can be reduced by 10% to 30%. Thus, in the United States the productivity of manufacturing would increase about three times more than anytime during the past 15 years. When the impact of effective facilities planning on an order picking system and equipment was measured, it showed that the total cost of operation has been reduced by 30% (Tompkins et al, 2010)[10].

2.3 Objectives of facilities planning:

The following are objectives of facilities planning as explained by Tompkins[10] (Tompkins et al, 2010):

- Improving customer satisfaction levels
- Increasing return on assets
- Increasing customer response time
- Increasing profitability of the supply chain
- Integrating the supply chain by improving communication and partnership
- Supporting the company's goal
- Utilizing resources well
- Maximizing return on investment
- Promoting easiness of maintenance and adaptability
- Offering job satisfaction, safety, energy conservation and environment responsibility
- Enabling endurance and flexibility

2.4 Feasibility study methodology:

According to Hofstrand[4], a feasibility study is a methodology that is used to determine whether an idea will work and if one should proceed with changes by revealing the strengths and weaknesses of opportunities, extortion and other challenges that the environment presents. It tests the viability of an idea while emphasizing the importance of identifying problems that may occur. It identifies the required resources and enables the user to forecast the success of the outcome. The sooner a potential failure is realized the more time and money is saved.

Feasibility has five areas of interest, denoted by the acronym TELOS – Technology, Economic, Legal, Operational and Scheduling (Hofstrand[4]):

- Technology and system feasibility – Technological feasibility is applied when one wants to determine whether the capability of a company is sufficient to complete the project, in terms of software, hardware, personnel and competence. The valuation is built on the strategy of system requirements regarding input, processes, output, fields, programs and procedures. In order to determine if the new system will perform satisfactorily, the valuation can be quantified by data volumes, trends, updating frequency etc.

- Economic feasibility – Economic analysis is one of the main techniques used when the efficiency of a new system is to be determined. It refers also to a cost/benefit analysis, where the cost to be incurred by the proposed system is compared with the benefits and savings offered by the output of the system. The cost and benefit factors must be determined as development cost and operating cost. The proposed system will be designed and implemented if its benefits outweigh the costs. In a time-based study the time required to obtain a return on investments is analysed. Here the project's future value plays a vital role.

- Legal Feasibility – When a proposed system is analysed according to legal requirements.

- Operational feasibility – Operational feasibility determines how effectively the problems are solved by the new system, and it uses the identified opportunities to its advantage while evaluating the applicability of the identified requirements.

- Schedule feasibility – It measures the sensitivity of the project's timetable as it estimates the development time of mandatory and desirable deadlines of the system.

There are also other feasibility factors (Hofstrand[4]):

- Market and real estate feasibility – Development of a real estate project requires a market feasibility study which involves the testing of geographic locations and portions of real estate land, while considering the importance of business in the selected area. Market studies are often conducted to determine the best possible location (within legal requirements), especially with alternative land uses for specified portions.

- Resource feasibility – Here the study is concerned with sufficient available time to build a new resource system for a business, when it can be build and whether it will have an influence on the normal business activities. Also, which resources are necessary and how many?

Hofstrand[4] states that when a proposal appears effective and pleasing it may seem unnecessary to conduct a feasibility study, but a study will force the stakeholders to put their ideas on paper and to assess whether it is as realistic as it appeared in the beginning. It is also the first step into the formal evaluation of the strategic plan (Hofstrand[4]).

2.4.1 Hofstrand and Holz-Clause's[4] approach to a feasibility study:

Factors that must be considered when business ventures are studied for feasibility are:

- Cash flow and generated profits
- Ability to withstand the risks that it will encounter
- Ability to remain viable in the long run
- Ability to meet the intended goals

Steps to follow (Hofstrand[4])**:**

- Evaluate alternatives – After a set of alternative ideas have been discussed, specific business scenarios are identified in order to study these alternatives in more detail.
- Pre-feasibility study – Conducting a pre-study first may assist in deleting certain scenarios. When found that an idea is not feasible during the pre-study, time and money are saved.
- Market assessment – This assessment may assist in determining the feasibility of a planned product in the marketplace and identifying possible opportunities. If no opportunities are found, the study must be terminated, if there is an opportunity then the assessment can provide insight to the scenarios that must be investigated.
- Results and conclusions – Conclusions of the study should state the examined scenarios, implications, strengths and weaknesses.

The best alternative will probably not be over convincing, but the study will assist one in assessing the trade-offs between the risks and rewards of proceeding with a specific alternative (Hofstrand[4]).

2.4.2 Witt's[13] approach to a feasibility study:

Will Witt[13] states that any project must go through the following steps in order to be successful, as seen in figure 3:

- Step 1 – Identify and clarify every aspect of your objective
- Step 2 – Identify the possible ways to accomplish the objective
- Step 3 – Select and optimize the best alternative for reaching the objective
- Step 4 – Convince everybody that the selected alternative is the best one to reach the objective
- Step 5 – Execute the project

Step 1 and 2 must show that the idea will work. Step 3 and 4 must show how to make the idea work. More and better detail must the provided at every stage before going to the next stage, where more obstacles will appear. It is very important that the relevant data in steps 1 to 3 be available otherwise the feasibility study must be cancelled.

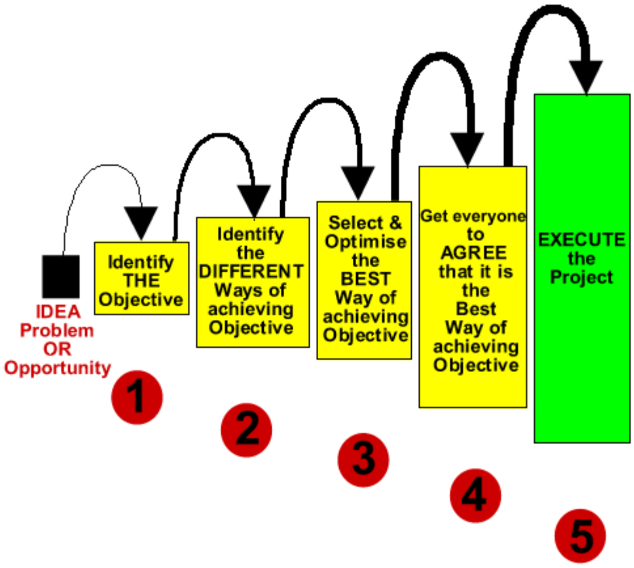


Figure 3 Witt's approach to feasibility study

2.5 Feasibility study techniques:

2.5.1 Decision matrix:

A decision matrix is a technique that is often used for selecting a decision among a set of options. (Valuestreamguru, 2012)[11]. An example is shown in table 2:

Criteria	Weight	Available Options					
		Option 1		Option 2		Option 3	
		Rating	Score	Rating	Score	Rating	Score
Health and safety	1	3	3	3	3	3	3
Quality control	2	2	4	1	2	2	4
Customer satisfaction rates	3	1	3	3	9	2	6
Total	6	6	10	7	14	7	13

Table 2 Decision Matrix

The criteria together with the weight of the criteria are listed vertically and form the basis of the decision. The alternative options are listed horizontally. Each criterion is weighed according to importance and should be an accurate indication of the situation by addressing the following two questions:

- What is important?
- Why is it important?

Each option is then rated, against each criterion. The weight that the criterion carries is then multiplied with the specific option's rate, to determine the score. This calculation must be completed for each option and the total is then found by adding the scores for each option. The option that receives the highest score is the best option according to the decision matrix (Valuestreamguru, 2012)[11].

2.5.2 Decision tree:

According to James Holloway,[5] a decision tree is a technique that is very useful when one wants to visualize choices and possible outcomes when a specific decision is made. The choice that will probably produce the best outcome can be identified by using this method. Decision trees can become very complicated but in its simplest form can be regarded as a type of flow chart.

A decision tree can be constructed as follows (Holloway,2012)[5]:

- Sketch a small box (containing the decision to be made) on the left-hand side of a paper
- Draw a line from the box to the right-hand side which will represent each possible outcome of the decision
- Draw another small box on a line wherever another decision is to be made
- If the outcome of the decision is uncertain and depends on external factors, a circle is drawn on that particular line
- A line must be drawn for every outcome of all the uncertain situations
- In order to complete the structure of the diagram, ensure that each branch of the tree contains an uncertain situation and its possible outcomes
- A value must be assigned to each outcome. These values may be monetary or simply a numerical evaluation of how desirable the specific outcome may be
- Each outcome must be allocated with a probability value (between 0 and 1). The sum of the probabilities from outcomes from each node must equal one
- Each decision that results in uncertainty must be assigned with a cost value which is on the same scale as the values of the outcomes (monetary or a scale of cost and reward)
- Each value of an outcome must be multiplied with its probability and then added together in order to determine the value of each node
- To determine the final score of a branch the cost that leads to that specific node must be subtracted from the node's final score
- The nodes must be compared with one another. The node that leads to the highest value after the cost has been deducted is the node that will lead to the best possible outcome.

An example of the structure of a decision tree can be seen in figure 4 where the decision to make a new product or to consolidate, is being evaluated.

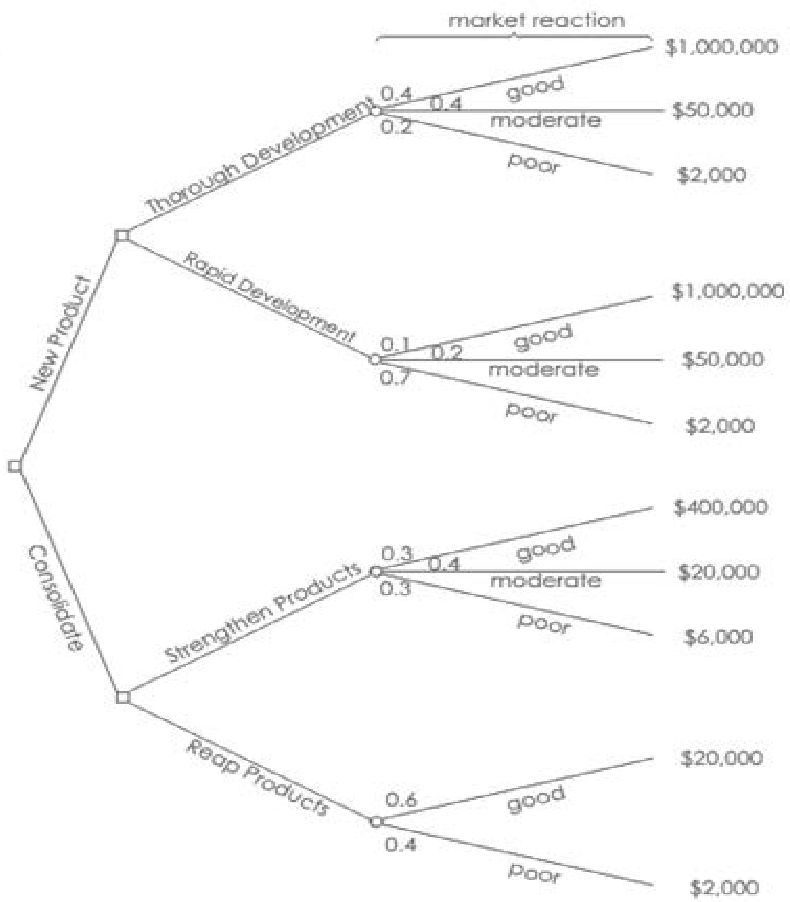


Figure 4 Decision tree

2.6 Formulating a location strategy:

According to Karl Heil,[3] a location strategy is a plan that is used when the best possible location for a company is to be established. The company will generally attempt to minimize the costs and threats but maximize the opportunity. The needs and objectives of the company must be defined, and locations that fulfil these needs and objectives must be identified.

Heil[3] states that the following factors are included when formulating a location strategy:

- Facilities – Determining space requirements for long- and short-term goals, included in facilities planning
- Feasibility – Assessing the different operating costs and other factors associated with each alternative location
- Logistics – Evaluating the transportation options and cost for the prospective manufacturing and warehousing facilities
- Labour – Analysing whether the company's labour requirements are met by the prospective locations

- Community and site – Evaluating whether the company will be compatible with the prospective community and site in the long-term
- Trade zones – Evaluating the benefits offered by free-trade zones (free-trade zones are closed facilities that are monitored by customs services, where goods can be brought without the usual customs requirements)
- Political risk- Must be considered when a company plans to expand into other countries
- Governmental regulation – Government barriers and restrictions when attempting to expand to other countries
- Environmental regulation – Consider the environmental regulations that may be applicable to a specific location
- Incentives – Assess the chance of negotiating with a community in terms of property and any benefits that the company may receive

The first part of developing a location strategy according to Heil,[3] is to identify the company's requirements for a location, which are listed as:

- Size – What size is needed for the facility?
- Traffic – When in the service industry, statistics of traffic or pedestrians passing the location must be obtained
- Population – Population must be considered at the proposed locations to ensure that there is enough customers/workers
- Total costs – What is the maximum amount that the company will pay for the facility?
- Infrastructure – Requirements for transportation modes, telecommunication services and equipment
- Labour – Determine the labour criteria and level of skills needed
- Suppliers – Establish the kind of suppliers that will be needed near the location
- Unique requirements – Any requirement that is unique to a company/industry

2.7 Location selection techniques:

2.7.1 Heil's[3] location selection techniques:

The main techniques used for selecting locations among different regions and communities are:

- Factor – rating systems
- Linear programming (operations research)
- Centre of gravity

2.7.1.1 Factor - rating systems:

It is a technique that is often used and is similar to the decision matrix. It contains a weighted list of important factors that will be used as criteria and a range of values for each criterion, see table 3. Each site location is then rated with a number from the range, based on the costs and benefits that are offered by each alternative. This value is multiplied by the specific weight. The total factor rating is calculated simply by adding these values. The total ratings can then be compared in order to identify the best alternative.

Table 1

Sample Factor-Rating System

Factor	Rating (1-100)	Weight	Factor-Rating
Energy availability	60	.3	18
Labor availability	80	.2	16
Transportation	40	.2	8
Supplies	90	.1	9
Taxes and regulations	70	.1	7
Infrastructure	70	.1	7
Overall Factor-Rating	—	—	65

Table 3 Factor – rating system for a location

2.7.1.2 Operations research systems:

Operations research as presented by (Winston & Venkataramanan, 2003)[12] is a scientific methodology that is used when decision making is to be improved. It tries to find the best design and operating system by assigning conditions to limited resources. The word "system" refers to a group of interdependent components that works together in order to achieve its objective. This approach to decision making implicates that mathematical models are applied, which will improve decisions and clarify uncertainties in the real situation.

Generally, models are used that are either prescriptive or optimizing. A prescriptive model "prescribes" actions for a company in order to help it to accomplish its goals. Prescriptive models consist of (Winston & Venkataramanan, 2003)[12]:

- Objective function(s)
- Decision variables
- Constraints

An optimization model looks for decision variables' values in order to optimize (minimize or maximize) an objective function. These resulting values are selected among a set of all values that satisfy the given constraints for the decision variables (Winston & Venkataramanan, 2003)[12].

The objective function is the function that must be optimized, for instance the profit must be maximized or the expenses must be minimized. A problem can have multiple objective functions.

Decision variables are the values that influence the system's performance and are controlled by the modeller, for example the volume of a container (in litres).

Constraints are those restrictions that accept only certain values for the decision variables. For example, certain values for temperature combinations may be dangerous and must therefore not be allowed.

The feasible region is the area where any specification of the decision variables satisfies all of the constraints. An optimal solution is any point in the feasible region which optimizes the objective function and can be determined by using a programming package like LINGO (Winston & Venkataramanan, 2003).[12]

Winston[12] states that the following models exist in operations research:

- Static and dynamic models
- Linear and nonlinear models
- Integer and non-integer models
- Deterministic and stochastic models

Operations research can be applied in numerous situations, like solving transportation or inventory problems. With transportation problems, the scheduling of the scarce resources (like trucks) can be prescribed while the optimal inventory level can be determined by using an optimization model. Location problems can also be solved by using operational research as the optimal location will be found within a feasible region.

2.7.1.2.1 Linear programming model:

A linear model is when decision variables that appear in the objective function and constraints of the optimization model are always multiplied and added together (Winston & Venkataramanan, 2003).[12]

According to Heil,[3] linear programming is an approach that is often used to determine cost associated with a specific location. Total costs can be determined by the use of a matrix which contains the following:

- Production facilities and warehouses
- Unit shipping cost from a manufacturing location, denoted by variable X to proposed destinations (like warehouses) denoted by other variables E, F and G
- Amount of goods that can be produced by proposed manufacturer X
- The same information for each proposed manufacturing location

When the total cost for each alternative location has been determined, the one with the lowest total cost can be identified.

2.7.1.3 Centre of gravity:

According to Heil[3] this approach is used by many companies that wish to determine the optimal location for a facility, especially distribution warehouses. This method considers existing locations, distances between them and the volume of the products to be transported.

One can apply this technique by plotting the existing locations on a grid with any coordinate system. Then the relative distances between the locations must be found. The centre of gravity is determined by calculating the X and Y coordinates that will reveal the location with the lowest transportation cost.

