A

Technical Document

For

BIG COCK

BREWING COMPANY

Submitted To:
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1.0 EXECUTIVE SUMMARY

Results

BCB Company proposes to install two breweries in Indianapolis, Indiana in the first year and Milwaukee, Wisconsin in the fourth year of operation. The Milwaukee plant will be expanded from 6,000 barrels per year to 15,000 barrels per year in the same year it is built. Based on financial data on labor costs, equipment costs, leasing costs, cost of raw materials, and operating costs, a total revenue of $1.08 million for the first year was determined. This is based on operating on a 30 barrel system process producing four batches per week and selling the product for $180 per barrel. A net present worth was determined to be $5,413,000 for a 20 year lifetime of the project.

Description of the Business

Big Cock Brewing (BCB) Company will be incorporated as a privately held corporation managed by the president. The business of the company is the production of high-quality pale ale beer for local and regional markets. BCB Company will initially produce Rooster Brew to be distributed in bottles and kegs, depending on market demand. The company will produce beer using a 30 barrel system process producing approximately four batches per week, which corresponds to 6,000 barrels per year. The addition of more fermenters as demands increase will increase the capacity by 1.5% each year.

Management Responsibility

The president is responsible for the management and overall operation of the business. In the start-up phase, the president will choose and supervise all utility subcontractors; will approve, supervise, and assist in all construction; and will approve the design, purchase, and installation of all brewing equipment. In future operations, the president will be responsible for overseeing all aspects of daily operation. This includes brewing, bottling, distributing, marketing, sales, and customer satisfaction, and will also carry out the licensing process, secure financing of operational expenses, and direct the daily start-up operations.

Marketing and Distribution

BCB Company will produce pale ale beer in bottles and kegs for distribution. The typical craft beer consumer is a Caucasian male between the ages of 21 and 35 years who makes $50,000 or more a year. These targeted individuals are more likely to pay the additional cost for a premium, craft brewed beer. BCB Company will compete with fellow microbrewers in the specialty division distributing in that market. Currently, the specialty brews division holds approximately 3% of the total U.S. beer market shares. In the first year, we anticipate on cornering 2% of the specialty division's market shares. This would result in 0.06% of the total market share for the targeted market.

Supporting Arguments

A mathematical model was created to simultaneously account for all possible scenarios, based upon input variables, to determine the optimal placement and conditions for a microbrewery, which is nearly impossible to do by traditional decision making processes. This powerful tool makes it possible to analyze dozens of variables at the same time and calculate the optimal plant locations, market locations, and raw materials locations based on the input data. The advantage of using a mathematical model is the flexibility in updating parameters and different business strategies as new information becomes available over time. By doing this, the effect of varying parameters can be evaluated. Factors, such as demand or shipping costs, might change during the course of the study, and the mathematical model can easily be updated to ensure accurate and precise results. This capability will be instrumental in determining the reliability of the final results.

2.0 INTRODUCTION

Microbreweries are defined by the industry as small breweries that produce less than 15,000 barrels of beer per year and distribute the product for consumption off-premise. Microbreweries sell to the public by one or more of the following methods: the traditional three-tier system (brewer to wholesaler to retailer to consumer); the two-tier system (brewer acting as wholesaler to retailer to consumer); and, directly to the consumer through carry outs and/or on-site tap-room or restaurant sales.

According to the Association of Brewers, craft beer production has increased by 3.4% in 2003. The growth is measured by the number of barrels of beer U.S breweries produced in that year. The continued growth trend from year to year addresses the stability of craft beer in a variety of economic environments. As of 2003, there were 358 microbreweries in operation in the United States.

The current demand for more flavorful beers began with the imported beers market. As this market grew, beer drinkers were able to increase their tastes for a variety of world beer styles. As a result, the microbrewery industry in the United States has benefited from this increased awareness and demand.

2.1 Advantage of a Microbrewery

One main advantage of a microbrewery is that they are able to supply their product to the consumer when the product is at its peak of freshness. For a microbrewery, quality is the most important concern, given their small market share and limited competitive edge compared to large national breweries. For this reason, using the highest quality ingredients (malted barley, hops, yeast, and water) is more justified, as opposed to using corn and rice which is used by large scale breweries to cut costs.

2.2 Microbrewery Markets

Beer consumption is greatly dominated by male consumers, with men accounting for over 80% of the volume consumed. A large number of these drinkers are white and favor a light beer. Of all the beer types, light beer has the strongest following among women consumers. Women beer drinkers are more strongly attracted to microbrewed beers than domestic beers. The appeal of microbrewed beers is stronger among white beer drinkers than any other ethnicity.

2.3 Production Process of Microbreweries

At the beginning of the brewing process, hot water and malted barley are introduced into a mash tun. The mash tun facilitates enzymatic activities, which result in the production of wort. Wort is a solution of sugars, dextrin, and proteins.

Upon completion in the mash tun, the wort must be separated from any leftover grains. To do this, the solution is passed through a lauter tun. The lauter tun contains a strainer, which allows the purified wort to pass through while withholding the grain.

Next, the wort is fed into a boil kettle. At this stage, hops are added, which provide the desired bitterness and fragrance to the wort. At the completion of the boiling stage, coagulated protein must be separated from the wort. To do this, the solution is fed into a whirlpool.

Finally, the yeast is added to the clarified wort, which is then passed through a chiller. After passing through the chiller, the wort/yeast combination is sent to a fermenter. Finally, the solution is fed into a tank containing carbon dioxide. After passing through the carbon dioxide tank, the brewing process is complete. The next step is to bottle and/or keg the final product.

The following is a process flow diagram of a basic microbrewing system:

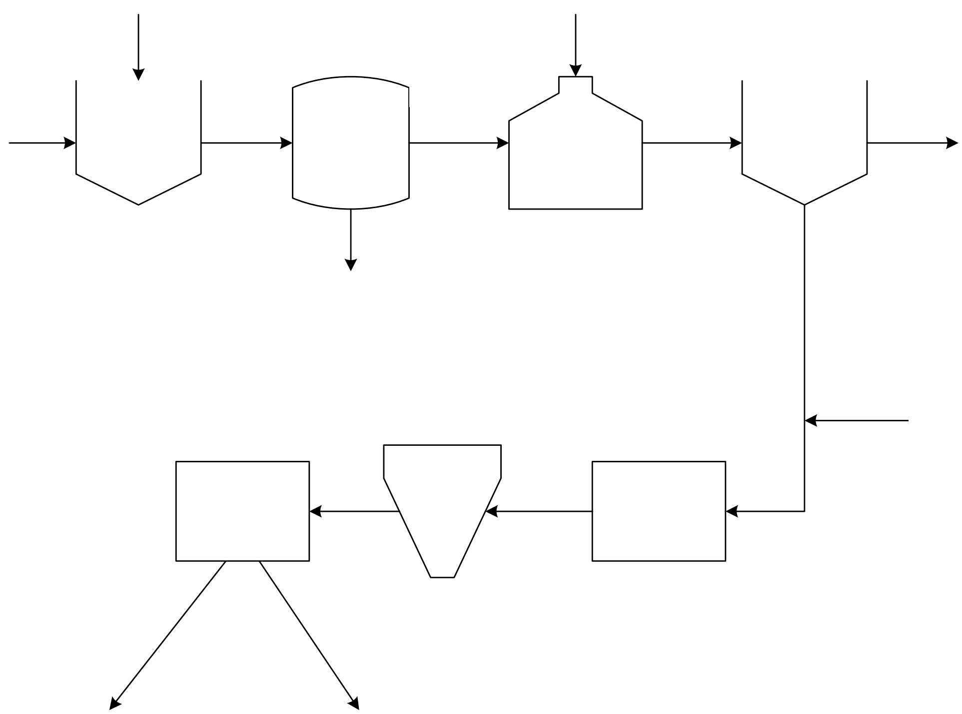

Figure 2.1: Process Flow Diagram of Basic Microbrewery

2.4 Microbrewery Organization

The following is the typical organizational chart of a microbrewery in its first year of production.

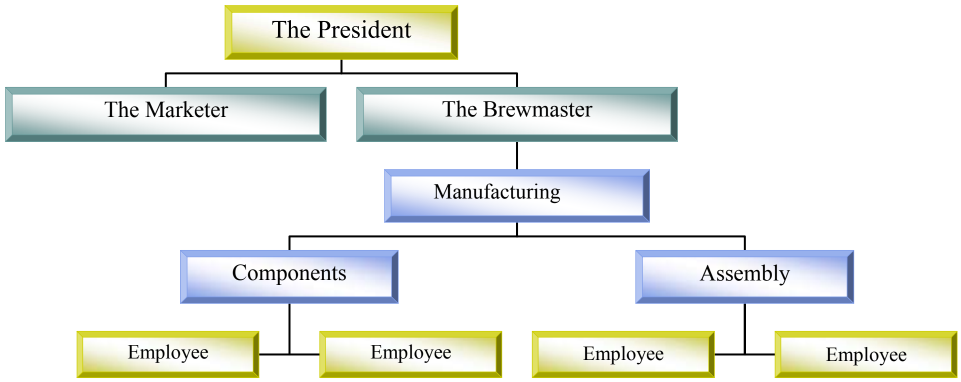

Figure 2.2: Organizational Chart

The president has overall responsibility for the start-up and daily operation of the microbrewery. In the start-up phase, the president will choose and supervise all utility subcontractors; will approve, supervise, and assist in all construction; will approve the design, purchase, and installation of all brewing equipment.

The brewmaster will be responsible for all tasks related to the production of beer in the daily operations phase of the project; will perform the regular brewing routine and all tasks associated with preparing all products for the market.

The marketer will be responsible for selling the product to as many businesses as possible in order to keep the demand and production growing at a considerable pace. He/she will be responsible for marketing ads and research to keep up with the changing times to determine who will best benefit from the product.

The components manufacturing team will be responsible for assisting the brewmaster in daily brewing tasks and keeping the operation running smoothly.

The assembly manufacturing team will be responsible for the packaging of the final product in order to get it ready for distribution. This includes bottling and kegging and all other aspects related to the process, such as capping and labeling of the bottles and kegs.

3.0 THE PROCESS

There are several important aspects related to the production of beer. Using the highest quality of ingredients is of utmost importance along with keeping the process as sterilized as possible. The main process includes mashing, boiling, wort clarification, wort cooling, fermentation, bottling, and kegging.

3.1 Raw Material Description

The main raw materials used in the production of microbrewed beer are hops, malted barley, and yeast. Hops is a cultivated flower that contains both a male and a female part. The female part is what is taken from the flower to use in the production process for the bittering and fragrance of the beer. Malted barley is a type of grain that contains kernels and is used in the production process for the sweet flavoring of the beer. Yeast is added during the process prior to fermentation, which actually makes the beer. Some types of yeast are used for fruity flavoring of the beer.

3.2 Process Flow

The following is a detailed description of the process used to make beer.

Mashing

Mash is a mixture of malted crushed grains and hot water that is subjected to a temperature which facilitates enzymatic activities that gives the desired characteristics of the wort. Wort is the solution of sugars, dextrin, and proteins that exists after the fluid is separated from the grains' solids and prior to fermentation.

The simplest mashing procedure is the single temperature infusion mash wherein the grains and water are mixed at the optimum sugar conversion temperature, typically around 150ºF.

Alternatively, the decoction or multi-temperature infusion mash requires the use of a heated reactor vessel so that the mash temperature can be raised in steps. This method facilitates in maximizing certain sugar conversions and extraction.

Lautering

Upon completion of the mashing process, the wort must be separated from the residual grains. The lauter tun is flat-bottomed vessel with a strainer as a false bottom. Large lauter tuns require rotating knives to prevent the grains from creating a plug preventing the wort to flow.

Boiling

The wort, once isolated, must be boiled vigorously for up to 90 minutes in a boil kettle. Hops are added at various times for bittering and adding fragrance (flowering) the wort. Boiling will extract flavors and tannins from the hops, coagulate unwanted proteins, remove excess water, and inactivate enzymes. Heat transfer is must be designed to prevent carmelization, and the kettle vent stack must permit the escape of large amounts of water vapor.

Wort Clarification

At the end of boiling, the coagulated protein, which has formed, must be separated. This is generally done by centripetal action either in the kettle, if it was designed for this purpose, or in a dedicated, flat-bottomed, whirlpool tank. The wort pump must transfer the wort rapidly, produce the velocity needed to create the liquid rotation in the tank, and not damage the agglomerated solids (trub).

Wort Cooling

The wort must be cooled from approximately 195 ºF to the desired temperature at which the yeast is added (pitching temperature). Cooling of a brew must be completed in less than 60 minutes. A plate-type regenerative heat exchanger is generally used. Microbreweries producing two, three, or more brews per day should use a single-stage cooler. Water that has been pre-chilled to at least 40 F enters the cooler and leaves at 175ºF. This water is then used in the mashing and lautering operations. The wort is cooled to between 50 ºF and 70 ºF, depending on the product being made. With at least five hours between cooling cycles, the chilled water can be produced over a 5 hour span and stored in a chilled water tank. This reduces the wort cooling live load refrigeration demand by a factor of five. The wort cooler must be designed to permit frequent cleaning, preferably in the flow direction opposite from the wort flow.

Fermentation

After the wort has been cooled and the yeast has been added, the mixture can then be sent to the fermenters for fermentation. Since BCB Company will be producing a pale ale, this will require a shorter fermentation time at a high temperature. Fermentation time will be approximately two weeks. BCB Company will have a series of twelve fermenters. The following is a description of the fermentation process on a day to day basis:

- Day 1 – Fermenter one is filled
- Day 2 – Fermenter two is filled

- Day 3 – Fermenter three is filled
- Day 4 – Fermenter four is filled
- Day 5 – Fermenter five is filled.
- Day 6 & 7 – No Brewing
- Day 8 – Fermenter six is filled
- Day 9 – Fermenter seven is filled
- Day 10 – Fermenter eight is filled
- Day 11 – Fermenter nine is filled
- Day 12 – Fermenter ten is filled
- Day 13 & 14 – No Brewing
- Day 15 – Fermenter eleven is filled while fermenter one is emptied
- Day 16 – Fermenter twelve is filled while fermenter two is emptied
- Day 17 – Fermenter one is filled again while fermenter three is emptied

Once a fermenter is emptied, it can then be thoroughly rinsed and sanitized to get it ready for a new batch. Having two fermenters empty at a time, gives ample time to rinse and sanitize each one. It also gives leeway in case there is a ruined batch of beer that has to be thrown out. Once the beer has aged the appropriate amount of time, the batch can then be charged with carbon dioxide and sent to bottling and kegging for distribution.

Bottling and Kegging

Most beers are bottled in black, brown, green, or clear bottles. Black or brown bottles are preferred due to their ability to minimize the access of light. Green or clear bottles provide no protection whatsoever which results in the skunky smell and taste that is experienced with most beer packaged in these types of bottles.

To begin, the bottles must be thoroughly rinsed and sanitized inside and out, which includes soaking and jetting with hot, caustic detergent followed by a thorough rinsing with water. The cleaned and sanitized bottles must then pass an empty bottle inspector (EBI), which is a light-based detection system that will spot anything that may be remaining in the bottles. The bottles are then fed via a conveyor and raised into position beneath the next vacant filler head. The bottles are then filled while an airtight seal is made. They are then counter-pressured with carbon dioxide and capped. They are then sent to labeling and packing for distribution.

The following is a detailed diagram of this process.

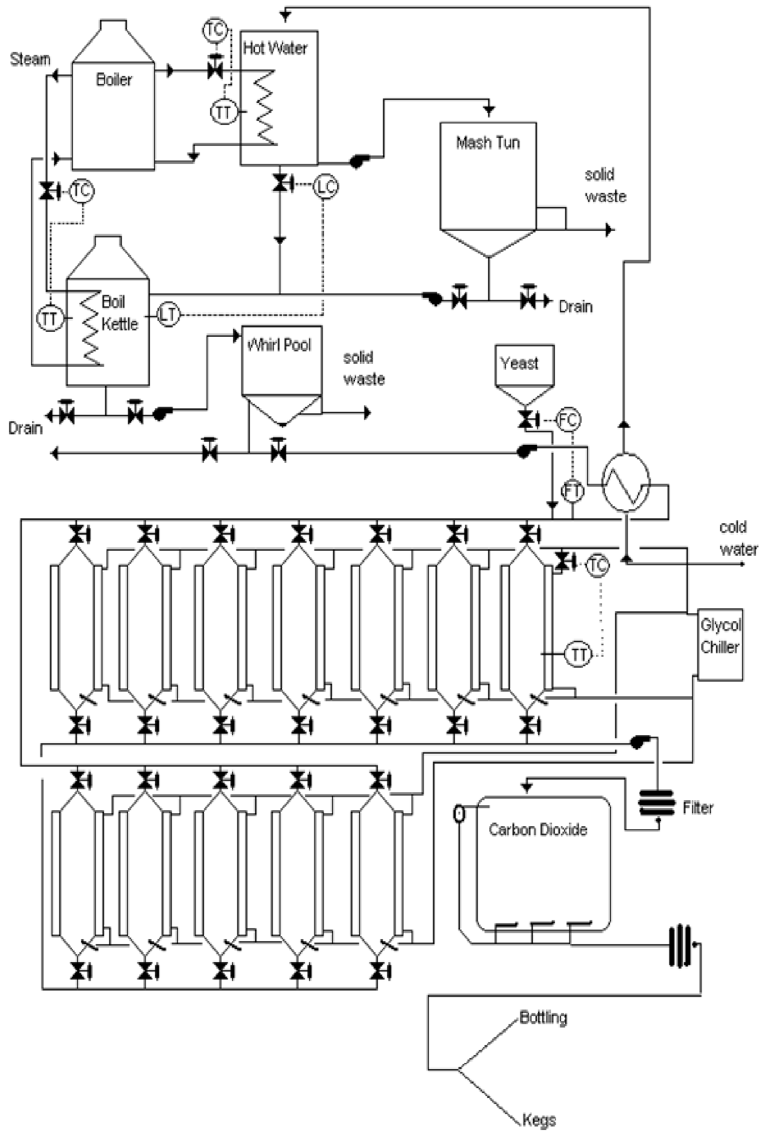

Figure 3.1: Process Flow Diagram

3.3 Schedule of Operations

There is a daily process that should be followed in the production of beer. The following is a detailed description of what should be done and how long each task should take.

Table 3.1: Schedule of Daily Operations

	Time (minutes)																		
	10	20	30	1 hr	1 hr	1 hr	250	260	1 hr	330	340	350	360	370	2 weeks	1 hr	24 hours	Continuous	1 hr
Check Hot Water Temp. (175°F)																			
Adjust pH on Water																			
Add Malted Barley to Mash Tun																			
Add Water to Mash Tun																			
Sparge Water & Fill Boil Kettle																			
Boil Up																			
Dispose of Barley Waste																			
Clean Mash Tun (Rinse & Sanitize)																			
Add Hops to Boil Kettle at Boil																			
Add Hops to Boil Kettle at end of Boil																			
Whirlpool																			
Chiller																			
Add Yeast																			
Fermentation Process*																			
Clean Whirlpool (Rinse & Sanitize)																			
Charge with CO_2 (24 hours)																			
Bottling (Continuous)																			
Clean Fermenters (Rinse & Sanitize)																			

The sections highlighted in red indicate a deviation from the time scale, which is in minutes. The longest process in the production is the time for fermentation, which will take approximately two weeks.