2.7.2 Tompkins'[10] facility location model:

Tompkins[10] states that the location of a facility is essential to its success and this model can assist in determining the optimal location similarly to the centre of gravity approach.

Tompkins[10] classifies facility location problems as:

- Number of new facilities to be located – Categorize between single-facility location problems and multi-facility location problems
- Solution space – Categorize between a continuous (location can be anywhere within a two- or three-dimensional region) or a discrete space (location can only be at a specific place)
- Criteria used to determine the location – Categorize between a minisum location problem (locating one or more new facilities in order that the weighted sum of distances among pairs of facilities is minimized) and a minimax location problem (locating one or more new facilities in order that the weighted maximum distance travelled from a new facility to an existing or new facility is minimized)
- Categorize between points in two- or three-dimensional space and areas
- Distance measure used in the model – Categorize between four distance measurements:
    - Rectilinear distance – Measures path distances that are perpendicular to each other
    - Straight-line distance – Measures straight-line path between two points
    - Chebyshev distance – The measured distance between two points in a two-dimensional space is greater than the horizontal and vertical distance travelled
    - Actual distance – Measures distance along the actual path crossed between two points

All the applicable coordinates must be obtained as well as the amount of travel among facilities for a single–facility rectilinear minisum location problem. Then the sum of the weights must be determined. The first partial sum of a coordinate that is greater or equal to one half of the sum of the weights, will be the optimal coordinate. If the identified optimal location is impossible to implement, the objective function can be used to determine the best available location (Tompkins et al, 2010).[10]

2.8 Facility space requirements:

2.8.1 Tompkins'[10] approach to determine space requirements:

Determining the space required when planning a facility can be very difficult as the plan must consider possible future changes for 5 to 10 years. Significant uncertainty exists when the impact of technology, changes in demand, product mix and organizational designs is kept in mind. The facilities planner must usually project true space requirements from overstated estimates as the great uncertainty causes individuals to exaggerate requirements. Aside from the uncertainty the Parkinson's law also exists, leading to more obstacles. The Parkinson's law implies that even though there is adequate planned space for the future, there will be no space left when the future arrives, as all available space will be filled by expanded fixed assets.

When determining space requirements, Tompkins[10] states that the following requirements must be considered:

- Warehousing activities
- Inventory levels
- Storage units
- Storage methods and strategies
- Equipment
- Building constraints
- Personnel

Production, storage area and office space requirements have changed significantly as modern approaches are established. Space requirements are reduced due to several reasons (Tompkins et al, 2010)[10]:

- Just in time delivery of products
- Decentralized storage areas are situated near points of interest
- Inventory levels have decreased
- Layout arrangements are improved
- Companies are scaling down
- Sharing offices and improved communication
- Outsourcing is being implemented

2.8.1.1 Workstation Specification:

A workstation comprises of fixed assets which are necessary to complete certain operations, therefore it is quite important as its productivity compares to that of the company. A workstation needs space for equipment, materials and personnel (Tompkins et al, 2010).[10]

The space required for equipment in a workstation involves:

- Equipment
- Travelling of machines

- Maintenance machines
- Plant services

Tompkins[10] states that the space required for equipment can be obtained from machinery data sheets. The floor area requirement for a machine, including machine travel can be determined as follows:

Floor area requirements for a machine is

$$A = B \times C$$

where

A = Floor area required for a machine
B = Total width, i.e. static width + maximum travel to the left and right
C = Total depth, i.e. static depth + maximum travel toward and away from the operator
D = Total machinery area for a machine
E = Maintenance area requirements
F = Plant service area requirements
G = Machinery area requirement for the workstation
n = Number of machines in the workstation

and
Total machinery area for a machine is

$$D = A + E + F$$

and
workstation area requirement is

$$G = \sum_{i=1}^{n} D \qquad \text{where } n \geq 1$$

According to Tompkins[10] the space required for material in a workstation involves:

- Received and store inbound materials
- Hold materials that is being processed
- Store and ship outbound materials
- Store and ship waste material
- Holding maintenance materials, tools and fixtures

In order to know the space requirements for receiving, storing, shipping and holding material the flow of material through the machine as well as the dimensions of the unit loads must be known. The number of unit loads stored at the machine as ingoing and outgoing material must have adequate space available. Space requirements for holding maintenance materials, tools and fixtures depends on whether it is stored at the workstation or in a centralized storage room. It is generally desirable to have a centralized storage room, because expensive and special tools could be shared among many workstations (Tompkins et al, 2010).[10]

Tompkins[10] mentions that the space required for personnel in a workstation involves:

- Operator's working area
- Material handling
- Entering and exiting of operator

The way in which operations are executed will determine how much space is necessary. The methods used to perform operations can be identified by the use of a motion study of the task and an ergonomics study of the operator. Factors to keep in mind when conducting these studies are (Tompkins et al, 2010)[10]:

- The operator must handle materials without walking and making difficult reaches
- The operator must be utilized effectively
- Manual material handling must be a minimum
- Safety, comfort and productivity of the operator must be increased
- Danger, exhaustion and eye strain must be minimum
- Adequate illumination of the machine and work area

According to Tompkins[10] the space needed for an operator to enter and exit an area is as follows:

- Travelling past stationary objects: Minimum of 0.762 m aisle
- Travelling between an operating machine and a stationary object: Minimum 0.914 m aisle
- Travelling between two operating machines: Minimum 1.067 m aisle

2.8.1.2 Department Specification:

Tompkins[10] states that after determining every workstation's space requirements, the requirements of each department can be calculated, but the departmental service requirements must first be established. It is possible that tools, plant services, housekeeping items, storage areas, operators etc. may be shared in order to save space and resources. However, it must be kept in mind that areas needed by individual workstations must not cause operational obstructions when these areas are combined. Each department needs additional space for material handling within the department. Aisle requirements can be estimated when the load sizes are known. Departmental service requirements equal the sum of the service requirements for the individual workstations in that department. These requirements together with the departmental requirements must be documented on a departmental service and area requirements sheet.

2.8.1.3 Aisle Space Specification:

Tompkins[10] mentions that aisles are designed to increase effective flow at a facility. If the aisles are too wide space will go to waste and poor housekeeping activities may result. If the aisles are too narrow congestion may appear with an increase in hazards and damages.

Factors to be considered when the aisle widths are determined are the type of flow and the volume of flow. The type of flow includes the kind of material handling equipment and the people that use the aisle must be specified. When people and material handling equipment use the same aisles, safety requirements is important, therefore it is imperative to clearly mark the aisles that are used by equipment. Aisles should be straight to avoid clogging and columns which are used to border the aisles, will often be located in the aisle when it is not considered in the space requirements.

2.8.1.4 Personnel Specification:

According to Tompkins[10] the space required for personnel in a facilities plan involves:

- Employee parking
- Restrooms
- Health services
- Office

Employee parking must be planned according to the number of automobiles and their type. Restrooms must be located within 60 m of each permanent workstation. Decentralized restrooms for each sex are preferred by employees. Provision must be made for handicapped employees.

Tompkins[10] feels that it is hard to plan a facility's requirements for health services. The minimum requirements at the least are a first aid room of minimum 9 m^2 with an approved first aid kit, a bed and two chairs.

Tompkins[10] states that planning an office can become difficult as each office employee has their own judgment on how to plan the office space. It is important to keep in mind which activities will be executed in the office in order to identify the space requirements.

2.8.1.5 Receiving and shipping area specification:

In order to determine the space requirements for receiving and shipping, the following steps must be followed:

1. Determine what is to be shipped and received
2. Determine the number and type of docks
3. Determine space requirements for receiving and shipping inside within the facility.

In order to determine the total space requirements for truck manoeuvring outside a facility, one can do the following:

- Determine required number of docks
- Establish truck flow patterns
- Determine if 90° docks may be used otherwise select the largest angle finger dock according to available space
- Specify dock width
- Establish apron depth for the specific dock width

- Determine overall outside requirements by allocating the space determined in previous step for the number of docks required

2.8.2 The Environmental Protection Agency's[1] approach to determine space requirements:

According to the Environmental Protection Agency (EPA, 2004)[1] when determining space requirements for a facility, the following technical and performance characteristics must be considered:

- Amount and type of space
- Location of the facility
- Lease terms (when applicable)
- Proposal submission guidelines
- Evaluation of criteria for alternatives
- Project schedule
- Base building requirements (appearance, quality, code compliance, building systems)
- Tenant fit-out requirements (when applicable)
- Building services, utilities and maintenance
- Miscellaneous provisions (parking, landscaping, security)

The EPA[1] states that in order to explain the company's specific requirements and to form a basis for developing the facility layout, the following factors must be addressed:

- List the number and type of space for the facility's office, workstations, laboratories and support spaces
- List the applicable special spaces like conference space, storage of hazardous materials, food services etc.
- Describe the building systems with relation to lighting, power, telecommunication needs, ventilation etc.
- Security system requirements
- Interior finishes
- Proposed furniture

2.9 Cost evaluation techniques:

2.9.1 Net present value (NPV) method as described by (Kolakowski, 2011)[6]:

Net present value is a technique that is often applied when capital budgeting decisions must be made as to whether a project or investment is acceptable or not. This method applies the fundamental concept of economics and finance that is known as Time Value of Money.

According to Kolakowski[6], the NPV method can be applied as follows:

- The project or investment at stake must be analysed in order to determine the cash flows as well as the period in which it will occur
- If money is spend the cash flow will be negative, and positive if it is received
- Each future cash flow must be converted to its equivalent present value, therefore an appropriate interest rate (or discount rate) must be determined for each period
- The present values of all cash flows (negative and positive) must be added up to determine the NPV
- If the NPV ≥ 0 the project is acceptable
- If the NPV < 0 the project is unacceptable

2.9.2 Cost benefit analysis according to (Reh, 2011)[8]:

A cost benefit analysis is a method used to determine whether the outcome of an action will be positive or negative. It can be applied in many situations but is mainly used as a decision making tool when companies are faced with financial ventures.

F. John Reh[8] states that when a cost benefit analysis is undertaken, all the benefits associated with the venture must be found, quantified and added together. Then all the cost must be identified, quantified and subtracted. The difference between the benefits and the cost will reveal whether the venture is advisable or not. If the difference is positive the venture is acceptable, if it is negative it is not advisable. It is of great importance to include all the cost as well as all the benefits and to ensure that they are properly quantified.

2.9.3 Routing and scheduling according to (Haksever & Render, 2000)[2]:

In routing and scheduling problems the main objective is usually to keep the cost of providing a particular service to a minimum. These costs may include mileage, vehicle capital cost and employee cost. Other objectives may be to minimize distance and travel time. Graphical networks are often used to present routing and scheduling problems visually which makes it easier to understand.

In order to find a solution to minimize cost the tour must also be feasible which means that:

- The tour must include all nodes
- A node must only be visited once
- The tour must begin and end at a depot

Routing and scheduling systems are relatively alike regarding the output as a route or schedule must be provided for each vehicle (or provider). The route specifies the sequence in which nodes must be visited while a schedule specifies when each node must be visited. A pure routing problem is one where the customer being serviced has no time restrictions and no precedence relationships. A scheduling problem is when there is a specified time for the service to take place. A combination of these 2 problems may also exist (Haksever & Render, 2000).[2]

Routing and scheduling problems depends on characteristics of the service delivery system like delivery fleet size, where the fleet is housed, vehicle capacities and the objectives. These problems can be classified as follows (Haksever & Render, 2000)[2]:

- Travelling salesman problem (TSP) – A single vehicle problem where the nodes are only visited once and the route begins and ends at the depot node. The objective is to minimize cost by developing a set of routes
- Multiple travelling salesman problem (MTSP) – An extension of the TSP problem as it has a fleet of vehicles to be routed from a single depot. A set of routes must be generated, one for each vehicle. A node will be assigned to only one vehicle while each vehicle will have many nodes assigned to it. The solution to this problem will reveal the order in which each vehicle visits its assigned nodes
- Vehicle routing problem (VRP) – Problems where the capacity of multiple vehicles are restricted and varying demands at the nodes may occur
- Chinese postman problem (CRP) – The demand is on the arcs (not the nodes). These problems are very complex to solve

Mathematical programming is used as a basis in order to solve travelling salesman problems optimally. But when problems become too complex it is impossible to find an optimal solution. When approximate solutions are acceptable or when finding an optimal solution is impossible, heuristics are applied. The heuristics that are mainly used for the travelling salesman problem are the nearest neighbour procedure and the Clark and Wright savings heuristic (Haksever & Render, 2000).[2]

For multiple travelling salesman problems one wishes to construct a tour for each vehicle by breaking it down to many single-vehicle travelling salesman problems, one for each vehicle. Then the same approaches (nearest neighbour procedure and the Clark and Wright savings heuristic) can be applied for each individual problem.

2.9.3.1 Nearest neighbour procedure:

According to Haksever and Render (2000),[2] when using this procedure a tour is designed, based on only the cost or distance travelling from a last-visited node to the closest one in a network. It is relatively simple but may be a disadvantage as it is short-sighted. An estimated optimal solution is generated from a distance matrix by applying the following procedure:

Step 1 - Start with the depot node, which is the node at the beginning of the tour

Step 2 - Identify the node which is closest to the previous node on the tour

Step 3 - Repeat the previous step until all the nodes have been added

Step 4 – To form a complete tour the first and the last nodes must be connected

2.9.3.2 Clark and Wright savings heuristic:

Haksever and Render (2000)[2] states that the Clark and Wright savings heuristic is one of the most popular techniques used when the travelling salesman problems is to be solved. In order to apply the abovementioned technique a depot node must be selected and labelled as node 1. The assumption must be made that there is $n - 1$ vehicles available (if n is the number of nodes). Each vehicle must travel from the depot directly to a node and back to the depot. As the objective of TSP is to have all nodes visited by only one vehicle, the number of vehicles required must be reduced by combining the $n - 1$ tours that have been specified originally.

The computation of savings (trip length or cost) is the key to success when applying this technique. Savings can be accomplished by 'hooking up' a pair of nodes and to then to create a tour to be assigned to a single vehicle. Haksever and Render (2000)[2] explain that the savings for every possible pair of nodes is to be determined (for a network with n nodes), then the saving gains must be placed in a decreasing order and only then can a tour be constructed by linking the pairs of nodes in order to find a complete route.

As a summary, Haksever and Render (2000)[2] state the following:

1. Select any node as the depot node (label it as node 1)
2. Compute the savings, S_{ij} for linking nodes i and j (if i and j = nodes 2, 3, …n)

$$S_{ij} = c_{1i} + c_{1j} - c_{ij}$$

where C_{ij} = traveling cost from node i to j

3. Rank the savings from largest to smallest
4. Form larger sub-tours by linking appropriate nodes i and j by starting at the top of the list. Stop when a complete tour is found.

2.9.4 Transportation method according to (Aquilano & Chase, 2009)[14]:

The transportation method under discussion is a linear programming technique (par 2.7.1.2.1) that is often used for solving transportation problems. The aim is to meet the objective of either minimizing the cost or maximizing the profit when products are to be delivered from various sources to several destinations.

Linear programming models can be solved by a graphical method if there are only one or two variables, otherwise software like LINGO, Matlab and even Microsoft Solver from Microsoft Excel can be used. The steps to follow when using Microsoft Excel are:

1. Define changing cells – The cells where the variables will be presented
2. Calculate the total profit or cost – This is the objective function which will be calculated by multiplying the variables produced by Solver with the associated cost
3. Set up the resource usage – Enter the capacity of all the resources and any other constraints
4. Set up Solver –
   4.1 Select the objective function cell as the target cell and select the minimize or maximize option
   4.2 The "by changing cells" option refers to the area of cells which Solver can change to satisfy the objective function
   4.3 Enter all the constraints in the area labelled "subject to the constraints"
   4.4 Select the assumptions of a linear model and non-negativity
5. Solve the problem – Click on solve and a solution will be presented

Chapter 3

Solution Approach:

The approach that will be followed in order to obtain a solution to the problem of the Bailing Plant is explained by data analysis, alternative facilities plans and data gathering of the current environment:

3.1 Data analysis:

Data must be obtained and investigated in order to acquire a good understanding of the environment (industry), the problem as well as the application of the relative methods to be able to reach the objectives. The calculations required for this project will be presented in chapter 4.

3.1.1 Feasibility study methodology:

As the literature study revealed, the methodology of the feasibility study plays an essential role in determining whether a business opportunity or decision is viable. Therefore it is decided that a feasibility study will be conducted by using Witt's approach (par 2.4.2) as it clearly explains how the study must be executed and it considers all the factors that is of importance to the Bailing Plant's situation after the new facilities have been established.

3.1.2 Feasibility study technique:

The optimal decision among various alternatives should be based on mathematical calculations, which eliminate biased or subjective views and fortunately, these techniques have been discussed in the literature in the previous chapter.

A decision matrix, as explained in the literature study will be used to identify the most viable alternative out of a set of alternatives. This technique may be used on almost any problem as the criteria can be generated according to one's specific needs and it is very effective as it gives a visual representation of decision making, which may be useful to refer back to the motivation of a specific decision. The criteria that will be used are location, space requirements and costs (operating cost and transportation costs).

The optimal solution will be calculated by applying the theory of:

- Tompkins[10] for the location and space requirements
- Reh[8] for the operating cost calculations and
- Aquilano & Chase[14] for determining the transportation cost

These theories are regarded as the most applicable to find a new location for the Bailing Plant.

The probabilities of the popular decision tree are to be agreed upon by a team of various disciplines before it can be accepted as applicable to the problem. A lack of time and professional fees prohibits this approach.

For the purpose of this project, the final conclusion and recommendations will be based on the outcome of a decision matrix. Software like Microsoft Excel can be used to calculate the rates and to construct the matrix.

Some alternatives will be biased by construction cost, which is a once-off cost during the first year. However, the study focuses on a sustainable future, which stretches for many years after construction.

3.1.2.1 Location selection technique:

The method to determine the optimal location is Tompkins' facility location model as explained in par 2.7.2. The application of this technique enables one to determine an optimal location accurately, without the use of complicated software compared to the complex software, e.g. LINGO used in operations research models.

After determining the optimal location, the location(s) from the identified set of alternatives close to the optimal location, will receive a higher score in the decision matrix (where the final decision will be made) under the distance criterion.

By using this model the global positioning system (GPS) coordinates as well as the number of journeys from the new facility to the chicken-houses must be obtained from the plant supervisor. The optimal location will then be determined by using Microsoft Excel software. The locations of the alternatives can also be sequenced in order of decreasing optimality.

3.1.2.2 Facility space requirements approach:

The space requirements will be determined by using Tompkins' approach as a guideline, as discussed in par 2.8.1. The approach is explained very well and it is from a trusted source. This approach addresses all the required factors that are to be considered when determining the space requirements. All the data required to make a realistic estimation of space requirements will be obtained from interviews with experts in the industry, physical measurements and observations.

3.1.2.3 Cost evaluation techniques:

A cost benefit analysis, as discussed in par 2.9.2, will be used to evaluate the cost implications of each alternative. Costs and benefits (income) must be identified and quantified. The necessary values must be obtained from the Bailing Plant's income statements and interviews with the financial team.

Facility construction, concrete floor's cost and the transportation of the machinery must be obtained by quotations from construction and transport companies. Real estate agents can also be consulted to find cost of land and monthly lease expenses. The values that are not known must be estimated in a realistic manner. Microsoft Excel will be used to create a template and formulas will determine the output of the analysis.

3.1.2.3.1 Transportation cost:

The transportation cost of the different alternatives is required when one is to decide among the alternatives. Linear modelling can be used to determine these costs as it will optimize the distance travelled between warehouses and chicken-houses for each alternative, subjected to a set of constraints.

The distances can be obtained from using Google Earth and the model can be solved with Microsoft Excel Solver. This transportation problem is not too complex for Solver, therefore this tool is preferred as other mathematical programs are very complex and sensitive to use.

In this case a linear model will be appropriate as the objective function as well as the constraints are calculated by linear formulas.

3.2 Generate alternative facilities plans:

The alternatives and influencing factors that were identified in section 1.2, will be used together with the output from the data analysis in order to compare the alternatives with one another. The rating and comparison of the alternatives will be done in the decision matrix which will reveal the final solution.

3.3 Data gathering of the current environment:

3.3.1 Bedding Material:

Bedding material is a vital aspect in a chicken's life cycle, as young chicks are unable to maintain their body temperatures. An environment that can provide the required temperature is needed to keep the chick's body from using energy to control its temperature to normal body temperature. Whenever the body is trying to reach a temperature of about 32.5℃, the growth and development process is delayed, resulting in poor performance, disorders, diseases and sometimes death.

In order to create an environment where the chicks' optimal temperature is sustained, bedding material is used as an isolation material. Earlybird Farms also uses a coal burning heat source to heat the houses on several sites where the chicks are taken after they have hatched. The bedding material minimizes the heat escape through the concrete floors. This isolating material is working quite effectively as it decreases the coal usage from 12 ton per house per cycle to 9 ton.

Apart from isolating the houses, bedding material serves as a blanket for the chickens to rest on as well as absorbing the moisture from the manure. Irritation, rash and infection may occur when failing to provide a dry environment, which will lead to a bad smell and a decrease in the quality of the final product. The raw material that the Bailing Plant uses for producing bedding material is sunflower husks, supplied by Willowton Oil.

3.3.2 Bailing Plant:

The Bailing Plant is a subsidiary company of Earlybird Farms, which supplies the chicken-houses with bedding material at minimum cost. This contributes to the competitive price of the final product to the customer. Thus, the Bailing Plant plays an essential role in the broiler process. Operational information of the plant is as follows:

There are 5 trucks (8 – 12 ton each) available for inbound transportation, which unloads 48 loads in one month at the plant's receiving point. There are 3 trucks (8 – 12 ton each) available for outbound transportation. The fuel consumption for a loaded truck is 40 litre/100 km diesel and 25 litre/100 km diesel for an empty truck.

The annual operation of the Bailing Plant is divided into cycles, viz. 7 cycles per year, which means that the plant must supply each chicken-house 7 times per year with bedding material. The houses must be prepared with fresh bedding material at the beginning of a new cycle, before the chicks are delivered. (A cycle equates to a rearing period.)

The Bailing Plant purchases raw material for R280/ton and sells it to the farmers at the chicken-houses for approximately R650/ton in 20 kg plastic bags, or R612/ton in 85 kg bales (woolsacks). The plant prefers the woolsacks instead of the plastic bags as it is reusable and long lasting, while the plastic bags are used only once, but the woolsacks are very expensive and difficult to obtain. The plastic bag workstation requires more labour than the bales workstation, which uses more machinery.

The Bailing Plant has agreed with its supplier that there will always be a truck waiting to be filled with raw material between operating hours. Thus, inventory levels will be high as raw material will continue to flow into the plant for as long as the supplier has material available.

The warehouse of the Bailing Plant can currently only store bedding material for two days. If the demand is greater than the supply, bedding material is shipped from the off-site warehouses (warehouses close to the chicken-houses). If the supply is greater than the demand, the inventory levels of the off-site warehouses are increased.

The available warehouses are as follows:

- Hekpoort
- Kaalplaas
- Tedstone
- Shannon
- The Bailing Plant

3.3.2.1 Bailing Plant's activities:

An extensive process flow of the Bailing Plant's activities are as follows:
As seen in figure 5, the raw material is delivered from the supplier (Willowton Oil) to the Bailing Plant's receiving point. The transportation activities between the supplier and the Bailing Plant are referred to as inbound transportation (the shaded part on the left hand side of the figure).

The raw material is then distributed from the receiving point to the applicable workstation with a grain bucket elevator where the raw material will be processed.

At the plastic bag workstation the raw material is processed by labourers compressing the material into black plastic bags. At the bales workstation a bailing press compacts the raw material into woolsacks.

The products are then moved to the finished goods storage area or directly to the shipping area with trolleys. A mobile bag stacker conveyor then loads the items onto a truck. (Note that there is no difference between the plastic bag products and the woolsack products except for the packaging size, with a ratio of 4:1 respectively.)

The outbound transportation can be seen in the shaded part on the right hand side of the figure. It includes the following transportation between the plant's shipping area and off-site warehouses (close to the chicken-houses); between the Bailing Plant's warehouse and the chicken-houses (on farms); between the off-site warehouses and the chicken-houses (on farms).

When the bedding material is unpacked at the chicken-house, it goes through a disinfecting process whilst been spread across the floors.

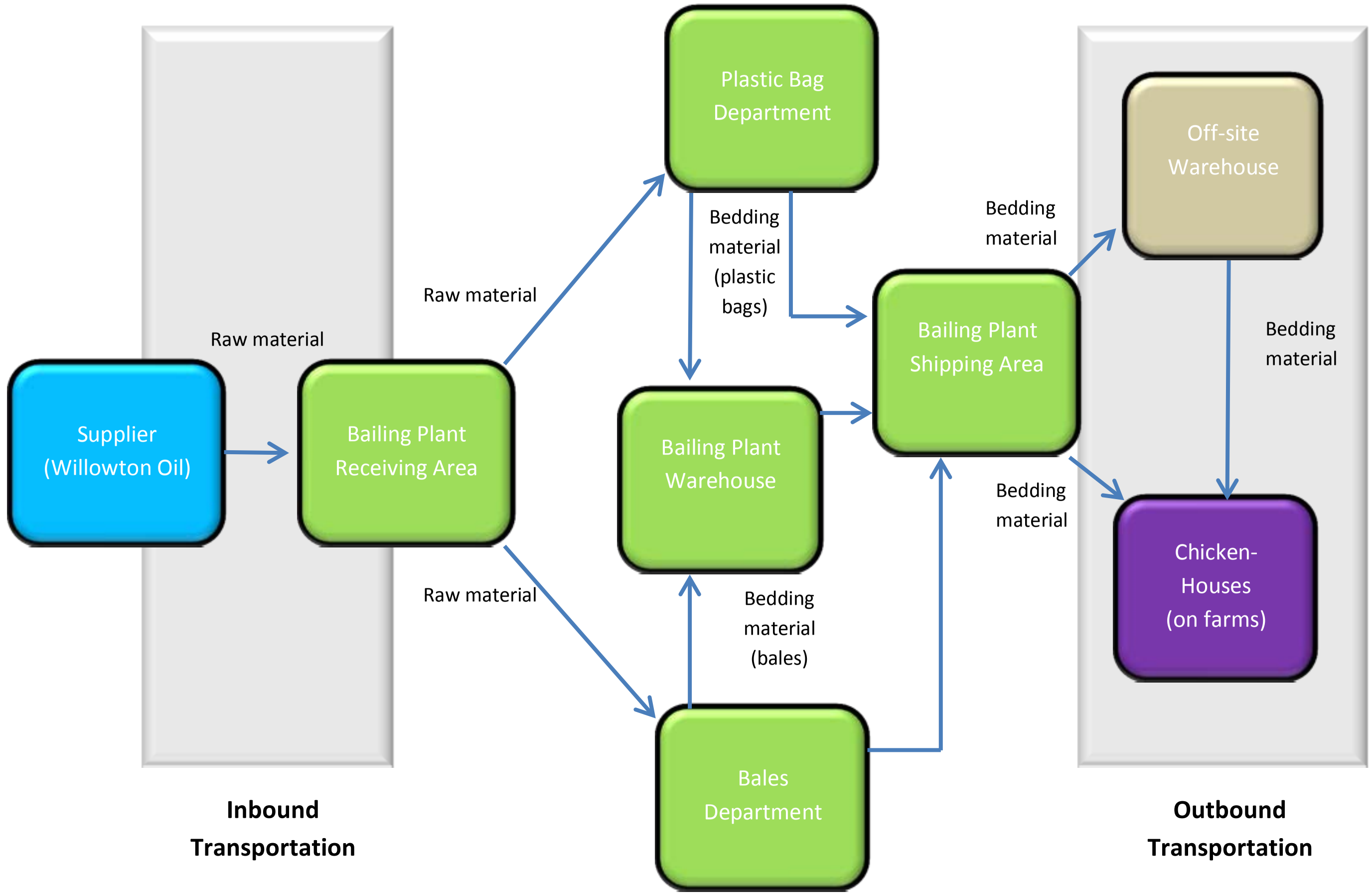


Figure 5 Bailing Plant activities

Chapter 4

Development of the feasibility study:

4.1 Feasibility study methodology:

The problem facing Earlybird Farms is the sustainability of the Bailing Plant's future. The plant is currently operated from the property of a foreign company and this lease agreement is about to expire. Thus, a decision must be made regarding the plant's future premises.

The solution of the Bailing Plant scenario will be addressed through Witt's theory, as explained in section 2.4.2 and 3.1.1.

4.1.1 Step 1: Identify the objective

The objective of this feasibility study is to find an optimal solution for the Bailing Plant's future that is sustainable and cost effective while the quality and customer service levels are maintained.

4.1.2 Step 2: Identify different ways of achieving the objective

In an attempt to achieve the objective, the solution discussed in chapter 3 will be followed to evaluate the criteria that will be applied in the decision matrix, i.e.

- Establish the location criterion
- Determine the space requirement criterion
- Determine the cost criterion (operating-, transport- and once-off cost)

4.1.2.1 Step 2.1: Location criterion – Tompkins' location model

According to Tompkins' classification, as discussed in chapter 2 section 2.7.2, the facility location problems of the Bailing Plant's scenario is as follows:

- Number of new facilities to be located – The plant is facing a single-facility location problem
- Solution space – The plant's solution space is discrete (the facility can only be located at specific locations)
- Criteria used to determine the location – The problem is a minisum location problem which means one or more new facilities are located in such a way that the weighted sum of distances among pairs of facilities is minimized
- In this problem the facilities are represented by points in two or three – dimensional space
- Distances measured in the model – Rectilinear distance measurements will be used, which measures path distances that are perpendicular to each other

In order to use this model, the GPS coordinates of the chicken-houses and the number of journeys per cycle (a cycle equals a rearing period) from the new locations to the existing chicken-houses, were obtained and entered into Microsoft Excel, which were used to do the necessary calculations.

For the application of this model, the east and south coordinates were used as the *x* and *y* coordinates respectively. The following figure is a scattered diagram which indicates the position of the chicken-houses relatively to one another:

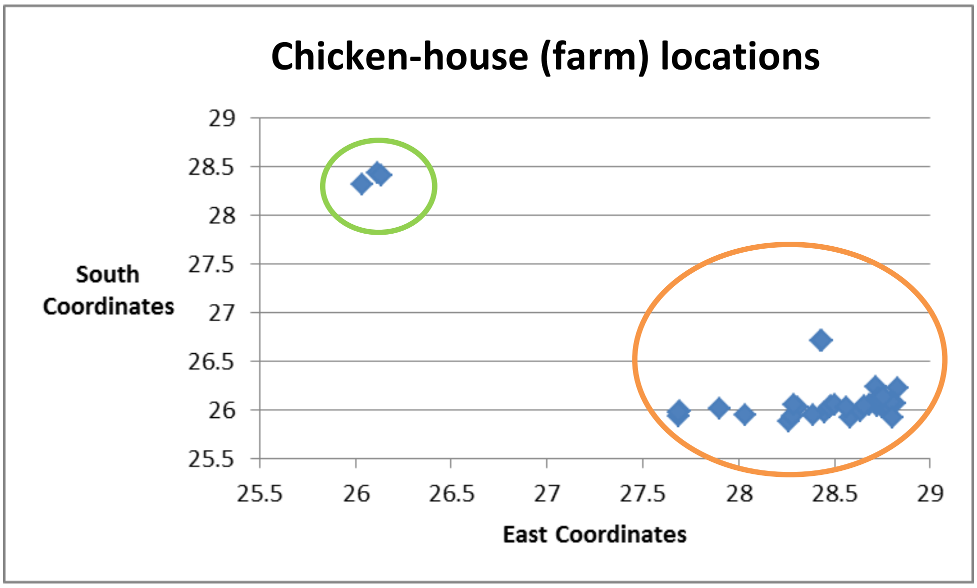


Figure 6

As can be seen in figure 6, most of the sites are located relatively close to each other (orange circle), except for a few being at a distance (green circle). There are a few sites far away from the majority, which requires that the number of journeys to the chicken-houses from the new facility is even more essential in order to find the optimal location.

The following notation was applied in this model:

X = (x, y) denotes a new location of the Bailing Plant

$P_i = (a_i, b_i)$ denotes locations of existing chicken-houses *i*, $i = 1, 2, 3 \ldots m$

W_i denotes the "weight" associated to the journey between the new locations (X) and the existing chicken-houses (P)

$d(x, p_i)$ denotes the distance between the new locations (X) and chicken-houses (P)

$\Sigma^{i}_{b=1} W_b$ denotes the sum of the weights

The data were first sorted according to increasing coordinate values. (See Appendix A for complete calculation).

Then the sum of the weights was calculated for the east and south coordinates. Whichever coordinate's partial sum equals or exceeds the sum of weights divided by 2, reveals the optimal coordinate for east and south respectively. The total weight was calculated as 129, thus the optimal coordinate will be the first partial sum >= 64.5 (129 x 0.5). Table 4 represents only a part of the data tables in appendix A:

East Coordinates					
Site number i	Site name	Coordinate a_i	Weight w_i	$\Sigma^i_{b=1} w_b$	
2	Fairview	27.695	1	7	
6	Tedstone	27.8989	2	9	
10	Diepsloot	28.0369	1	10	10 < 64.5
39	Willowton Oil (SUPPLIER)	28.207513	83	93	93 > 64.5
11	Doornkloof	28.26	1	94	
14	Idle & Wild	28.285	1	95	
35	Witfontein	28.2897	1	96	

South Coordinates					
Site number i	Site name	Coordinate b_i	Weight w_i	$\Sigma^i_{b=1} w_b$	
25	Shannon	26.1106	3	37	
13	Hoffman	26.115	1	38	
32	Weltevrede	26.1342	1	39	39 < 64.5
39	Willowton Oil (SUPPLIER)	26.145997	83	122	83 > 64.5
18	Moolman 2	26.2289	1	123	
9	Boobaas Kuikens	26.2375	1	124	
37	Goedgedagt	26.7161	1	125	

Table 4 East and South coordinates of the chicken-houses

For the east coordinates, the partial sum of Willowton Oil equals 93 which is greater than 64.5. Therefore the optimal east coordinate will be 28.207513 (shaded cells in table 4).