4.0 ENVIRONMENTAL CONCERNS

There are several environmental issues associated with the brewing process, including byproducts and waste that occur in all three physical states of matter: solid, liquid, and gaseous. Energy recovery should also be considered for the brewing and packaging process to reduced energy consumption wherever possible.

4.1 Solid Waste

Solid waste is the most apparent byproduct produced during the brewing process. This solid waste comes in the form of spent grains, hot trub, spent hop cones, and excess yeast. All of these byproducts can be used as livestock feed, which is the most common procedure for disposing these products. Spent grains are an inexpensive source of protein and carbohydrates for livestock. These spent grains can be sold to local farmers or feed producers. If they don't pay for these products, then they will come and remove them at no charge, which saves the brewery disposal costs. The hot trub, because of the extreme bitterness, should be put into the rest of the feed sparingly or the animals will reject it. If the excess yeast is put into a local stream or lake, it will contribute to the oxygen depletion of the waterway and should not be done. An overdose of yeast will give livestock stomach problems and deplete the animals' vitamin supply.

4.2 Liquid Waste

The liquid waste produced during the brewing process is one of the most troublesome. These mainly include waste water and beer. A brewery should make every effort to use the least amount of water as possible because the brewing process requires five to ten times more water than the amount of beer produced. One way to save water is to repair leaks or faulty equipment immediately. Also, a properly sized heat exchanger for wort cooling generates only as much water as the amount of wort being cooled. The water can be recycled for rinse water, cleaning vehicles, washing floors, or any other use for water that is not wasteful.

4.3 Gaseous Waste

The gaseous byproducts produced during the brewing process occur in two main forms: carbon dioxide from fermentation and smoke from the boiler. Carbon dioxide in the atmosphere from fermentation is negligible when compared to the amount of CO_2 produced from burning fossil fuels. How clean the boiler vapors should be is dictated by local and federal laws.

5.0 THE MATHEMATICAL MODEL

A mathematical model was created to simultaneously account for all possible scenarios, based upon input variables, to determine the optimal placement and conditions for a microbrewery, which is nearly impossible to do by traditional decision making processes. This powerful tool makes it possible to analyze dozens of variables at the same time and calculate the optimal answer. This model calculates the optimal plant locations, market locations, and raw materials locations based on the input variables.

5.1 Model Variables

Figures 5.1 and 5.2 below are diagrams of the mathematical model variables. Figure 5.1 depicts the variables that are input into the mathematical model. Figure 5.2 shows the results that were outputs by the model.

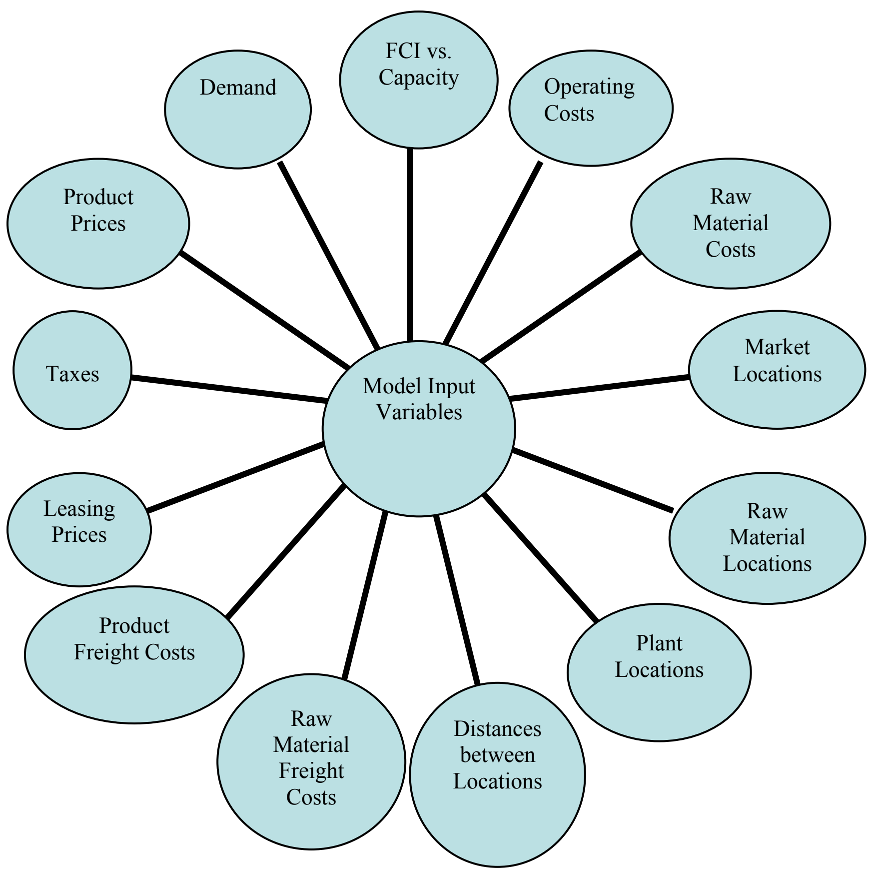

Figure 5.1: Mathematical Model Input Variables

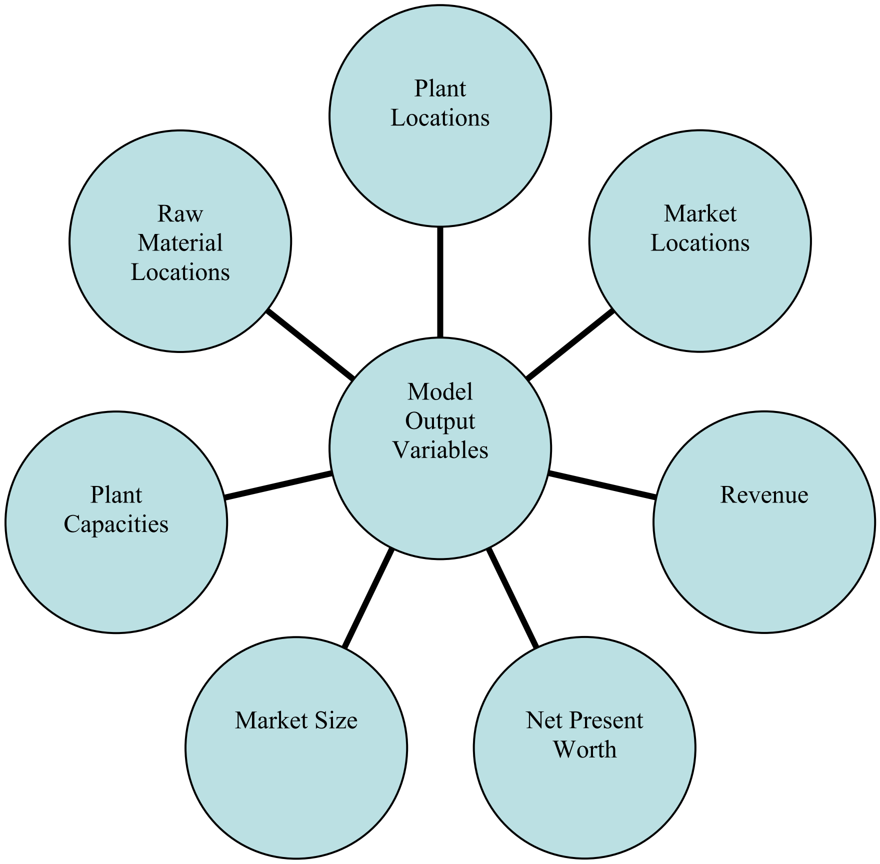

Figure 5.2: Mathematical Model Output Variables

Each of the input variables is discussed in detail in its perspective location throughout this report. All sources for these variables can be found in the appendix.

The advantage of using a mathematical model is the flexibility in updating parameters and different business strategies as new information become available over time. By doing this, the effect of varying parameters can by evaluated. Factors, such as demand or shipping costs, might change during the course of the study, and the mathematical model can easily be updated to ensure accurate and precise results. This capability will be instrumental in determining the reliability of the final results. The mathematical model was implemented using GAMS interface with the CPLEX solver.

5.2 Model Procedure: Equations and Constraints

This section includes the necessary equations the mathematical model used to determine whether the production of a new brewery is a worthwhile venture. Additionally, constraints were necessary in making the mathematical model more realistic. The main purpose of the model is to maximize the net present worth without violating any constraint, such as market demand or brewery capacity. This was accomplished by a set of equations and constraints implemented in the model. Below is a summary of the equation utilized in the mathematical model.

Equations

$$\text{Total Costs} = \text{Raw Material Costs} + \text{Operating Costs} + \text{Product Shipping}$$

$$RawMaterialCosts = Cbarley + Chops + Cyeast + Cshipping$$

where,

Cbarley = Cost of barley

Chops = Cost of hops

Cyeast = Cost of yeast

Cshipping = Cost of shipping raw materials to brewery

$$OperatingCosts = FixedOp + PlantCap$$

where,

FixedOp = Fixed Operating cost of plant

PlantCap = Plant Capacity Cost

$$\text{Product Shipping} = \text{Amount Prod} \times \text{CostShip} \times \text{Mileage}$$

where,

AmountProd = Amount of the Product to ship

CostShip = Cost to ship the product per amount distance

Mileage = Mileage to ship the product

$$\text{Revenue} = \text{ProdPrice} \times \text{AmountSold} - \text{TotalCosts}$$

where,

ProdPrice = Selling price of the product

AmountProd = Amount of product sold

Constraints

The constraints served the purpose of making the model realistic. For example, it limited the supply by the demand and the amount of raw materials used by the amount of raw materials bought.

where,

Supply = Supply of product sold to market

Demand = Demand of market

MarketShare = Percentage of demand

$$Capacity \geq TotalSupply$$

where,

Capacity = maximum production by brewery

TotalSupply = Total amount of product sold to all markets from brewery

Defining parameter “brewtimes”;

Costs to Produce 1 Barrel of Beer

Listed below are the equations used to calculate the cost to produce one barrel of beer.

Electricity

The cost of electricity needed to produce 1 barrel of beer was found using the equation below.

$$Cost = \frac{\$0.062}{kW-hr} * \frac{28kW-hr}{bbl} = \$1.736/bbl$$

Natural Gas

The cost of natural gas needed to produce 1 barrel of beer was found using the following equation.

$$Cost = \frac{\$0.64}{therm} * \frac{3.0 \cdot therm}{bbl} = \$1.92 / bbl$$

Water

The cost of water needed to produce 1 barrel of beer was found using the equation below.

$$Cost = \frac{\$0.005}{gal} * \frac{31 \cdot gal}{bbl} * \frac{7 \cdot bbl \cdot water}{bbl \cdot beer} = \$1.085 / bbl$$

Sewage

The cost of sewage needed to produce 1 barrel of beer was found using the following equation. Notice that there are six barrels of waste for every one barrel of beer.

$$Cost = \frac{\$0.018}{gal} * 31 \cdot gal * \frac{6 \cdot bbl \cdot water}{bbl \cdot beer} = \$3.348 / bbl$$

Labor

The cost of labor needed to produce 1 barrel of beer was found using the equation below.

$$Cost = \frac{\$60.00}{bbl}$$

Summing these result in a total cost of $68.089 to produce 1 barrel of beer.

5.3 Advertising

Advertising is defined as the communication of goods and services that are available from various sellers. In addition, advertising generates demand by providing specific information about a products, services, or brands. The advertising industry is composed of three different categories: media institutions, clients, and advertising agencies. Media institutions include radio stations, television stations, newspapers, and magazines. Clients are those whom produce the products and want to sell their products. Advertising agencies are hired by the clients to help advertise and create for the products.

In order to effectively advertise a product, service or good, the following concerns must be addressed and determined. These concerns include:

1) The size of the total advertising budget
2) The allocation of this budget to marketing areas
3) The allocation of the individual market area budgets among media
4) The timing of advertising
5) The theme of the campaign
6) The effort to be invested in a campaign

The following chart represents the basic advertising trend for any type of product, service or good. The chart relates sales to the advertising rate per year. During the beginning of advertising, there is a linear trend between the advertising rate and sales of the product. Once the product begins to gain popularity, the sales will reach a threshold, and the trend between sales and advertising rate is no longer linear. Soon, the product will begin to saturate the market and the product will soon reach its height in popularity. At this point, with an increased advertising rate, the product will begin to oversaturate the market. As a result, sales will begin to decline. This trend and concept of advertising and sales was a crucial aspect in modeling advertising for the deterministic model.

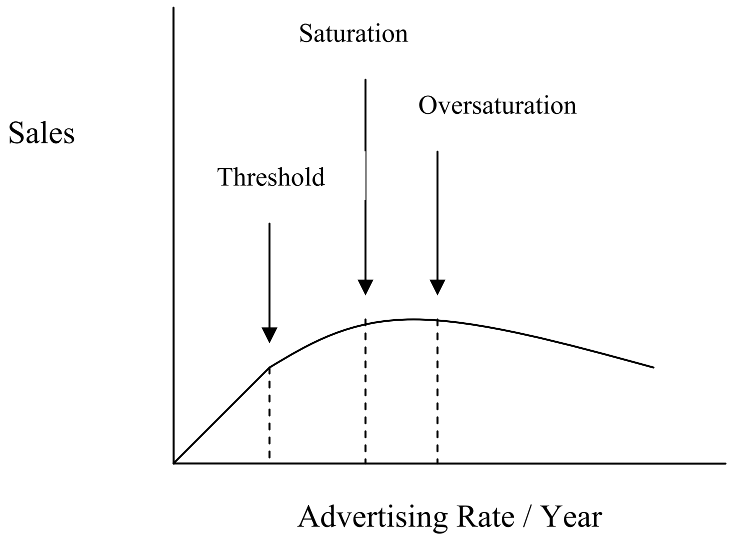

Figure 5.3: Advertising vs. Sales

For the deterministic model, data needed to be gathered that would reflect how much money needed to be spent on advertising to obtain the 0.06% of our targeted market. First, the different forms of advertising media and their costs were found. Below is a table that reflects how much the different forms of advertising media cost per day to reach 1,000 people:

Table 5.1: Advertising Costs per Media

Media	Cost/Day
Radio	$1.53
Television	$11.26
Newspaper	$6.66
Magazine	$4.91
Billboards	$1.43

Due to the high cost, Big Cock Brewing Company will not utilize television for a form of advertisement. Therefore, BCB will spend $14.53 a day to reach a 1,000 people with the various forms of advertising media. This corresponds to $5,303.45 to reach 1,000. However, there is not a guarantee that each of the 1,000 people reached will buy Rooster Brew. Therefore, it was assumed that only 5% of those reached by the ads would buy Rooster Brew. This means that BCB would have to spend $106.069 to get 50 people each day to buy Rooster Brew.

In one year, the average person consumes 23.8 gallons of beer. BCB Company projects that each of those 50 customers will switch 30% of their beer consumption to Rooster Brew (corresponds to 7.14 gallons). Therefore, if BCB Company is producing approximately 83,626 gallons of beer in a year, it will cost

$$\frac{\$106.069}{person} \times \frac{person}{7.14 gal} \times 83{,}626 gal = \$1{,}242{,}319$$

on advertising to obtain the 0.06% market share.

The mathematical model considers market share gain as a linear relationship to money invested. The market share increase to money invested ratio, based upon the marketing research, was determined to be 0.00005 (%/$). The maximum market share attained by advertising was assumed to be 10%, and that advertising cost was an annual investment to maintain the increased market share. The mathematical model was restricted to pay for advertising cost out of the reinvestment fund.

In general, advertising cost allowed the model to concentrate sales on two or three markets, and allowed the breweries to be closer together. Without advertising cost, each brewery had to reach more markets at a lesser market share, the breweries were required to be further apart, and the NPW was decreased approximately by $100,000.

5.4 Sensitivity and Uncertainty

The mathematical model assumes all parameters are accurate and does not account for uncertainty in the parameters or random events in the future that effect those parameters positively or negatively. Performing sensitivity analysis on all parameters within the model at two standard deviations away from the original evaluated mean revealed the pertinent parameters in the model. Below is a description of the parameters

- Cost per barrel- Increasing or decreasing the cost to produce a barrel of beer affects the NPW.
- Change in FCI- Decreasing the FCI allows for the second brewery to be built sooner, inversely, increasing the FCI prolongs the production of a second brewery.
- No advertising- Removing advertising from the model changes the locations of the breweries due to adverse affects in the market percentage.

- Marketing Campaigns- If the marketing campaign is more or less successful than expected, the locations of the breweries and markets will change.
- Freight Cost- Changes in the cost of freight affect the impact on distances from breweries to markets and distances from raw materials to breweries.
- Raw Material Costs- Increasing the raw material costs should decrease the NPW and might

Evaluating at two standard deviations away from the mean, assuming a normal distribution, would place 95% of all probable values in that range. Nine parameters were found to have discernable effects on the model. The following table lists the parameters and their associated original mean value and the standard deviation. Parameters affecting the sensitivity of the model are listed below.

Table 5.2: Standard Deviations of Parameters

Parameter Description	Original Value(mean)	Standard Deviation
Freight Cost ($/lb*bbl)	.00009	.000005
Cost per bbl ($/bbl)	41	1.5
Barley Price ($/lb)	67	2.5
FCI of a brewery ($)	240,000	30,000
Working Capital ($)	80,000	10,000
Additional Market Share to Advertising Cost (%/$)	.0000005	.00000025
FCI of Expansion ($)	33,000	7,500
Initial Market Share (%)	.00003-.00007	15%
Leasing Cost ($/year)	32,000-80,000	30%

The results of the sensitivity analysis can be found in the table in Appendix N.

5.5 Competition

To incorporate competition into the model, the production of all breweries in every market was looked up. This data was tabulated and inputted into the model. The model takes into account that a market with more breweries competing in it will allow for a smaller market percentage than a market with less competition.

5.6 Reinvestment

Our model is allowed to use up to 40% of our profits for future reinvestments. These reinvestments are the sole source of advertising, expansions and future breweries. The model is capable of selecting any amount up to the 40% limit, which will maximize the net present worth over the life span of the project.

5.7 Risk

Using the nine parameters and their associated deviations, three hundred randomly and normally distributed combinations of the nine parameters were created. The program takes a set of parameters and determines the optimal brewery locations and expansions. It then fixes this scenario and continues with inputting the other 299 sets of parameters and finds the NPW. With this data, a cumulative probability curve can be generated for each scenario generated. Eight scenarios are plotted in the figure below.