For the south coordinates, Willowton Oil was once again identified for having the optimal coordinate. Thus the optimal south coordinate will be 26.145997 (shaded cells in table 4). In other words, the optimal location for the Bailing Plant, considering the coordinates of all chicken-houses, the supplier and number of visits per cycle, will be 28.207513 E 26.145997 S.

The objective of this rectilinear model is to minimize the distance travelled, which is assumed to be proportional to the cost of travelling between the new and existing locations with W_i denoting the constant of proportionality. The objective is found by:

$$Minimize\ f(x,y) = \sum_{i=1}^{m} W_i (|x - a_i|) + \sum_{i=1}^{m} W_i (|y - b_i|)$$

Using the objective function to find the total weighed distance resulting from the optimal location X = (28.207513E ; 26.145997S), results in f (28.207513 ; 26.145997) = 377.715322 (See Appendix A for the complete calculation)

The solution has a discrete set of possible sites, but the objective function, which identifies the optimal solution among alternatives, can be calculated with the GPS coordinates of each possible site and the output can then be compared to the optimal output. The coordinates for the possible location at each alternative is given as:

- Alternative 1 – Renew the agreement: Thus staying at the location from which the plant is currently operated, at coordinates 26.214904 S 28.2875 E

- Alternative 2 – Move to another location: An available location in Isando (Kempton Park) was identified as an available location, at coordinates 26.139462 S 28.20594 E

- Alternative 3 – Build a new facility: Kaalplaas is one of the chicken-houses which is owned by Earlybird Farms and has plenty of open space available to build a new facility, at coordinates 26.0275 S 28.3094 E

The following graph focuses on the orange part of figure 6 as well as the locations of alternatives 1 to 3:

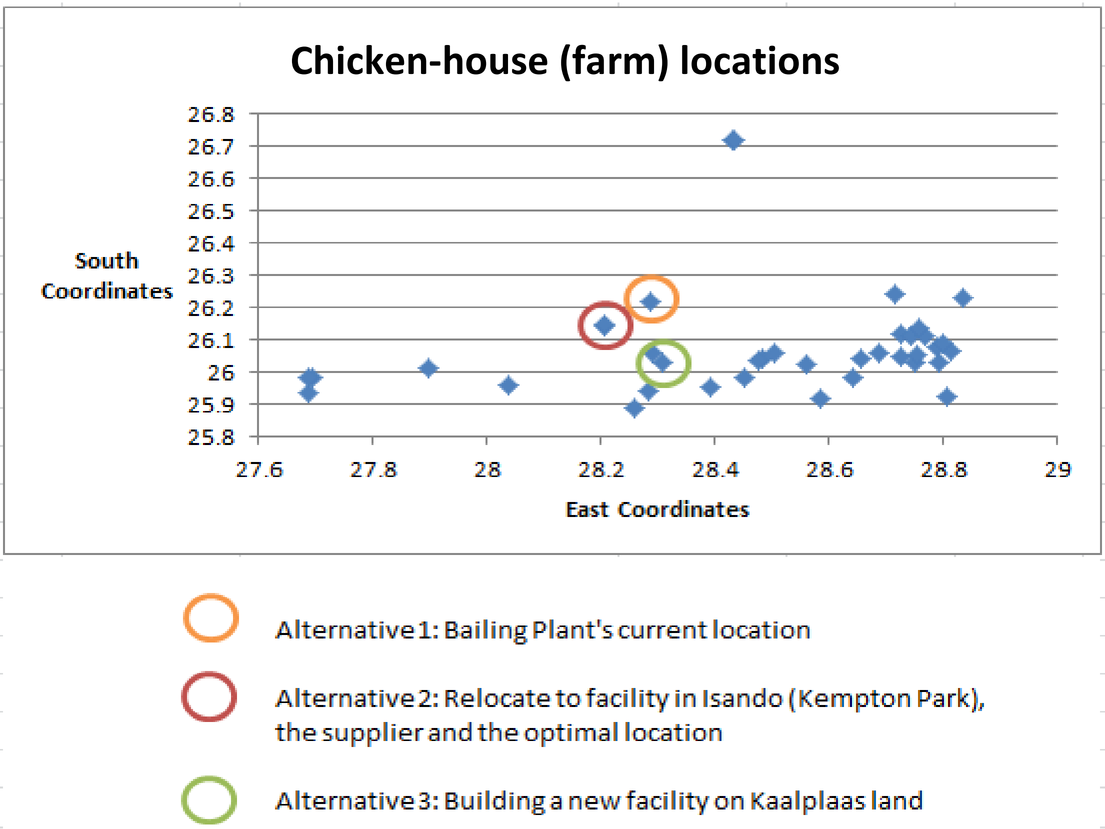


Figure 7

After ... be able to identify the solution closest to the optimal one, which will then be the best option.

The following table shows the solution calculated (the complete tables can be seen in appendix A):

	South coordinate:	East coordinate:	Objective function output:
Optimal location	26.145997	28.207513	377.715322
Alternative 1 : Renew agreement	26.214904	28.2875	378.820324
Alternative 2 : Relocate	26.139462	28.20594	377.958946
Alternative 3 : Build a new facility	26.0275	28.3094	391.411228

Table 5 Output of objective function

As indicated in table 5 (orange cell), the objective function solution that is closest to the optimal value (which is 377.715322) is 377.958946. Therefore the order of "best" locations will first be at a location in Isando (Kepmpton Park), then to stay at the current premises and lastly to build a new facility at Kaalplaas.

A visual representation of this order of optimal locations can also be seen in figure 7, as the red circle indicates the position of Willowton Oil (which has the optimal coordinates) as well as the facility in Isando. The orange circle shows the facility where the plant currently operates, which is the second best option with regards to location and the green circle indicates Kaalplaas which is the farthest from the optimal point.

4.1.2.2 Step 2.2: Space requirements criterion – Tompkins' approach

In order to determine the space that is required by the Bailing Plant, attention should be given to the following factors:

1. Office
2. Ablution for labour
3. First aid room
4. Safety equipment
5. Receiving and shipping
6. Bailing press and other equipment
7. Grain bucket elevator
8. Storage for packaging material
9. Storage for raw material
10. Storage for finished goods (warehouse)
11. Storage for maintenance tools and housekeeping
12. Aisle widths inside the facility
13. Moving of trucks and tractors
14. Parking for trucks and tractors

Step 2.2.1 Office:

Tomkins mentions Tenant's rules of thumb when he discusses office space requirements. This rule suggests that 10 m^2 to 25 m^2 of usable space is allocated to each person working in the office. The Bailing Plant has only one person working in the office, which is the supervisor. According to Tenant's rule (Tompkins et al, 2010), the standard space for a supervisor's office is 15 m^2 to 18 m^2, therefore the plant's office should be about 16 m^2.

Step 2.2.2 Ablution for labour:

Tompkins suggests that a restroom is to be located within 61 m of every permanent workstation and that male and female restrooms be separated. The Bailing Plant currently employs no female and 46 male employees, leading to the following specifications when planning the restrooms:

- Requirements for male employees: 2 toilets (1.16 m^2 each) and 1 urinal (0.56 m^2)
  2 sinks (0.56 m^2 each)
  1.4 m^2 for the entrance
  add 35% of abovementioned measurements
  for aisle space and other clearances

$$\text{Floor space requirements} = 1.35\,(2 \times 1.16 + 0.56 + 2 \times 0.56 + 1.4) = 7.3\ m^2$$

A female restroom will be added to the requirements of the facility for future use.

- Requirements for female employees: 1 toilet (1.16 m^2) and 2 sinks (0.56 m^2 each)
  1.4 m^2 for the entrance
  Add 35% of abovementioned measurements
  for aisle space and other clearances

$$\text{Floor space requirements} = 1.35\,(1.16 + 2 \times 0.56 + 1.4) = 5\ m^2$$

Thus the female and male restrooms should be 5 m^2 and 7.3 m^2 respectively.

Step 2.2.3 First aid room:

According to Tompkins, at the very least should a small first aid room be included when a facility is planned with the following minimum requirements:

- Approved first aid kit
- 1 bed
- 2 chairs
- Area of 9.3 m^2

The area of 10 m^2 should be used for the first aid room.

Step 2.2.4 Safety equipment:

Safety equipment like fire extinguishers must be placed against walls and pillars across the facility to be accessible in the case of an emergency. Therefore no extra space has been allocated to it.

Step 2.2.5 Receiving and shipping:

In order to determine the space requirements for receiving and shipping, Tomkins mentions the following steps:

Step 2.2.5.1 Determine what is to be shipped and received:

The main activities of the Bailing Plant are the receiving of raw material (sunflower husks), compressing the material, placing it into wool or plastic bags, storing of the product and distributing it to the farms. Only the sunflower husks is received at the receiving dock and only the final product in the form of bales or plastic bags are shipped from the shipping dock, therefore the operations at these docks are relatively simple. Furthermore, only one truck will be at the receiving dock ready to unload and one at the shipping dock ready to load, at a specified time. When the bags (packaging material) are delivered at the plant, it is moved with trolleys to the nearby storage area.

Step 2.2.5.2 Determine the number and type of docks:

There is only one dock required in each area, because there is only one truck at the receiving and shipping areas at a time.

A drive through dock will be used in the receiving area because the husks are unloaded into a grain hopper, which is below ground level. The truck simply enters the dock, stops over the hopper and releases the load. The dimensions of the receiving area are 4 x 22 m, thus an area of 88 m^2 will be sufficient.

Tompkins states that 90˚ docks are used whenever space is available, as the cost of outside space is lower to construct and maintain than inside space, therefore the shipping area will use a 90˚ dock. The longest truck of the Bailing Plant is 22 m, therefore the 90˚ dock requires a width of 4 m and apron length of 22 m, thus an area of 88 m^2 will be sufficient.

If truck traffic patterns are used as shown in figure 8 to the entrance of the plant, Tompkins recommends that the indicated dimensions are used (a possible layout for the shipping and receiving area is also shown):

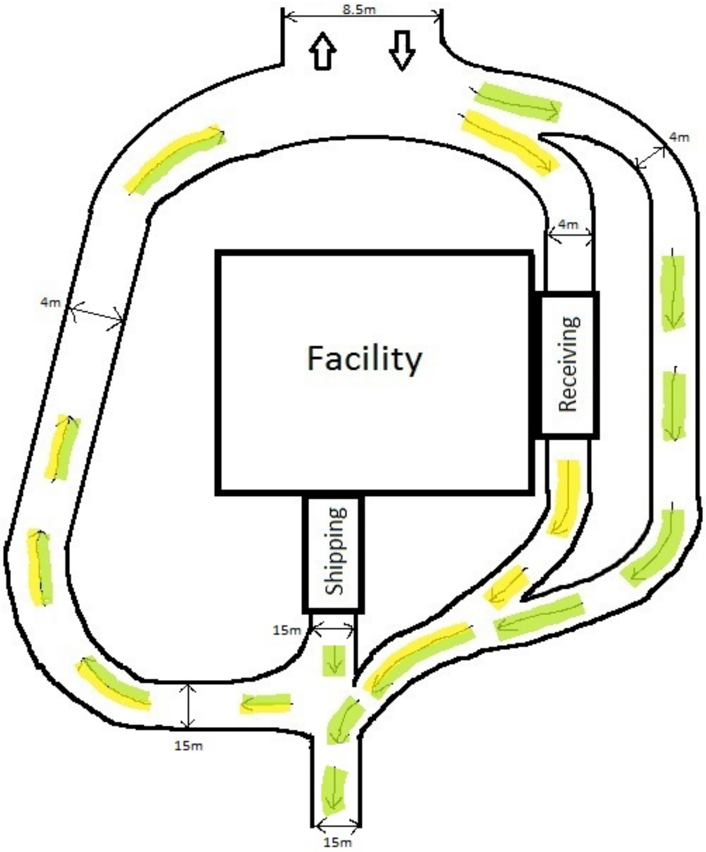


Figure 8
Possible layout for shipping, receiving and traffic flow

The bidirectional entrance to the facility grounds must be 8.5 m wide while the clockwise direction road widths are 4 m. Road widths of 15 m are allocated for truck manoeuvring around the shipping dock.

If a vehicle is to deliver raw material, it follows the yellow path on the figure. At the receiving dock it releases its load into the hopper and then leaves the dock. It continues its path towards the exit.

If a truck is to be loaded with finished goods, it follows the green arrows on the figure. As the truck comes to the dead end, it reverses until it reaches the shipping dock. After it has been loaded it simply moves forward towards the exit.

Step 2.2.5.3 Determine space requirements for receiving and shipping inside the facility:

Space allocations will be needed for:

- Trash disposal and recycling bins – As dock operations generate trash and waste material space must be allocated for the disposal thereof. The plant will need

3 m^2 at each dock to maintain good housekeeping principles and prevent congestion

- Manoeuvring of material handling equipment – The space required from the backside of the dock board to the end of the production areas will be 20 m^2 in order to accommodate the mobile bag stacker conveyor, which loads the finished product onto the trucks.

Therefore space needed inside the facility for receiving and shipping operations are 3 m^2 and 23 m^2 respectively.

Step 2.2.6 Press machinery in bale and plastic bag workstations:

The space required by machinery is 2.8 x 8 m, thus 23 m^2 will be sufficient.

Step 2.2.7 Grain bucket elevator:

The husks are fed to the bailing press as well as the manual press with of a grain bucket elevator. This elevator doesn't take up any floor space as it is an overhead inclined structure from the hopper to a specific workstation.

Step 2.2.8 Storage for packaging material (inventory):

The area required to store the packaging material is 15 m^2.

Step 2.2.9 Storage for raw material:

As mentioned earlier, raw material is stored in a grain hopper that is below ground level. The hopper holds a few tonnes of material and the area about 12 m^2.

Step 2.2.10 Storage for finished goods (warehouse):

The Bailing Plant currently uses 600 m^2 for storage of finished goods. The bags are stacked up to a height not exceeding 5 m. The remainder of the products are shipped to offsite warehouses close to the chicken-houses from where it's distributed to the sites (farms).

Step 2.2.11 Storage for maintenance and housekeeping:

The tools used for maintenance and housekeeping are 2 shovels and forks as well as 6 industrial brooms. About 16 m^2 will be planned for to have some extra storage space available if it is required for future items.

Step 2.2.12 Aisle widths inside the facility:

The layout of the plant is mainly open plan, therefore aisle specifications are relatively simple. The aisle width required for movement of trolleys and workers among workstations and other designated areas is 4 m.

Step 2.2.13 Moving of trucks and tractors:

The movement of trucks were discussed in step 2.2.5.2 of this chapter, it also applies to tractors as they are smaller than trucks.

Step 2.2.14 Parking for trucks and tractors:

Parking space for the 8 trucks will be planned according to the plant's largest truck, which is 22 x 2.5 m. Parking space for a single 2.5 x 3.2 m tractor is also to be provided. If a space of 1 m between the trucks (and tractor) is taken into account, the total area required will be (2.5m x 9 + 1m x 8) x 22m = 671 m^2. A layout for the parking area as well as the dimensions can be seen in figure 9:

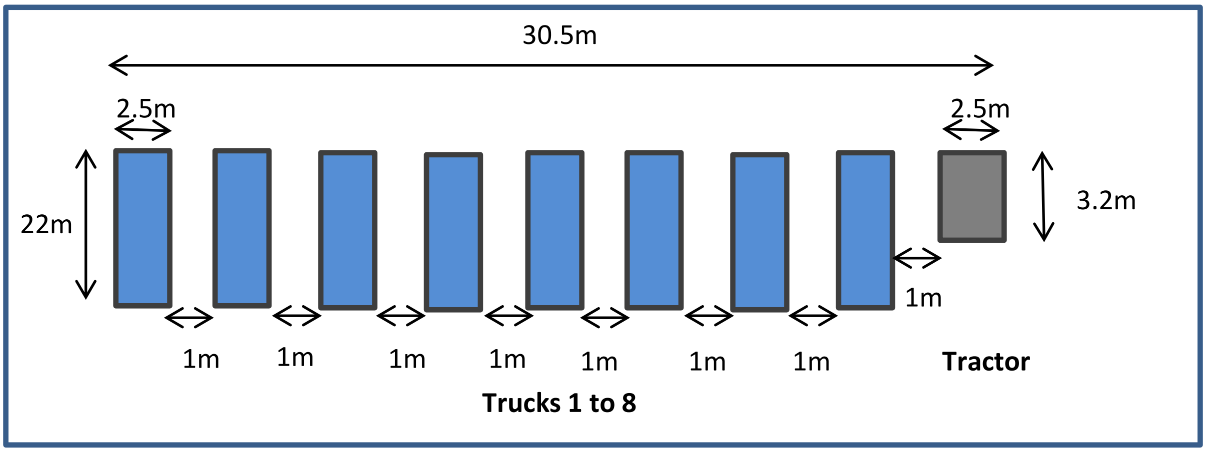


Figure 9 Trucks and tractor parking layout

Employee parking has not been considered as the majority of the employees make use of public transportation.

4.1.2.3 Step 2.3: Cost criterion: Cost benefit analysis

In order to rate the cost criterion for the alternatives, the influencing factors at each one must be identified, quantified and classified as cost or benefit. (In this case there are cyclical costs as well as once-off costs.)

Then the data can be analysed and calculations will reveal whether the alternatives are acceptable or not. The following table contains the classification of the influencing cost factors:

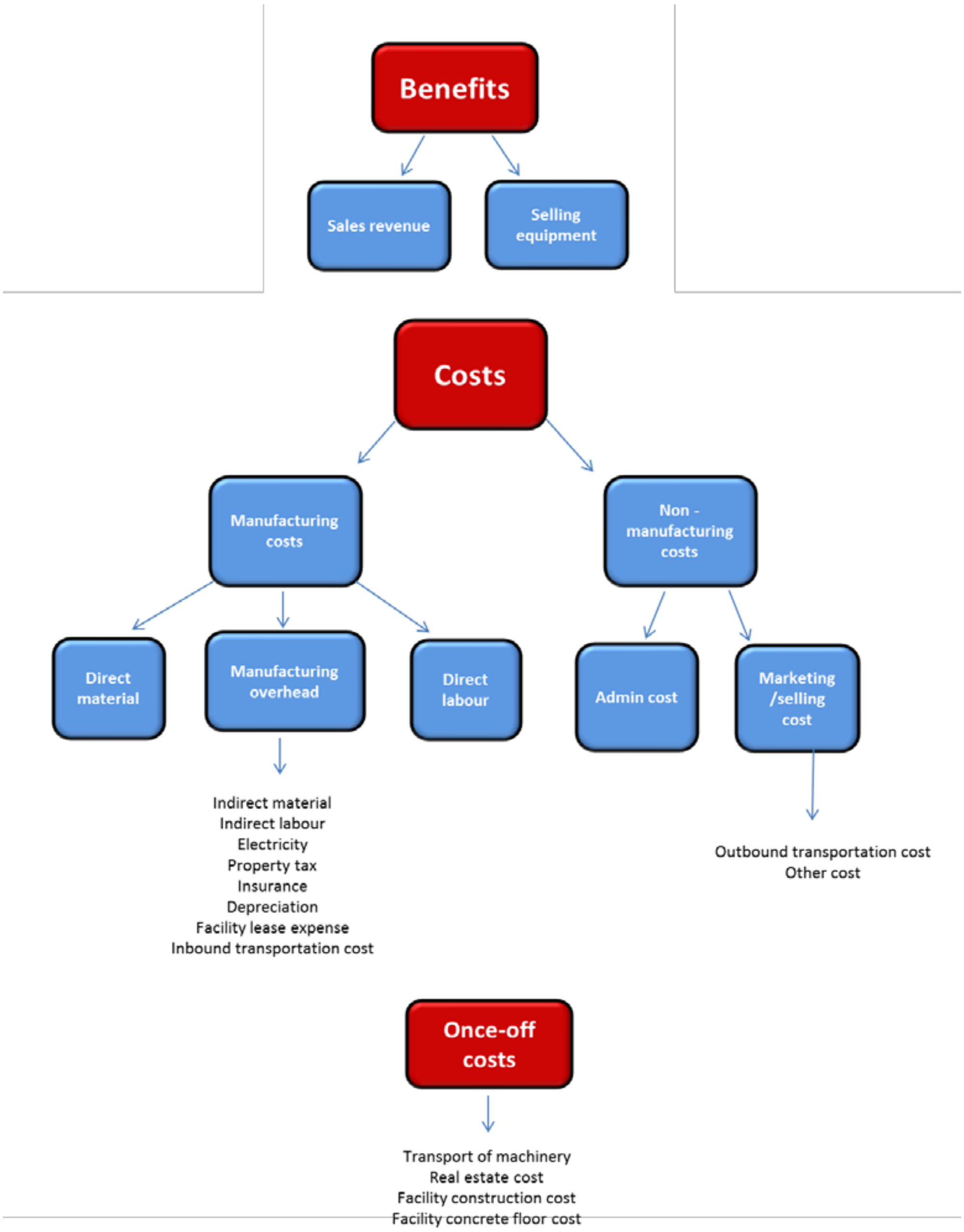


Figure 10 Classification of cost factors

The distance travelled between the new facility, warehouses, chicken-houses and supplier of the raw material must first be known before the in – and outbound transportation cost could be determined. The cost associated with the distance travelled for outbound transportation is calculated and optimized by following the transportation problem approach as discussed in chapter 3 section 3.1.2.3.1. (The cost for distance travelled for the inbound transportation was calculated with Microsoft Excel formulas and added to the output from Solver to determine the total transportation cost).

The assumption will be made that this transportation problem is linear and that all the unconstrained variables are positive integers. The assumption of linearity is acceptable because the constraints and objective functions are calculated with linear equations. For this evaluation it is assumed that the Bailing Plant's warehouse can store up to 3961 tonnes of bedding material so that the different alternatives can be evaluated under the same conditions. A summary of calculations and other assumptions are as indicated in table 6:

Summary of calculations:	**per cycle**	
Demand	4359 t	
Raw material (sunflower husks) cost from Willowton Oil	R 420 / t	
Bailing Plant's average bedding material selling price	R 631 / t	
Bedding material purchasing price from outside supplier (if the Bailing Plant is closed)	R 1430 / t	(assumption)
Bailing Plant warehouse capacity	3961 t	(assumption)
Facility size (equal for all alternatives to make comparison)	1463 m^2	(assumption)
Facility lease expense - Alternative1	R 79 / m^2	
Facility lease expense - Alternative2	R 68 / m^2	
Property tax rate	10.15%	(assumption)
Average fuel consumption of a truck	3.25 km / litre	
Fuel price	R 12.8 / litre	
Average truck load	10 t / load	
Cost to transport 1 ton for 1 km	R 0.394	

Table 6 Summary of calculations and assumptions

The Microsoft Solver process is as follows:

1. Define changing cells – The cells where the variables must be presented were defined
2. Calculate the total profit or cost – For this problem the objective is to minimize the cost of transportation. The objective function is the sum of the products of a variable and its associated cost. The variables are to be determined by Solver and they represent the optimal distance travelled by a truck to transport material from a warehouse to a chicken-house.
3. Set up the resource usage – Enter the capacity of all the resources and any other constraints. Ensure that:

    - Amount of material supplied is equal to the demand of each chicken-house
    - Total material supplied from a warehouse are less than or equal to its inventory levels

4. Set up Solver – 4.1 Select the objective function cell as the target cell as well as the minimize option

    4.2 Enter the cell numbers where Solver must change the variables (the distances travelled) in the "by changing cells" option

    4.3 Enter the constraints from step 3 in the area labelled "subject to the constraints"

4.4 Select the assumptions of a linear model and non-negativity

5. Solve the problem – Click on solve and a solution will be presented

Table 7 represents a summary of the transportation cost per cycle, where the Solver solution represents the outbound transport cost, the inbound transport cost was calculated separately using Excel formulas and the total cost was determined for each alternative:

1 – remain at current facility
2 – relocate to facility in Isando (Kempton Park)
3 – Build a new facility at Kaalplaas
(see appendix B for all the data tables, the Solver setup menu and the solutions):

.

	Alternative 1:	Alternative 2:	Alternative 3:
Outbound transportation cost	R 136 587.78	R 128 875.31	R 114 751.48
Inbound transportation cost	R 11 437.00	R 711.00	R 17 253.00
Total transportation cost	R 148 024.78	R 129 586.09	R 132 003.98

Table 7 Transportation cost summary

The results from table 7 as well as the costs for the remainder of the cyclical influencing factors were used to calculate the cost associated with each alternative, the following were found (see appendix C for complete tables):

Costing factor:	Alternative 1: Bailing Plant's current facility	Alternative 2: Relocate to facility in Isando (Kempton Park)	Alternative 3: Build a new facility at Kaalplaas
Direct material	1830780	1830780	1830780
Direct labour	391000	391000	391000
Total Manufacturing overhead	205214	178395	115757
Total Manufacturing costs	R 2 426 994	R 2 400 175	R 2 337 537
Administrative costs	7000	7000	7000
Total marketing/selling cost	142087.78	134375.31	120251.48
Total Non-manufacturing costs	R 149 087.78	R 141 375.31	R 127 251.48
Total expenses per cycle	R 2 576 081.78	R 2 541 550.31	R 2 464 788.48
Sales per cycle	R 2 750 529	R 2 750 529	R 2 750 529
Profit per cycle	R 174 447.22	R 208 978.69	R 285 740.52
	≥ 0 thus acceptable	≥ 0 thus acceptable	≥ 0 thus acceptable

Table 8 Cost calculations for alternative 1 to 3

According to the cost benefit analysis, alternatives 1 to 3 are all acceptable as the profit per cycle is greater than zero. Alternative 3 seems to generate the highest profit which may be due to the facility lease expense not being applicable to its circumstances. Second highest profit is generated by alternative 2 and the lowest by alternative 1. Calculations in table 8 do not include once-off costs which may influence the overall cost rating. Once-off costs are presented in table 9:

Once-off costing factors:	Alternative 1: Bailing Plant's current facility	Alternative 2: Relocate to facility in Isando (Kempton Park)	Alternative 3: Build a new facility at Kaalplaas
Transport of machinery	N/A	100000	100000
Real estate cost	N/A	N/A	0
Facility construction cost	N/A	N/A	612967.74
Facility concrete floor cost	N/A	N/A	100000
Total once-off costs	**R 0.00**	**R 100 000.00**	**R 812 967.74**

Table 9 Once-off cost calculations

Alternative 1 does not impose any once-off costs, but alternative 2 and 3 do. (The real estate cost for alternative 3 was assumed to be zero as Kaalplaas is Earlybird Farms' property and an investigation of opportunity cost was not part of the project.) It is very important to take these costs into account therefore the cumulative costs for each alternative over a five year period were examined to evaluate future sustainability.

Table 10 shows the total expenses per cycle for each alternative that were converted to total expenses per year (there is 7 cycles per year) and the once-off costs that are used as the initial expense (the starting point). It was assumed that these costs remain constant over the entire period and all revenues were excluded.

	Alternative 1	Alternative 2	Alternative 3
Total expenses per cycle:	R 2 576 081.78	R 2 541 550.31	R 2 464 788.48
Total expenses per year: (7 cycles per year)	R 18 032 572.46	R 17 790 852.17	R 17 253 519.36
Total once-off cost:	R 0.00	R 100 000.00	R 812 967.74

Table 10 Cyclical and once-off costs

The information in table 10 was used to construct table 11, which shows the cost accumulation over the five years.

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Alternative 1	R 0.00	R 18 032 572.46	R 36 065 144.92	R 54 097 717.38	R 72 130 289.84	R 90 162 862.30
Alternative 2	R 100 000.00	R 17 890 852.17	R 35 681 704.34	R 53 472 556.51	R 71 263 408.68	R 89 054 260.85
Alternative 3	R 812 967.74	R 18 066 487.10	R 35 320 006.46	R 52 573 525.82	R 69 827 045.18	R 87 080 564.54

Table 11 Accumulation of cost for 5 years

The following graphs were constructed from table 11 to give a visual indication of each alternative regarding its costs: (The combined graph for the cumulative cost of alternative 1 to 3 can be seen in Appendix C)

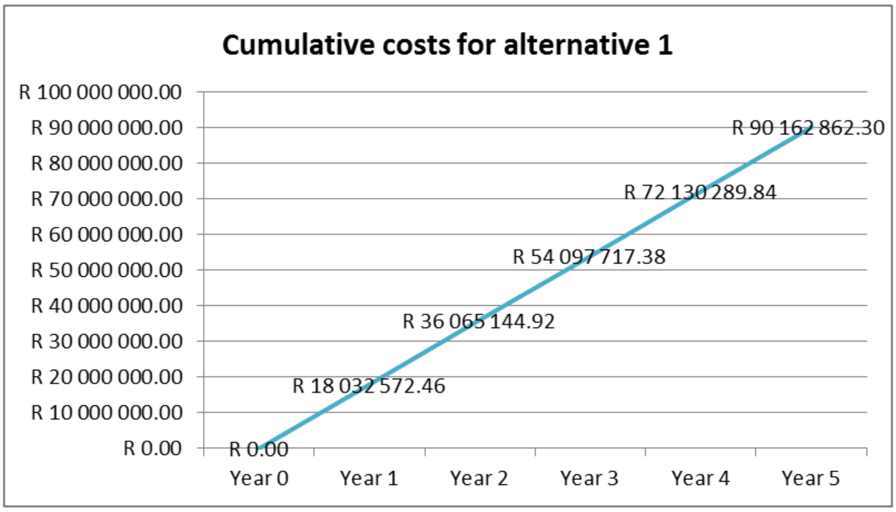


Figure 11 Cumulative costs for alternative 1

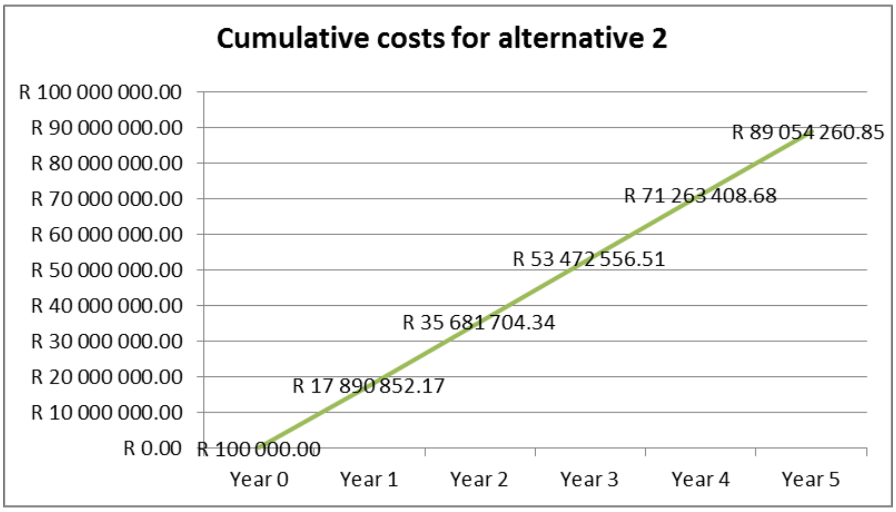


Figure 12 Cumulative costs for alternative 2

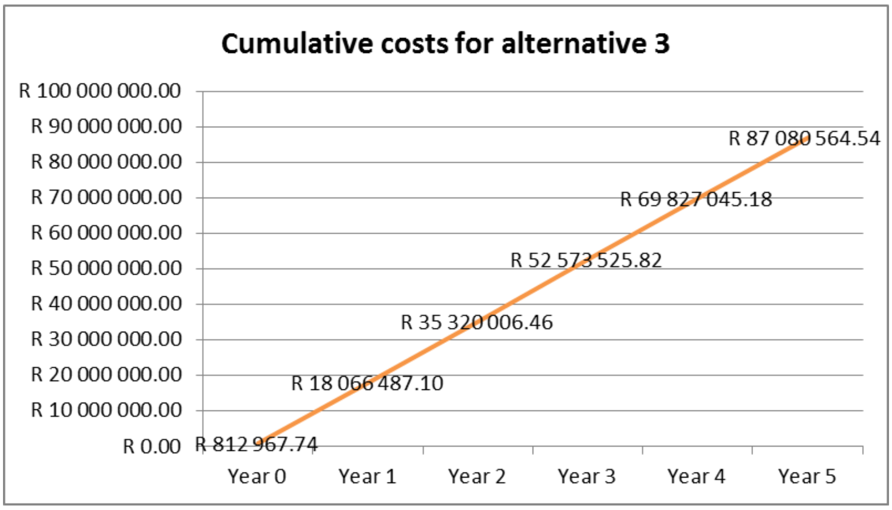


Figure 13 Cumulative costs for alternative 3

It is clear that after 5 years the cost for the alternatives will be (in order from lowest to highest): Alternative 3 ; Alternative 2 ; Alternative 1.

There are only a few costs or benefits for alternative 4, as it has only bedding material to be purchased by the farmers, at a cost much higher than before (a 127% increase), and the once-off revenue that will be generated by selling all the equipment, see table 12:

Alternative 4: Close the Bailing Plant	
Expenses: (cyclical)	
Bedding material purchasing cost for farmers	R 6 233 370
Revenues: (once-off)	
Market value of equipment for Earlybird Farms	R 472 634

Table 12 Cost associated with alternative 4

Chapter 5

Recommendations:

5.1 Step 3 : Select and optimize the best alternative

The third step of the feasibility study methodology is to select and optimize one alternative from the set of four.

The following information was generated by applying several techniques in chapter 4:

- For the location criterion, the results revealed that the order for optimal locations will be:

  First – Moving to Isando
  Second – Renewing the current facility
  Third – Build a facility at Kaalplaas

- For the space requirements, the following table will be used as the minimum requirements for mainly in the indoor areas. Aisle requirements should be taken into consideration when the facility layout is planned (not within the scope of this project) and therefore it is suggested to use a bigger facility. (Parking is included but the outside receiving and shipping areas are excluded.)