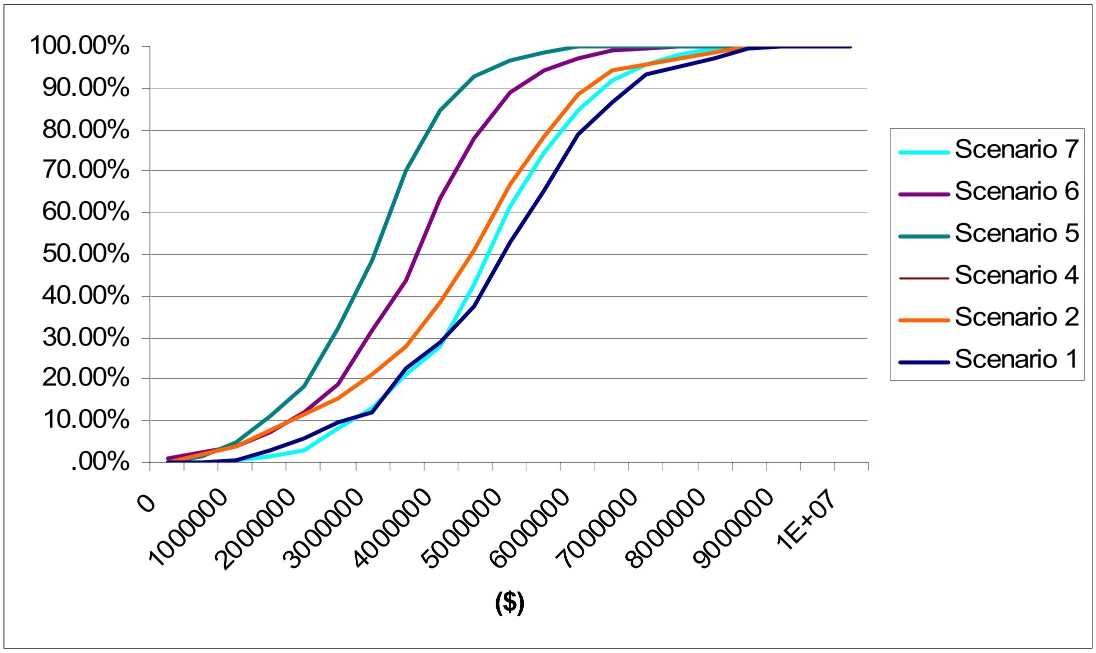

Figure 5.4: Risk Analysis

Each scenario, which represents the decision of when and where to build breweries and how big, can now be evaluated based on the uncertainty in the parameters. The question to ask at this point is what scenario has the highest probability of success.

Scenario 1 is the obvious choice. There is, however, a 10% chance that Scenario 7 may be slightly more successful than Scenario 1, but the regret is negligible. Scenario 7 has the same brewery locations. The first brewery is in Indianapolis, but the second brewery is built in year five instead of year four as in Scenario 1.

The financial projections are based on Scenario 1's 50% value, which considering uncertainty is the most likely value.

6.0 THE PRODUCT

Big Cock Brewing Company's product, Rooster Brew, an American pale ale, will be one of the most unique and distinctive products of its kind on the market. The name, Rooster Brew, is not yet trademarked and will be an appropriate name for BCB Company's product. Factors related to manufacturing, prospect knowledge, industry standards, and regulatory controls are likely to generate a few problems for BCB Company. However, these problems should only exist during the introduction period of Rooster Brew into the market, but will reduce as time goes by.

6.1 Description

Big Cock Brewing Company will produce a high-quality pale ale beer. A pale ale has been chosen for the recipe of the beer to be produced because it is lighter in taste than other microbrews, but it has more taste than the watered-down national brands. This light, yet distinct, taste of Rooster Brew should appeal to the public. Rooster Brew will be an American pale ale, which is the American adaptation of the English pale ale. American pale ale has the appearance of a pale golden to amber color. It has a moderate hop and malt flavor compared to the aggressive hop flavor and bitterness of other types of beer. To achieve this desired type and flavor of beer, specific raw materials and the type of processing must be met. This includes choosing the desired types of malted barley, hops, and yeast. In addition, the preparation of the raw materials and how the beer is made, aged, and bottled must be performed in a specific way to achieve the desired taste.

6.2 Types of Beer

There are several different types of beers that can be produced. These different types are characterized by their different yeast temperatures and the time of fermentation. There are two different types of fermentation: top-fermenting and bottom-fermenting. Top fermenting corresponds to short fermentation times at high temperatures and bottom-fermenting corresponds to long fermentation times and low temperatures. It is called top-fermenting because the yeast rises to the top of the beer near the end of the fermentation process and it is called bottom fermenting because the yeast settles to the bottom of the beer near the end of the fermentation process. Top-fermenting produces ales and wheat beers, whereas, bottom-fermenting produces lagers and bock beers.

6.3 Rooster Brew Recipe

The recipe used in the production of Rooster Brew is based on a 30 barrel system process for one batch of beer. The material balances, which are discussed in detail in Appendix M, are also based on this recipe. In order to produce Rooster Brew, the following will be required:

- 1210 pounds of pale malted barley
- 5740 pounds of water for the mash tun
- 24 pounds of Cascade pellet hops
- 4 pounds of yeast
- 7000 pounds of water for the boil kettle

6.4 Market Status

The markets for Big Cock Brewing Company's Rooster Brew will be located in Illinios and Indianapolis in the first year and Wisconsin in the fourth year. It will not be marketed nationwide because of the size of the brewery, the shipping cost, and the capacity of the brewery. As Rooster Brew becomes more desirable to its patronages, more breweries may be opened in other parts of the United States. For now, only two breweries will be built.

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Appendix A

Mathematical (GAMS) Model

```
adcost1(market,tp).. marperinc(market,tp)=l= maxmark;
adcost2(market,tp).. marperinc(market,tp)=e= marper(market)+adtomarper*adcost(market,tp);
adcost3(market,tp)..  adcost(market,tp) =l= maxadcost;
constraint1(market,tp)..    sum(brewery,sales(brewery,market,tp))=l=
consumption(market)*marperinc(market,tp)-(competition(market)*.0000003 );

bankbudget1 ..  bank('1') =e=initialinvest-sum(brewery,fci(brewery,'1'))-
sum(brewery,workingcap(brewery,'1'))-sum(brewery,fciexp(brewery,'1'))-
sum(market,adcost(market,'1'));
bankbudget(tp)$(ord(tp) gt 1).. bank(tp) =e=bank(tp-1)+ sum(brewery,reinvest(brewery,tp-1))
-sum(brewery,fci(brewery,tp))-sum(brewery,workingcap(brewery,tp))-
sum(brewery,fciexp(brewery,tp))-sum(market,adcost(market,tp));


Reinvestamount(brewery,tp).. Reinvest(brewery,tp) =l= rev(brewery,tp)*reinvestportion;

build(brewery)..        sum(tp,b(brewery,tp)) =l= 2;

brewerynum..          sum(tp,sum(brewery,b(brewery,tp)))=l= 2;

maxbrewery(brewery,tp)..   breweryprod(brewery,tp)=l=capacity(brewery,tp);

constraint2(brewery,tp).. sum(market,sales(brewery, market,tp))=e=  breweryprod(brewery,tp)  ;



Costbarley(brewery,tp).. purchCbarley(brewery,tp) =e=
                         sum(barleyloc,barley_purchase(brewery,barleyloc,tp))*barleyprice;

Amountbarley(brewery,tp).. sum(barleyloc,barley_purchase(brewery,barleyloc,tp)) =e=
                                breweryprod(brewery,tp)*barleyweightperbbl;

shpbarley(brewery,tp)..  Cshipbarley(brewery,tp)=e=

sum(barleyloc,barley_purchase(brewery,barleyloc,tp)*dist_barley_brewery(brewery,barleyloc))*
ffp ;

expansion1(brewery,tp).. capacity(brewery,tp) =e= capacity (brewery,tp-1) + ep(brewery,tp)*
expancap +b(brewery,tp)*capac;

capacityyear1(brewery)..  capacity(brewery,'1') =e= capac*b(brewery,'1')+ep(brewery,'1')*
expancap;

expansion2(brewery)..  sum(tp,ep(brewery,tp)) =l= maxexpan;

expansion3(brewery,tp)..  ep(brewery,tp) =l= maxexpan * b(brewery,tp);
```

```
distancesbetweenbrew(brewery,bbbrewery).. (sum(tp,b(brewery,tp))+sum(tp,b(bbbrewery,tp))-
1)
                    *dist_brewery(brewery,bbbrewery) =l= maxdistbreweries;

*expansion4(brewery,tp).. ep(brewery,tp) =l= sum(tpp $(ord(tpp) le ord (tp)),b(brewery,tpp));

Costhops(brewery,tp).. purchChops(brewery,tp) =e=
                         sum(hopsloc,hops_purchase(brewery,hopsloc,tp))*hopsprice;

Amounthops(brewery,tp).. sum(hopsloc,hops_purchase(brewery,hopsloc,tp)) =e=
                              breweryprod(brewery,tp)*hopsweightperbbl;


shphops(brewery,tp).. Cshiphops(brewery,tp) =e=

sum(hopsloc,hops_purchase(brewery,hopsloc,tp)*dist_hops_brewery(brewery,hopsloc))*ffp;


taxall(brewery,tp)..   taxes(brewery,tp)=e=
                         sum(market,sales(brewery,market,tp))*(tax(brewery)*galperbbl+fedtax);



fixedcapital(brewery,tp)..     fci(brewery,tp) =e= FCIperbrewery*b(brewery,tp);

fixedcaptialexp(brewery,tp)..  fciexp(brewery,tp) =e= FCIperexp*ep(brewery,tp);

workingcapital(brewery,tp)..   workingcap(brewery,tp) =e=
workingamount*b(brewery,tp)+workingcapexp*ep(brewery,tp);

shippingproduct(brewery,tp).. Cshippingbeer(brewery,tp)=e=

sum(market,sales(brewery,market,tp)*dist_brewery_market(brewery,market))*ffp*galbar*lbgal;

Opercost(brewery,tp).. Coper(brewery,tp)=e=costbar*sum(market,sales(brewery,market,tp))   ;

totalopercost(brewery,tp).. tc(brewery,tp)=e=
(purchCbarley(brewery,tp)+Cshipbarley(brewery,tp)
+purchChops(brewery,tp)+Cshiphops(brewery,tp)+taxes(brewery,tp)+Cshippingbeer(brewery,tp
)
+Coper(brewery, tp)+lease(brewery)*sum(tpp $(ORD (tpp) le ord(tp)),b(brewery,tpp)));

Revenue(brewery,tp).. rev(brewery,tp)=e=sum(market,sales(brewery,market,tp)*price(market))-
tc(brewery,tp);
Prof(brewery,tp).. profit(brewery,tp)=e=rev(brewery,tp)-reinvest(brewery,tp);
```

```
NetPresentWorth.. ztot=e=sum(tp,sum(brewery,profit(brewery,tp)*(1-
taxincome))/power((1+int),year(tp)))-initialinvest;

model oubeer /all/;


solve oubeer using mip maximizing ztot;
display ztot.l,breweryprod.l,sales.l,
   Coper.l,tc.l,b.l,ep.l,bank.l,fci.l,fciexp.l,Reinvest.l,rev.l,adcost.l;
```

Appendix B

Possible Brewery Locations

Possible Brewery Locations

A very crucial aspect of developing a production brewery is location of the brewery. In order to determine this location, several cities have been chosen as input variables for the deterministic model. Along with other variables, such as raw material production sites, market location, shipping costs, the deterministic model should be able to pinpoint which city is the best city to construct the brewery. The table below is a list of the 61 best cities to start a new business. The list was found on the entrepreneur.com website.

Table 1. Best Cities to Start a Business

Ranking	City	Entrepreneurial Activity	Small Business Growth	Job Growth	Risk
1	Minneapolis/St. Paul, MN	58	96	77	93
2	Washington, DC, MD	66	78	78	96
3	Atlanta, GA	99	63	70	82
4	Fort Lauderdale, FL	90	45	95	76
5	Salt Lake City, UT	76	93	82	53
6	West Palm Beach, FL	90	27	99	78
7	Norfolk, VA	69	79	63	78
8	Miami, FL	77	57	73	76
9	Charlotte, NC	71	78	61	70
10	Orlando, FL	98	20	71	80
11	Las Vegas, NV	100	53	100	13
12	Baltimore, MD	43	82	56	84
13	Phoenix, AZ	93	64	97	7
14	Monmouth, NJ	51	28	94	87
15	Louisville, KY /IN	56	99	13	90
16	Sacramento, CA	76	68	90	21
16	San Diego, CA	80	59	79	39
18	San Antonio, TX	85	80	68	22
19	Jacksonville, FL	88	39	67	59
20	Austin, TX	96	75	61	19
21	Houston, TX	81	51	67	44
22	Oklahoma City, OK	50	90	50	49
23	Boston, MA	17	86	46	85
24	Dallas, TX	87	70	29	48
25	Middlesex, NJ	53	62	38	80
25	Tampa, FL	78	65	83	7
27	Denver, CO	88	69	37	36
27	Providence, RI	11	30	96	95
29	New York, NY	31	52	46	97
30	Columbus, OH	67	50	50	52
30	Kansas City, MO	49	91	18	61

Ranking	City	Entrepreneurial Activity	Small Business Growth	Job Growth	Risk
32	Greensboro, NC	57	33	48	75
32	New Orleans, LA	23	82	12	95
34	Orange County, CA	82	38	62	24
35	Memphis, TN	68	67	31	39
36	Fort Worth, TX	83	22	58	40
36	Riverside, CA	86	15	97	5
38	St. Louis, MO	27	76	35	65
39	Milwaukee, WI	38	88	36	37
40	Raleigh, NC	80	18	75	24
41	Oakland, CA	55	22	52	64
42	Bergen, NJ	36	29	28	99
43	Nassau, NY	12	8	65	100
44	Indianapolis, IN	31	97	54	2
45	Nashville, TN	69	24	35	52
46	Philadelphia, PA	15	56	52	58
47	Newark, NJ	28	37	40	74
48	San Jose, CA	73	44	1	56
49	Cincinnati, OH	32	55	41	44
50	Buffalo, NY	18	71	37	41
50	Seattle, WA	89	12	10	56
52	Chicago, IL	34	87	12	31
53	Pittsburgh, PA	3	61	39	48
54	Portland, OR	70	48	15	16
55	Hartford, CT	2	24	20	97
56	Detroit, MI	64	31	2	46
57	Cleveland, OH	41	49	11	33
58	Grand Rapids, MI	52	19	6	43
59	Rochester, NY	29	46	22	20
60	San Francisco, CA	37	5	3	67
61	Los Angeles, CA	48	4	21	5

This information was gathered during a study conducted by Dun and Bradstreet. Dun and Bradstreet has the world's largest database that contains information concerning businesses and how to build a profitable business. The information found in the Dun and Bradstreet database is gathered and compiled from millions of trade and bank transactions, federal bankruptcy filings, information from business owners, public utilities, and the offices of all the U.S. secretaries of state.

In regards to the table listed above, Dun and Bradstreet used four separate criteria to rank the cities. The first category, entrepreneurial activity is based on the number of business five years old or younger in each city. The ranking for small-business growth is determined by the number of businesses with 20 employees or less that have significant growth over a period of one year. Job growth is based on the change in job growth over a three-year period. Finally, risk is associated with the bankruptcy rates of businesses in each city. All of the ratings are on a scale from 1 to 100, with 100 being the highest and best rating. The overall ranking of each city is simply the average of the ratings for all of the categories.

After researching Dun and Bradstreet and analyzing the methods in which they conducted this study, this is the most useful and accurate information regarding possible brewery locations.

Appendix C

Possible Market Locations

Possible Market Locations

In order to determine the different market locations of the new beer, several sets of data will be entered into the deterministic model. First, each market region consists of a state or a state broken up into multiple regions. California, Texas, Montana, New York, and Pennsylvania are divided into regions due to size of the state or concentration of populations in each state. Colorado is divided at the Rocky Mountains, and Michigan is broken up by the Great Lakes. For each state, the general population numbers, such as population of the state and percent growth of the population, were gathered from the 2000 U.S. Census. Also from the census, data was gathered pertaining to the percentage of the population of each state that is between the ages of 21 to 34 years old. This age group is the desired target market of our brewery. Next, estimations of what the population of each state will be in 2005, 2015, and 2025 were gathered from the census. This data will help determine how our target age group will grow in the future. One of the most important pieces of information to gather for this portion of the deterministic model was how much alcohol each state consumes. The following chart, obtained from the Beer Institute, illustrates the beer consumption in each state.

Table 2: Beer consumption in each state (listed as the number of 31-gallon barrels)

State	1994	1995	1996	1997	1998	1999	2000
Alabama	2,851,865	2,820,439	2,888,198	2,891,862	2,970,376	3,002,112	3,028,088
Alaska	482,039	477,539	439,107	461,951	461,766	494,654	463,632
Arizona	3,646,144	3,730,809	3,933,277	3,948,730	4,000,034	4,246,358	4,287,390
Arkansas	1,556,600	1,565,821	1,623,274	1,611,266	1,662,084	1,676,132	1,697,506
California	20,553,937	20,058,944	19,661,994	20,247,745	20,339,789	20,581,191	20,550,978
Colorado	2,952,661	2,942,915	3,052,332	3,010,555	3,180,221	3,243,356	3,339,662
Connecticut	1,893,136	1,862,562	1,818,366	1,840,482	1,873,410	1,886,584	1,854,550
Delaware	588,993	567,841	575,431	588,113	600,080	615,114	617,937
D.C.	528,100	518,454	484,287	474,297	464,557	467,440	465,423
Florida	11,626,428	11,603,750	11,760,237	11,914,737	11,834,300	12,027,500	12,236,618
Georgia	4,920,603	4,986,825	5,207,611	5,218,977	5,409,067	5,622,317	5,711,652
Hawaii	968,096	964,595	969,098	952,026	927,322	920,948	942,051
Idaho	777,272	754,834	789,581	784,595	809,559	835,005	846,990
Illinois	8,954,755	8,853,579	8,761,963	8,779,305	8,936,316	9,017,249	9,038,323
Indiana	3,823,111	3,767,912	3,825,685	3,844,952	3,846,528	3,925,908	3,954,209
Iowa	2,132,711	2,081,731	2,124,787	2,138,501	2,221,431	2,265,235	2,299,003
Kansas	1,602,500	1,580,259	1,570,899	1,645,056	1,658,955	1,739,534	1,768,782
Kentucky	2,390,959	2,355,269	2,388,707	2,426,649	2,460,388	2,492,168	2,517,894
Louisiana	3,776,935	3,654,519	3,722,215	3,744,104	3,769,572	3,883,523	3,804,421
Maine	809,825	844,848	852,646	843,055	840,194	862,728	882,900
Maryland	3,109,113	3,077,410	3,052,481	3,090,912	3,127,789	3,141,977	3,153,355
Massachusetts	4,172,453	4,041,187	4,099,203	4,077,238	4,075,482	4,102,540	4,166,720
Michigan	6,689,471	6,625,566	6,677,081	6,537,630	6,735,381	6,718,333	6,761,561
Minnesota	3,310,862	3,283,822	3,367,882	3,355,943	3,488,472	3,488,651	3,588,539
Mississippi	2,105,074	2,084,650	2,130,864	2,153,067	2,215,678	2,317,472	2,316,864
Missouri	4,123,556	4,029,618	4,072,706	4,087,072	4,174,257	4,267,708	4,333,699
Montana	734,331	743,788	757,773	766,481	777,199	808,621	814,751
Nebraska	1,291,768	1,271,740	1,298,519	1,302,932	1,356,782	1,393,517	1,399,454
Nevada	1,655,911	1,694,179	1,821,306	1,860,834	1,908,351	2,008,641	2,066,301
New Hampshire	1,135,669	1,148,019	1,165,258	1,182,638	1,193,089	1,234,355	1,258,107
New Jersey	4,831,298	4,803,697	4,713,252	4,682,021	4,672,682	4,657,493	4,673,639
New Mexico	1,456,635	1,488,317	1,502,050	1,505,655	1,501,995	1,559,661	1,575,664
New York	10,574,026	10,440,066	10,335,811	10,096,517	10,182,484	10,126,253	10,164,810

North Carolina	4,751,892	4,753,758	4,981,624	5,105,518	5,126,684	5,335,422	5,590,081
North Dakota	531,467	527,177	551,996	546,493	559,652	559,304	572,619
Ohio	8,238,399	8,203,797	8,406,418	8,296,894	8,550,931	8,592,717	8,493,144
Oklahoma	2,145,277	2,111,738	2,118,362	2,149,164	2,200,799	2,265,363	2,213,729
Oregon	2,205,564	2,230,889	2,302,579	2,281,990	2,339,624	2,384,037	2,391,559
Pennsylvania	9,083,249	8,703,058	8,694,910	8,576,348	8,678,532	8,642,803	8,709,865
Rhode Island	727,121	707,627	691,873	729,011	689,391	696,935	707,004
South Carolina	2,922,700	2,954,748	3,028,173	3,103,436	3,202,145	3,283,276	3,358,582
South Dakota	565,496	557,055	573,844	573,406	601,786	611,442	624,155
Tennessee	3,581,711	3,620,512	3,692,504	3,695,130	3,845,871	3,952,732	4,001,309
Texas	16,767,609	16,383,991	16,749,947	16,943,907	17,147,913	17,981,159	17,966,620
Utah	792,202	804,270	853,279	861,515	852,191	937,798	928,923
Vermont	436,227	429,889	442,189	426,972	435,966	435,342	440,506
Virginia	4,514,246	4,426,756	4,429,597	4,458,696	4,697,874	4,871,009	4,862,375
Washington	3,602,716	3,565,042	3,591,150	3,625,295	3,697,645	3,681,787	3,714,436
West Virginia	1,261,351	1,231,142	1,234,586	1,230,481	1,265,999	1,275,708	1,274,626
Wisconsin	4,643,580	4,619,145	4,595,916	4,769,896	4,912,088	4,714,637	4,741,019
Wyoming	383,459	366,318	381,669	380,640	389,116	400,765	406,568
Total	**189,181,103**	**186,922,416**	**188,764,497**	**189,820,690**	**192,869,797**	**196,252,514**	**197,578,593**

Table 3: Percentage of Population for Desired Demographic

State	**Caucasian**	**Male**	**$50,000 or more**
Alabama	71.1%	48.3%	32.5%
Alaska	69.3%	51.7%	59.1%
Arizona	75.7%	49.9%	46.4%
Arkansas	80.0%	48.8%	28.7%
California	59.5%	49.8%	47.9%
Colorado	82.8%	50.4%	56.8%
Connecticut	81.6%	48.4%	53.8%
Delaware	74.6%	48.6%	47.3%
District of Columbia	30.8%	47.1%	41.3%
Florida	78.0%	48.8%	37.6%
Georgia	65.1%	49.2%	42.5%
Hawaii	24.3%	50.2%	49.9%
Idaho	91.0%	50.1%	34.7%
Illinois	73.5%	49.0%	46.7%
Indiana	87.5%	49.0%	40.8%
Iowa	93.9%	49.1%	37.1%
Kansas	86.1%	49.4%	39.3%
Kentucky	90.1%	48.9%	39.6%
Louisiana	63.9%	48.4%	31.6%
Maine	96.9%	48.7%	43.9%
Maryland	64.0%	48.3%	53.3%
Massachusetts	84.5%	48.2%	50.6%
Michigan	80.2%	49.0%	44.2%
Minnesota	89.4%	49.5%	47.1%
Mississippi	61.4%	48.3%	28.9%

Missouri	84.9%	48.6%	36.4%
Montana	90.6%	49.8%	29.0%
Nebraska	89.6%	49.3%	37.2%
Nevada	75.2%	50.9%	51.3%
New Hampshire	96.0%	49.2%	49.6%
New Jersey	72.6%	48.5%	54.7%
New Mexico	66.8%	49.2%	31.9%
New York	67.9%	48.2%	44.3%
North Carolina	72.1%	49.0%	37.7%
North Dakota	92.4%	49.9%	31.0%
Ohio	85.0%	48.6%	40.2%
Oklahoma	76.2%	49.1%	30.8%
Oregon	86.6%	49.6%	39.9%
Pennsylvania	85.4%	48.3%	49.1%
Rhode Island	85.0%	48.0%	42.3%
South Carolina	67.2%	48.6%	43.3%
South Dakota	88.7%	49.6%	31.3%
Tennessee	80.2%	48.7%	34.4%
Texas	71.0%	49.6%	39.4%
Utah	89.2%	50.1%	45.0%
Vermont	96.8%	49.0%	39.0%
Virginia	72.3%	49.0%	46.8%
Washington	81.8%	49.8%	45.6%
West Virginia	95.0%	48.6%	26.3%
Wisconsin	88.9%	49.4%	43.0%
Wyoming	92.1%	50.3%	36.0%

Table 4: Population Growth

State	**Population in the Thousands**				
	1995	**2000**	**2005**	**2015**	**2025**
Alabama	4,253	4,451	4,631	4,956	5,224
Alaska	604	653	700	791	885
Arizona	4,218	4,798	5,230	5,808	6,412
Arkansas	2,484	2,631	2,750	2,922	3,055
California	31,589	32,521	34,441	41,373	49,285
Colorado	3,747	4,168	4,468	4,833	5,188
Connecticut	3,275	3,284	3,317	3,506	3,739
Delaware	717	768	800	832	861
District of Columbia	554	523	529	594	655
Florida	14,166	15,233	16,279	18,497	20,710
Georgia	7,201	7,875	8,413	9,200	9,869
Hawaii	1,187	1,257	1,342	1,553	1,812
Idaho	1,163	1,347	1,480	1,622	1,739
Illinois	11,830	12,051	12,266	12,808	13,440
Indiana	5,803	6,045	6,215	6,404	6,546
Iowa	2,842	2,900	2,941	2,994	3,040
Kansas	2,565	2,668	2,761	2,939	3,108
Kentucky	3,860	3,995	4,098	4,231	4,314
Louisiana	4,342	4,425	4,535	4,840	5,133

Maine	1,241	1,259	1,285	1,362	1,423
Maryland	5,042	5,275	5,467	5,862	6,274
Massachusetts	6,074	6,199	6,310	6,574	6,902
Michigan	9,549	9,679	9,763	9,917	10,078
Minnesota	4,610	4,830	5,005	5,283	5,510
Mississippi	2,697	2,816	2,908	3,035	3,142
Missouri	5,324	5,540	5,718	6,005	6,250
Montana	870	950	1,006	1,069	1,121
Nebraska	1,637	1,705	1,761	1,850	1,930
Nevada	1,530	1,871	2,070	2,179	2,312
New Hampshire	1,148	1,224	1,281	1,372	1,439
New Jersey	7,945	8,178	8,392	8,924	9,558
New Mexico	1,685	1,860	2,016	2,300	2,612
New York	18,316	18,146	18,250	18,916	19,830
North Carolina	7,195	7,777	8,227	8,840	9,349
North Dakota	641	662	677	704	729
Ohio	11,151	11,319	11,428	11,588	11,744
Oklahoma	3,278	3,373	3,491	3,789	4,057
Oregon	3,141	3,397	3,613	3,992	4,349
Pennsylvania	12,072	12,202	12,281	12,449	12,683
Rhode Island	990	998	1,012	1,070	1,141
South Carolina	3,673	3,858	4,033	4,369	4,645
South Dakota	729	777	810	840	866
Tennessee	5,256	5,657	5,966	6,365	6,665
Texas	18,724	20,119	21,487	24,280	27,183
Utah	1,951	2,207	2,411	2,670	2,883
Vermont	585	617	638	662	678
Virginia	6,618	6,997	7,324	7,921	8,466
Washington	5,431	5,858	6,258	7,058	7,808
West Virginia	1,828	1,841	1,849	1,851	1,845
Wisconsin	5,123	5,326	5,479	5,693	5,867
Wyoming	480	525	568	641	694

Using the gathered data, the deterministic model should be able to accurately pinpoint the best locations or regions to market the new beer.

Appendix D

Raw Materials

The raw materials used in the production of beer are malted barley, hops, yeast, and water. The optimal locations to receive these materials from were determined based on maximum production in certain areas of the United States.

The most hop growing production in the United States takes place in Idaho, Oregon, and Washington. This is based on yields of hop production in pounds. Data was generated indicating the variety of hops grown in each state along with production amounts, the acres of hops harvested per state in acres, hop yields per state in pounds per acre, and season average price of hops in dollars per pound.

The optimal locations in which to receive the malted barley from are Arizona, Nevada, Oregon, Wyoming, and Colorado. This will be taken into consideration when specifying input variables for the mathematical model in determining distances from the brewery for shipping costs.

The amount of each raw material is determined by the recipe chosen for the beer. BCB Company will brew a pale ale, so for a 30 barrel process, this indicates that approximately 40 pounds of malted barley per barrel, 0.80 pounds of hops per barrel, 5 pounds of yeast per barrel (includes the recycling of the yeast from batch to batch), and 210 gallons of water per barrel are needed for each production batch. The prices of these raw materials can be found below.

Table 5: U.S. Hop Production

U.S. Hop Production by State & Variety

State & Variety	Hop Production (pounds)					
	1998	**1999**	**2000**	**2001**	**2002**	**%±**
IDAHO						
Chinook	507,600	383,900	340,000	195,200	-	-
Cluster	886,300	694,600	384,700	363,400	-	-
Galena	895,700	1,049,300	971,000	823,500	-	-
Mt_Hood	15,000	22,900	106,000	38,400	-	-
Nugget	131,900	152,500	136,000	81,000	-	-
Willamette	160,700	333,000	297,600	231,500	-	-
Zeus	2,000	397,100	824,500	893,000	-	-
Other_Varieties	1,932,200	1,693,700	1,870,000	1,983,300	-	-
Total_Idaho	4,531,400	4,734,000	4,929,800	4,609,300	5,519,600	19.75%
OREGON						
Cascade	-	-	-	-	320,500	-
Fuggle	206,600	105,400	67,100	-	-	-
Golding	198,900	153,500	134,600	-	-	-
Liberty	-	-	-	-	52,800	-
Millennium	-	-	-	300,700	631,900	110.14%
Mt_Hood	339,700	461,700	447,500	506,300	420,100	-17.03%
Nugget	4,875,200	4,822,700	4,989,500	5,545,300	3,996,900	-27.92%
Perle	502,800	542,000	454,300	665,300	525,700	-20.98%
Santiam	-	-	22,500	-	-	-
Sterling	-	-	105,700	187,900	163,000	-13.25%
Willamette	3,473,200	3,284,200	3,318,000	3,463,600	2,921,500	-15.65%
Other_Varieties	449,700	594,700	847,800	774,100	405,600	-47.60%
Total_Oregon	10,227,400	10,072,000	10,387,000	11,443,200	9,438,000	-17.52%
WASHINGTON						
Cascade	1,785,600	1,821,100	1,798,800	1,790,400	2,125,600	18.72%
Chelan	-	-	-	573,500	652,200	13.72%
Chinook	1,570,900	1,582,000	1,311,200	918,600	802,600	-12.63%
Cluster	4,975,600	2,536,300	1,875,200	1,045,600	958,100	-8.37%
Columbus/Tomahawk	9,956,500	10,628,800	11,778,000	12,253,100	10,534,800	-14.02%
Galena	9,824,300	10,615,800	9,538,200	7,345,600	6,170,300	-16.00%

Golding	89,600	51,500	39,500	55,400	30,900	-44.22%
Hallertauer	-	-	-	73,600	90,700	23.23%
Horizon	97,500	332,300	395,000	414,900	474,800	14.44%
Magnum	-	148,500	118,000	59,800	-	-
Millennium	-	-	-	2,815,100	3,417,800	21.41%
Mt_Hood						
Northern_Brewer	-	-	-	124.,500	193,200	-
Nugget	7,237,400	8,683,700	8,522,200	8,086,500	2,698,400	-66.63%
Perle	186,500	292,100	215,900	226,300	120,200	-46.88%
Tettnanger	226,800	129,000	-	63,500	61,300	-3.46%
Tillicum	-	-	-	677,500	402,600	-40.58%
Vanguard	-	-	-	74,100	-	-
Willamette	4,628,000	4,844,200	4,888,400	4,674,400	5,025,500	7.51%
YCR5	-	-	-	2670100	2099500	0
	Hop Production (pounds)					
State & Variety	**1998**	**1999**	**2000**	**2001**	**2002**	**%±**
WASHINGTON						
Zeus	-	3,480,800	5,381,800	5,834,400	6,779,100	16.19%
Other_Alpha	2,632,600	2,106,300	4,162,600	281,811	362,500	28.63%
Other_Aroma	220,000	222,000	374,000	224,542	160,800	-28.39%
Other	780,000	1,748,400	1,439,700	119,924	82,000	-31.62%
Total_Washington	44,791,000	49,649,000	52,260,000	50,779,600	43,379,000	-14.57%
Total_United_States	59,549,800	64,455,000	67,576,800	66,832,100	58,336,600	-12.71%

U.S Hop Acreage by State & Variety

	Acres Harvested					**2002**
State & Variety	**1998**	**1999**	**2000**	**2001**	**2002**	**%±**
IDAHO						
Chinook	384	202	170	120	-	-
Cluster	657	417	198	234	-	-
Galena	733	625	535	552	-	-
Mt_Hood	10	32	53	32	-	-
Nugget	97	89	68	54	-	-
Willamette	225	248	194	215	-	-
Zeus	-	201	403	477	-	-
Other_Varieties	1,803	1,541	1,700	1,785	-	-
Total_Idaho	3,909	3,362	3,321	3,469	3,399	-2.02%
OREGON						
Cascade	-	-	-	-	217	-
Fuggle	189	98	63	-	-	-
Golding	235	110	115	-	-	-
Liberty	-	-	-	-	36	-
Millennium	-	-	-	117	421	259.83%
Mt_Hood	225	253	250	257	243	-5.45%
Nugget	2,415	2,153	2,308	2,268	1,967	-13.27%
Perle	385	406	402	491	452	-7.94%
Santiam	-	-	17	-	-	-
Sterling	-	-	62	91	86	-5.49%

Willamette	2,290	2,321	2,142	2,434	1,912	-21.45%
Other_Varieties	268	393	460	445	243	-45.39%
Total_Oregon	6,161	5,822	5,819	6,103	5,577	-8.62%
WASHINGTON						
Cascade	992	906	996	1,003	1,216	21.24%
Chelan	-	-	-	317	295	-6.94%
Chinook	1,007	791	670	535	422	-21.12%
Cluster	2,605	1,321	939	534	480	-10.11%
Columbus/Tomahawk	3,999	4,374	4,594	4,915	3,663	-25.47%
Galena	5,779	5,282	5,044	4,375	3,239	-25.97%
Golding	83	35	36	45	26	-42.22%
Hallertauer	-	-	-	76	76	0.00%
Horizon	130	268	316	339	337	-0.59%
Magnum	-	99	73	42	-	-
	Acres Harvested					**2002**
State & Variety	**1998**	**1999**	**2000**	**2001**	**2002**	**%±**
WASHINGTON						
Millennium	-	-	-	1,382	1,455	5.28%
Northern_Brewer	107	-				
Mt_Hood	361	384	367	333	97	-70.87%
Nugget	4,793	4,195	4,597	4,109	1,288	-68.65%
Perle	296	273	275	209	124	-40.67%
Tettnanger	252	129	-	60	48	-20.00%
Tillicum	-	-	-	369	194	-47.43%
Vanguard	-	-	-	54	-	-
Willamette	3,922	3,364	3,563	3,571	3,639	1.90%
YCR5	-	-	-	1370	988	0
Zeus	-	1,520	1,994	2,186	2,265	3.61%
Other_Alpha	1,408	1,048	2,363	157	203	29.30%
Other_Aroma	251	206	330	163	120	-26.38%
Other	569	881	824	98	51	-47.96%
Total_Washington	26,573	25,076	26,980	26,339	20,333	-22.80%
Total_United_States	36,643	34,260	36,120	35,911	29,309	-18.38%

U.S. Hop Yields by State and Variety

	Yields (lbs/acre)					
State & Variety	**1998**	**1999**	**2000**	**2001**	**2002**	**% (±)**
IDAHO						
Chinook	1,322	1,900	2,000	1,627	-	-
Cluster	1,349	1,666	1,943	1,553	-	-
Galena	1,222	1,679	1,815	1,492	-	-
Mt_Hood	1,500	716	2,000	1,200	-	-
Nugget	1,360	1,713	2,000	1,500	-	-
Willamette	714	1,343	1,534	1,077	-	-
Zeus	2,046	1,872	-	-		
Other_Varieties	1,072	1,099	1,100	1,111	-	-
Total_Idaho	1,220	1,408	1,484	1,329	1,624	22.20%
OREGON						

Cascade	-	-	-	-	1,477	-
Fuggle	1,093	1,076	1,065	-	-	-
Golding	846	1,395	1,170	-	-	-
Liberty	-	-	-	-	1,467	-
Millennium	-	-	-	2,570	1,501	-41.60%
Mt_Hood	1,510	1,825	1,790	1,970	1,729	-12.23%
Nugget	2,019	2,240	2,162	2,445	2,032	-16.89%
Perle	1,306	1,335	1,130	1,355	1,163	-14.17%
Santiam	-	-	1,324	-	-	-
Sterling	-	-	1,705	2,065	1,895	-8.23%
Willamette	1,517	1,415	1,549	1,423	1,528	7.38%
Other_Varieties	1,678	1,513	1,843	1,740	1,669	-4.08%
Total_Oregon	1,393	1,730	1,785	1,875	1,692	-9.76%

WASHINGTON						
Cascade	1,800	2,010	1,806	1,785	1,748	-2.07%
Chelan	-	-	-	1,809	2,211	22.22%
Chinook	1,560	2,000	1,957	1,717	1,902	10.77%
Cluster	1,910	1,920	1,997	1,958	1,996	1.94%
Columbus/Tomahawk	2,490	2,430	2,564	2,493	2,876	15.36%
Galena	1,700	2,010	1,891	1,679	1,905	13.46%
Golding	1,080	1,470	1,098	1,231	1,188	-3.49%
Hallertauer	-	-	-	968	1,193	23.24%
Horizon	-	1,240	1,250	1,224	1,409	15.11%
Magnum	-	1,500	1,616	1,424	-	-
Millennium	-	-	-	2,037	2,349	15.32%
Mt_Hood	1,030	1,100	1,147	1,130	1,272	12.57%
Northern	Brewer	1,992	-			
Nugget	1,510	2,070	1,854	1,968	2,095	6.45%
Perle	630	1,070	785	1,083	969	-10.53%
Tettnanger	900	1,000	-	1,058	1,277	20.70%
Tillicum	-	-	-	1,836	2,075	13.02%
Vanguard	-	-	-	1,372	-	-
Willamette	1,180	1,440	1,372	1,309	1,381	5.50%
YCR5	-	-	-	1949	2125	0
Zeus	-	2,290	2,699	2,669	2,993	12.14%
Other_Alpha	1,869	2,010	2,050	1,648	1,619	-1.76%
Other_Aroma	876	1,078	1,134	1,378	1,340	-2.76%
Other	1,371	1,985	1,748	1,224	1,610	31.54%
Total_Washington	1,402	1,980	1,937	1,928	2,133	10.63%
Total_United_States	1,338	1,884	1,871	1,861	1,990	6.93%

U.S. Hop Acreage By State (in Acres)

YEAR	WASHINGTON	OREGON	IDAHO	TOTAL
1992	30,366	7,900	4,000	42,266
1993	31,239	7,900	3,961	43,100
1994	30,375	8,000	4,037	42,412
1995	30,621	8,641	3,927	43,189
1996	31,678	8,486	3,997	44,161
1997	31,080	8,352	3,870	43,302

1998	26,573	6,161	3,909	36,643
1999	25,076	5,822	3,362	34,260
2000	26,980	5,819	3,321	36,120
2001	26,339	6,103	3,469	35,911
2002	20,333	5,577	3,399	29,309

U.S. Average Hop Yields (lbs/acre) -

YEAR	WASHINGTON	OREGON	IDAHO	Total U.S.
1992	1,881	1,479	1,387	1,759
1993	1,884	1,500	1,375	1,767
1994	1,800	1,715	1,527	1,758
1995	1,930	1,595	1,520	1,826
1996	1,820	1,383	1,400	1,698
1997	1,796	1,625	1,417	1,729
1998	1,686	1,660	1,159	1,625
1999	1,980	1,730	1,408	1,884
2000	1,937	1,785	1,484	1,871
2001	1,928	1,875	1,329	1,861
2002	2,133	1,692	1,624	1,990

U.S. Hops: Season Average Price & Total Crop Value

Marketing					U.S.	Total Crop Value
Year	Washington	Oregon	Idaho	U.S.	Production	
	($/lb)				(lbs x 1000)	(x 1000)
1987	$1.32	$1.78	$2.74	$1.51	50,048	$75,578
1988	$1.36	$1.64	$1.09	$1.40	54,696	$76,415
1989	$1.33	$1.58	$1.26	$1.38	59,326	$81,583
1990	$1.44	$1.63	$1.50	$1.48	56,855	$84,178
1991	$1.68	$1.71	$1.59	$1.68	69,155	$115,997
1992	$1.72	$1.86	$1.69	$1.74	74,337	$129,096
1993	$1.72	$1.95	$1.77	$1.76	76,144	$133,965
1994	$1.77	$1.96	$1.79	$1.81	74,560	$134,701
1995	$1.68	$1.90	$1.61	$1.71	78,852	$135,087
1996	$1.63	$1.81	$1.49	$1.65	74,970	$123,530
1997	$1.60	$1.68	$1.41	$1.60	74,872	$119,840
1998	$1.64	$1.98	$1.55	$1.69	59,548	$100,728
1999	$1.63	$2.04	$1.61	$1.69	64,455	$109,099
2000	$1.82	$2.19	$1.78	$1.87	67,576	$126,217
2001	$1.81	$2.15	$1.59	$1.91	66,832	$123,843
2002	$1.95	$2.13	$1.58	$1.94	58,336	$113,413

Table 6: Variety of Hops

Hops Varieties and Prices

Hops Variety	a/a (%)	Weight (lbs)	Price ($)	Price ($/lb)
Cascade Pellet Hops	5 - 6.5	44	$143.00	$3.25
Cluster Pellet Hops	6.5 - 8	44	$121.00	$2.75
E.K. Golding Pellet Hops	5.5 - 6.1	44	$242.00	$5.50
Fuggle Pellet Hops	4 - 5.8	44	$182.60	$4.15
Perle Pellet Hops	5.0 - 8.0	44	$173.80	$4.10
Tradition (GR) Pellet Hops	6.8	44	$191.40	$4.35

Barley Malt Variety and Prices

Malt Variety	Description	Weight (lbs)	Price ($)
British Pale Ale Malt	2 Row	55	$53.10
Pale Malted Barley	2 Row	50	$33.50
Pale Malted Barley	6 Row	50	$31.50
Briess Pale Ale Malt	2 Row	50	$31.50

Yeast Variety and Prices

	Batch Pitch Size (bbl)	Cost per barrel ($)
California Ale	1	$70.00
English Ale	2	$100.00
German Ale	7	$150.00
Irish Ale	10	$210.00
British Ale	15	$255.00
Dry English Ale	20	$300.00
East Coast Ale	25	$350.00
European Ale	30	$395.00
London Ale	35	$445.00

These prices are standard for each variety of yeast.

Appendix E

Taxes

Taxes

The Federal annual taxes is normally $18 per barrel, but for breweries under a 2 million barrel production process which applies to our project the tax is only $7 per barrel for the first 60,000 barrels.

The state taxes vary, and the following is a list of excise tax by state:

Table 7: Tax Information

	EXCISE TAX RATES ($ per gallon)	SALES TAXES APPLIED	OTHER TAXES
Alabama	$0.53	Yes	$0.52/gallon local tax
Alaska	1.07	n.a.	$0.35/gallon small breweries
Arizona	0.16	Yes	
Arkansas	0.23	Yes	under 3.2% - $0.16/gallon; $0.008/gallon and 3% off-10% on-premise tax
California	0.20	Yes	
Colorado	0.08	Yes	
Connecticut	0.19	Yes	
Delaware	0.16	n.a.	
Florida	0.48	Yes	2.67¢/12 ounces on-premise retail tax
Georgia	0.48	Yes	$0.53/gallon local tax
Hawaii	0.92	Yes	$0.53/gallon draft beer
Idaho	0.15	Yes	Over 4% - $0.45/gallon
Illinois	0.185	Yes	$0.16/gallon in Chicago and $0.06/gallon in Cook County
Indiana	0.12	Yes	
Iowa	0.19	Yes	
Kansas	0.18	--	over 3.2% - {8% off- and 10% on-premise}, under 3.2% - 4.25% sales tax.
Kentucky	0.08	Yes*	9% wholesale tax
Louisiana	0.32	Yes	$0.048/gallon local tax
Maine	0.35	Yes	additional 5% on-premise tax
Maryland	0.09	Yes	$0.2333/gallon in Garrett County
Massachusetts	0.11	Yes*	0.57% on private club sales
Michigan	0.20	Yes	
Minnesota	0.15	--	under 3.2% - $0.077/gallon. 9.0% sales tax
Mississippi	0.43	Yes	
Missouri	0.06	Yes	
Montana	0.14	n.a.	
Nebraska	0.23	Yes	

Nevada	0.09	Yes	
New Hampshire	0.30	n.a.	
New Jersey	0.12	Yes	
New Mexico	0.41	Yes	
New York (1)	0.125	Yes	$0.12/gallon in New York City
North Carolina	0.53	Yes	$0.48/gallon bulk beer
North Dakota	0.16	--	7% state sales tax, bulk beer $0.08/gal.
Ohio	0.18	Yes	
Oklahoma	0.40	Yes	under 3.2% - $0.36/gallon; $1.00/case on-premise and 12% on-premise
Oregon	0.08	n.a.	
Pennsylvania	0.08	Yes	
Rhode Island	0.10	Yes	$0.04/case wholesale tax
South Carolina	0.77	Yes	
South Dakota	0.27	Yes	
Tennessee	0.14	Yes	17% wholesale tax
Texas	0.19	Yes	over 4% - $0.198/gallon, 14% on-premise and $0.05/drink on airline sales
Utah	0.35	Yes	Over 3.2% - sold through state store
Vermont	0.265	no	6% to 8% alcohol - $0.55; 10% on-premise sales tax
Virginia	0.26	Yes	
Washington	0.261	Yes	
West Virginia	0.18	Yes	
Wisconsin	0.06	Yes	
Wyoming	0.02	Yes	
Dist. of Columbia	0.09	Yes	8% off- and 10% on-premise sales tax
U.S. Median	$0.185		

Appendix F

Distances

How Distance was Found

In order to find the distances between two locations the longitude and latitude for each location had to be found. The longitude and latitude for 61 cities, which seem to be the best locations to start a brewery, were found using a pair of websites. The first website, www.bcca.org/misc/qiblih/latlong_us, was used to determine the longitude and latitude of major cities in the United States. It gave them in degrees and minutes, so additional work had to be done to determine the longitudes and latitudes in degrees only. The second website, www.census.gov/cgi-bin/gazetteer, was used to determine the longitude and latitude of minor cities in the United States. It gave them in degrees only, so no additional work was needed. Below are the results:

Table 8: Latitude and Longitude Data

City	Latitude	Longitude	Latitude	Longitude
Minneapolis/St. Paul, MN	44° 53' N	93° 13' W	44.8833	93.2167
Washington, DC, MD	38° 51' N	77° 2' W	38.8500	77.0333
Atlanta, GA	33° 39' N	84° 26' W	33.6500	84.4333
Fort Lauderdale, FL	26° 4' N	80° 9' W	26.0667	80.1500
Salt Lake City, UT	40° 46' N	111° 58' W	40.7667	111.9667
West Palm Beach, FL	26° 41' N	80° 6' W	26.6833	80.1000
Norfolk, VA	36° 54' N	76° 12' W	36.9000	76.2000
Miami, FL	25° 48' N	80° 16' W	25.8000	80.2667
Charlotte, NC	35° 13' N	80° 56' W	35.2167	80.9333
Orlando, FL	28° 33' N	81° 23' W	28.5500	81.3833
Las Vegas, NV	36° 5' N	115° 10' W	36.0833	115.1667
Baltimore, MD	39° 11' N	76° 40' W	39.1833	76.6667
Phoenix, AZ	33° 26' N	112° 1' W	33.4333	112.0167
Monmouth, NJ	40.28780 N	74.15435 W	40.2878	74.1544
Louisville, KY /IN	38° 11' N	85° 44' W	38.1833	85.7333

Sacramento, CA	38° 31' N	121° 30' W	38.5167	121.5000
San Diego, CA	32° 44' N	117° 10' W	32.7333	117.1667
San Antonio, TX	29° 32' N	98° 28' W	29.5333	98.4667
Jacksonville, FL	30° 30' N	81° 42' W	30.5000	81.7000
Austin, TX	30° 18' N	97° 42' W	30.3000	97.7000
Houston, TX	29° 58' N	95° 21' W	29.9667	95.3500
Oklahoma City, OK	35° 24' N	97° 36' W	35.4000	97.6000
Boston, MA	42° 22' N	71° 2' W	42.3667	71.0333
Dallas, TX	32° 51' N	96° 51' W	32.8500	96.8500
Middlesex, NJ	40.57370 N	74.50214 W	40.5737	74.5021
Tampa, FL	27° 58' N	82° 32' W	27.9667	82.5333
Denver, CO	39° 45' N	104° 52' W	39.7500	104.8667
Providence, RI	41° 44' N	71° 26' W	41.7333	71.4333
New York, NY	40° 47' N	73° 58' W	40.7833	73.9667
Columbus, OH	40° 0' N	82° 53' W	40.0000	82.8833
Kansas City, MO	39° 7' N	94° 35' W	39.1167	94.5833
Greensboro, NC	36° 5' N	79° 57' W	36.0833	79.9500
New Orleans, LA	29° 59' N	90° 15' W	29.9833	90.2500
Orange County, CA	33.67496 N	117.77739 W	33.6750	117.7774
Memphis, TN	35° 3' N	90° 0' W	35.0500	90.0000
Fort Worth, TX	32° 50' N	97° 3' W	32.8333	97.0500
Riverside, CA	33° 54' N	117° 15' W	33.9000	117.2500
St. Louis, MO	38° 45' N	90° 23' W	38.7500	90.3833

Milwaukee, WI	42° 57' N	87° 54' W	42.9500	87.9000
Raleigh, NC	35° 52' N	78° 47' W	35.8667	78.7833
Oakland, CA	37° 49' N	122° 19' W	37.8167	122.3167
Bergen, NJ	40.95870 N	74.07436 W	40.9587	74.4744
Nassau, NY	42.51371 N	73.61158 W	42.5137	73.6116
Indianapolis, IN	39° 44' N	86° 17' W	39.7333	86.2833
Nashville, TN	36° 7' N	86° 41' W	36.1167	86.6833
Philadelphia, PA	39° 53' N	75° 15' W	39.8833	75.2500
Newark, NJ	40° 42' N	74° 10' W	40.7000	74.1667
San Jose, CA	37° 22' N	121° 56' W	37.3667	121.9333
Cincinnati, OH	39° 9' N	84° 31' W	39.1500	84.5167
Buffalo, NY	42° 56' N	78° 44' W	42.9333	78.7333
Seattle, WA	47° 39' N	122° 18' W	47.6500	122.3000
Chicago, IL	41° 53' N	87° 38' W	41.8833	87.6333
Pittsburgh, PA	40° 30' N	80° 13' W	40.5000	80.2167
Portland, OR	45° 36' N	122° 36' W	45.6000	122.6000
Hartford, CT	41° 44' N	72° 39' W	41.73333333	72.6500
Detroit, MI	42° 25' N	83° 1' W	42.4167	83.0167
Cleveland, OH	41° 24' N	81° 51' W	41.4000	81.8500
Grand Rapids, MI	42° 53' N	85° 31' W	42.8833	85.5167
Rochester, NY	43° 7' N	77° 40' W	43.1167	77.6667
San Francisco, CA	37° 37' N	122° 23' W	37.6167	122.3833
Los Angeles, CA	33° 56' N	118° 24' W	33.9333	118.4000

The longitudes and latitudes for the various market locations were found based on the population centers for each state. Several states were broken up due to size, natural barriers and/or population. In this case the largest city in each section was chosen. These longitudes and latitudes were found using the website, www.acsm.net/statecenters. They were listed in degrees only, so no additional calculations were needed. Below are the results:

Table 9: Conversion of Latitude and Longitude

State	Population	Latitude (N)	Longitude (W)	
Alabama	4447100	33.001471	86.766233	
Alaska	626932	61.288254	148.716968	
Arizona	5130632	33.373506	111.828711	
Arkansas	2673400	35.080251	92.576816	
California-South	33871648	34.09095	118.40844	Los Angeles
California-North		38.56685	121.46736	Sacramento
Colorado-West	4301261	39.0873	108.55292	Grand Junction
Colorado-East		39.76803	104.87265	Denver
Connecticut	3405565	41.494852	72.874365	
Delaware	783600	39.397164	75.561908	
District of Columbia	572059	38.910092	77.014001	
Florida-South	15982378	25.70805	80.29534	Miami
Florida-North		30.33455	81.65769	Jacksonville
Georgia	8186453	33.332208	83.868887	
Hawaii	1211537	21.146768	157.524452	
Idaho	1293953	44.242605	115.133222	
Illinois	12419293	41.278216	88.380238	
Indiana	6080485	40.163935	86.261515	
Iowa	2926324	41.960392	93.049161	
Kansas	2688418	38.454303	96.536052	
Kentucky	4041769	37.808159	85.241819	
Louisiana	4468976	30.69927	91.457133	
Maine	1274923	44.313614	69.719931	
Maryland	5296486	39.145653	76.797396	
Massachusetts	6349097	42.271831	71.363628	
Michigan-South	9938444	42.7091	84.55399	Lansing
Michigan-North		46.5508	87.39572	Marquette
Minnesota	4919479	45.210782	93.583003	
Mississippi	2844658	32.56642	89.593164	
Missouri	5595211	38.437715	92.15377	
Montana	902195	46.813302	111.209708	
Nebraska	1711263	41.183753	97.403875	
Nevada	1998257	37.165965	116.304648	
New Hampshire	1235786	43.153046	71.463342	

New Jersey	8414350	40.438458	74.428055	
New Mexico	1819046	34.623012	106.342108	
New York-South	18976457	40.6698	73.94384	New York
New York-North		43.04105	76.14406	Syracuse
North Carolina	8049313	35.553334	79.667654	
North Dakota	642200	47.375168	99.334736	
Ohio	11353140	40.480854	82.749366	
Oklahoma	3450654	35.59794	96.834653	
Oregon	3421399	44.732273	122.579524	
Pennsylvania-East	12281054	40.00681	75.13467	Philadelphia
Pennsylvania-West		40.4392	79.9767	Pittsburgh
Rhode Island	1048319	41.753318	71.448902	
South Carolina	4012012	34.034551	81.032387	
South Dakota	754844	44.047502	99.043799	
Tennessee	5689283	35.795862	86.397772	
Texas-NW	20851820	33.57585	101.87537	Lubbock
Texas-NE		32.79415	96.76524	Dallas
Texas-SW		31.87443	102.34834	
Texas-SE		29.7687	95.38672	Houston
Utah	2233169	40.438987	111.90016	
Vermont	608827	44.081127	72.814309	
Virginia	7078515	37.750345	77.835857	
Washington	5894121	47.341728	121.624501	
West Virginia	1808344	38.767195	80.820221	
Wisconsin	5363675	43.728544	89.001006	
Wyoming	493782	42.675762	107.008835	

The longitude and latitude for the various locations from which the barley malt will be shipped from (see below) were found using the website, www.census.gov/cgi-bin/gazetteer.

Barley Malt Locations	**Latitude (N)**	**Longitude (W)**
Yuma, AZ	32.76476	113.89721
Phoenix, AZ	33.43333	112.01666
Tucson, AZ	32.19581	110.89171
Nogales, AZ	31.36371	110.93263
Douglas, AZ	31.34268	109.52819
Elko, NV	40.83871	115.76066
Medford, OR	42.3398	122.85309
Roseburg, OR	43.21969	123.35762
Cody, WY	44.51948	109.05414
Fort Morgan, CO	40.26518	103.79457

The longitude and latitude for the various locations from which the hops will be shipped from (see below) were found using the website, www.census.gov/cgi-bin/gazetteer.

Hops Locations	Latitude (N)	Longitude (W)
Willamette Valley, OR	45.53825	122.65649
Yakima Valley, Wa	47.42566	120.32492
Caldwell Region, ID	44.25083	116.96674
Bonners Ferry Region, ID	48.69166	116.31511

Once the longitudes and latitudes were found, the distances from the barley malt and hops location to the brewery and from the brewery to the market were calculated using the following equation.

$$\mathrm{D}_{1,2} = 3963 \cdot \arccos\left[\sin\left(\frac{lat1}{a}\right) \cdot \sin\left(\frac{lat2}{a}\right) + \cos\left(\frac{lat1}{a}\right) \cdot \cos\left(\frac{lat2}{a}\right) \cdot \cos\left(\frac{lon2}{a} - \frac{lon1}{a}\right)\right]$$

$$a = \frac{180}{\pi} = 57.2958$$

$$lat = citylatitude$$

$$lon = citylongitude$$

A full listing of the distances can be found on the M: Drive for Group 10 in Keith Orendorff's folder.

Appendix G

Leasing Costs

Leasing Costs

The leasing costs for buildings in the various possible plant locations were found in the following way. First the leasing cost for buildings in Oklahoma City was found by using the website www.loopnet.com. Once several costs were obtained, the average leasing cost for buildings in Oklahoma City was calculated to be $7.23/SF/yr. This average leasing cost for Oklahoma City was then used to calculate the leasing costs of the other possible plant locations by adjusting it with the cost of living for each possible plant location. The cost of living for each possible plant location was found using the website www.bestplaces.net/html/col1.asp. In order to use the cost of living to find the leasing costs for the each possible plant location, the equation shown below was used.

$$LC_{Plant} = LC_{OKC} * COL + LC_{OKC}$$
$$LC_{OKC} = \$7.23 / SF / yr$$

For this equation, LC is the leasing cost and COL is the cost of living. Below are the calculated leasing costs for each of the possible plant locations along with the cost of living in each location.

Table 10: Leasing Costs

	Cities	**Cost of Living**	**Avg. Leasing Costs OKC ($/SF/yr)**	**Leasing Costs ($/SF/yr)**
Plant Locations	Minneapolis/St. Paul, MN	0.13	$7.23	$8.17
	Washington, DC, MD	0.373	$7.23	$9.93
	Atlanta, GA	0.143	$7.23	$8.26
	Fort Lauderdale, FL	0.195	$7.23	$8.64
	Salt Lake City, UT	0.186	$7.23	$8.57
	West Palm Beach, FL	0.2	$7.23	$8.68
	Norfolk, VA	0.101	$7.23	$7.96
	Miami, FL	0.195	$7.23	$8.64
	Charlotte, NC	0.109	$7.23	$8.02
	Orlando, FL	0.11	$7.23	$8.03
	Las Vegas, NV	0.164	$7.23	$8.42
	Baltimore, MD	0.074	$7.23	$7.77
	Phoenix, AZ	0.125	$7.23	$8.13
	Monmouth, NJ	0.306	$7.23	$9.44
	Louisville, KY /IN	0.045	$7.23	$7.56
	Sacramento, CA	0.22	$7.23	$8.82
	San Diego, CA	0.491	$7.23	$10.78
	San Antonio, TX	-0.001	$7.23	$7.22
	Jacksonville, FL	-0.069	$7.23	$6.73
	Austin, TX	0.065	$7.23	$7.70
	Houston, TX	0.031	$7.23	$7.45
	Oklahoma City, OK	0	$7.23	$7.23
	Boston, MA	0.584	$7.23	$11.45
	Dallas, TX	0.113	$7.23	$8.05
	Middlesex, NJ	0.398	$7.23	$10.11
	Tampa, FL	0.078	$7.23	$7.79
	Denver, CO	0.251	$7.23	$9.04
	Providence, RI	0.173	$7.23	$8.48

	New York, NY	1.598	$7.23	$18.78
	Columbus, OH	0.103	$7.23	$7.97
	Kansas City, MO	0.069	$7.23	$7.73
	Greensboro, NC	0.084	$7.23	$7.84
	New Orleans, LA	0.044	$7.23	$7.55
	Orange County, CA	0.623	$7.23	$11.73
	Memphis, TN	0.023	$7.23	$7.40
	Fort Worth, TX	0.009	$7.23	$7.30
	Riverside, CA	0.188	$7.23	$8.59
	St. Louis, MO	0.083	$7.23	$7.83
	Milwaukee, WI	0.185	$7.23	$8.57
	Raleigh, NC	0.193	$7.23	$8.63
	Oakland, CA	0.633	$7.23	$11.81
	Bergen, NJ	0.468	$7.23	$10.61
	Nassau, NY	0.587	$7.23	$11.47
	Indianapolis, IN	0.049	$7.23	$7.58
	Nashville, TN	0.054	$7.23	$7.62
	Philadelphia, PA	0.363	$7.23	$9.85
	Newark, NJ	0.453	$7.23	$10.51
	San Jose, CA	1.142	$7.23	$15.49
	Cincinnati, OH	0.084	$7.23	$7.84
	Buffalo, NY	0.075	$7.23	$7.77
	Seattle, WA	0.442	$7.23	$10.43
	Chicago, IL	0.233	$7.23	$8.91
	Pittsburgh, PA	0.102	$7.23	$7.97
	Portland, OR	0.229	$7.23	$8.89
	Hartford, CT	0.246	$7.23	$9.01
	Detroit, MI	0.165	$7.23	$8.42
	Cleveland, OH	0.246	$7.23	$9.01
	Grand Rapids, MI	0.1	$7.23	$7.95
	Rochester, NY	0.072	$7.23	$7.75
	San Francisco, CA	1.072	$7.23	$14.98
	Los Angeles, CA	0.441	$7.23	$10.42

Appendix H

Labor Costs

Labor Costs

In order to calculate the labor costs for each state, the minimum wage was found for each of the states in which a brewery might be constructed. The minimum wage data was gathered from http://www.dol.gov/esa/minwage/america.htm. Below is the minimum wage for each state:

Table 11: Minimum Wage by State

State	Minimum Wage
Alabama	$5.15
Alaska	$7.15
Arizona	$5.15
Arkansas	$5.15
California	$6.75
Colorado	$5.15
Connecticut	$7.10
Delaware	$6.15
District of Columbia	$6.15
Florida	$5.15
Georgia	$5.15
Hawaii	$6.25
Idaho	$5.15
Illinois	$5.50
Indiana	$5.15
Iowa	$5.15
Kansas	$5.15
Kentucky	$5.15
Louisiana	$5.15
Maine	$6.25
Maryland	$5.15
Massachusetts	$6.75
Michigan	$5.15
Minnesota	$5.15
Mississippi	$5.15
Missouri	$5.15
Montana	$5.15
Nebraska	$5.15
Nevada	$5.15
New Hampshire	$5.15
New Jersey	$5.15
New Mexico	$5.15
New York	$5.15
North Carolina	$5.15
North Dakota	$5.15
Ohio	$5.15
Oklahoma	$5.15

Oregon	$7.05
Pennsylvania	$5.15
Rhode Island	$6.75
South Carolina	$5.15
South Dakota	$5.15
Tennessee	$5.15
Texas	$5.15
Utah	$5.15
Vermont	$6.75
Virginia	$5.15
Washington	$7.16
West Virginia	$5.15
Wisconsin	$5.15
Wyoming	$5.15

Appendix I

Equipment Costs for 15 Barrel System

15 Barrel Brewery System				
System parameters	steam heated brewhouse; brewkettle/whirlpool & mash/lauter tun			
	hot liquor tank with double brew capacity			
	3 x 30 barrel unitanks			
	1 x 30 barrel bright tank			
	glycol system expansion capability			
Annual production capability	assume 100% ales @ 14 day fermentation length (26 cycles/year/tank)			
	3 x 30 barrel unitanks x 26 cycles/year = **2340 barrels/year initially**			
	1 barrel = 31 USgallons			
Brews/year @ 2340 barrels	2340 bbls / 15 bbl brewhouse = **156 brews/year = 3 brews/week**			
Item	**Description**	**Qty.**	**Unit Price**	**Extended Price**
Brewhouse Equipment				
Brewkettle / Whirlpool	steam heated, side and bottom	1	$14,465.00	$14,465.00
	gas fired (U.L. classified)	not quoted	$21,830.00	
	Conversion to MashKettle; mash agitator with variable speed drive, modified bottom arrangement, includes additional plumbing	not quoted	$5,285.00	
Brewkettle Venting	internal drip ring for exhausting steam to atmosphere; vent tubing not included	1	$365.00	$365.00
	stack condenser - does not require atmospheric steam exhaust	not quoted	$2,050.00	
Combi-Vessel	one vessel consisting of an upper lauter tun / lower hot liquor tank	not quoted	$24,590.00	
Mash / Lauter Tun	"V-Wire" false bottom, rotating sparge assembly, vorlauf assembly, side steam jacket, other standard features	1	$16,360.00	$16,360.00
	top head	not quoted	$850.00	
	lautering rakes with variable speed drive and spent grain plow	not quoted	$6,650.00	
	retractable lift system for lautering rake	not quoted	$3,910.00	
Hot Liquor Tank	single brew capacity	1	$8,230.00	$8,230.00
Cosmetic Finishes	copper clad mash tun & brewkettle	not quoted	$2,200.00	
	copper clad hot liquor tank	not quoted	$1,100.00	
	brass or copper banding	not quoted	$600.00	
	polished mirror finish on Brewkettle head	not quoted	$1,260.00	
	polished mirror finish on mash tun	not quoted	$1,260.00	

	head			
Diverter Panel	two pumps & controls	1	$5,090.00	$5,090.00
	variable speed motor	2	$650.00	$1,300.00
	washdown pump motor	2	$115.00	$230.00
Hot Wort Grant	closed / horizontal grant on lauter tun	1	$1,300.00	$1,300.00
	auto level control	not quoted	$650.00	
Heat Exchanger	2 stage with water & glycol	1	$4,750.00	$4,750.00
Brewhouse Process Plumbing	complete stainless pre-plumb	1	$4,200.00	$4,200.00
Flow Control Valves	micro adjustable butterfly	1	$280.00	$280.00
	butterfly	3	$116.50	$349.50
Thermometer		1	$190.00	$190.00
Gas Diffuser		1	$425.00	$425.00
1.5" Sight Glass Assembly	includes extra glass	1	$170.00	$170.00
Brewer's Platform	all stainless	1	$3,700.00	$3,700.00
Wrenches		2	$25.00	$50.00
Mash Mixing Oar		1	$150.00	$150.00
Temperature Control Panel	U.L. listed panel	1	$2,500.00	$2,500.00
	number of controllers	6		
			Total	**$64,104.50**
Grain Handling / Milling Equipment				
Malt Mill	1.5 Hp, 2 roll, 750kg/hr throughput	1	$3,800.00	$3,800.00
Mill Stand & Boot Assembly		1	$430.00	$430.00
Grist Hopper with Cover		1	$3,000.00	$3,000.00
Hopper Slide Gate		1	$175.00	$175.00
Grist Hydrator	SMS style	1	$550.00	$550.00
Flex Auger	50 feet c/w 2 elbows	1	$1,800.00	$1,800.00
			Total	**$9,755.00**
Fermentation / Cellar Equipment				
Unitank / Fermenter	15 bbl working capacity, 30% excess	not quoted	$12,240.00	
	30 bbl working capacity, 30% excess	3	$16,480.00	$49,440.00
Open Fermenters	15 bbl working capacity	not quoted	$6,675.00	
	30 bbl working capacity	not quoted	$8,505.00	
Conditioning/Serving Vessel (single walled vessel for walk-in cooler)	15bbl	not quoted	$5,670.00	
	30bbl	not quoted	$8,345.00	
Conditioning/Serving Vessel (glycol cooled vessel)	15bbl	not quoted	$7,790.00	
	30bbl	1	$11,555.00	$11,555.00
Carbonating Stone Assembly	sintered stainless stone	1	$330.00	$330.00

Glycol Chilling System	7.5 hp. air cooled condensing unit with 550 gallon glycol reservoir, recirculating and supply pumps, glycol/freon heat exchanger, stainless plumbing	1	$14,300.00	$14,300.00
	plumbed for expansion	1	$600.00	$600.00
	10 Hp. Condensing unit w/ 550 gal reservoir	not quoted	$15,800.00	
	2 x 7.5 hp. condensing units w/ 550 gal reservoir	not quoted	$22,630.00	
Solenoid Valve		3	$100.00	$300.00
Stainless Glycol Fittings		3	$50.00	$150.00
CIP/Beer Transfer Pump	1.5 Hp.	1	$1,400.00	$1,400.00
	variable speed motor	not quoted	$850.00	
Filter	plate & frame w/ 31 plates	1	$5,545.00	$5,545.00
			Total	**$83,620.00**
Supporting Equipment				
Fittings Package	1" TC hose end fitting	4	$30.00	$120.00
	1.5" TC hose end fitting	not quoted	$35.00	
	2" TC x 1.5" TC	1	$75.00	$75.00
	1.5" BS to TC adapter	2	$40.00	$80.00
Perlick Tank Tapping Fittings		4	$50.00	$200.00
TC Clamp and Cap Kit	10 caps and clamps	2	$170.00	$340.00
Stainless Quick Disconnects	male	6	$3.50	$21.00
	female	6	$18.50	$111.00
	1/4" s.s ball valve	6	$19.00	$114.00
	1/4" s.s. nipple	4	$3.00	$12.00
	1/4" NPT(M) x 3/8" hose end	6	$8.00	$48.00
Gasket Kit	miscellaneous gaskets	1	$100.00	$100.00
Process Pump Seal Kit	Thomsen pumps	1	$22.80	$22.80
Glycol Pump Seal Kit	Gould pumps	1	$60.75	$60.75
Brewer's Hose	1.5" @ 100 feet	1	$900.00	$900.00
CIP Hose	15 feet	not quoted	$30.00	
Portable CIP Tank		not quoted	$1,660.00	
Hydrometer Flask		1	$110.00	$110.00
Hydrometers	0-8 Brix, 8-16 Brix	2	$52.00	$104.00
Thermometers		2	$47.00	$94.00
Sugar Refractometer		1	$370.00	$370.00
Perlick Proof Coil		not quoted	$160.00	
			Total	**$2,882.55**
Steam Boiler & Equipment				
Low Pressure Steam Boiler	750,000 BTU input	1	$6,300.00	$6,300.00
Assembled condition, skid mounted	condensate receiver w/ pump	1	$1,300.00	$1,300.00
	1.5" brass gate valve	4	$34.25	$137.00
	3/4" swing check valve	9	$20.00	$180.00
	3/4" float & thermostatic steam trap	5	$117.00	$585.00

	3/4" strainer	5	$19.00	$95.00
	1 1/2" actuated steam solenoid valve	1	$310.00	$310.00
			Total	**$8,907.00**
Kegging Equipment				
Sankey Keg Racker	single head	not quoted	$275.00	
	double head	not quoted	$475.00	
	triple head	1	$675.00	$675.00
Sankey Keg Rinser/Washer	SMS 050 - manual system with single head, requires pump and CIP tank	not quoted	$480.00	
	SMS 911 (single head) semi-automated	not quoted	$8,600.00	
	SMS 912 (two head) semi-automated	not quoted	$9,500.00	
	SMS 913 (three head) semi-automated	1	$9,700.00	$9,700.00
Side Bung Keg Racker	keg racking spear & stand	not quoted	$1,050.00	
Side Bung Keg Rinser/Washer	SMS 100 (two head - very manual)	not quoted	$2,150.00	
	SMS 101(two head)	not quoted	$4,290.00	
			Total	**$10,375.00**
Total - 15 Barrel Brewing Equipment as listed above			**US**	**$179,644.05**
All applicable taxes extra				
F.O.B. factory, Victoria, BC, Canada				
Delivery - to be determined upon placement of order				
Prices are valid for 30 days				
Shipping Services				Estimated
Brokerage Fees		2	$110.00	$220.00
Freight to Site - estimated	price per 48' container	2	$3,000.00	$6,000.00
			Total	**$6,220.00**
Supervision of Brewery Re-Assembly Package (5 days on-site)				Estimated
SMS Technician to provide on-site, hands on direction and support to local trades				
Airfare (cost to be confirmed)				
Local Transportation				
Lodging				
Meals				
Tool Freight				
Two Days Travel Time				
Additional Time, if required @ $ 60.00 per hour plus expenses (minimum 8 hours charged per day)				
Supervision & Direction of Local Trades On-Site ; Labor 40 hrs. @ $ 60/hr.				
re-assembly of brewhouse stainless plumbing, "leveling vessels on their floor pads, attach vessel components				
			Total	**$6,530.00**

Appendix J

Equipment Costs for 30 Barrel System

30 Barrel Brewery System				
System Configuration	30 barrel, 2 vessel, low pressure steam fired brewhouse -			
	brewkettle/whirlpool and mash/lauter tun			
	3 x 60 barrel unitank/fermenters			
	1 x 60 barrel bright tank			
	kegging equipment			
Annual Production	Assume 100% ales @ 14 day fermentation cycles (26 cyles/year/vessel)			
	3 x 60 barrel unitanks x 26 cyles/year = **4680 barrels/year**			
	4680 barrels/year / 30 barrel brewhouse = 156 brews/year			
Item	**Description**	**Qty.**	**Unit Price**	**Extended Price**
30 Barrel Brewhouse				
Mash / Lauter Tun	"V-Wire" false bottom with underscreen flush	1	$31,135.00	$31,135.00
	lautering rakes w/ spent grain plow and variable speed drive	included		
	side steam jacket	included		
Option	retractable rake assembly with hydraulic piston	not quoted	$3,910.00	
Brewkettle / Whirlpool	2 low pressure steam heat transfer panels	1	$19,365.00	$19,365.00
Option	Conversion to MashKettle; mash agitator with variable speed drive, modified bottom arrangement, includes additional plumbing	not quoted	$5,800.00	
Brewkettle Venting	internal drip ring	1	$365.00	$365.00
Whirlpool		not quoted	$10,300.00	
Hot Liquor Tank	single batch capacity - 45 barrels	not quoted	$10,750.00	
	double batch capacity - 90 barrels	1	$16,370.00	$16,370.00
Hot Liquor Pump	stationary	not quoted	$1,235.00	
Cold Liquor Tank	single batch capacity - 45 barrels	not quoted	$10,750.00	
	double batch capacity - 90 barrels	1	$16,370.00	$16,370.00
Diverter Panel	two pumps & controls	1	$5,090.00	$5,090.00
	variable speed motor	2	$850.00	$1,700.00
	washdown pump motor	2	$115.00	
Hot Wort Grant	closed / horizontal grant on lauter tun	1	$1,300.00	$1,300.00
	auto level control	not quoted	$650.00	
Heat Exchanger	2 stage with water & glycol	1	$6,500.00	$6,500.00
Brewhouse Process	complete stainless pre-plumb	1	$4,200.00	$4,200.00

Plumbing				
Flow Control Valves	micro adjustable butterfly	1	$280.00	$280.00
	butterfly	3	$145.00	$435.00
Thermometer		1	$190.00	$190.00
Gas Diffuser		1	$425.00	$425.00
1.5" Sight Glass Assembly	includes extra glass	1	$170.00	$170.00
Brewer's Platform	all stainless	1	$5,200.00	$5,200.00
Wrenches		2	$25.00	$50.00
Brewhouse Control Panel	U.L. listed panel	1	$1,100.00	$1,100.00
	number of controllers	2		
			Total	**$110,245.00**
Grain Handling / Milling Equipment				
Malt Mill	2 roll; capacity @ 750 KG/hr	1	$5,400.00	$5,400.00
Mill Stand & Boot Assembly		1	$430.00	$430.00
Grist Hopper with Cover		1	$3,700.00	$3,700.00
Hopper Slide Gate		1	$175.00	$175.00
Grist Hydrator	SMS style	1	$550.00	$550.00
Flex Auger	50 feet c/w 2 elbows	1	$1,800.00	$1,800.00
			Total	**$12,055.00**
Fermentation / Cellar Equipment				
Unitank / Fermenter	30 BBL working capacity, 30% headspace	not quoted	$16,480.00	
	60 BBL working capacity, 30% headspace	3	$22,150.00	$66,450.00
Conditioning/Bright Vessel (for walk-in cooler)	30 BBL	not quoted	$8,345.00	
	60 BBL	not quoted	$12,625.00	
Conditioning/Bright Vessel (glycol cooled vessel)	30 BBL	not quoted	$11,555.00	
	60 BBL	1	$17,065.00	$17,065.00
Carbonating Stone Assembly	Zahm & Nagel ceramic	1	$500.00	$500.00
Fermentation / Bright Control Panel	U.L. listed panel	1	$3,200.00	$3,200.00
	number of controllers (with 3 spare for future tanks)	8		
Glycol Chilling System	7.5 Hp. condensing unit w/ 800 gallon glycol reservoir, glycol supply and recirculating pumps, and liquid chiller - all stainless plumbed	not quoted	$15,040.00	
	10 Hp. Condensing unit w/ 800 gal reservoir	1	$16,300.00	$16,300.00
	2 x 7.5 hp. condensing units w/ 800 gal reservoir	not quoted	$22,630.00	
Solenoid Valve		4	$100.00	$400.00
Stainless/Brass Glycol Fittings		4	$50.00	$200.00

CIP/Beer Transfer Pump	2 Hp.	1	$1,500.00	$1,500.00
	variable speed motor	1	$850.00	$850.00
Filter		not quoted		
			Total	**$106,465.00**
Supporting Equipment				
Fittings Package	1" TC hose end fitting	10	$30.00	$300.00
	1.5" TC hose end fitting	10	$35.00	$350.00
	2" TC x 1.5" TC	1	$75.00	$75.00
	1.5" BS to TC adapter	2	$40.00	$80.00
Perlick Tank Tapping Fittings		1	$50.00	$50.00
TC Clamp and Cap Kit	10 caps and clamps	1	$170.00	$170.00
Stainless Quick Disconnects	male	15	$3.50	$52.50
	female	11	$18.50	$203.50
	1/4" s.s ball valve	15	$19.00	$285.00
	1/4" s.s. nipple	9	$3.00	$27.00
	1/4" NPT(M) x 3/8" hose end	11	$8.00	$88.00
Gasket Kit		1	$100.00	$100.00
Process Pumps Seal Kit		1	$22.80	$22.80
Glycol Pumps Seal Kit		1	$60.75	$60.75
Brewer's Hose	1.5" @ 100 feet	1	$900.00	$900.00
Hydrometer Flask		1	$110.00	$110.00
Hydrometers	0-8 Brix, 8-16 Brix	2	$52.00	$104.00
Thermometers		2	$47.00	$94.00
Sugar Refractometer		1	$370.00	$370.00
CIP Hose	15 feet	not quoted	$30.00	
Portable CIP Tank		not quoted	$1,660.00	
Lab Kit		not quoted	$1,950.00	
Perlick Proof Coil		not quoted	$160.00	
			Total	**$3,442.55**
Steam Boiler & Equipment				
Low Pressure Steam Boiler	1,050,000 BTU input	not quoted	$8,300.00	
Assembled condition, skid mounted				
	condensate receiver w/ pump	not quoted	$1,300.00	
4 x	1.5" brass gate valve	not quoted	$34.25	
9 x	3/4" swing check valve	not quoted	$20.00	
5 x	3/4" float & thermostatic steam trap	not quoted	$117.00	
5 x	3/4" strainer	not	$19.00	

		quoted		
1 x	1 1/2" actuated steam solenoid valve	not quoted	$310.00	
			Total	
Kegging Equipment				
Sankey Keg Racker	single head	not quoted	$275.00	
	double head	not quoted	$475.00	
	triple head	1	$675.00	$675.00
Sankey Keg Rinser/Washer	SMS 050 - manual system with single head, requires pump and CIP tank	not quoted	$480.00	
	SMS 911 (single head) semi-automated	not quoted	$8,600.00	
	SMS 912 (two head) semi-automated	not quoted	$9,500.00	
	SMS 913 (three head) semi-automated	1	$9,700.00	$9,700.00
			Total	**$10,375.00**
Total - 30 Barrel Brewery Equipment Package			**US**	**$242,582.55**
All applicable taxes extra				
F.O.B. factory, Victoria, BC, Canada				
Delivery - to be determined upon placement of order				
Prices are valid for 30 days				
Start-Up & Recipe Formulation Package				
includes:	Planning			
	Brewing Formulae - 3 recipes			
	Start-up Assistance - 4 days on site			
	Personnel Training			
	Raw Materials & Supplies Sourcing			
	Continued Telephone Consulting for up to 6 months			
Additional Recipes	$600 per additional recipe (not included)			
Additional Start-up Assistance	$400 for each day exceeding initial start-up time			
	Airfare & Expenses not included			
			Total	**$5,400.00**
Shipping Services				
Brokerage Fees		2	$110.00	$220.00
Freight to Site - estimated	price per 48' container	2	$2,500.00	$5,000.00
			Total	**$5,220.00**
Supervision of Brewery Re-Assembly Package (5 days on-site)				
SMS Technician to provide on-site, hands on direction and support to local trades				

Airfare (cost to be confirmed)				
Local Transportation				
Lodging				
Meals				
Tool Freight				
Two Days Travel Time				
Additional Time, if required @ $ 60.00 per hour plus expenses (minimum 8 hours charged per day)				
Supervision & Direction of Local Trades On-Site ; Labor 40 hrs. @ $ 60/hr.				
re-assembly of brewhouse stainless plumbing, "leveling vessels on their floor pads, attach vessel components				
			Total	**$6,530.00**

Appendix K

Equipment Costs for 50 Barrel System

50 Barrel Brewery System

System Configuration	50 barrel, 4 vessel, low pressure steam fired brewhouse - brewkettle, whirlpool, mash tun, and lauter tun 6 x 100 barrel unitank/fermenters 2 x 100 barrel bright tank
Annual Production	Assume 100% ales @ 14 day fermentation cycles (26 cyles/year/vessel) 6 x 100 barrel unitanks x 26 cyles/year = **15600 barrels/year** 15600 barrels/year / 50 barrel brewhouse = 312 brews/year

Item	Description	Qty.	Unit Price	Extended Price
4 Vessel Brewhouse				
Mash Vessel		1	$34,540.00	$34,540.00
	2 low pressure steam heat transfer panels	included		
	mash agitator with variable speed drive, includes stainless plumbing	included		
	internal light	included		
option	50 psig ASME rated high pressure steam jacket	not quoted	$3,750.00	
Mash Vessel Venting	internal drip ring	1	$365.00	$365.00
Lauter Tun		1	$44,300.00	$44,300.00
	"V-Wire" false bottom with underscreen flush	included		
	coned head	included		
	lautering rakes w/ spent grain plow and variable speed drive	included		
	internal light	included		
option	retractable rake assembly with hydraulic piston	not quoted	$3,910.00	
Brewkettle		1	$25,145.00	$25,145.00
	2 low pressure steam heat transfer panels	included		
	internal light	included		
option	50 psig ASME rated high pressure steam jacket	not quoted	$3,750.00	
option	50 psig ASME rated high pressure internal calandria	not quoted	$7,500.00	
Brewkettle Venting	internal drip ring	1	$365.00	$365.00
Whirlpool		1	$11,650.00	$11,650.00
Hot Liquor Tank	double batch capacity (150 bbl)	1	$21,050.00	$21,050.00
option	50 psig ASME rated high pressure steam jacket	not quoted	$2,950.00	
Liquor Pump	stationary	1	$1,235.00	$1,235.00
Cold Liquor Tank	double batch (150 bbl) capacity	1	$21,050.00	$21,050.00

Diverter Panel	brewer's workstation / swing link panel	1	$6,690.00	$6,690.00
	three stainless pumps & controls	included		
	variable speed motor	2	$650.00	$1,300.00
	washdown pump motor	2	$150.00	$300.00
Hot Wort Grant	closed / horizontal grant on lauter tun	1	$1,300.00	$1,300.00
	auto level control	1	$650.00	$650.00
Heat Exchanger	1 stage with cold liquor cooling	1	$8,925.00	$8,925.00
Brewhouse Process Plumbing	complete stainless pre-plumb	1	$5,700.00	$5,700.00
Flow Control Valves	micro adjustable butterfly	1	$280.00	$280.00
	butterfly	8	$116.50	$932.00
Flow Meter		1	$680.00	$680.00
Thermometer		2	$190.00	$380.00
Gas Diffuser		1	$425.00	$425.00
1.5" Sight Glass Assembly	includes extra glass	3	$170.00	$510.00
Brewer's Platform	all stainless	1	$9,500.00	$9,500.00
Wrenches		2	$25.00	$50.00
Brewhouse Control Panel	U.L. listed panel	1	$1,450.00	$1,450.00
	number of controllers	3		
			Total	**$198,772.00**
Grain Handling / Milling Equipment				
Malt Mill	2 roll; capacity @ 750 KG/hr	not quoted	$3,800.00	
	4 roll	1	$8,450.00	$8,450.00
Mill Stand & Boot Assembly		1	$430.00	$430.00
Grist Hopper with Cover		1	$4,500.00	$4,500.00
Hopper Slide Gate		1	$175.00	$175.00
Grist Hydrator	SMS style	1	$550.00	$550.00
Flex Auger	50 feet c/w 2 elbows	1	$1,800.00	$1,800.00
			Total	**$15,905.00**
Fermentation / Cellar Equipment				
Unitank / Fermenter	50 bbl working capacity, 30% excess	not quoted	$20,865.00	
	100 bbl working capacity, 30% excess	6	$27,900.00	$167,400.00
Conditioning/Bright Vessel (glycol cooled vessel)	50 bbl	not quoted	$15,090.00	
	100 bbl	2	$23,300.00	$46,600.00
Carbonating Stone Assembly	Zahm & Nagel ceramic	2	$510.00	$1,020.00
Fermentation / Bright Control Panel	U.L. listed panel	1	$3,550.00	$3,550.00
	number of controllers	9		

Glycol Chilling System	2 x 10 hp. condensing units with 800 gallon glycol reservoir, glycol supply and recirculation pump, and liquid chiller; all stainless plumbing	1	$26,000.00	$26,000.00
	2 x 15 hp. condensing units w/ 800 gal reservoir	not quoted	$36,400.00	
Solenoid Valve		8	$100.00	$800.00
Stainless/'Brass Glycol Fittings		8	$50.00	$400.00
CIP/Beer Transfer Pump	2 Hp.	1	$1,500.00	$1,500.00
	variable speed motor	1	$850.00	$850.00
Filter		not quoted		
			Total	**$248,120.00**
Supporting Equipment				
Fittings Package				
	1.5" TC hose end fitting	20	$35.00	$700.00
	2" TC x 1.5" TC	2	$75.00	$150.00
	1.5" BS to TC adapter	2	$40.00	$80.00
Perlick Tank Tapping Fittings		1	$50.00	$50.00
Process pump seal kit		1	$22.80	$22.80
Glycol pump seal kit		1	$60.75	$60.75
TC Clamp and Cap Kit	10 caps and clamps	2	$170.00	$340.00
Stainless Quick Disconnects	male	15	$3.50	$52.50
	female	11	$18.50	$203.50
	1/4" s.s ball valve	15	$19.00	$285.00
	1/4" s.s. nipple	9	$3.00	$27.00
	1/4" NPT(M) x 3/8" hose end	11	$8.00	$88.00
Gasket Kit		2	$100.00	$200.00
Brewer's Hose	1.5" @ 100 feet	1	$900.00	$900.00
Hydrometer Flask		1	$110.00	$110.00
Hydrometers	0-8 Brix, 8-16 Brix	2	$52.00	$104.00
Thermometers		2	$47.00	$94.00
Sugar Refractometer		1	$370.00	$370.00
Perlick Proof Coil		not quoted	$160.00	
			Total	**$3,837.55**
3 Vessel CIP System - manual arrangment				
	230 gallon caustic tank (one for brewery vessels and one dedicated for bottling line), low pressure steam jacket, inulated and clad in #4 stainless	2		
	290 rinse water tank, single walled with level monitoring and solenoid valve for water inlet	1		

	CIP hose	inc.		
	Brewer to use portable pump quoted above			
			Total	**$14,900.00**
Steam Boiler & Equipment	To Be Supplied by Client			
Low Pressure Steam Boiler	2,500,000 BTU input	not quoted	$16,630.00	
Assembled condition, skid mounted				
	condensate receiver w/ pump	not quoted	$1,600.00	
	1 1/2" actuated steam solenoid valve	not quoted	$310.00	
steam plumbing, insulation, valves, traps, strainers, etc. not included Steam installation by local qualified people				
			Total	**$0.00**
Kegging Equipment				
Sankey Keg Racker	triple head	1	$675.00	$675.00
Sankey Keg Rinser/Washer	SMS 913 (three head) semi-automated	1	$8,995.00	$8,995.00
			Total	**$9,670.00**
Total - 50/100 Barrel Brewing Equipment			**US**	**$491,204.55**

Appendix L

Material Balances

Mass and Volume Balances for Beer Production

Please refer to Figure 3.1 in Section 3 to locate equipment and streams discussed below in the calculations.

Mash Tun

Barley Malt into Mash Tun

The recipe calls for 40.3 lbs barley malt per barrel, so for a 30 bbl process the below amount of barley malt will be needed. The bulk density of barley malt was found to be 30.5 lbs/ft^3 from the source below.

40.3 lb / bbl * 30 bbl = 1209 lbs

1209 lbs / (30.5 lbs / ft^3) = 39.639 ft^3

Source: www.smico.com/pdf/SMICO%20MATERIAL%20BULK%20DENSITY%20REFERENCE%20CHART.pdf

Water into Mash Tun

From The Brewer's Handbook on pg. 174, it states that 4.5 – 5.0 hL water are needed per 100 kg barley malt. Therefore, the total amount of water needed for the amount of barley malt used is shown below.

$$\frac{4.75\ hL}{100\ kg\ malt} \times \frac{3.5316\ ft^3}{hL} \times \frac{1\ kg\ malt}{2.205\ lbs\ malt} \times 1209\ lbs\ malt = \underline{91.978\ ft^3}$$

$$91.978\,ft^3 \times \frac{62.4\ lbs}{ft^3} = \underline{5739.4\ lbs\ water}$$

Sugar out of Mash Tun

From the source shown below, 0.81 is the maximum yield of sugar for malted barley and 0.9 is the percentage of maximum yield typically obtained by breweries. Therefore, the total amount of sugar which can be obtained from mashing malted barley is shown below.

1209 lbs malt * 0.81 * 0.9 = 881.36 lb sugar

39.639 ft^3 *0.81 * 0.9 = 28.897 ft^3

Source: www.howtobrew.com/section2/chapter12-4-1.

Amount of Grains out Mash Tun as Waste

This was calculated using the number found above for the amount of malted barley and subtracted from the amount of sugar out of the mash tun.

1209 lbs malt – 881.36 lbs sugar = 327.64 lbs Grains

39.639 ft^3 - 28.897 ft^3 = 10.743 ft^3

Water Lost in Grains out of Mash Tun

From the source listed below, the solid waste out of the mash tun is composed of 20% grains and 80% water. Therefore, 80% divided by 20% equals 4, which is what the amount of grains in the solid waste needs to be multiplied by to obtain the amount of water lost.

327.64 lbs of grains * 4 = 1310.6 lbs

1310.6 lbs / (62.4 lbs / ft^3) = 21.003 ft^3

Source: www.allaboutbeer.com/homebrew/water.html

Solid Waste and Water out of Mash Tun

The total amount of solid waste and lost water is calculated by summing the amount of spent grains and water lost.

327.64 lbs + 1310.6 lbs = 1638.2 lbs

10.742 ft^3 + 21.003 ft^3 = 31.745 ft^3

Water out of Mash Tun

The water out of the mash tun will be the amount of water in minus the amount of water lost in spent grains.

5739.4 lbs – 1310.6 lbs = 4428.8 lbs

4428.8 lbs * 1 ft^3 / 62.4 lbs = 70.974 ft^3

Wort out of Mash Tun

The simple material balance below calculates the amount of wort out of the mash tun. The values come from previously calculated values for the amount of sugar out of the mash tun, the amount of water into the mash tun, and the water lost in the grains out of the mash tun.

881.36 lbs + 5739.4 lbs – 1310.6 lbs = 5310.2 lbs

91.978 ft^3 + 28.897 ft^3 – 21.003 ft^3 = 99.872 ft^3

Boil Kettle

Water into Boil Kettle

The amount of water into the boil kettle is equal to the amount coming out of the mash tun in the wort plus water added from the hot water tank to keep the wort from burning. The amount of water supplied to the boil kettle during boiling to keep the wort from burning is 1200 pounds. The amount of water added after boiling to flush the wort out of the boiling kettle is 2000 pounds.

Water used during boiling

4428.8 lbs + 1200 lbs = 5628.8 lbs Water

5628.8 lbs * 1 ft^3 / 62.4 lbs = 90.205 ft^3

Total Water into Boil Kettle

5628.8 lbs + 2000 lbs = 7628.8 lbs

7628.8 lbs * 1 ft^3 / 62.4 lbs = 122.26 ft^3

Wort into Boil Kettle

The amount of wort added to the boil kettle is the amount leaving the mash tun plus the amount of water added from the hot water tank.

5310.2 lbs + 1200 lbs = 6510.2 lbs Wort

$90.205\ ft^3 + 28.897\ ft^3 = \underline{119.10\ ft^3}$

Hops into Boil Kettle

The recipe calls for 0.775 pounds of hops per barrel, so by multiplying by 30 for a 30 bbl process, the amount of hops needed is obtained. The bulk density of hops was found from the source below.

0.775 lb / bbl * 30 bbl = 23.25 lbs

$23.25\ lbs / (35\ lbs / ft^3) = \underline{0.664\ ft^3}$

Source: www.inter-bulk.com/BulkDensityList.htm

Hops added to Sugars

A very small percentage (1 %) of the hops will be added to the sugar. This accounts for the hoppy tastes that result in the beer.

23.25 lbs * 0.01 = 0.2325 lbs

$0.2325\ lb * 1\ ft^3 / 35\ lbs = \underline{.00664\ ft^3}$

Evaporated Water out of Boil Kettle

The amount of water evaporated by the boil kettle will be 10 % of the total amount of water into it.

(5739.4 lbs – 1310.6 lbs + 1200 lbs) * 10 % = 562.88 lbs Water Lost

$562.88\ lbs / (62.4\ lbs / ft^3) = \underline{9.02\ ft^3}$

Water out of Boil Kettle

The amount of water out of the boil kettle will be the total amount of water going into it minus the evaporated water.

7628.8 lbs – 562.88 lbs = 7065.9 lbs

$7065.9\ lbs * 1\ ft^3 / 62.4\ lbs = \underline{113.24\ ft^3}$

Hopped Wort out of Boil Kettle

The amount of hopped wort out of the boil kettle will be the calculated by the simple balance below by using values calculated previously.

(7065.9 lbs + 881.36 lbs + 23.25 lbs = 7970.5 lbs Wort

$119.10\ ft^3 + 0.664\ ft^3 – 9.02\ ft^3 + 2000\ lbs / 62.4\ lbs / ft^3 = \underline{142.79\ ft^3}$

Hot Water Tank

Water to Hot Water Tank

The following balance finds the total water needed to be sent to the hot water tank during the production of pale ale. 5793.4 lbs is the amount of water needed for the mash tun and 1200 lbs is the amount of water added to the boil kettle after the wort is there.

5793.4 lbs + 1200 lbs +2000 lbs = 8939.4 lbs

8939.4 lbs * 1 ft^3 / 62.4 lbs = 143.26 ft^3

Whirlpool

Trub out of Whirlpool

The value for the amount of trub separated from the wort by the whirlpool was found from the first source. The bulk density of the trub was estimated to be the same as that of mixed protein from the source shown second.

352.5 g / bbl * 30 bbl * 1 kg / 1000 g * 2.205 lbs / kg = 23.318 lbs

23.25 lbs / (39 lbs / ft^3) = 0.596 ft^3

Source: www.brewingtechniques.com/library/backissues/issue1.4/barchet

Source: www.inter-bulk.com/BulkDensityList.htm

Hops out of Whirlpool

The amount of hops out of the whirlpool is the amount going into the boil kettle minus the amount added to the sugars.

(23.25 lbs hops – 23.25 lbs * 0.01) = 23.018 lbs

(0.664 ft^3 – 0.664 ft^3 * 0.01) = 0.657 ft^3

Water in Hops and Trub

The amount of water that is absorbed by the hops and trub is calculated the same way as the amount absorbed by the grain. The total amount of trub and hops is multiplied by the factor 4.

(23.018 lbs + 23.318 lbs) * 4 = 185.34 lbs

185.34 lbs / (62.4 lbs / ft^3) = 2.97 ft^3

Solid Waste out of Whirlpool

The simple balance below finds the amount of solid waste that will be collected from the whirlpool. The values come from previous values.

23.318 lbs trub + 23.018 lbs + 185.34 lbs = 231.68 lbs

0.597 ft^3 + 0.657 ft^3 + 2.97 ft^3 = 4.22 ft^3

Water out of Whirlpool into Fermenters

The amount of water that will be coming out of the whirlpool in the wort is found below.

7628.8 lbs – 562.88 lbs – 185.34 lbs = 6880.6 lbs Water

6880.6 lb / (62.4 lbs / ft^3) = 110.27 ft^3

Wort out of Whirlpool into Fermenters

The amount of wort that will be traveling to the fermenters will be the amount of water plus the amount of sugars.

7970.5 lbs – 231.68 lbs = 7738.8 lbs

142.79 ft^3 – 4.22 ft^3 = 138.57 ft^3

Fermenters

Fermentation

In order to ferment the wort, yeast has to be used. There are various types of yeast depending on the type of beer being produced. From the source below, it was found that 1056 American Ale Yeast will work very well to produce a pale ale. The yeast attenuation for this type of yeast is 73–77 % which was averaged to 75 %. How the yeast attenuation is used will be discussed later.

Source: www.wyeastlab.com/beprlist.htm.

Formula

This is the basic equation for fermentation, which can be found in any microbiology book found.

$$C_6H_{12}O_6 \rightarrow 2\ CO_2 + 2\ CH_3CH_2OH + \square H$$

Total Sugars

The total amount of sugar that will be entering the fermenters is found below.

881.36 lbs sugar – 23.318 lbs trub + 0.2325 lbs= 858.27 lb sugars

Fermentable Sugar

To determine the amount of fermentable sugar, the value for yeast attenuation is used. The equation for this calculation is shown below.

Amount of fermentable sugar = yeast attenuation * total sugars
= 0.75 * 858.27 lbs
= 643.70 lbs

Yeast Needed

The total amount of yeast needed for the recipe proposed is 5 gal / 300 bbl. This correlates to 0.5 gal / 30 bbl, so for a 30 bbl process 0.5 gallons of yeast are needed. The mass amount needed is found below. The bulk density was found from the following source.

0.5 gal * 59 lbs / ft^3 * 0.1337 ft^3 / gal = 3.94 lbs

Source:
www.smico.com/pdf/SMICO%20MATERIAL%20BULK%20DENSITY%20REFERENCE%20CHART.pdf

Non-Fermentable Sugar

The amount of non-fermentable sugar is equal to the amount of total sugars entering the fermenters minus the amount of fermentable sugars.

858.27 lbs – 643.70 lbs = 214.57 lbs

Ethanol out of Fermenter

The amount of ethanol produced during fermentation is calculated by using the formula above to find the number of moles and then multiplying that number by the molecular weight.

EtOH produced = 643.70 lbs * 653.6 g / lb * 1 mol / 180 g * 2 = 4674.7 mol
= 4674.7 mol * 46 g / mol * lbs / 653.6 g = 329 lbs

329 lbs * 1 / (0.789 g / mL) * 1 L / 1000 mL * (1 g / L) / (0.0083 lbs / gal) * 0.1337 ft^3 / gal
= 6.717 ft^3

CO_2 out of Fermenter

The amount of carbon dioxide coming out of the fermenters will have the same number of moles as the ethanol and a molecular weight of 44 g / mol. In order to determine the volume of CO_2, the liquid density of CO_2 was used because the gas will be compressed and have a greater density.

4674.7 mol * 44 g / mol * lbs / 653.6 g = 314.7 lbs

314.7 lbs * 1 ft^3 / 47.64 lbs = 6.61 ft^3

Water out of Fermenter

The amount of water out of the fermenter will be the same as the amount of water in it.

7738.8 lbs – 329 lbs – 314.7 lbs - 214.57 lbs = 6880.5 lbs

6880.5 lbs / (62.4 lbs / ft^3) = 110.26 ft^3

Heat of Fermentation

In fermentation heat is released at 555 kJ / kg, as stated from the following source. Therefore, the total heat due to fermentation for a 30 bbl fermenter will be determined by the following equation. This heat is for one fermenter only, but since there will initially be 4 brews per week and the average beer is fermented for 2 weeks at a time, there will actually be 8 fermenters in operation at a time, and therefore, the heat shown should be multiplied by 8.

H_f = 555 kJ / kg

Q= $m_s H_f$ = 643.70 lbs * 555 kJ / kg * 0.45 kg / lb = 160760 kJ / fermenter

Total heat from fermentation = 160760 kJ * 8 = 1286080 kJ

Source: www.grapeandwine.com.au/oct02/06.htm

Glycol Chiller

The glycol chiller will need to cool the fermenters by taking 1,286,080 kJ of heat that is released during fermentation.

Beer

% Ethanol

The percentage of ethanol in the beer produced is found below.

% EtOH = 329 lbs / 7738.8 lbs = 0.0425 = 4.25 %

Total Amount of Beer

The total amount of beer produced for a thirty bbl process is 7738.8 lbs. In order to determine the volume of the beer, the target specific gravity of the beer was used to yield the density and thus the volume.

$$Spgr = 1.05 = \Delta_b / \Delta_w = \Delta_b / 62.4 \text{ lbs} / \text{ft}^3$$

$$\Delta_b = 1.05 * 62.4 \text{ lbs} / \text{ft}^3 = 65.52 \text{ lbs} / \text{ft}^3$$

$$7738.8 \text{ lbs} / 65.52 \text{ lbs} / \text{ft}^3 = 118.11 \text{ ft}^3 \text{ beer} \sim 30 \text{ bbl}$$

Carbonation

The conditions chosen to carbonate the beer at were determined from the following source. The beer is chosen to be 2.5 volumes CO_2 / volume beer at 34 F. These conditions yield a pressure of 9.2 psi.

Source: www.bossbeer.org/tips/carbonation_imp

Energy Balance for Boiler

Energy Requirements for Hot Water Tank

The amount of energy needed to heat the hot water in the hot water tank from 60°C to 77°C was found by the following equation. The specific heat of water was found from the following source. The amount of water being heated is from previous calculations.

$$q = \Delta h = c_p \Delta T = c_p (T_2 - T_1)$$

c_p = 4.1868 kJ / kg-K

Source: www.scienceworld.wolfram.com/physics/SpecificHeat.html

$$q = 4.1868 \text{ kJ / kg-K} * (77 - 60) \text{ K} = \underline{71.176 \text{ kJ / kg}}$$

$$Q = 71.176 \text{ kJ / kg} * 8939.4 \text{ lbs} * 0.45 \text{ kg / lb} = \underline{286322 \text{ kJ}}$$

Energy Requirements for Boil Kettle

The amount of energy needed to heat the wort from 77°C to 102°C was found by the following equation.

$$q = \Delta h = c_p\, \Delta T = c_p\, (T_2 - T_1)$$
$$c_p = 4.1868 \text{ kJ / kg-K}$$

$$q = 4.1868 \text{ kJ / kg-K} * (102 - 77) \text{ K} = \underline{104.67 \text{ kJ / kg}}$$

$$Q = 104.67 \text{ kJ / kg} * 5628.8 \text{ lbs} * 0.45 \text{ kg / lb} = \underline{265125 \text{ kJ}}$$

The amount of energy lost to vaporization of the water during boiling is found by multiplying the heat of vaporization of water by the mass of the water leaving.

Heat of Vaporization of Water = H_v = 2256 kJ / kg

Source: www.hyperphysics.phy-astr.gsu.edu/hbase/tables/phase.html#c2

$$m_s H_v = 562.88 \text{ lbs} * 0.45 \text{ kg / lb} * 2256 \text{ kJ / kg} = \underline{571436 \text{ kJ}} = Q_{out}$$

The amount of energy needed to keep the wort at 102 C is calculated below.

$$Q_{102} = Q_{out} - Q = 571436 \text{ kJ} - 265125 \text{ kJ} = \underline{306311 \text{ kJ}}$$

The amount of total energy entering the boil kettle is equal to the total energy leaving it.

$$Q_{in} = Q_{out} = \underline{571436 \text{ kJ}}$$

Total Heat Needed from Boiler to Heat Hot Water Tank and Boil Kettle

The total heat required from the boiler to heat the hot water tank and the boil kettle is calculated by summing the two heat requirements found earlier.

$$Q_T = Q_{HWT} + Q_{BK} = 286322 \text{ kJ} + 571436 \text{ kJ} = \underline{857758 \text{ kJ}}$$

Steam Needed

In order to determine the amount of steam needed to heat the hot water tank and the boil kettle, first a table of the properties of steam used was set up by using the steam tables in the thermodynamics book by Black and Hartley. The inlet temperature and pressure of the steam was chosen to be 250°C and 5000 kPa, respectively. The outlet temperature and pressure was chosen to be 280°C and 5000 kPa, respectively. By using these values for the inlet and outlet streams, the enthalpies of these streams can be determined.

	IN	**OUT**
T (°C)	250	280
P (kPa)	5000	5000
State	Compressed Liquid	Superheated Steam
h (kJ / kg)	1085.9	2802.5

To Heat Hot Water Tank

The amount of steam needed to heat the hot water tank is found by the following equation and values found previously.

$$Q = m * (h_{out} – h_{in})$$

$$m = Q / (h_{out} – h_{in}) = 286322 \text{ kJ} / (2802.5 – 1085.9) \text{ kJ / kg} = \underline{166.80 \text{ kg}}$$

To Heat Boil Kettle

The amount of steam needed to heat the boil kettle is found by the following equation and values found previously.

$$m = Q / (h_{out} – h_{in}) = 571436 \text{ kJ} / (2802.5 – 1085.9) \text{ kJ / kg} = \underline{332.89 \text{ kg}}$$

Appendix M

Hazop Analysis

HAZOP STUDY

Equipment	Deviation	Cause	Consequence	Safeguards
Hot Water Tank	Temperature-More	Steam Coils too Hot	Water Fed to Mash Tun too Hot	Temperature Controller
		Water Fed too Hot		Temperature Alarm
		Controller Fails		Check Temperature Regularly
		Alarm Fails		
	Temperature-Less	Steam Coils too Cold	Water Fed to Mash Tun too Cold	Temperature Controller
		Water Fed too Cold		Temperature Alarm
		Controller Fails		Check Temperature Regularly
		Alarm Fails		
	Level-More	Pump Failure	Water Overflows	Level Alarm
		Water Fed to Tank too Fast	Equipement Damage	Level Controller
		Controller Fails		Check Level Regularly
		Alarm Fails		
	Level-Less	Drain Valve Open	Not Enough Water to Mash Tun	Level Alarm
		Water Fed to Tank too Slow		Level Controller
		Controller Fails		Check Level Regularly
		Alarm Fails		
Mash Tun	Level-More	Too Much Water or Barley Fed	Mash Tun False Bottom Collapse	Level Alarm
		Pump Failure		Level Controller
		Controller Fails		Check Level Regularly
		Alarm Fails		
	Level-Less	Not Enough Fed	Bad Mashing	Level Alarm
		Drain Valve Open		Level Controller
		Controller Fails		Check Level Regularly
		Alarm Fails		
Boil Kettle	Temperature-More	Steam Coils too Hot	Wort Burned	Temperature Controller
		Controller Fails	Bad Taste	Temperature Alarm
		Alarm Fails		Check Temperature Regularly
	Temperature-	Steam Coils too Cold	Wort not Cooked	Temperature

	Less			Controller
		Controller Fails		Temperature Alarm
		Alarm Fails		Check Temperature Regularly
	Level-More	Too Much Hop or Water Fed	Wort Overflow	Level Alarm
		Pump Failure		Level Controller
		Controller Fails		Check Level Regularly
		Alarm Fails		
	Level-Less	Not Enough Fed	Wort Burned	Level Alarm
		Drain Valve Open		Check Valve Regularly
		Controller Fails		Level Controller
		Alarm Fails		Check Level Regularly
	Pressure-More	Evaporated Water Can't Escape	Possible Explosion	Pressure Alarm
			Equipement Failure	Vent
Boiler	Temperature-More	Too Much Fuel Fed	Boiler Overheats	Temperature Controller
		Controller Fails	Water Heated too Hot	Temperature Alarm
		Alarm Fails	Wort Burned	Check Temperature Regularly
	Temperature-Less	Not Enough Fuel Fed	Wort Not Boiled	Temperature Controller
		Controller Fails		Temperature Alarm
		Alarm Fails		Check Temperature Regularly
	Pressure-More	Valve Closed	Possible Explosion	Vent
			Equipement Damage	Pressure Alarm
Whirlpool	Level-Less	Drain Valve Open	Loss of Wort	Check Valve Regularly
		Controller Fails		Level Controller
		Alarm Fails		Check Level Regularly
				Level Alarm
Fermenters	Temperature-More	More Fermentation Than Expected	None or too Much Fermentation	Temperature Controller
		Chiller Malfunction	Kills Yeast	Temperature Alarm
		Controller Fails		Check Temperature Regularly
		Alarm Fails		

	Temperature-Less	Chiller Cools too Much	Kills Yeast	Temperature Controller
		Controller Fails	Freezes Beer	Temperature Alarm
		Alarm Fails	No Fermentation	Check Temperature Regularly
	Level-Less	Drain Valve Open	Loss of Beer	Check Valve Regularly
		Controller Fails		Level Controller
		Alarm Fails		Check Level Regularly
				Level Alarm

Appendix N

Sensitivity Analysis Results

Parameter Changed	Brewery Location 1 (year)	Market	Advertising	Market	Advertising	Market	Advertising	Market	Advertising	Expansion (year)
Decreasing FCI by 60K	Indianapolis (1)	IN	$3,352.00							3000 (1)
Advertising Increase by 10x	Indianapolis (1)	IN	$183.00							
Advertising Decrease by 10x	Louisville (1)	IN	$0.00	KY	$0.00	TN	$0.00			
No Advertising	Louisville (1)	AL	$0.00	KY	$0.00	OH	$0.00	TN	$0.00	
Increase cost per bbl 10%	Indianapolis (1)	IL	$0.00	IN	$1,835.00					
increase Barley Price by .20	Indianapolis (1)	IL	$0.00	IN	$1,835.00					
Increase freight cost by 20%	Indianapolis (1)	IL	$0.00	IN	$1,835.00					

Parameter Changed	Brewery Location 2 (year)	Market	Advertising	Market	Advertising	Market
Decreasing FCI by 60K	Milwaukee (2)	WI	$5,527.00			
Advertising Increase by 10x	Milwaukee (2)	WI	$553.00			
Advertising Decrease by 10x	Milwaukee (3)	WI	$0.00	IL	$18,995.00	
No Advertising	Milwaukee (3)	WI	$0.00	IL	$0.00	IN
Increase cost per bbl 10%	Milwaukee (3)	WI	$5,528.00			
increase Barley Price by .20	Milwaukee (3)	WI	$5,528.00			
Increase freight cost by 20%	Milwaukee (3)	WI	$5,528.00			

Parameter Changed	Market	Advertising	Market	Advertising	Market	Advertising	Expansion (year)	NPW ($MM)
Decreasing FCI by 60K							9000 (2)	$10.1
Advertising Increase by 10x							9000 (3)	$7.7
Advertising Decrease by 10x							9000 (3)	$7.5
No Advertising	IA	$0.00	MN	$0.00	OH	$0.00	9000 (3)	$7.3
Increase cost per bbl 10%							9000 (3)	$7.4
increase Barley Price by .20							9000 (3)	$7.0
Increase freight cost by 20%							9000 (3)	$7.6