Space requirements:	(m^2)
Office	16
Ablution	12.3
First aid room	10
Receiving and shipping space inside facility (trash disposal & manoeuvring of material handling equipment)	26
Machinery	23
Inventory	15
Warehouse	600
Housekeeping and maintenance equipment	16
Parking	671
Total space required for these areas:	**1389.3**

Table 13 Space requirements

The available space for the different alternatives are:

- Current facility - 1463 m^2
- Isando facility - 2000 m^2
- Kaalplaas facility - 2300 m^2

➢ For the cost criterion the results were as follows:

Because the revenue generated from the sales for alternatives 1 to 3 are assumed to be constant at R 2 750 529 / cycle, it is sufficient to compare only the costs associated with each alternative. As mentioned earlier, an evaluation of the costs for 5 years will be used to rate the cost criterion in order to ensure future sustainability. (Higher cost will receive a lower rating and vice versa.)

	Alternative 1	Alternative 2	Alternative 3
Total expenses per cycle:	R 2 576 081.78	R 2 541 550.31	R 2 464 788.48
Total expenses per year: (7 cycles per year)	R 18 032 572.46	R 17 790 852.17	R 17 253 519.36
Total once-off cost:	R 0.00	R 100 000.00	R 812 967.74
Total costs for 5 years:	R 90 162 862.30	R 89 054 260.85	R 87 080 564.54

Table 14 Cost evaluation for alternative 1 to 3

The rates and scores for each alternative are applied to the decision matrix, which will reveal the best candidate. The matrix is shown in table 15:

Decision Matrix

		Available options:							
		Alternative 1 (Renew current agreement)		Alternative 2 (Move to Isando)		Alternative 3 (Build facility at Kaalplaas)		Alternative 4 (Close the plant)	
Criteria	**Weight**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Location	3	2	6	3	9	1	3	N/A	N/A
Space requirements	2	2	4	3	6	3	6	N/A	N/A
Cost (operating, once-off & transportation)	3	2	6	2	6	3	9	2	6
Total:	**8**	**6**	**16**	**8**	**21**	**7**	**18**	**2**	**6**

Rating:	
1	Low
2	Moderate
3	High

Table 15 Decision matrix

The optimal alternative is to move to the facility in Isando which received a total score of 21. To build a facility at Kaalplaas is second in place with a score of 18. The score for renewing the current agreement is 16. The lowest score of 6 is given to the alternative of closing the plant, because it is not ideal to force farmers to buy bedding material at such a high cost as it will have an influence on the price of the final product which will result in losing the market. If the farmers switch to another bedding material than sunflower husks, the meat quality may deteriorate. The once-off revenue of R 472 634 by selling the equipment is also not worthwhile.

5.2 Step 4: Get everyone to agree that this is the best alternative

Being selected as the optimal alternative, it is recommended to move the facility to Isando, as it is optimally situated it has adequate space for the operation and even future expansion. Although not having the lowest cost, it is still acceptable and less than the cost of alternative 1. The Bailing Plant is a non-profit organization, but any profit generated can be used to supply the farmers with bedding material at a lower cost.

Chapter 6

Conclusion:

The purpose of this project was to find the best alternative for the Bailing Plant’s facility. Several alternatives were identified as well as the influencing factors associated with each one. Literature studies were undertaken to ensure that the problem and the environment is well understood. Data gathering, analysis and many techniques were applied in attempt to find the best alternative.

The outcome of the techniques were used to rate the alternatives under a certain criteria in a decision matrix, which finally revealed that the optimal solution is to move to the facility located in Isando.

Appendix A:

The objective function:

$$Minimize\ f(x,y)=\sum_{i=1}^{m}W_i(|x-a_i|)+\sum_{i=1}^{m}W_i(|y-b_i|)$$

The tables used in the location model are as follows:

Establishing optimal east coordinates

East Coordinates					
Site number i	Site name	Coordinate a_i	Weight w_i	$\Sigma^i_{b=1} w_b$	
8	Ashley	26.0341	1	1	
21	Oosterhuizen	26.1136	1	2	
31	Weilaagte	26.1332	1	3	
7	Woodlands	27.6878	1	4	
4	Hekpoort	27.6886	2	6	
2	Fairview	27.695	1	7	
6	Tedstone	27.8989	2	9	
10	Diepsloot	28.0369	1	10	10 < 64.5
39	Willowton Oil (SUPPLIER)	28.207513	83	93	93 > 64.5
11	Doornkloof	28.26	1	94	
14	Idle & Wild	28.285	1	95	
35	Witfontein	28.2897	1	96	
5	Kaalplaas	28.3094	5	101	
20	Nooitgedaght	28.3922	1	102	
37	Goedgedagt	28.4317	1	103	
38	Hofman	28.4333	1	104	
12	Elandsvlei	28.4511	1	105	
23	Rietfontein	28.4753	1	106	
15	Kgobokano	28.4836	1	107	
33	White Hot Trading	28.5039	1	108	
36	Ystervarkfontein	28.5617	1	109	
1	Bayview	28.5861	1	110	
16	Klipspruit	28.6403	1	111	
34	Witblipbank	28.6561	1	112	
17	Moolman 1	28.6869	1	113	
9	Boobaas Kuikens	28.715	1	114	
3	Groenfontein	28.725	1	115	
13	Hoffman	28.7275	1	116	
25	Shannon	28.7439	3	119	
22	Pumelela	28.75	1	120	
24	Rondevlei	28.7542	1	121	
32	Weltevrede	28.7578	1	122	
26	TRU Bee	28.7678	1	123	
19	Ndlovu	28.7875	1	124	
28	TRU Grow	28.7922	1	125	
29	TRU Sko	28.7983	1	126	
30	Van Rensburg	28.8072	1	127	
27	TRU Chicks	28.815	1	128	
18	Moolman 2	28.8333	1	129	
			Total:	129	
			0.5 x Total:	**64.5**	
			E coordinate	28.207513	

Establishing optimal south coordinates

South Coordinates					
Site number i	Site name	Coordinate b_i	Weight w_i	$\Sigma^i_{b=1}\ w_b$	
11	Doornkloof	25.8847	1	1	
1	Bayview	25.9169	1	2	
30	Van Rensburg	25.9233	1	3	
4	Hekpoort	25.9336	2	5	
14	Idle & Wild	25.9375	1	6	
20	Nooitgedaght	25.9536	1	7	
10	Diepsloot	25.9556	1	8	
7	Woodlands	25.9808	1	9	
12	Elandsvlei	25.9819	1	10	
16	Klipspruit	25.9833	1	11	
2	Fairview	25.9836	1	12	
6	Tedstone	26.0117	2	14	
36	Ystervarkfontein	26.0242	1	15	
5	Kaalplaas	26.0275	5	20	
22	Pumelela	26.0278	1	21	
28	TRU Grow	26.0308	1	22	
23	Rietfontein	26.0333	1	23	
34	Witblipbank	26.0378	1	24	
15	Kgobokano	26.0383	1	25	
3	Groenfontein	26.0456	1	26	
24	Rondevlei	26.0539	1	27	
33	White Hot Trading	26.0547	1	28	
17	Moolman 1	26.0597	1	29	
35	Witfontein	26.06	1	30	
27	TRU Chicks	26.0611	1	31	
19	Ndlovu	26.0725	1	32	
29	TRU Sko	26.0864	1	33	
26	TRU Bee	26.1086	1	34	
25	Shannon	26.1106	3	37	
13	Hoffman	26.115	1	38	
32	Weltevrede	26.1342	1	39	39 < 64.5
39	Willowton Oil (SUPPLIER)	26.145997	83	122	83 > 64.5
18	Moolman 2	26.2289	1	123	
9	Boobaas Kuikens	26.2375	1	124	
37	Goedgedagt	26.7161	1	125	
38	Hofman	26.7161	1	126	
8	Ashley	28.3143	1	127	
31	Weilaagte	28.4147	1	128	
21	Oosterhuizen	28.4337	1	129	
			Total:	129	
			0.5 x Total:	**64.5**	
			S coordinate	26.145997	

Objective function calculation for optimal coordinates

	Site name	S	E	Number of trips	Formula
1	Bayview	25.9169	28.5861	1	0.607684
2	Fairview	25.9836	27.695	1	0.67491
3	Groenfontein	26.0456	28.725	1	0.617884
4	Hekpoort	25.9336	27.6886	2	1.46262
5	Kaalplaas	26.0275	28.3094	5	1.10192
6	Tedstone	26.0117	27.8989	2	0.88582
7	Woodlands	25.9808	27.6878	1	0.68491
8	Ashley	28.3143	26.0341	1	4.341716
9	Boobaas Kuikens	26.2375	28.715	1	0.59899
10	Diepsloot	25.9556	28.0369	1	0.36101
11	Doornkloof	25.8847	28.26	1	0.313784
12	Elandsvlei	25.9819	28.4511	1	0.407684
13	Hoffman	26.115	28.7275	1	0.550984
14	Idle & Wild	25.9375	28.285	1	0.285984
15	Kgobokano	26.0383	28.4836	1	0.383784
16	Klipspruit	25.9833	28.6403	1	0.595484
17	Moolman 1	26.0597	28.6869	1	0.565684
18	Moolman 2	26.2289	28.8333	1	0.70869
19	Ndlovu	26.0725	28.7875	1	0.653484
20	Nooitgedaght	25.9536	28.3922	1	0.377084
21	Oosterhuizen	28.4337	26.1136	1	4.381616
22	Pumelela	26.0278	28.75	1	0.660684
23	Rietfontein	26.0333	28.4753	1	0.380484
24	Rondevlei	26.0539	28.7542	1	0.638784
25	Shannon	26.1106	28.7439	3	1.715352
26	TRU Bee	26.1086	28.7678	1	0.597684
27	TRU Chicks	26.0611	28.815	1	0.692384
28	TRU Grow	26.0308	28.7922	1	0.699884
29	TRU Sko	26.0864	28.7983	1	0.650384
30	Van Rensburg	25.9233	28.8072	1	0.822384
31	Weilaagte	28.4147	26.1332	1	4.343016
32	Weltevrede	26.1342	28.7578	1	0.562084
33	White Hot Trading	26.0547	28.5039	1	0.387684
34	Witblipbank	26.0378	28.6561	1	0.556784
35	Witfontein	26.06	28.2897	1	0.168184
36	Ystervarkfontein	26.0242	28.5617	1	0.475984
37	Goedgedagt	26.7161	28.4317	1	0.79429
38	Hofman	26.7161	28.4333	1	0.79589
39	Willowton Oil (SUPPLIER)	26.145997	28.207513	83	342.211656
				Total:	**377.715322**

Objective function calculation for alternatives' coordinates

Alternative 1 : Renew agreement at current facility		**Alternative 2 : Relocate to Isando (Kempton Park)**		**Alternative 3 : Build a new facility at Kaalplaas**	
S	**E**	**S**	**E**	**S**	**E**
26.214904	28.2875	26.139462	28.20594	26.0275	28.3094
0.596604		0.602722		0.3873	
0.823804		0.666802		0.6583	
0.606804		0.612922		0.4337	
1.760408		1.446404		1.4294	
1.04652		1.07711		0	
1.183608		0.869604		0.8526	
0.833804		0.676802		0.6683	
4.352796		4.346678		4.5621	
0.450096		0.607098		0.6156	
0.509904		0.352902		0.3444	
0.357704		0.308822		0.1922	
0.396604		0.402722		0.1873	
0.539904		0.546022		0.5056	
0.279904		0.281022		0.1144	
0.372704		0.378822		0.185	
0.584404		0.590522		0.3751	
0.554604		0.560722		0.4097	
0.559796		0.716798		0.7253	
0.642404		0.648522		0.5231	
0.366004		0.372122		0.1567	
4.392696		4.386578		4.602	
0.649604		0.655722		0.4409	
0.369404		0.375522		0.1717	
0.627704		0.633822		0.4712	
1.682112		1.700466		1.5528	
0.586604		0.592722		0.5395	
0.681304		0.687422		0.5392	
0.688804		0.694922		0.4861	
0.639304		0.645422		0.5478	
0.811304		0.817422		0.602	
4.354096		4.347978		4.5634	
0.551004		0.557122		0.5551	
0.376604		0.382722		0.2217	
0.545704		0.551822		0.357	
0.157104		0.163222		0.0522	
0.464904		0.471022		0.2556	
0.645396		0.802398		0.8109	
0.646996		0.803998		0.8125	
343.131296		342.623502		360.503528	
378.820324		**377.958946**		**391.411228**	

Appendix B:

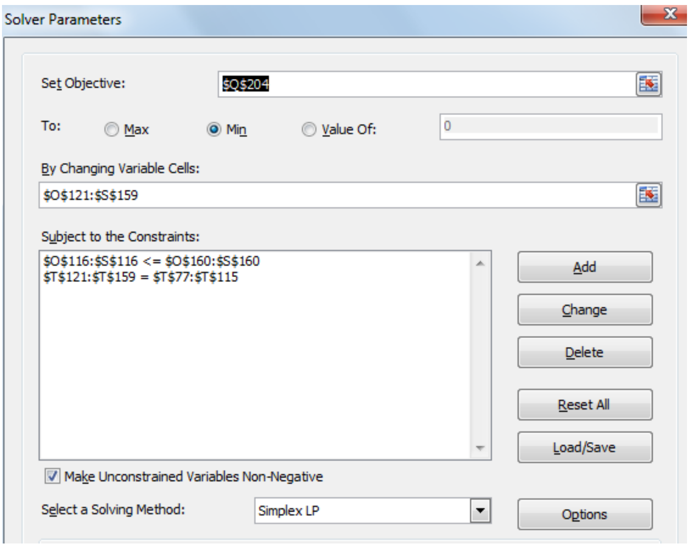
Distance table for alternative 1, 2 and 3:

	Distances (km)				
			Warehouses		
FROM					
TO	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant
Bayview	116	37.2	92.1	42.1	58.5
Fairview	7.6	98.4	28.4	141	83.1
Groenfontein	137	50.9	110	12.5	60.5
Hekpoort	0	97	35.7	135.2	79.2
Kaalplaas	97	0	72.4	48.3	34.1
Tedstone	35.7	72.4	0	112	63.6
Woodlands	6.2	97.2	29.2	140	82
Ashley	368	384	365	424	365
Boobaas Kuikens	128	56.8	116	18.6	56
Diepsloot	47.5	41.2	20.7	106	57.3
Doornkloof	74.6	24	50.3	69.7	47.2
Elandsvlei	102.4	17.7	79.8	37	39
Hoffman	135.8	50.4	110	1.3	54.1
Idle & Wild	74.8	22.1	54.7	73.1	45
Kgobokano	104.5	19.9	82	32.4	41.3
Klipspruit	120	39.9	116	30.6	60.5
Moolman 1	130	46	105	17.6	52.7
Moolman 2	147.3	62.8	122	22	66.5
Ndlovu	140.5	60	119	6.1	63.7
Nooitgedaght	89.6	18.2	71.7	48.4	42.8
Oosterhuizen	369.2	386	370	427	368
Pumelela	140	55.3	115	11	59
Rietfontein	100	17.2	81.5	33	40.7
Rondevlei	135.8	51.7	111	7.9	58
Shannon	135.2	48.3	112	0	58.6
TRU Bee	139	55.9	115	3	57
TRU Chicks	140.3	57	116	10.2	60.4
TRU Grow	139.5	58.9	118	13.7	64
TRU Sko	136	55.4	114	5.7	60
Van Rensburg	140	67.4	120	28.2	76.1
Weilaagte	347	388	372	429	370
Weltevrede	138	54	113	5.5	57.8
White Hot Trading	108	25	89.2	30	36.8
Witblipbank	130	51	108	22.8	55
Witfontein	85	11.7	65.7	53	20.3
Ystervarkfontein	110	30	93.3	33.2	41.8
Goedgedagt	148	127	140	95.1	85.7
Hofman	148	127	140	95.1	85.7
Bailing Plant	79.2	34.1	63.6	58.6	0

Shipping cost table for alternative 1:

		Shipping cost per ton (in Rands)				
FROM						
TO	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant	Chicken-house demand (t)
Bayview	R 45.70	R 14.66	R 36.29	R 16.59	R 23.05	392
Fairview	R 2.99	R 38.77	R 11.19	R 55.55	R 32.74	118
Groenfontein	R 53.98	R 20.05	R 43.34	R 4.93	R 23.84	276
Hekpoort	R 0.00	R 38.22	R 14.07	R 53.27	R 31.20	121
Kaalplaas	R 38.22	R 0.00	R 28.53	R 19.03	R 13.44	119
Tedstone	R 14.07	R 28.53	R 0.00	R 44.13	R 25.06	109
Woodlands	R 2.44	R 38.30	R 11.50	R 55.16	R 32.31	116
Ashley	R 144.99	R 151.30	R 143.81	R 167.06	R 143.81	92
Boobaas Kuikens	R 50.43	R 22.38	R 45.70	R 7.33	R 22.06	123
Diepsloot	R 18.72	R 16.23	R 8.16	R 41.76	R 22.58	128
Doornkloof	R 29.39	R 9.46	R 19.82	R 27.46	R 18.60	6
Elandsvlei	R 40.35	R 6.97	R 31.44	R 14.58	R 15.37	63
Hoffman	R 53.51	R 19.86	R 43.34	R 0.51	R 21.32	60
Idle & Wild	R 29.47	R 8.71	R 21.55	R 28.80	R 17.73	99
Kgobokano	R 41.17	R 7.84	R 32.31	R 12.77	R 16.27	115
Klipspruit	R 47.28	R 15.72	R 45.70	R 12.06	R 23.84	123
Moolman 1	R 51.22	R 18.12	R 41.37	R 6.93	R 20.76	104
Moolman 2	R 58.04	R 24.74	R 48.07	R 8.67	R 26.20	124
Ndlovu	R 55.36	R 23.64	R 46.89	R 2.40	R 25.10	120
Nooitgedaght	R 35.30	R 7.17	R 28.25	R 19.07	R 16.86	82
Oosterhuizen	R 145.46	R 152.08	R 145.78	R 168.24	R 144.99	70
Pumelela	R 55.16	R 21.79	R 45.31	R 4.33	R 23.25	120
Rietfontein	R 39.40	R 6.78	R 32.11	R 13.00	R 16.04	112
Rondevlei	R 53.51	R 20.37	R 43.73	R 3.11	R 22.85	109
Shannon	R 53.27	R 19.03	R 44.13	R 0.00	R 23.09	120
TRU Bee	R 54.77	R 22.02	R 45.31	R 1.18	R 22.46	103
TRU Chicks	R 55.28	R 22.46	R 45.70	R 4.02	R 23.80	103
TRU Grow	R 54.96	R 23.21	R 46.49	R 5.40	R 25.22	103
TRU Sko	R 53.58	R 21.83	R 44.92	R 2.25	R 23.64	103
Van Rensburg	R 55.16	R 26.56	R 47.28	R 11.11	R 29.98	103
Weilaagte	R 136.72	R 152.87	R 146.57	R 169.03	R 145.78	123
Weltevrede	R 54.37	R 21.28	R 44.52	R 2.17	R 22.77	109
White Hot Trading	R 42.55	R 9.85	R 35.14	R 11.82	R 14.50	115
Witblipbank	R 51.22	R 20.09	R 42.55	R 8.98	R 21.67	85
Witfontein	R 33.49	R 4.61	R 25.89	R 20.88	R 8.00	82
Ystervarkfontein	R 43.34	R 11.82	R 36.76	R 13.08	R 16.47	122
Goedgedagt	R 58.31	R 50.04	R 55.16	R 37.47	R 33.77	123
Hofman	R 58.31	R 50.04	R 55.16	R 37.47	R 33.77	64
Bailing Plant	R 31.20	R 13.44	R 25.06	R 23.09	R 0.00	0
Warehouse supply (t)	**126**	**317**	**117**	**155**	**3644**	**TOTAL: 4359 t**

Solver setup menu for alternative 1:



Candidate solution table for alternative 1:

Candidate solution:						
	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant	Total supplied (t):
Bayview	0	0	0	0	392	392
Fairview	0	0	0	0	118	118
Groenfontein	0	0	0	0	276	276
Hekpoort	0	0	117	0	4	121
Kaalplaas	0	0	0	32	87	119
Tedstone	0	0	0	0	109	109
Woodlands	0	0	0	0	116	116
Ashley	0	92	0	0	0	92
Boobaas Kuikens	0	0	0	0	123	123
Diepsloot	0	0	0	0	128	128
Doornkloof	0	0	0	0	6	6
Elandsvlei	0	0	0	0	63	63
Hoffman	0	0	0	0	60	60
Idle & Wild	0	0	0	0	99	99
Kgobokano	0	0	0	0	115	115
Klipspruit	0	0	0	123	0	123
Moolman 1	0	0	0	0	104	104
Moolman 2	0	0	0	0	124	124
Ndlovu	0	0	0	0	120	120
Nooitgedaght	0	0	0	0	82	82
Oosterhuizen	32	38	0	0	0	70
Pumelela	0	0	0	0	120	120
Rietfontein	0	0	0	0	112	112
Rondevlei	0	0	0	0	109	109
Shannon	0	0	0	0	120	120
TRU Bee	0	0	0	0	103	103
TRU Chicks	0	0	0	0	103	103
TRU Grow	0	0	0	0	103	103
TRU Sko	0	0	0	0	103	103
Van Rensburg	0	0	0	0	103	103
Weilaagte	0	123	0	0	0	123
Weltevrede	0	0	0	0	109	109
White Hot Trading	0	0	0	0	115	115
Witblipbank	0	0	0	0	85	85
Witfontein	0	0	0	0	82	82
Ystervarkfontein	0	0	0	0	122	122
Goedgedagt	94	0	0	0	29	123
Hofman	0	64	0	0	0	64
Bailing Plant	0	0	0	0	0	0
Total shipped from warehouse(t):	126	317	117	155	3644	**Total: 4359 t**

Cost calculations table for alternative 1:

Cost calculations:	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant
Bayview	R 0.00	R 0.00	R 0.00	R 0.00	R 9 035.21
Fairview	R 0.00	R 0.00	R 0.00	R 0.00	R 3 863.49
Groenfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 6 579.01
Hekpoort	R 0.00	R 0.00	R 1 645.70	R 0.00	R 124.82
Kaalplaas	R 0.00	R 0.00	R 0.00	R 608.97	R 1 168.88
Tedstone	R 0.00	R 0.00	R 0.00	R 0.00	R 2 731.37
Woodlands	R 0.00	R 0.00	R 0.00	R 0.00	R 3 747.73
Ashley	R 0.00	R 13 919.23	R 0.00	R 0.00	R 0.00
Boobaas Kuikens	R 0.00	R 0.00	R 0.00	R 0.00	R 2 713.87
Diepsloot	R 0.00	R 0.00	R 0.00	R 0.00	R 2 889.75
Doornkloof	R 0.00	R 0.00	R 0.00	R 0.00	R 111.58
Elandsvlei	R 0.00	R 0.00	R 0.00	R 0.00	R 968.06
Hoffman	R 0.00	R 0.00	R 0.00	R 0.00	R 1 278.92
Idle & Wild	R 0.00	R 0.00	R 0.00	R 0.00	R 1 755.27
Kgobokano	R 0.00	R 0.00	R 0.00	R 0.00	R 1 871.30
Klipspruit	R 0.00	R 0.00	R 0.00	R 1 482.94	R 0.00
Moolman 1	R 0.00	R 0.00	R 0.00	R 0.00	R 2 159.44
Moolman 2	R 0.00	R 0.00	R 0.00	R 0.00	R 3 248.92
Ndlovu	R 0.00	R 0.00	R 0.00	R 0.00	R 3 011.74
Nooitgedaght	R 0.00	R 0.00	R 0.00	R 0.00	R 1 382.78
Oosterhuizen	R 4 654.87	R 5 779.19	R 0.00	R 0.00	R 0.00
Pumelela	R 0.00	R 0.00	R 0.00	R 0.00	R 2 789.52
Rietfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 1 796.01
Rondevlei	R 0.00	R 0.00	R 0.00	R 0.00	R 2 490.87
Shannon	R 0.00	R 0.00	R 0.00	R 0.00	R 2 770.61
TRU Bee	R 0.00	R 0.00	R 0.00	R 0.00	R 2 313.17
TRU Chicks	R 0.00	R 0.00	R 0.00	R 0.00	R 2 451.15
TRU Grow	R 0.00	R 0.00	R 0.00	R 0.00	R 2 597.25
TRU Sko	R 0.00	R 0.00	R 0.00	R 0.00	R 2 434.92
Van Rensburg	R 0.00	R 0.00	R 0.00	R 0.00	R 3 088.29
Weilaagte	R 0.00	R 18 803.26	R 0.00	R 0.00	R 0.00
Weltevrede	R 0.00	R 0.00	R 0.00	R 0.00	R 2 482.28
White Hot Trading	R 0.00	R 0.00	R 0.00	R 0.00	R 1 667.41
Witblipbank	R 0.00	R 0.00	R 0.00	R 0.00	R 1 841.95
Witfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 655.85
Ystervarkfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 2 009.24
Goedgedagt	R 5 481.33	R 0.00	R 0.00	R 0.00	R 979.21
Hofman	R 0.00	R 3 202.43	R 0.00	R 0.00	R 0.00
Bailing Plant	R 0.00	R 0.00	R 0.00	R 0.00	R 0.00
	Total outbound cost:		**R 136 587.78**		

Inbound transportation		
82 loads unloaded at Bailing Plant per cycle		
Average truck load:	10	t/load
to transport 1 ton for 1 km =	**R 0.394**	
Distance from the plant to supplier and back to the plant: 35.4 km		
Total inbound cost =	**R 11 437**	
Total transportation cost:	**R 148 024.78**	

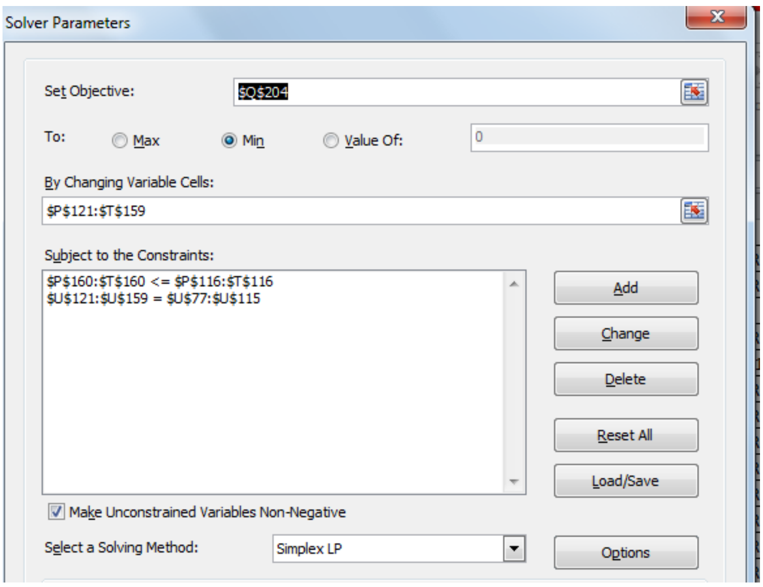
Shipping cost for alternative 2:

		Shipping cost per ton (in Rands)				
FROM						
TO	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant	Chicken-house demand (t)
Bayview	R 45.70	R 14.66	R 36.29	R 16.59	R 24.19	**392**
Fairview	R 2.99	R 38.77	R 11.19	R 55.55	R 31.72	**118**
Groenfontein	R 53.98	R 20.05	R 43.34	R 4.93	R 25.96	**276**
Hekpoort	R 0.00	R 38.22	R 14.07	R 53.27	R 30.26	**121**
Kaalplaas	R 38.22	R 0.00	R 28.53	R 19.03	R 9.46	**119**
Tedstone	R 14.07	R 28.53	R 0.00	R 44.13	R 20.25	**109**
Woodlands	R 2.44	R 38.30	R 11.50	R 55.16	R 31.17	**116**
Ashley	R 144.99	R 151.30	R 143.81	R 167.06	R 143.02	**92**
Boobaas Kuikens	R 50.43	R 22.38	R 45.70	R 7.33	R 28.05	**123**
Diepsloot	R 18.72	R 16.23	R 8.16	R 41.76	R 12.77	**128**
Doornkloof	R 29.39	R 9.46	R 19.82	R 27.46	R 15.05	**6**
Elandsvlei	R 40.35	R 6.97	R 31.44	R 14.58	R 16.51	**63**
Hoffman	R 53.51	R 19.86	R 43.34	R 0.51	R 25.53	**60**
Idle & Wild	R 29.47	R 8.71	R 21.55	R 28.80	R 13.59	**99**
Kgobokano	R 41.17	R 7.84	R 32.31	R 12.77	R 17.38	**115**
Klipspruit	R 47.28	R 15.72	R 45.70	R 12.06	R 28.05	**123**
Moolman 1	R 51.22	R 18.12	R 41.37	R 6.93	R 24.82	**104**
Moolman 2	R 58.04	R 24.74	R 48.07	R 8.67	R 30.42	**124**
Ndlovu	R 55.36	R 23.64	R 46.89	R 2.40	R 29.31	**120**
Nooitgedaght	R 35.30	R 7.17	R 28.25	R 19.07	R 16.71	**82**
Oosterhuizen	R 145.46	R 152.08	R 145.78	R 168.24	R 144.20	**70**
Pumelela	R 55.16	R 21.79	R 45.31	R 4.33	R 27.46	**120**
Rietfontein	R 39.40	R 6.78	R 32.11	R 13.00	R 16.67	**112**
Rondevlei	R 53.51	R 20.37	R 43.73	R 3.11	R 26.79	**109**
Shannon	R 53.27	R 19.03	R 44.13	R 0.00	R 26.71	**120**
TRU Bee	R 54.77	R 22.02	R 45.31	R 1.18	R 27.74	**103**
TRU Chicks	R 55.28	R 22.46	R 45.70	R 4.02	R 27.66	**103**
TRU Grow	R 54.96	R 23.21	R 46.49	R 5.40	R 28.88	**103**
TRU Sko	R 53.58	R 21.83	R 44.92	R 2.25	R 27.78	**103**
Van Rensburg	R 55.16	R 26.56	R 47.28	R 11.11	R 34.20	**103**
Weilaagte	R 136.72	R 152.87	R 146.57	R 169.03	R 144.99	**123**
Weltevrede	R 54.37	R 21.28	R 44.52	R 2.17	R 26.99	**109**
White Hot Trading	R 42.55	R 9.85	R 35.14	R 11.82	R 20.21	**115**
Witblipbank	R 51.22	R 20.09	R 42.55	R 8.98	R 26.95	**85**
Witfontein	R 33.49	R 4.61	R 25.89	R 20.88	R 6.03	**82**
Ystervarkfontein	R 43.34	R 11.82	R 36.76	R 13.08	R 21.83	**122**
Goedgedagt	R 58.31	R 50.04	R 55.16	R 37.47	R 41.76	**123**
Hofman	R 58.31	R 50.04	R 55.16	R 37.47	R 41.76	**64**
Bailing Plant	R 30.26	R 9.46	R 20.25	R 26.71	R 0.00	**0**
Warehouse supply (t)	**126**	**317**	**117**	**155**	**3644**	**TOTAL: 4359 t**

Candidate solution for alternative 2:

Candidate solution:	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant	Total supplied (t):
Bayview	0	0	0	0	392	392
Fairview	1	0	117	0	0	118
Groenfontein	0	0	0	0	276	276
Hekpoort	121	0	0	0	0	121
Kaalplaas	0	0	0	0	119	119
Tedstone	0	0	0	0	109	109
Woodlands	4	0	0	0	112	116
Ashley	0	0	0	0	92	92
Boobaas Kuikens	0	0	0	0	123	123
Diepsloot	0	0	0	0	128	128
Doornkloof	0	0	0	0	6	6
Elandsvlei	0	0	0	0	63	63
Hoffman	0	0	0	0	60	60
Idle & Wild	0	0	0	0	99	99
Kgobokano	0	0	0	0	115	115
Klipspruit	0	123	0	0	0	123
Moolman 1	0	0	0	0	104	104
Moolman 2	0	0	0	0	124	124
Ndlovu	0	0	0	120	0	120
Nooitgedaght	0	0	0	0	82	82
Oosterhuizen	0	0	0	0	70	70
Pumelela	0	0	0	0	120	120
Rietfontein	0	0	0	0	112	112
Rondevlei	0	0	0	0	109	109
Shannon	0	0	0	35	85	120
TRU Bee	0	0	0	0	103	103
TRU Chicks	0	0	0	0	103	103
TRU Grow	0	0	0	0	103	103
TRU Sko	0	0	0	0	103	103
Van Rensburg	0	0	0	0	103	103
Weilaagte	0	0	0	0	123	123
Weltevrede	0	0	0	0	109	109
White Hot Trading	0	115	0	0	0	115
Witblipbank	0	0	0	0	85	85
Witfontein	0	0	0	0	82	82
Ystervarkfontein	0	79	0	0	43	122
Goedgedagt	0	0	0	0	123	123
Hofman	0	0	0	0	64	64
Bailing Plant	0	0	0	0	0	0
Total shipped from warehouse (t):	126	317	117	155	3644	**TOTAL: 4359 t**

Solver setup menu for alternative 2:



Cost calculations table for alternative 2:

Cost calculations:	Hekpoort	Kaalplaas	Tedstone	Shannon	Bailing Plant
Bayview	R 0.00	R 0.00	R 0.00	R 0.00	R 9 483.11
Fairview	R 2.99	R 0.00	R 1 309.18	R 0.00	R 0.00
Groenfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 7 166.23
Hekpoort	R 0.00	R 0.00	R 0.00	R 0.00	R 0.00
Kaalplaas	R 0.00	R 0.00	R 0.00	R 0.00	R 1 125.26
Tedstone	R 0.00	R 0.00	R 0.00	R 0.00	R 2 207.42
Woodlands	R 9.77	R 0.00	R 0.00	R 0.00	R 3 490.52
Ashley	R 0.00	R 0.00	R 0.00	R 0.00	R 13 158.02
Boobaas Kuikens	R 0.00	R 0.00	R 0.00	R 0.00	R 3 450.49
Diepsloot	R 0.00	R 0.00	R 0.00	R 0.00	R 1 634.00
Doornkloof	R 0.00	R 0.00	R 0.00	R 0.00	R 90.30
Elandsvlei	R 0.00	R 0.00	R 0.00	R 0.00	R 1 040.04
Hoffman	R 0.00	R 0.00	R 0.00	R 0.00	R 1 531.87
Idle & Wild	R 0.00	R 0.00	R 0.00	R 0.00	R 1 345.71
Kgobokano	R 0.00	R 0.00	R 0.00	R 0.00	R 1 998.17
Klipspruit	R 0.00	R 1 933.63	R 0.00	R 0.00	R 0.00
Moolman 1	R 0.00	R 0.00	R 0.00	R 0.00	R 2 581.49
Moolman 2	R 0.00	R 0.00	R 0.00	R 0.00	R 3 771.68
Ndlovu	R 0.00	R 0.00	R 0.00	R 288.41	R 0.00
Nooitgedaght	R 0.00	R 0.00	R 0.00	R 0.00	R 1 369.86
Oosterhuizen	R 0.00	R 0.00	R 0.00	R 0.00	R 10 094.28
Pumelela	R 0.00	R 0.00	R 0.00	R 0.00	R 3 295.42
Rietfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 1 866.61
Rondevlei	R 0.00	R 0.00	R 0.00	R 0.00	R 2 920.33
Shannon	R 0.00	R 0.00	R 0.00	R 0.00	R 2 270.62
TRU Bee	R 0.00	R 0.00	R 0.00	R 0.00	R 2 856.97
TRU Chicks	R 0.00	R 0.00	R 0.00	R 0.00	R 2 848.86
TRU Grow	R 0.00	R 0.00	R 0.00	R 0.00	R 2 974.66
TRU Sko	R 0.00	R 0.00	R 0.00	R 0.00	R 2 861.03
Van Rensburg	R 0.00	R 0.00	R 0.00	R 0.00	R 3 522.52
Weilaagte	R 0.00	R 0.00	R 0.00	R 0.00	R 17 834.02
Weltevrede	R 0.00	R 0.00	R 0.00	R 0.00	R 2 941.80
White Hot Trading	R 0.00	R 1 132.75	R 0.00	R 0.00	R 0.00
Witblipbank	R 0.00	R 0.00	R 0.00	R 0.00	R 2 290.72
Witfontein	R 0.00	R 0.00	R 0.00	R 0.00	R 494.31
Ystervarkfontein	R 0.00	R 933.78	R 0.00	R 0.00	R 938.59
Goedgedagt	R 0.00	R 0.00	R 0.00	R 0.00	R 5 136.97
Hofman	R 0.00	R 0.00	R 0.00	R 0.00	R 2 672.90
Bailing Plant	R 0.00	R 0.00	R 0.00	R 0.00	R 0.00
Total outbound cost: R 128 875.31					

Transportation cost for alternative 2:

Inbound transportation	
82 loads unloaded at Bailing Plant per cycle	
Average truck load:	10 t/load
to transport 1 ton for 1 km =	**R 0.394**
Distance from the plant to supplier and back to the plant: 2.2 km	
Total inbound cost =	**R 711**
Total transportation cost:	**R 129 586.09**

Shipping cost for alternative 3:

	Shipping cost per ton (in Rands)				
FROM					
TO	Hekpoort	Kaalplaas	Tedstone	Shannon	Chicken-house demand (t)
Bayview	R 45.70	R 14.66	R 36.29	R 16.59	**392**
Fairview	R 2.99	R 38.77	R 11.19	R 55.55	**118**
Groenfontein	R 53.98	R 20.05	R 43.34	R 4.93	**276**
Hekpoort	R 0.00	R 38.22	R 14.07	R 53.27	**121**
Kaalplaas	R 38.22	R 0.00	R 28.53	R 19.03	**119**
Tedstone	R 14.07	R 28.53	R 0.00	R 44.13	**109**
Woodlands	R 2.44	R 38.30	R 11.50	R 55.16	**116**
Ashley	R 144.99	R 151.30	R 143.81	R 167.06	**92**
Boobaas Kuikens	R 50.43	R 22.38	R 45.70	R 7.33	**123**
Diepsloot	R 18.72	R 16.23	R 8.16	R 41.76	**128**
Doornkloof	R 29.39	R 9.46	R 19.82	R 27.46	**6**
Elandsvlei	R 40.35	R 6.97	R 31.44	R 14.58	**63**
Hoffman	R 53.51	R 19.86	R 43.34	R 0.51	**60**
Idle & Wild	R 29.47	R 8.71	R 21.55	R 28.80	**99**
Kgobokano	R 41.17	R 7.84	R 32.31	R 12.77	**115**
Klipspruit	R 47.28	R 15.72	R 45.70	R 12.06	**123**
Moolman 1	R 51.22	R 18.12	R 41.37	R 6.93	**104**
Moolman 2	R 58.04	R 24.74	R 48.07	R 8.67	**124**
Ndlovu	R 55.36	R 23.64	R 46.89	R 2.40	**120**
Nooitgedaght	R 35.30	R 7.17	R 28.25	R 19.07	**82**
Oosterhuizen	R 145.46	R 152.08	R 145.78	R 168.24	**70**
Pumelela	R 55.16	R 21.79	R 45.31	R 4.33	**120**
Rietfontein	R 39.40	R 6.78	R 32.11	R 13.00	**112**
Rondevlei	R 53.51	R 20.37	R 43.73	R 3.11	**109**
Shannon	R 53.27	R 19.03	R 44.13	R 0.00	**120**
TRU Bee	R 54.77	R 22.02	R 45.31	R 1.18	**103**
TRU Chicks	R 55.28	R 22.46	R 45.70	R 4.02	**103**
TRU Grow	R 54.96	R 23.21	R 46.49	R 5.40	**103**
TRU Sko	R 53.58	R 21.83	R 44.92	R 2.25	**103**
Van Rensburg	R 55.16	R 26.56	R 47.28	R 11.11	**103**
Weilaagte	R 136.72	R 152.87	R 146.57	R 169.03	**123**
Weltevrede	R 54.37	R 21.28	R 44.52	R 2.17	**109**
White Hot Trading	R 42.55	R 9.85	R 35.14	R 11.82	**115**
Witblipbank	R 51.22	R 20.09	R 42.55	R 8.98	**85**
Witfontein	R 33.49	R 4.61	R 25.89	R 20.88	**82**
Ystervarkfontein	R 43.34	R 11.82	R 36.76	R 13.08	**122**
Goedgedagt	R 58.31	R 50.04	R 55.16	R 37.47	**123**
Hofman	R 58.31	R 50.04	R 55.16	R 37.47	**64**
Warehouse supply (t)	**126**	**3961**	**117**	**155**	**TOTAL: 4359 t**

Candidate solution for alternative 3:

Candidate solution:					
	Hekpoort	Kaalplaas	Tedstone	Shannon	Total supplied (t):
Bayview	0	392	0	0	392
Fairview	0	110	8	0	118
Groenfontein	0	276	0	0	276
Hekpoort	121	0	0	0	121
Kaalplaas	0	119	0	0	119
Tedstone	0	0	109	0	109
Woodlands	5	111	0	0	116
Ashley	0	92	0	0	92
Boobaas Kuikens	0	123	0	0	123
Diepsloot	0	128	0	0	128
Doornkloof	0	6	0	0	6
Elandsvlei	0	63	0	0	63
Hoffman	0	60	0	0	60
Idle & Wild	0	99	0	0	99
Kgobokano	0	115	0	0	115
Klipspruit	0	123	0	0	123
Moolman 1	0	104	0	0	104
Moolman 2	0	124	0	0	124
Ndlovu	0	0	0	120	120
Nooitgedaght	0	82	0	0	82
Oosterhuizen	0	70	0	0	70
Pumelela	0	120	0	0	120
Rietfontein	0	112	0	0	112
Rondevlei	0	109	0	0	109
Shannon	0	120	0	0	120
TRU Bee	0	68	0	35	103
TRU Chicks	0	103	0	0	103
TRU Grow	0	103	0	0	103
TRU Sko	0	103	0	0	103
Van Rensburg	0	103	0	0	103
Weilaagte	0	123	0	0	123
Weltevrede	0	109	0	0	109
White Hot Trading	0	115	0	0	115
Witblipbank	0	85	0	0	85
Witfontein	0	82	0	0	82
Ystervarkfontein	0	122	0	0	122
Goedgedagt	0	123	0	0	123
Hofman	0	64	0	0	64
Total shipped from warehouse(t):	126	3961	117	155	**Total: 4359 t**

Cost calculations for alternative 3:

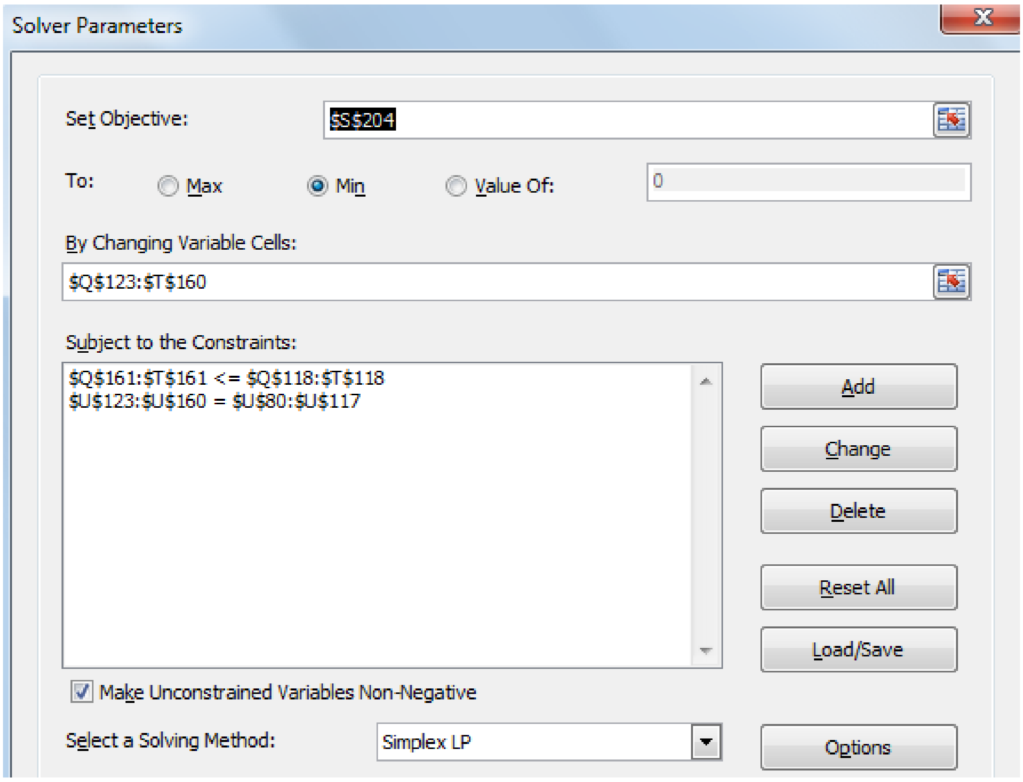
Transportation cost for alternative 3:

Cost calculations:

	Hekpoort	Kaalplaas	Tedstone	Shannon
Bayview	R 0.00	R 5 745.47	R 0.00	R 0.00
Fairview	R 0.00	R 4 264.66	R 89.52	R 0.00
Groenfontein	R 0.00	R 5 535.07	R 0.00	R 0.00
Hekpoort	R 0.00	R 0.00	R 0.00	R 0.00
Kaalplaas	R 0.00	R 0.00	R 0.00	R 0.00
Tedstone	R 0.00	R 0.00	R 0.00	R 0.00
Woodlands	R 12.21	R 4 250.94	R 0.00	R 0.00
Ashley	R 0.00	R 13 919.23	R 0.00	R 0.00
Boobaas Kuikens	R 0.00	R 2 752.64	R 0.00	R 0.00
Diepsloot	R 0.00	R 2 077.80	R 0.00	R 0.00
Doornkloof	R 0.00	R 56.74	R 0.00	R 0.00
Elandsvlei	R 0.00	R 439.35	R 0.00	R 0.00
Hoffman	R 0.00	R 1 191.46	R 0.00	R 0.00
Idle & Wild	R 0.00	R 862.03	R 0.00	R 0.00
Kgobokano	R 0.00	R 901.67	R 0.00	R 0.00
Klipspruit	R 0.00	R 1 933.63	R 0.00	R 0.00
Moolman 1	R 0.00	R 1 884.90	R 0.00	R 0.00
Moolman 2	R 0.00	R 3 068.16	R 0.00	R 0.00
Ndlovu	R 0.00	R 0.00	R 0.00	R 288.41
Nooitgedaght	R 0.00	R 588.01	R 0.00	R 0.00
Oosterhuizen	R 0.00	R 10 645.88	R 0.00	R 0.00
Pumelela	R 0.00	R 2 614.58	R 0.00	R 0.00
Rietfontein	R 0.00	R 759.00	R 0.00	R 0.00
Rondevlei	R 0.00	R 2 220.31	R 0.00	R 0.00
Shannon	R 0.00	R 2 283.62	R 0.00	R 0.00
TRU Bee	R 0.00	R 1 497.67	R 0.00	R 41.37
TRU Chicks	R 0.00	R 2 313.17	R 0.00	R 0.00
TRU Grow	R 0.00	R 2 390.28	R 0.00	R 0.00
TRU Sko	R 0.00	R 2 248.24	R 0.00	R 0.00
Van Rensburg	R 0.00	R 2 735.23	R 0.00	R 0.00
Weilaagte	R 0.00	R 18 803.26	R 0.00	R 0.00
Weltevrede	R 0.00	R 2 319.08	R 0.00	R 0.00
White Hot Trading	R 0.00	R 1 132.75	R 0.00	R 0.00
Witblipbank	R 0.00	R 1 707.99	R 0.00	R 0.00
Witfontein	R 0.00	R 378.00	R 0.00	R 0.00
Ystervarkfontein	R 0.00	R 1 442.04	R 0.00	R 0.00
Goedgedagt	R 0.00	R 6 154.67	R 0.00	R 0.00
Hofman	R 0.00	R 3 202.43	R 0.00	R 0.00
	Total outbound cost:		**R 114 751.48**	

Inbound transportation		
82 loads unloaded at Bailing Plant per cycle		
Average truck load:	10	t/load
to transport 1 ton for 1 km =	**R 0.394**	
Distance from plant to supplier and back to the plant: 53.4 km		
Total inbound cost =	**R 17 253**	
Total transportation cost:	**R 132 003.98**	

Solver setup menu for alternative 3:



Appendix C:

Tables for calculating costs:

	Costing factor:	Alternative 1: Bailing Plant's current facility	Alternative 2: Relocate to facility in Isando (Kempton Park)	Alternative 3: Build a new facility at Kaalplaas	
Manufacturing cost	**Direct material**	**1830780**	**1830780**	**1830780**	(4359 t x R 420 / t)
	Direct labour	**391000**	**391000**	**391000**	(Assumption)
	Manufacturing overhead:				
	Indirect material (plastic bags, woolsacks etc)	8500	8500	8500	(Assumption)
	Indirect labour	20000	20000	20000	(Assumption)
	Electricity	20000	20000	20000	(Assumption)
	Property tax	N/A	N/A	20304	(Assumption)
	Insurance	9700	9700	9700	(Assumption)
	Depreciation	20000	20000	20000	(Assumption)
	Facility lease expense	115577	99484	N/A	(cost / m^2 x 1463 m^2)
	Inbound transportation cost	11437	711	17253	(from transportation cost calculations)
	Total Manufacturing overhead	**205214**	**178395**	**115757**	
	Total Manufacturing costs	**R 2 426 994**	**R 2 400 175**	**R 2 337 537**	
Non-manufacturing cost	**Administrative costs**	**7000**	**7000**	**7000**	(Assumption)
	Marketing / selling costs:				
	Outbound transportation cost	136587.78	128875.31	114751.48	(from transportation cost calculations)
	Other cost	5500	5500	5500	(Assumption)
	Total marketing/selling cost	**142087.78**	**134375.31**	**120251.48**	
	Total Non-manufacturing costs	**R 149 087.78**	**R 141 375.31**	**R 127 251.48**	
	Total expenses per cycle	**R 2 576 081.78**	**R 2 541 550.31**	**R 2 464 788.48**	
	Sales per cycle	**R 2 750 529**	**R 2 750 529**	**R 2 750 529**	(4359 t x R 631 / t)
	Profit per cycle	**R 174 447.22**	**R 208 978.69**	**R 285 740.52**	

Alternative 4: Close the Bailing Plant		
Expenses: (cyclical)		
Bedding material purchasing cost for farmers	R 6 233 370	(4359 t x R 1430 / t)
Revenues: (once-off)		
Market value of equipment for Earlybird Farms	R 472 634	(Market value of equipment and machinery)

Graph of cumulative cost for each alternative: