INL/EXT-06-11815

Feasibility of a Producer Owned Ground-Straw Feedstock Supply System for Bioethanol and Other Products

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Duane Grant

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A Model For A Lignocellulosic Biomass Feedstock Assembly System For Wheat And Barley Straw

1. INTRODUCTION

Assumptions

- Ethanol Plant Location: Idaho Falls, ID
- This operation will provide 800,000 tons of ground wheat and barley straw a year to an ethanol production plant: Irrigated Spring Barley = 30.84% or 246,720 tons; Irrigated Spring Wheat = 43.59% or 348,720 tons; Irrigated Winter Wheat = 25.57% or 204,560 tons.
- The straw collection, storage, grinding and transportation activities will be conducted up to 16 hours a day, 6 days a week with 10 days of paid holiday (302 days a year).
- The ethanol production plant will consume 800,000 tons of wheat and barley straw per year
- The ethanol-manufacturing plant will operate 24/7 for 350 days/year (96%). There will be 15 days of plant maintenance time.
- The ethanol production plant will be located in Idaho Falls, ID area.

Establishing the value of and requirements for feedstock assembly processes to feed bioconversion processes is necessary for the development of biorefineries. Linking feedstock harvest/collection/transport/storage (i.e., feedstock assembly) and preprocessing processes with conversion processes allows evaluation of technology options and trade-offs.

Biomass feedstock assembly comprises the activities and operations of removing the biomass from the production field and inserting the biomass into the conversion process. Dry biomass is characterized as having a moisture content of less than 15%, which is sufficiently low for stable storage without threat of spoilage and/or combustion.

Biomass feedstock collection, preprocessing, and transportation are integral components of biomass utilization. Feedstock cost constitutes about 35-50% of the total production cost of ethanol or power. The actual percentage depends upon geographical factors such as biomass species, yield, location, climate, local economy, and the type of systems used for harvesting, collection, processing, and transportation. The biomass supply enterprise (or feedstock assembly system) procures biomass, and preprocess it to a form and quality that satisfies biorefinery specifications. It is essential for biomass supplier and biomass producer to profit from their activities. An optimal feedstock flow design from production site to biorefinery generally takes the minimum number of unit operations. As such, feedstock assembly systems are key operations in the integrated biorefinery, and can potentially improve equipment costs, efficiencies, and biomass characteristics that lead to enhanced biochemical and thermo-chemical conversion performances. Critical feedstock attributes that must be addressed and controlled for biorefining processes include both equipment specifications, such as cost, throughput, and efficiencies; and biomass specifications, such as composition, cost, format, and consistency.

The primary concern with any handling and transportation operation is to minimize the amount of handling and transporting of the biomass. Altering the format of the biomass to a bulk flowable form (i.e., grinding, etc.) can greatly improve handling efficiencies, but the cost to reformat the biomass and final bulk densities must also be considered.

Using the Idaho dairy industry as a model, an estimated 400,000 to 500,000 tons of straw are currently harvested for livestock in south central Idaho (Grant, 2004). While this very large crop residue biomass market provides an excellent baseline feedstock market model, it also demonstrates that biorefineries are not the only potential large users of biomass resources. Therefore, the South-central Idaho straw market provides a good value baseline for biomass.

The 2004 value of straw in the Idaho diary market was $32 to $42 per ton delivered to the dairy (Grant, 2004). The price to the grower depends on proximity to the purchasing dairy, but typically ranges between $19 and $28 per ton baled and stacked on the road side at the farm (Grant, 2004). For high quality straw, or in years that alfalfa is in short supply, straw market values as high as $60 per ton delivered to the dairy may occur (Grant, 2004). The 2004 incremental merchandising costs for the straw dairy market includes: a raw straw purchase (i.e., laying in the field) of $0 to $10 per ton (normally $3.80 to $5.75 per ton), a baling charge of $15.25 to $17.25 per ton; $4.00 to $5.50 per ton to remove bales from the field and stack by the road at fieldside (often this charge is avoided and the bales are transported directly to the purchasing dairy); and a transportation charge of $10.00 to $12.00 per ton for up to 70 miles, plus $0.10 per ton mile over 70 miles (note the transportation charge includes handling).

The major bottleneck in transport is loading and unloading transportation vehicles. For example loading a 36-bale truck may take 30-40 minutes, roughly the same amount of time it takes to unload the truck. For interstate highway transport, bales must be secured. Altering the format of the biomass to a bulk flowable form (i.e., grinding, etc.) can greatly improve handling efficiencies, but the cost to reformat the biomass and final bulk densities must also be considered.

2. COST METHODOLOGY FOR BULK SUPPLY SYSTEM ANALYSIS

The cost calculation for harvest and handling of biomass involves a multiple step process:

1. The cost of equipment or buildings.
2. The performance of machinery in handling and processing biomass.
3. The cost of labor.

The cost of equipment and buildings is expressed as capital cost and operating cost. Capital cost is a fixed annual cost that includes fixed costs of annualized capital cost plus other fixed costs such as machinery storage and insurance. Operating costs are variable annual cost that includes fuel, general maintenance and repairs. Equipment costs may be expressed as $/yr, or if we assume a number of working hours per year for the equipment, then equipment costs may be expressed in $/hr.

The costs associated with the performance of machinery are expressed in $/ton, $ per item, or $/acre. For example we may express mowing a field in $/acre, baling in $/bale, and grinding the biomass in $/ton. These costs are calculated after the machine has performed a function on the product or on the land. For calculating these costs we need the operating characteristics of the machines such as speed, efficiency, width of operation, and/or throughput.

The costs associated with labor include the labor for operating the equipment as well as support tasks either directly associated with field operations (baling, roadsiding and transportation) or feedstock storage and handling operations at the plant.

All costing is done in constant dollars, so in cases where costs in a given base year require scaling to another year, price indices were used for some pieces of equipment in this model. For some of the agriculture machinery 2006 price quotes were obtained from dealers. For the rest of the equipment the Index of Prices paid by growers for farm machinery in the U.S. Department of Agriculture's Agricultural Prices was used to adjust prices to the chosen base year. For handling equipment at the plant, the Chemical Engineering Plant Cost Index was used to adjust prices to the chosen base year. Likewise, for scaling labor costs, Bureau of Labor Statistics (BLS) indices are used. The USDA indices, Chemical Engineering indices and BLS indices are shown in the Indices worksheet of the Excel model of this bulk feedstock supply system model.

Two engineering-economic approaches to costing are presented by the American Society of Agricultural Engineers (ASAE 2001) and the American Agricultural Economics Association (AAEA 2000). These two approaches are slightly different, but the AAEA method incorporates much from the ASAE method. The ASAE method was used in this analysis.

The Cost of Equipment

We focus primarily on equipment and buildings, but there are also variable costs (e.g. fertilizers, pesticides). Variable costs are easy to cost, usually the quantity multiplied by the unit price or a rental cost. For equipment and buildings the following costs have to be accounted for:

1. Capital recovery (depreciation and interest)
2. Repairs and maintenance
3. Fuel and electricity
4. Insurance, housing, and taxes

Capital Recovery (Depreciation And Interest)

The ASAE lists two different methods, 1) calculate depreciation and interest separately and 2) calculate depreciation and interest on the value to be depreciated and calculate interest on the salvage value [6.2.2 and 6.2.4 in ASAE S495 JAN01 (ASAE 2001)]. This second method is what the AAEA uses.

$$R = (P - S)\left[\frac{(i)(1+i)^n}{\{(1+i)^n\} - 1}\right] + Si \quad (1.1)$$

where *R* is the annual fixed cost representing initial investment, *P* is the purchase price of equipment, *i* is the annual interest rate, *n* is the life of the equipment in years. k is the sum of rates for taxes, housing (shelter), insurance (see section 4 below). *S* is the salvage value. The salvage value S is a fraction of the initial purchase price.

The list price of machinery is usually different from purchase price *P*. The AAEA indicates that the difference between purchase price and list price may be up to 15% [pp. 6-8[1] AAEA (2000)]. However, the equipment prices used in this analysis were generally obtained from local dealers. While this quoted price may be the list price, no adjustment of this price per AAEA guidance was applied.

Salvage value (remaining value) must be known or estimated to determine interest and depreciation. The ASAE (2001) uses Cross and Perry (1995, 1996) as one source for their data (ASAE D497.4). The remaining value at the end of year *n* (as a fraction of the list price) is expressed as follows:

$$S = \left(C_1 - C_2 n^{0.5} - C_3 h^{0.5}\right)^2 \quad (1.2)$$

where *n* is in years, and *h* is average hours of operation in a year.

Table 1. Coefficients for the ASAE remaining value equations (Table 4 in ASAE D497.4).

Equipment type	C_1	C_2	C_3	RF_1	RF_2
22-59 kW tractors	0.9809	0.0934	0.0058	a,b	2.0
60-112 kW tractors	0.9421	0.0997	0.0008	a,b	2.0
112+ kW tractors	0.9756	0.1187	0.0019	a,b	2.0
Mowers	0.7557	0.0672	—	0.44	2.0
Balers	0.8521	0.1013	—	0.10	1.8
Combines	1.1318	0.1645	0.0079	0.12	2.3
Swathers and all other harvest (forage) equipment	0.7911	0.0913	—	0.03	2.0
Manure spreaders and other miscellaneous equipment	0.9427	0.1111	—	0.41	1.3
Skid-steer loaders and all other vehicles[1]	0.7858	0.0629	0.0033	0.06	2.0

Source : ASAE (2001)
a=0.007 for 2 wheel drive tractor,
b=0.003 for 4-wheal drive tractor
[1]The values for self pulled forage harvester is used.

Note that only powered equipment has a coefficient (C_3) on hours of annual use. In the revised ASAE equations, remaining values are calculated for windrowers and forage harvesters using the swathers and all other harvest equipment category, telescopic handlers using the skid-steer loaders and all other vehicles category, and wagons using the manure spreaders and all other miscellaneous equipment category.

For the current analysis, the ASAE salvage value equation (Eq. 1.2) was used for tractors, bailers, stingers and bale loader. The salvage value for the grinders and over-the-road vehicles was based on dealer or manufacturer estimates. The salvage value for non-machinery items (buildings, automated handling equipment) is difficult to estimate and a common method used is simply to estimate a long life and minimal salvage value [p. 6-11[1] AAEA (2000)]. For biomass harvest, collection and transportation operations this is not a major issue, but for handling and storage operations at the plant this is important. We assume that buildings have a 20-year life with no salvage value and the handling equipment has a 15-year life with a 10% (undiscounted) salvage value at the end of their useful lives.

Repairs and Maintenance

For this analysis, the equipment maintenance costs were based on the manufacturer or dealer recommended service schedules and dealer servicing costs when available. For agricultural machinery where specific maintenance schedules and costs were not available from manufacturers or dealers, the following ASAE equation was used to estimate the repair and maintenance costs:

$$C_{rm} = RF_1 P \left(\frac{h}{1000} \right)^{RF_2} \tag{1.3}$$

Where

Crm is accumulated repair and maintenance cost, dollars

RF1 and RF2 are repair and maintenance factors (RF_1 and RF_2 in Table 1 are extracted from Table 3 in ASAE D497.4, Agricultural Machinery Management Data. Coefficients RF_1 and RF_2 spread repair costs over time, spreading more cost to later in a machine's life.)

P is the current list price of the machine, dollars

h is hours of accumulated use. (the original source of the data.

When *h* is equal to the hours of useful life, the accumulated repairs equal lifetime repairs; dividing lifetime repair cost by the life in hours gives an average hourly maintenance cost. In this analysis we assume that equipment is used for its useful lifetime.

The ASAE equation only applies to machinery, so for non-machinery items (buildings, automated handling equipment, etc.) where manufacturer/dealer estimates were not available an annual maintenance cost equal to 2% of the purchase price was assumed.

Fuel and Electricity

Fuel consumption was based on actual consumption based either on machinery specifications or, manufacturer or dealer estimates when available. For agricultural machinery where specific fuel consumption was not available, the following ASAE equation was used to estimate the average annual diesel consumption:

$$Q_{avg} = 0.0438 \times P \tag{1.4}$$

where

Q_{avg} = average diesel consumption, gal/h

P = rated engine power, hp.

Although this equation was not used to estimate gasoline consumption, the constant (0.0438) in Eq. 1.4 can be replaced with the constant 0.06 to estimate annual gasoline consumption of gasoline powered machinery.

Insurance, Housing, and Taxes

Insurance, housing (cost of shelter for equipment), and taxes refers to the fixed costs related to the equipment; these costs are estimated as percentages of the purchase price. If actual data are not available the ASAE (2003) suggests using the following percentages : taxes 1.00, housing 0.75, and insurance 0. 25, for a total of 2.00. This total ownership cost percentage, when multiplied by the machine purchase price, yields the average annual total ownership cost. Ownership costs were included in the operating costs for the machinery used in the field operations (baling, roadsiding, grinding and transportation), but these costs were not included for the plant handling equipment.

The Performance of Machinery in Handling and Processing Biomass

We are interested in time that an operation covers a certain area of the field or processes certain tonnage of material. Once the time is known then the time is multiplied by the cost of the machine determined in section 1 to calculate $/ton, $/acre, $/bale, etc..

The performance of much of field equipment (balers, grinders, etc.) was determined by time-in-motion tests conducted by INL. This data is presented in the Experimental Data sections of each of the appropriate unit operations section. For cases where time-in-motion tests were not performed, performance information was obtained from manufacturers, dealers or other users of the equipment.

Transport Equipment Performance

Transport time consists of travel time, load time, and unload time, as well as wait time

$$t_{tr} = \frac{t_{haul} + t_{return} + t_{ld} + t_{uld} + t_{wait}}{e} \tag{1.5}$$

t_{tr} is the total transport time per load in hours, t_{haul} and t_{return} are the forward and return time of the transporter per load respectively in hours. t_{ld} and t_{uld} are loading and unloading times per load in hours respectively, t_{wait} is the time in hours that the transport equipment may have to wait in a queuing line while the previous transport equipment finishes loading the truck, and e is a constant, whose value is less than 1 considering turns and obstacles that increase transport time. A transporter capacity, W_b is expressed in terms of mass to be transported,

$$W_b = k\rho_b V\,. \tag{1.6}$$

W_b is the transporter capacity in wet ton, ρ_b is the bulk density of the biomass in kg/m^3, and V is volume of the container in m^3. Coefficient $k<1.0$ represents less than full situations and deviations from a straight plane for the top of the load in the transporter. In the absence of data on bulk density of biomass at given moisture content, we assume that volume remains unchanged when moisture content of biomass changes. The wet bulk density can be estimated from:

$$\frac{1}{\rho_b} = \frac{1-M_w}{\rho_d} + \frac{1}{\rho_w} \tag{1.7}$$

ρ_b is the moist bulk density, ρ_d is the dry bulk density, and ρ_w is the bulk density of water (62.4) all in kg/m^3. M_w is the wet basis moisture content (decimal). The effective transport rate is the ratio of transport capacity over the total transport time,

$$W_t = \frac{W_b}{t_{tr}} \tag{1.8}$$

W_t is the rate of in-field transportation in t/h. It should be noted that W_b has a maximum value based on legal weight limits. In other words if W_b exceeds the legal limits then V or k has to be reduced.

Labor

Labor rates were obtained from the Idaho Bureau of Labor Statistics., and labor hours were based on assumed shift schedules. The supply system schedule is 302 days/year, 6 days/week, 16 hours/day; this amount to two 8-hour shifts per day, 6 days per week. The labor costs for the supply system operations includes time-and-a-half overtime for the extended weekly schedules and 10 paid holidays per year. The plant schedule, for those working the operations feeding the reactor, is 350 days/year, 7 days/week, 24 hours/day. This requires three 8-hour shifts per day, and by using a weekly shift rotation of four crews, each employee works 40 hours per week, requiring no overtime pay. This shift is detailed as follows:

24/7 shift schedule parameters:

Coverage:	168 Hours/week, Continuous
Staffing:	Balanced from Shift to Shift
Shift Length:	8-hour shifts
Number of crews:	Four crews
Skill Requirements:	Equal on all shifts
Shift Rotation:	Rotating Weekly

Other assumptions:

- Lunches are paid.
- Skill requirements are the same on all shifts.

Shift schedule.

Week/Crew	M	T	W	T	F	S	S
1	d8	d8	d8	d8	d8	—	—
2	—	—	e8	e8	e8	e8	e8
3	e8	e8	—	n8	n8	n8	n8
4	n8	n8	n8	—	—	d8	d8
d8 = 8-hour day shift e8 = 8-hour evening shift n8 = 8-hour night shift — = Day off							

Implementing the Feedstock Supply Model

The cost methodology discussed in these sections was programmed in an Excel spreadsheet. Using the methodology described in section 2, capital recovery costs, operating costs (insurance and housing, repair and maintenance, electricity/fuel consumption) and labor costs were determined for each piece of equipment used in the supply system analysis. These costs were summed to provide an hourly usage cost ($/hr) for each piece of equipment. Furthermore, the capacity, represented in tons/hr, of each machine was determined, taking into account field efficiency factors for each operation. In some cases the capacity was determined from time-in-motion tests, while for others the machine capacity was determined from typical agricultural machinery speeds published in ASAE D497.4 FEB03 or from data provided by expert operators (e.g., custom harvest operators). The hourly costs ($/hr) were then divided by the machine capacity (ton/hr) to give a cost per ton for each operation. Finally, the feedstock cost (FC) was determined by summing the machine cost per ton for each piece of equipment used in the supply system analysis as shown in the following equation:

$$FC(\$/ton) = \sum_{i=1}^{i=n} \frac{\$/hr}{ton/hr} \tag{1.9}$$

Where n is the number of unit operations within the supply system.

Additionally, the number of equipment was determined by the equation

$$Q_{eq} = \frac{D_{tons/acres}}{C*t} \tag{1.10}$$

where

Qeq	=	the quantity of equipment
Dtons/acres	=	the processing demand for the equipment, given in acres or tons,
C	=	the equipmet capacity , given in acres/hr or tons/hr, and
T	=	the amount of time available for the operation, hr.

Finally, the total annual costs were determined by summing the operating costs ($/ton) for each piece of equipment and multiplying by the total annual tonnage (800,000 tons) processed by this equipment, and the total capital investment was determined by multiplying the number of equipment by the equipment purchase price for each piece of equipment used in the supply system analysis.

3. STRAW CONTRACTS AND SUPPLIES

Assumptions

- The majority of the straw contracts will be negotiated prior to initial operation of the plant.
- Contracts will be based on a minimum time frame of five years with options for longer contracts. Contract negotiations and customer contact will be the responsibility of the straw buyers.
- Straw contracts between the plant and the growers will be standardized.
- Production and contracting targets will be 10% higher (880K tons)

Equipment

½ ton trucks
GPS Units
Laptop Computers
Cell Phones

Personnel

Straw Buyers
Lawyer
Accountant
Bookkeepers

Discussion

Feedstock value refers to the price that must be paid for biomass, standing or laying on the land, in order to purchase it from the producer (farmer or forester). While different feedstocks (i.e., corn stover, cereal grain straw, sorghum stover, switchgrass, prairie grass, logging residues, forest thinnings, etc.) have different median or average values, the price range for these different feedstocks can vary from less than \$10/dry ton to \$40/dry ton (or more in some cases) (Perlack and Hess, 2006). The specific reasons for this variability are as wide and diverse as the geographic regions and growers producing the biomass. However, the single largest variable affecting the feedstock value is tied to the tonnage demanded with respect to competing demands (competing demands include competing markets as well as soil/agronomic sustainability).

In this scenario, the biorefinery will process 800,000 ton of straw per year. However, production and contracting targets will be 10% higher (or 880,000 ton) to provide a margin of safety for plant operation in the event of producer related problems such as crop failures, fires, etc.

Southeastern Idaho has approximately of 1,900 farms, but since many of these farms are rented and/or combined with other operations, contract will not be made with every farm on record. In the absence of specific contracting data, contracting and staff time to service those contracts will be determined based on information form the Patterson study and a knowledge of Idaho farming practices. The following assumptions can be arrived at using published reports and Idaho specific farming knowledge:

- The most frequent contract tonnage will be 2000 tons per year. Therefore, to contract for 60% of the tonnage (528,000 tons) it would require approximately 264 contracts.

- We'll assume a skewed distribution, and that the 60% quartile for contract size is 1000 tons per year and the smallest contract size is 400 tons (or one stack). Thus, the average contract size for the lower 40% quartile is 700 tons per year, so it would require and additional 502 contracts to secure the final 352,000 tons.

- Straw contracting will be based on $10 per ton payment to grower on the field in a windrow. More complex payment structures which include options such as adjusted payments based on crude oil prices and variable terms ranging over multiple years could be incorporated. However, for this analysis, we'll assume a standard $10 per ton grower payment.

Straw contracts between the plant and the growers will be standardized. Straw contracting will be facilitated and monitored by the Straw Buyers. The straw buyers will be located in Idaho Falls, Ashton and Pocatello Idaho, and service contracts in five regions to be determined by overall straw production. Straw buyers in Pocatello and Ashton may work from home offices.

In order to be acceptable to the plant, straw must:

- Be harvested during the past year
- Be free of rot and weathering
- Comprised of wheat, barley or agreed plant type
- Be segregated according to type
- Be free of preventable toxins or ethanol production inhibitors as identified by the ethanol producer.

In addition to meeting these criteria for straw type and condition, the growers will also be responsible for;

- Providing to the plant, an accurate forecast of grain crop acres planted, variety planted, type of irrigation, and expected crop yield by March 15 or each year;
- Giving the plant access to the Producer's Farm Services Agency (FSA) commodity reports on a timely basis
- Notifying the plant when there are changes in the crop type, acres farmed, planned rotation or any other data that my impact the volumes or yields
- Providing the plant with a revised forecast of the amount of straw to be made available for sale by July 1st of each year
- Storing bales in stacks that meet state and federal fire prevention recommendations and laws
- Locating the stacks a safe distance from power lines and canals to allow trucks, bale handling equipment and grinders to work safely and efficiently
- Insuring bales are stacked no higher than 4 high for 4x4x8 bales in order for loaders and grinding equipment to access the topmost bales
- Carrying insurance on the straw stacks.

4. HARVEST

Assumptions

- Production target is 880,000 tons/yr
- Contributing straw crop types: Spring Barley, Winter Wheat, Spring Wheat
- Straw yield will be approximately 1.88 tons/acre
- Straw bulk density will be approximately 1000/lbs /bale or 7.813 lbs/cuft
- Harvest will begin in the 4th week of July and finish in September
- 76% of the straw will come from farms within 50 miles of Idaho Falls, Idaho
- 17% of the straw will come from farms between 50 – 75 miles of Idaho Falls, Idaho
- 5% of the straw will come from farms between 75 – 100 miles of Idaho Falls, Idaho.
- 12% of the straw will come from farms greater than 100 miles from Idaho Falls, Idaho.
- No portion of the harvesting costs are applied to the feedstock cost since the harvesting the straw with the combine does not impact the cost of grain harvest.

Equipment

¾ ton trucks
Combines

Personnel

Field Labor

Discussion

Growers will be responsible for grain harvest and subsequent straw harvest and bailing.

In the dry feedstock assembly system, collection starts with windrowed biomass that is at or has been allowed to field dry to a moisture of less than 15%.

The windrowed biomass is then collected into a form that allows it to be removed from the field and stored. Grain harvest will be conducted in the normal way, except that combine harvester straw chopper/spreaders will be disengaged and/or removed causing the straw to be windrowed behind the combine. Subsequent mow and rake or swathing operations will not be done. It is recognized, that with the use of stripper headers and/or conventional combines that a two pass harvest may be viable. However, such two pass operation on small grains with the use of rotary combines does not appear to be necessary.

While the biorefinery will process 800,000 ton of straw per year, production and contracting targets will be 10% higher (or 880,000 ton) to provide a margin of safety for plant operation. As such, all of the following production calculations are based on producing and collecting into bales 880,000 tons of straw or 110% of the biorefinery feedstock requirements. However, since only 800,000 tons will be delivered to the biorefinery, the cost model is based on 800,000 ton annual delivery to the biorefinery. A study of available straw in Idaho prepared in 1995 and updated in 2003 estimates there is over 1,000,000 tons of wheat and barley straw available in eastern Idaho, 980,000 tons of which are available within a 100 mile radius of Idaho Falls, ID (Figure 1), (Patterson, 1995 and Patterson, 2003)

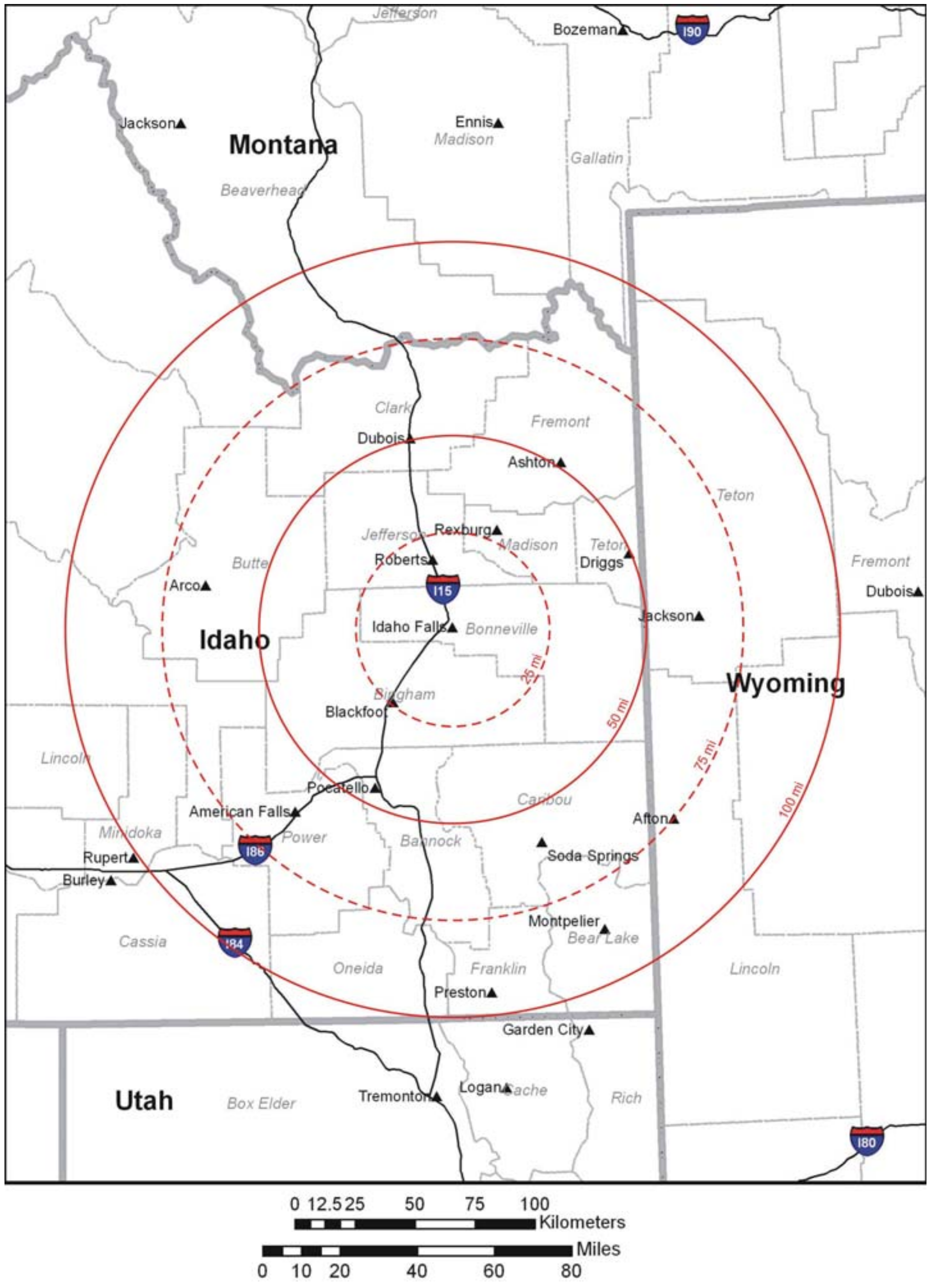


Figure 1. Southeast Idaho counties and towns within 100 miles of Idaho Falls.

1. 76% of the straw will come from farms within 50 miles of Idaho Falls, Idaho. Total tons of straw accessed within 50 miles of Idaho Falls, ID = 606,049 tons (80% of the 757,562 estimated net available).

   a. Basis of Estimate: Estimated 80% of the net available straw from the Patterson et al. 1995 (2003 update) study for each county and each contributing straw type.
   b. County estimates include: Bannock, Bingham, Bonneville, Clark, Fremont, Jefferson, and Madison.
   c. Contributing straw crop types: Spring Barley, Winter Wheat, Spring Wheat

d. Straw yield estimate: County specific estimates as reported in Patterson et al. 1995 (2003 update)

e. Spring Barley Harvest start:
   (1) 4th week of July: Bannock, Bingham
   (2) 1st week of August: Bonneville, Jefferson, Madison
   (3) 2nd week of August: Clark, Fremont
   (4) Winter Wheat Harvest window:
   (5) 1st week of August: Bannock, Bingham,
   (6) 2nd week of August: Bonneville, Jefferson, Madison
   (7) 3rd week of August: Clark, Fremont

f. Spring Wheat Harvest window:
   (1) 2nd week of August: Bannock, Bingham,
   (2) 3rd week of August: Bonneville, Jefferson, Madison
   (3) 4th week of August: Clark, Fremont

2. 17% of the straw will come from farms between 50 – 75 miles of Idaho Falls, Idaho. Total tons of straw accessed between 50 – 75 miles of Idaho Falls, ID = 136,992 tons (80% of the 171,240 estimated net available).

   a. Basis of Estimate: Estimated 80% of the net available straw from the Patterson et al. 1995(2003 update) study for each county and each contributing straw type.
   b. County estimates include: Butte, Power, Teton and 4,182 additional tons from other bordering counties.
   c. Contributing straw crop types: Spring Barley, Winter Wheat, Spring Wheat
   d. Straw yield estimate: County specific estimates as reported in Patterson et al. 1995(2003 update)
   e. Spring Barley Harvest start:
      (1) 4th week of July: Power
      (2) 1st week of August: Butte
      (3) 2nd week of August: Teton
   f. Winter Wheat Harvest window:
      (1) 1st week of August: Power
      (2) 2nd week of August: Butte
      (3) 3rd week of August: Teton
   g. Spring Wheat Harvest window:
      (1) 2nd week of August: Power
      (2) 3rd week of August: Butte
      (3) 4th week of August: Teton

3. 5% of the straw will come from farms between 75 – 100 miles of Idaho Falls, Idaho. Total tons of straw accessed between 75 – 100 miles of Idaho Falls, ID = 41,074 tons (80% of the 51,343 estimated net available).

   a. Basis of Estimate: Estimated 80% of the net available straw from the Patterson et al. 1995(2003 update) study for each county and each contributing straw type.
   b. County estimates include: Caribou, and 4,182 additional tons from other bordering counties.
   c. Contributing straw crop types: Spring Barley, Winter Wheat, Spring Wheat
   d. Straw yield estimate: County specific estimates as reported in Patterson et al. 1995(2003 update)
   e. Spring Barley Harvest start:
      (1) 2nd week of August: Caribou

f. Winter Wheat Harvest window:
   (1) 3rd week of August: Caribou
g. Spring Wheat Harvest window:
   (1) 4th week of August: Caribou.

4. 12% of the straw will come from farms greater than 100 miles from Idaho Falls, Idaho. By staying at or below the 80% draw on available straw within any given area, we avoid competition with some of the other uses of the straw (e.g., livestock bedding, feed, etc.) and the company is not force to pay higher prices to "hold out" growers, thus keeping the straw market stable. Total tons of straw accessed greater than 100 miles of Idaho Falls, ID = 105,600 tons. Remaining Southeastern Idaho counties will provide 32,615 tons (80% of the 40,769 estimated net available), and the remainder will come from Northern Utah and South Central Idaho (Magic Valley).

   a. Basis of Estimate: Estimated 80% of the net available straw from the Patterson et al. 1995(2003 update) study for each county and each contributing straw type.
   b. County estimates include: Bear Lake, Franklin, Oneida and 72,985 additional tons from Northern Utah and South Central Idaho.
   c. Contributing straw crop types: Spring Barley, Winter Wheat, Spring Wheat
   d. Straw yield estimate: County specific estimates as reported in Patterson et al. 1995(2003 update)
   e. Spring Barley Harvest start:
      (1) 4th week of July: Franklin, Oneida, Northern Utah, South Central Idaho
      (2) 1st week of August: Bear Lake
   f. Winter Wheat Harvest window:
      (1) 1st week of August: Franklin, Oneida, Northern Utah, South Central Idaho
      (2) 2nd week of August: Bear Lake
   a. Spring Wheat Harvest window:
      (1) 2nd week of August: Franklin, Oneida, Northern Utah, South Central Idaho
      (2) 3rd week of August: Bear Lake.

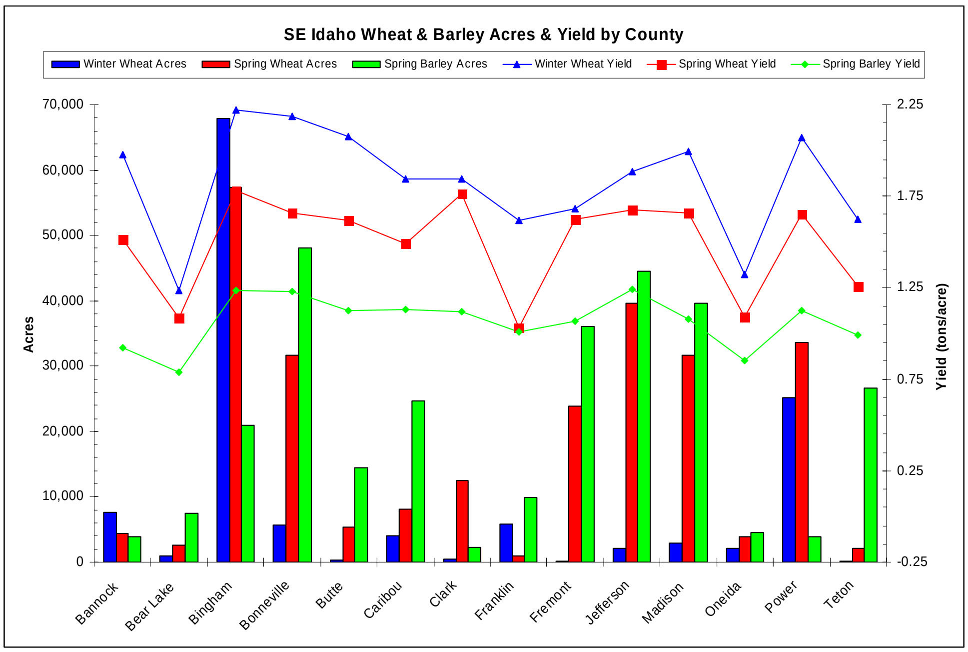


Figure 2. SE Idaho wheat and barley distribution and harvest yield.

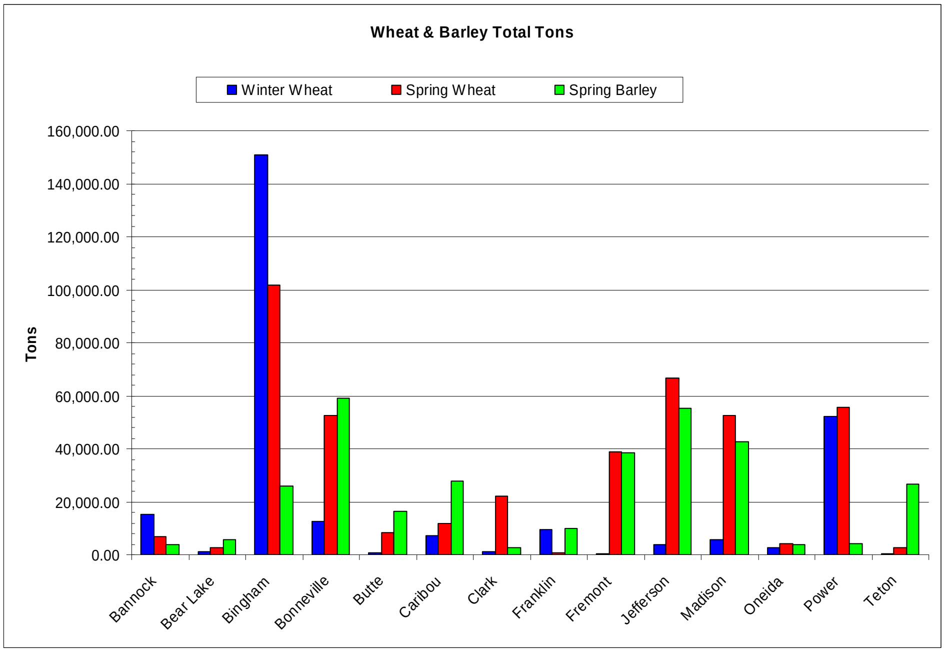


Figure 3. SE Idaho wheat and barley total tons.

5. COLLECTION OF HARVEST DATA

Assumptions

- Acreage and crop type are the same or have increased since publication of the 2003 Patterson report
- GPS/GIS mapping software will be used in the database system
- Straw Buyers will be full time employees
- Straw Buyers will collect samples in the field for QA/QC Analysis.

Equipment

½ ton truck
Laptop computer

Personnel

Straw Buyer
Clerk

Materials

GPS software
Standard PC Software
Digital Camera

Discussion

Harvest data will be collected and compiled by the contracting/field staff (i.e., straw buyers). The straw buyers will be located in Idaho Falls, Ashton and Pocatello Idaho, and service contracts in five regions to be determined by overall straw production. Straw buyers in Pocatello and Ashton may work from home offices. They will interface with the growers regarding harvest scheduling, stack locating, straw quality sampling, tonnage reports, etc. The field staff will provide this data to inventory management and schedule dispatch. Crop Information collection will begin prior to planting, using the data that growers routinely supply to the USDA (FSA commodity report) concerning planned crops and estimated acreage. After the planting is complete buyers will verify with the growers the total number acres planted with wheat and barley. As the crops mature the straw buyers will continue to update the database on any changes related to acreage or crop quality. Once the crop is harvested, the straw buyers will locate the stacks using GPS technology and provide pictures, bale counts, quality samples, stack conditions and other information pertinent to the management database.

6. SCHEDULE AND DISPATCH

Assumptions

- Field operations will be conducted 6 days/ week, 16 hrs/day
- Dispatchers will work 6 days/week, 16 hrs/day
- Dispatchers will coordinate both bailing and grinding operations
- GIS based software will be used to identify and map straw stack locations, roads, bridges, etc.
- GIS based software such as ArcLogisticsRoute will be used to optimize field operations
- Dispatchers will provide growers with 72 hours notice when grinding operations are to commence at the growers location. Grower will be responsible to make sure the stack is accessible by the grinding crews and haul trucks
- Straw Buyers will maintain daily baled-straw inventories in their assigned areas during bailing operations
- Some grinding may occur as the straw is brought from the field, eliminating the need for storage. When and where this occurs is up to the dispatcher
- Grinders will work in pairs at the same location or within 5 miles of each other to avoid stranding trucks in the event of a grinder breakdown or slowdown
- Dispatchers will work with plant operators to schedule grinding campaigns to grind and haul appropriate feedstock (wheat or barley) based on the biorefinery needs and field sampling data collected at the stacks
- Grinding operations will be schedule to evenly spread haul miles and cost throughout the year
- Grinding operations will be scheduled to avoid as best as possible, locations with heavy snow accumulations
- Radios will be available in all company vehicles to communicate scheduling changes to field crews
- Field personnel will operate from one of three Idaho base locations; Ashton, Idaho Falls, and Pocatello
- Tractors and balers used in bailing operations will remain at field locations during nonworking hours
- Grinders and Telehandlers used in grinding operations will remain at field locations during nonworking hours
- Semi tractors and trailers will begin and end their shifts at the plant in Idaho Falls or at a designated site in Ashton or Pocatello
- Grinders will be moved by Semi tractors that are idle (not hauling straw) at the end of shifts
- Telehandlers will be moved by trailers and 1 ton trucks assigned to field crews

Equipment

Radios
PC
Telephone

Personnel

Dispatcher

Discussion

This element will be closely tied to the QA activities at the plant. A good dispatching system will allow the plant to modify blends on a quick and efficient basis. Inventory of product in the field will be monitored and statused by the straw buyers who will be in the field on a regular basis. They will collect data on location, type, and amount of straw as well as field samples out of each stack, that will be analyzed at the plant. The 100 mile radius for biomass collection represents over 25,000 square miles of land. Some of the elements that will affect the scheduling of grinding operations include: feedstock type (barley or wheat), weather conditions, plant blend requirements, tonnage at site, road conditions, and distance to the grind sites. With the advent of inexpensive Global Positioning System (GPS) equipment and relatively inexpensive Geographical Information Systems (GIS) software, the feedstock inventory database is expected to include the exact locations of the stacks with information on type of straw, number of bales, total tonnage, sampling results, site access information, a picture of the site, road and bridge restrictions near the site and a host of other data. All of this information will help prioritize grinding locations and assist in making decision on the most cost effective and efficient operation of the field equipment and staff. There are a number of GIS software solutions available to address complex routing and scheduling problems. To the extent possible the dispatchers will incorporate 3-7 day weather forecasts into their scheduling, to avoid grinding in areas with high winds, rain or snow in the forecast. In addition, the dispatchers will incorporate spring thaw weight limits on Idaho roads into their planning. A good dispatching system with well designed GIS, GPS, and communications elements will pay for itself in fuel savings alone.

Harvest and bailing operations will be under the direction and control of the grower. Straw contracts may have requirements on maximum time that the straw can lay in the field prior to baling and stacking. Moisture content is a key factor in the baling requirements. The straw buyers will be in regular contact with the growers and the plant schedulers and dispatchers.

7. BAILING OPERATIONS

Assumptions

- Bales will be 4x4x8' and weigh approximately 1000 lbs each.
- Bales will be tied with 6 strands of standard baling twine.
- Baling operations will take 36 days working 16 hrs/day, 6 days/wk beginning in late July and ending in September.
- Baler capacity is 15 tons/hr.
- Moisture content of the straw at the time of bailing operations will be < 15%.

Equipment

Deere 8320 Tractor
Hesston 4910 Large Square Baler

Personnel

Tractor Operator

Materials

Bailing twine

Facilities

None. Since this equipment is owned either by the grower or custom harvesters, the equipment facilities for storage, maintenance and repair are not included in this analysis.

Discussion

Packaging straw into 4’X4’X8’ or 3’X4’X8’ bales for collection, handling and storage is common practice for Idaho producers that are supplying straw to Idaho livestock markets. Therefore this system serves as a baseline scenario, and clearly poses the least technical risk associated with delivery of straw to the biorefinery. However, while the livestock industry relies on the bale package for transport and handling right up to the point of final utilization, for this feedstock assembly system design using the bale and grind scenario, the bale will only be used to move the straw to the side of the field for storage. Using the “bulk” or bale and grind system, each bale is lifted three times, once to pick it up in the field, once to move it to the stack and one final time to put it in the grinder. The traditional bale and haul scenario would have a minimum of four and more likely five lifts.

The bale configuration used in this analysis and recommended for the feedstock assembly system is 4’ × 4’ × 8’ square bales (a common bale size in SE Idaho). Baling and transporting bales to roadside will be the farmer’s responsibility, either conducting the operation himself or contracting with a neighbor or custom operation. Although specific baling equipment is specified for the purpose of this analysis, the actual equipment will vary according to what is owned by the baling operator. INL studies indicate the most efficient method for both the bailing and roadsiding operations of 4’ × 4’ × 8’ square bales is the use of a standard tractor pulling a rectangular baler and bale accumulator. Using the accumulator allows the bales to be staged in the field in a manner that minimizes the pickup and transportation time during the roadsiding operation. In modeling and preparing cost estimates for this scenario we used a John Deer 8320 tractor with a Hesston 4910 baler and Hesston 4925 accumulator to bale the straw.

Experimental Data

Table 2 shows the baler performance measures recorded in the baling operation for a number of each harvest scenarios.

Table 2. Baling for entire field blocks.

Field Blocks	Baler Speed (mph)	Baling Time (min)	Repair Time (min)	Other Stop Time (min)	Fuel Used (gal)	Weight per Bale (lbs)[1]	Number of Bales	Baling (min/bale)	Baling (bales/hr)	Baling (tons/hr)	Fuel (gal/bale)
Rotary High Cut	3.5-4.2	121	131	8	11.7	1,051	72	1.68	35.7	18.8	0.16
Rotary Low Cut	3.6-4.8	126	57	10	14.6	1,143	64	1.97	30.5	17.4	0.23
Conventional High Cut	3.4-4.7	124	3	7	12.1	922	54	2.3	26.1	12.0	0.22
Conventional Low Cut	4.5-6.1	88	2	0	8.8	893	42	2.1	28.6	12.8	0.21

1. Bales were 4’ X 4’ X 8’ (128 ft^3) in size and bound with six poly twine strings.

Costs

The costs presented below include capital, maintenance, ownership, fuel, twine, and labor costs . These calculations are included in the cost estimation worksheet in the Excel model.

Baling:

Baling Window (hours/days/weeks)			12/6/4
Labor Schedule (# shifts - hours/shift)			1 -
Baling Costs			
Large Balers	Qty.	% Util.	$/dTon
01 Hesston 4910 Lg Sq 48" X 96"	111	100%	$ 11.11
00 None	—	—	$ —
00 None	—	—	$ —
00 None	—	—	$ —
00 None	—	—	$ —
00 None	—	—	$ —
Total Weighted Baling Costs			$ 11.11

Machinery costs, lifetime, maintenance schedules and fuel usage for most of the equipment was obtained from local equipment dealers. The maintenance cost is for routine service performed by the local dealership. The maintenance cost for the baler tractor is calculated using the ASAE repair and maintenance equation (Eq. 1.3), and the maintenance cost for the baler is based on manufacturer estimates. The salvage factors are calculated from the ASAE equation for remaining value (Eq. 1.2). Interest costs are calculated using the ASAE capital recovery equation (Eq. 1.1), and the ownership costs (for taxes, housing, and insurance) are calculated from the ASAE ownership cost equation (Eq. 1.4).

The total itemized costs for this unit operation are included in the cost estimation worksheet in the Excel model and are as follows:

Baling:

Capital Costs ($/yr)	$ 3,679,047
Operating Costs ($/yr)	$ 3,321,665
Labor Costs ($/yr)	$ 555,944
Total Annual Costs	$ 7,556,656
Total Capital	$ 28,495,508

8. ROADSIDING BALES

Assumptions

- Bales will be in a 4’x4’x8’ square-bale configuration, weighing approximately 1000 lbs.
- Bales will be scattered throughout the field (no bale accumulator will be installed on the baler).
- Distance from the furthest bale in field to the stack is less than 1 mile.
- A Stinger Stacker will be used to transport the bales from the field to the roadside stacking and grinding location and to stack the bales.
- Bales will be stacked one wide (~ 4 ft) and four high (~ 16 ft).
- Stacks will be located in areas that are well drained and free of standing moisture year round.
- There are no state fire codes for straw storage on a farm that must be adhered to for this analysis.
- The bales will not be covered during storage.

Equipment

Stinger Stacker 6500
Bale Loader, Caterpillar TH220B Telehandler 3300-5500 lbs capacity
Bale Loader Trailer, Siems 24' - 20,000 GVW Utility Trailer

Personnel

Stinger Operator
Bale Loader Operator

Materials

None.

Facilities

None. Since this equipment is owned by the grower or custom harvester, the equipment facilities for storage, maintenance and repair are not included in this analysis.

Discussion

A number of different scenarios for moving the feedstock have been examined. The most efficient is to go directly from the field during bailing or loafing operations to the grinder. This will likely occur for a small percentage of the feedstock during the approximately 40 day harvest period. A critical factor in the overall operation is the number of times the straw has to be handled or moved, especially once it has been baled. Some of the other options are:

In Field Grinding

Field to truck → truck to field grinder
Field to truck → truck to roadside stack → roadside stack to roadside grinder

At Plant Grinding

Field to truck → truck to plant grinder
Field to truck → truck to plant storage → plant storage to plant grinder
Field to truck → truck to roadside stack → roadside stack to truck → truck to plant storage → plant storage to plant grinder

This roadsiding analysis assumes the bales will be stacked at the edge of the field where the biomass was cut, or transported a short distance (1/4 to 1 mile) to be stacked at a common storage site with other stacks from the same grower or other growers in the area.

This roadsiding operation will be the farmer's responsibility, either conducting the operation himself or contracting with a neighbor or custom operation. A specific roadsiding scenario was assumed for this analysis based on the performance data shown below (see supporting Experimental Data section); however, the actual equipment will vary according to what is owned by the grower or custom operator. The bales must be moved off the field within seven days after the harvest, to allow the grower to conduct follow-on operations ranging from tilling to planting subsequent crops.

The common practice for roadsiding bales uses a loader and truck in the field. In this common practice, the loader loads the bales on the truck in the field, the truck drives to the stack location, and a loader moves the bales from the truck to the stack. However, the current design uses a different roadsiding scenario that, although not as widely used, it is much more efficient than the loader/truck scenario. The roadsiding scenario for this analysis uses a Stinger Stacker to move the bales from the field to the stack, and then also to stack the bales. The Stinger Stacker has the capability to pickup bales on-the-go at speeds of 3 to 5 miles per hour, to carry up to 8 bales at a time.

Experimental Data

Table 3 shows the machine performance measures recorded during testing of the fieldsiding operation. For each of these tests, the distance from the field to fieldside was about 0.3 miles, and the distance traveled within the field was about 0.28 miles, for an estimated 0.58 miles field travel.

Table 3. Equipment cycle times for bale fieldsiding and hauling.

Equipment and Operation	Load Time (min)		Travel Time one-way to or from Field to Fieldside Stack (min)		Stack Time (min)		Bale capacity (No. bales)
	mean±std	range	mean±std	range	mean±std	range	
Stinger 4400	2:41±0:44	1:50-3:35	1:24±0:23	1:00-2:00	2:01±0:40	1:06-3:00	8
Field Load Truck	27:10±1:56	25:00-30:00	4:20±1:38	3:00-7:00	14:40±2:04	12:00-18:00	20
Stack Load Truck	35:15±10:15	20:00-42:00	n/a	n/a	14:30±3:47	12:00-20:00	20

An interview with a grower in Firth, Idaho who uses Stingers and has conducted performance tests provided the following information.

- If you used loaders and trucks in the field you would need 3-4 trucks and 2 loaders to work the field at the same rate they can do with one Stinger and one loader.
- 4-trucks and 2-loaders, equates to at least 6 laborers.
- 1-stinger and 1-loader, requires 2 laborers.
- They use the 8-bale pick-up and dump. One stinger picks up the bales in the field, drives by and dumps the bales at a site. The loader stacks the bales in the field or onto a truck while the Stinger returns to the field and picks up more bales.
- They have tried the Stinger for stacking bales, but feel they can do a better and faster job stacking with the loader
- Depending upon field conditions and bale density (number per field), they typically handle 100-120 bales per hour. Last Fall they handled over 12,000 bales of straw with Stingers.
- They have field tested other equipment but have not found anything to compare with the quality and performance of the Stinger.
- The newest Stinger they have is 8 years old (they have 2).
- Local growers report low maintenance, just basic engine, grease and oil change.

Costs

The costs presented below include capital, maintenance, ownership, fuel, and labor costs . These calculations are included in the cost estimation worksheet in the Excel model.

Roadsiding:

Average Haul Distance (miles)			0.5
Square Bales - Tons			800,000
Round Bales - Tons			0
Collection Window (hours/days/weeks)			13.269/6/7
Labor Schedule (# shifts - hours/shift)			1 -
Collection Costs	Qty.	% Util.	$/dTon
Self Propelled Bale Hauler-Stackers			
01 Stinger Stacker 6500	48	100%	$ 2.04
00 None	—	—	$ —
Loader Option #1: Self Propelled Loaders			
00 None	—	—	$ —
00 None	—	—	$ —
Loader Option #2: Tractor Mounted Loaders			
00 None	—	—	$ —
00 None	—	—	$ —
Hauler Option #1: Tractor/Trailer Combo			
Unit # 1: Tractor/Trailer			
00 None	—	—	
00 None	—	—	$ —
Unit # 2: Tractor/Trailer			
00 None	—	—	
00 None	—	—	$ —
Unit # 3: Tractor/Trailer			
00 None	—	—	
00 None	—	—	$ —
Hauler Option #2: Tractor Drawn			
00 None	—	—	$ —
00 None	—	—	$ —
Unloading/Stacking Option #1: Self Propelled			
00 None	—	—	$ —
00 None	—	—	$ —
Unloading/Stacking Option #2: Tractor Mounted			
00 None	—	—	$ —
00 None	—	—	$ —
Total Weighted Collection Costs			$ 2.04

Machinery costs, lifetime, maintenance schedules, maintenance costs and fuel usage were obtained from local equipment dealers. The maintenance cost is for routine service performed by the local dealership. The salvage factors for the stingers and bale loaders are calculated from the ASAE equation for remaining value (Eq. 1.2). The salvage value for the bale loader trailer is based on manufacturer estimates. Interest costs are calculated using the ASAE capital recovery equation (Eq. 1.1), and the ownership costs (for taxes, housing, and insurance) are calculated from the ASAE ownership cost equation (Eq. 1.4).

The total itemized costs for this unit operation are included in the cost estimation worksheet in the Excel model and are summarized as follows:

Roadsiding:

Capital Costs ($/yr)	$ 565,560
Operating Costs ($/yr)	$ 585,703
Labor Costs ($/yr)	$ 237,339
Total Annual Costs	$ 1,388,603
Total Capital	$ 7,413,024

9. FIELD QUALITY ASSURANCE

Assumptions

- The company will have its own staff and laboratory to collect and analyze samples.
- Quality assurance (QA) samples will be collected from every stack location as soon as possible after the stacking operations have been completed in late summer or early fall.
- Field QA samples will be collected by the Straw Buyers.
- One field sample will be collected from each stack (nominally 400 tons), and this sample will be a composite of 5 core samples.
- QA samples will be archived for 3 years.
- QA sample data will be used by the plant to optimize the "blend" of the biomass being delivered to the plant.

Equipment

Vehicles:
½ ton trucks for Straw Buyers

Sampling Equipment:

5 Coring Tool Systems- Coring tool $150 each; Honda EU2000i Portable Generator $1,080 each; and Dewalt DW138 Heavy-Duty ¾" Drill $580 each

Laboratory Equipment:

Two NIR instruments @ $90,000 each ($180,000)
Four Laboratory Balances @ $10,000 each ($40,000)
One vacuum raffle splitter @ $800
Two Wiley #4 Mills @ $15,000 each ($30,000)
One Ro-Tap II 12" Shaker @ $2,250; 10 brass sieves @ $71 each (2,250 + 710 = $2,960
Two Drying ovens @ $10K
One DL77 Graphix Titrator @ $21,200
One Rondolino DL50 Automatic Titrator (automates sample changing) @ $4,590
Titration supplies – Approximately $5,000 / yr
Cleaning supplies, Kimwipes, weigh pans, grinder consumable parts – Approximately $2,000 / yr
Calibration, Spares and Repairs (1% First Year Cost)
1 Standard PC with LAN capability – Dell Optiplex GX620 processor with Dell UltraSharp 2001FP 20" Flat Panel Monitor ($1,455)

Figure 4. Titration equipment.

Personnel

The laboratory will be staffed by a full time lab manager and four laboratory technicians. The lab will operate six days a week. It is anticipated that the Laboratory manager will split his/her time between the morning and afternoon shifts. Two laboratory technicians will be assigned to each shift.

Laboratory Manager
Field Representatives
Lab Technicians (2/shift)

Materials

In addition to the equipment listed above, laboratory operations will also require routine expendable supplies such as cups, pipettes, dishes, cleaning agents, labels, bags, boxes, etc.

Facilities

The laboratory facility will be located at the ethanol plant and consist of approximately 2000 sq-ft of combined office, laboratory and storage space. The laboratory space will have a standard fume hood, sample receiving and preparation areas, and sinks. In addition, the facility will need limited chemical storage and a source of compressed air: The facility will also require a room-temperature dry-archiving storage room.

Discussion

Quality assurance will be an important element in the feedstock gathering and storing portion of the business. QA samples will be collected from each stack in the field by the Straw Buyers as soon as possible after the biomass is baled and stacked. Information form these samples will be used to prioritize and schedule grinding operations. This will allow the plant to blend the feedstock throughout the rest of the year, thus optimizing ethanol production.

Field sampling will involve collecting 5 cores from 5 bales in each stack; the 5 cores will be combined into a single composite sample, and then labeled and packaged for later analysis at the analytical laboratory. Laboratory analysis will determine feedstock chemical composition using Near

Figure 5. Typical coring device for collecting a representative sample from a bale of straw.

Infrared Spectroscopy (NIR) to report on the following constituents: glucan, xylan, lignin, protein, acetyl, uronic acids, galactan, arabinan, mannan and structural inorganics. In addition to the sampling and analysis of the biomass as it goes into storage in the field, there will be routine samples collected from every load or ground biomass that enters the plant. This analysis is covered in section 14.0 Plant Quality Assurance.

A laboratory facility dedicated to biomass QA/QC would be located at the ethanol plant and consist of approximately 2000 sq-ft of combined office, laboratory and storage space. The laboratory space would have a standard fume hood, sample receiving and preparation areas, and sinks. In addition, the facility will need chemical storage and a source of compressed air:

The field sampling activity will take the straw buyer approximately 15 minutes to complete. Laboratory preparation of the field samples includes grinding, weighing and cleaning; this is estimated to take approximately 5-8 minutes per sample. NIR analysis will take an additional 3-5 minutes per sample to load the sample, run the analysis and unload the sample. Data reporting and tabulation are estimated to take approximately 1 minute per sample, and archiving is estimated to also take approximately 1 minute per sample. The total time necessary for in lab testing procedure from receiving through archiving is estimated to be approximately 10-15 minutes per sample. If one sample is analyzed for every 400 tons in the field, there will be approximately 2,000 field samples collected and analyzed each year. Assuming 15 minutes per sample, laboratory testing of field samples requires 500 hrs of lab time annually. It is anticipated that for the first 3 years of operation, the biorefinery will want to archive samples for evaluating plant efficiency verses biomass type and origin. Therefore, the facility will also require a room-temperature dry-archiving storage room. Each sample will occupy a volume of approximately 1 cup.

It is assumed that the calibration for the NIR instrument is available for all the sample variances including crop and condition. In order to calibrate the equipment in the laboratory, it will be necessary to run a wet chemistry validation. This validation process will be run quarterly, or according to observed sample variance, or other problems that may become obvious during sample analysis. This calibration process is estimated to cost approximately $1000/sample.

Experimental Data

None.

10. INVENTORY MANAGEMENT & FIELD STORAGE

Assumptions

- Bales will be in a 4'x4'x8' square-bale configuration, weighing approximately 1000 lbs
- Nominal stack size will be 400 tons, stacked 4-high x 8-wide x 25-long (16' x 32' x 200').
- A single section will yield 1200 tons of straw, stored field-side in 3 stacks (400 tons each), which are co-located in the field side storage area.
- Rental of $300/acre will be paid to the grower for rent of the footprint the stack occupies plus a 20 ft. buffer around the accessible edges of the stack and access road into the stack if necessary
- Growers will carry insurance on the straw stacks. Insurance companies have varying criteria for separation between stacks.
- The average stack footprint including the 20' storage perimeter and 100 ft. stack separation is 60,480 ft^2 (1.40 acres)
- Straw from a single harvest may be stored from a week to a year at a site, depending on the plant demand and dispatching priorities

Equipment

Computer and Database
½ ton truck for Straw Buyers
GPS system

Personnel

Straw Buyers
Dispatcher

Materials

None

Facilities

No permanent facilities, but a 0.4 acre storage area is required at each field-side storage area (assumes 1-300-ton stack at each storage site).

Discussion

Biomass has relatively narrow harvest time windows, while the industrial utilization of biomass needs to be year-round. Therefore feedstock storage is mandatory. In the ideal scenario, the feedstock comes into and leaves a storage area or facility unchanged. In reality, however, the overall mass, the composition, and the industrial quality of the feedstock always changes while in storage. Therefore the target objective in storage is to minimize negative feedstock alterations. Storage format, stack configuration, and protective barriers can all be employed to reduce sugar yield losses in a dry storage system. Additionally, dry storage system designs need to be cognizant of fire risks. However, the cost of the measures taken to protect the biomass during storage need to be balanced against the value of the ultimate sugar yield they protect. Therefore, the primary objective of a storage system is the lowest cost method (including cost incurred from losses) of holding the biomass material in a stable unaltered form (i.e., neither quality improvements nor reductions) until it is called for by the biorefinery.

Major considerations for dry storage systems include overall gross shrinkage (dry matter loss), biomass material degradation leading to mass without yield (biological shrinkage) and quality changes. The key factor for controlling biological changes is low moisture (i.e., less than 15%) as the material enters storage and protection from moisture throughout the storage period. Accordingly, the outside storage of dry biomass is tremendously region specific. Tests conducted by the INL for dry storage in eastern Idaho showed that the precipitation levels in this area were low enough that chemical losses were not significantly affected by precipitation. Therefore, for dry storage in SE Idaho, the feedstock will be stacked at the side of the field in a well drained area where there is little chance for standing water. Tarps or covers are not necessary. The stacks must also be located a sufficient distance from public roads to allow for grinding operations without impinging on public byways.

Inventory of feedstock in the filed will be monitored by the straw buyers who will be in the field on a regular basis. They will provide updates on individual stack conditions to the inventory management system to ensure that the dispatcher is aware of any special site specific conditions that would affect material quality or grinding operations. With the advent of inexpensive GPS equipment and relatively inexpensive software it is envisioned that the inventory database will include exact locations of the stacks with information on type of straw, number of bales, total tonnage, quality sampling results, site access information, road and highway conditions or restrictions, weather data, and many other pieces of information that would assist in making decision on the most cost effective and efficient operation of the field equipment and staff.

The baled biomass will be transported to the nearest corner of the field and stored in stacks one bale wide and four bales high. In this case, there will be one stack per quarter section (0.5 mi. x 0.5 mi., 160 acres). The optimum stack size is one that will occupy a single grinder for a full work day. This allows the grinder to be moved only once per day and minimizes grinder down-time during transit to the next grind site. For the grinder capacity discussed in section 10.0, the optimum stack size is about 300 tons. With the assumed straw yield of 1.88 tons/acre (which is well within the range for the highest yielding varieties shown in Figure 1), this ideal stack size is achieved for each quarter-section. Assuming 300 ton stack sizes, the 800,000 ton supply is distributed among 2,660 stacks. Using the assumptions shown in Table 4, a single 300-ton stack has a land footprint of 4,800 ft^2 (0.11 acres), and the total land use for the 800,000 ton inventory (2,660 stacks) is 293.8 acres.

We have assumed that the stack storage areas would be rented from the grower as a storage fee. A 20 foot perimeter around the accessible edges (one side and one end) would also be included for stack access. The footprint for a single stack in this case is 17,360 ft^2 (0.40 acres). Scaling this for the 2,660 stacks required for the 800,000 ton inventory brings the total land usage to 1062.7 acres. If multiple stacks are co-located at the storage site, insurance policies in eastern Idaho require a minimum of 100 ft. separation between stacks. If the straw yields are low enough that the 300-ton stack size can not be achieved growers will co-locate their straw to maximize the amount of straw at a single location to make the most efficient use of the grinders and biomass transportation systems. This land-use analysis does not calculate land-use for this scenario.

Access to the bale stacks will be maintained by the growers. The growers will receive 48-72 hours notice prior to the grinding teams arriving at their locations, allowing the growers to prepare the location for grinder team access. The growers are responsible for providing access to the stacks and for providing adequate work area for the grinding equipment; this may require backfilling low areas with standing water, snow removal from stack area, and snow removal from access roads. The work area must be large enough to handle two 103 ft tractor-trailer rigs and space for them to turn around on site. The estimated footprint necessary for the grinders and loading operations at a site is approximately 300 X 200 ft for the

Table 4. Stack footprint assumptions.

16	ft	Stack Height (4-bales)
8	ft	Stack Width (1-bales)
0	ft/ 1-side	Stack Width Perimeter
0	ft/1-side	Stack Length Perimeter
600	ft	Stack Length
8	ft	Stack Width
4,800	ft2/stack	Stack Footprint per Stack

Table 5. Land Rental Assumptions.

16	ft	Stack Height (4-bales)
8	ft	Stack Width (1-bales)
20	ft/ 1-side	Stack Width Perimeter
20	ft/1-side	Stack Length Perimeter
620	ft	Stack Length
28	ft	Stack Width
17,360	ft^2/stack	Stack Footprint per Stack

loading operations and 100 X 100 ft for the grinding operations. The grinders and trucks weigh approximately 80,000 lbs. each and will require solid or frozen ground for most efficient grinding operations.

Experimental Data

Dry storage tests and observations conducted by INL to evaluate storage losses for various dry storage systems. The storage yard was set up at UTM Zone 12, NAD 27, E401498 N4827783, roughly 14 miles west of Idaho Falls, Idaho, and approximately 4 miles from the wheat fields supplying the senesced biomass. Environmental conditions were recorded from a weather station near the site with minimal topographic and native vegetation differences. Temperatures ranged from -28 to 37˚C, with 90 to 50% relatively humidity. Intermittent thundershowers, totaling 209.3 mm (8.2 in) of precipitation occurred throughout the year. Overall, the conditions in SE Idaho favor the evaporation of the precipitation if the storage systems are adequately ventilated and the moisture has not permeated too far into the core of the storage unit.

Gross Mass Losses

Most of the mass losses encountered during testing were attributable to mechanical losses, not chemical changes; as such, these mechanical losses can be minimized through process optimization and best field storage management practices. Bail, loaf and chopped pile systems were analyzed. The bale system exhibited the lowest total gross loss of 0.85%.

Table 6. Dry mass losses during storage of wheat straw loaves, the chopped pile, and in tarped bales. The tarp was damaged early in the year and blew off before the spring rains.

Bale	*in*	*out*	*in - out*	*% difference*
Total Mass (tons)	23.910	24.485	0.575	2.4
% Moisture	8.7±0.48	11.6±3.53	2.9	33
DM (tons)	21.830	21.645	0.19	0.85

Chop	*in*	*out*	*difference*	*% difference*
Total Mass (tons)	42.68	48.47	5.79	13.6
% Moisture	10.7±1.2	24.2±18.3	13.5	126
DM (tons)	38.1	36.7	1.4	3.67

Chemical Losses

Chemical losses were evaluated in all 3 storage scenarios. Dyes were applied to the stacks and piles (Figure 6) and the depth and extent of transport of the dye into the stack or pile was measured and evaluated.

Figure 6. Straw stacks with blue dye indicating moisture invasion during storage.

Samples were collected from each of the storage systems. These samples were analyzed for a number of physical and chemical characteristics. The relative amount of glucan and xylan were depressed in the zones that remained wet throughout the year, but were relatively unchanged in zones that were stained but later dried. Weighting the compositional differences in the different observed zones to the percent of the damaged areas within the piles, very little compositional changes were observed (Table 7). This analysis suggests that even in the storage systems that are observably poor; an economically significant amount of sugars could possibly be present. The overall chemical changes within the biomass storage systems were relatively insignificant.

Based on this data, tarps or covers are not necessary under typical Eastern Idaho conditions. Given much more annual precipitation, tarps may be necessary. Tarps are used locally in the area to protect animal feed from toxic fungal metabolites (hay rotting) more than for straw sugar and mass losses. No materials or labor time are identified for typical straw storage in this modeling scenario.

Table 7. Visibly damaged areas throughout the 1-year outside stored loaves, chopped pile, and bales, extended to total compositional changes over 1-year of outside storage.

				Final Area-Weighted Composition					
	Visibly-Damaged Area Quantification			**Glucan %**	**Xylan %**	**Galactan %**	**Arabinan %**	**Mannan %**	**% Acid insoluble Lignin & Ash**
1-yr Harvest Observations	**Loaves (n=6)**	mean	std	38.6	24.3	1.4	3.4	0.1	22.6
dry	visibly unchanged area (%)	78.8	14.7						
	visibly damaged area (%)	21.2	3.9						
dry	gray area (%)	4.3	1.2						
	brown area (%)	16.9	3.0						
1-yr Harvest Observations	**Chopped Pile (n=4)**			35.3	22.5	1.4	3.1	0.0	28.6
dry	visibly unchanged area (%)	81.6	15.3						
wet	brown area (%)	18.4	3.4						
1-yr Harvest Observations	**Top-of-Stack Bales (n=3/condition)**								
	untarped			36.6	22.2	1.3	3.0	0.0	23.6
dry	visibly unchanged area (%)	73.1	6.1						
	visibly damaged area (%)								
dry	gray area (%)	6.7	2.8						
wet	brown area (%)	20.2	7.2						
	tarped			37.6	23.5	1.4	3.3	0.1	24.6
dry	visibly unchanged area (%)	76.4	4.3						
	visibly damaged area (%)								
dry	gray area (%)	9.5	6.7						
wet	brown area (%)	14.9	2.4						

Costs

The detailed costs shown below for this unit operation included shrinkage costs, management costs, storage site (land) rental costs and insurance costs. Although there are personnel associated with this unit operation, the labor costs are included elsewhere in this analysis. These calculations are included in the cost estimation worksheet in the Excel model.

Storage:

Avg. Tons Stored per Site	300
Annual Precipitation, in.	8.23
Storage Dry Matter Losses	5.00%
Srorage Footprint at Site, sq. ft.	17,360
Min. Separation per Insurance, ft.	100
Land Rent Cost, $/acre/yr.	123.8
Management Cost per Ton	0.44
Insurance Cost per Ton	$ 0.05

Storage Costs	% Util.	$/dTon
Storage Format		
01 Stack	100%	$ 2.13
00 None	-	$ -
Storage Cover		
00 None	-	$ -
00 None	-	$ -
Total Weighted Storage Costs		$ 2.13

The total itemized costs for this unit operation are included in the cost estimation worksheet in the Excel model and are summarized as follows:

Storage:

Capital Costs ($/yr)	$ -
Operating Costs ($/yr)	$ 1,449,760
Labor Costs ($/yr)	$ -
Total Annual Costs	$ 1,449,760
Total Capital	$ -

11. GRINDING OPERATIONS

Assumptions

- Grinding operations will be conducted 302 days/yr, 6 days/wk, 16 hrs/day (two 8 hr shifts).
- Grinding crews will be stationed in Ashton, Pocatello and Idaho Falls to minimize transportation time and cost and maximize grinding operation time.
- Each grinder is capable of grinding a minimum of 26 tons/hour.
- A grinding team will consist of one grinder, one loader/telehandler, one grinder operator and one loader operator.
- The loader will be capable of moving two bales at a time from the stack to the grinder.
- The grinder will be capable of accepting at least two bales at a time into the tub feeder.
- Each grinder crew will have a service truck with tools for equipment maintenance and repair.
- Routine maintenance will be performed by the grinder operator and loader operator.
- Grinders will be moved from one grind site location to the next using the same tractors that are used for transporting bulk material from the grind site to the plant.
- Bale loaders will be transported from one grind site to another on a trailer towed by the service truck.

Equipment

Grinder; Diamond Z 1352L tub grinder with CAT 3412E-860 hp engine
Bale Loader; Caterpillar TH220B Telehandler 3300-5500 lbs capacity
Bale Loader Trailer; Siems 24' - 20,000 GVW Utility Trailer

Figure 7. 4’x4’x8’ straw bales being loaded into a tub grinder and the ground biomass being loaded to a truck from the tub grinder

Personnel

Grinder Operator
Bale Loader Operator

Materials

Grinder and bale loader fuel, lube, etc.

Facilities

None

Discussion

Grinding of the baled feedstock will occur at the stack locations. The tub grinder will be positioned next to the stack and a telehandler bale loader will move bales two at a time from the stack and drop them into the grinder tub. The ground material will then be conveyed into a truck as it is discharged from the grinder (Figure 7). The current analysis assumes that the grinders will be distributed individually among separate grinding sites. However, the efficiency of the feedstock assembly system may be improved by working two or even three grinders at the same site. This multiple grinder configuration would improve the efficiency of the transportation operation (discussed in section 11.0); the efficiency would also be improved if a single telehandler could feed multiple grinders. A more indepth sensitivity analysis for grinder operations will be conducted in the future.

For the current analysis, minimizing grinder downtime when moving the grinder from one site to the next was a key objective; therefore, grinder transportation from site to site was assumed to occur at the start or end of the work day. For this to occur, the stack sizes must be scaled according to grinder capacity. Testing performed by INL measured the Diamond Z grinder capacity for barley straw to be 26 tons/hr. Observations of grinder performance during this testing also revealed potential process and design changes that would likely increase grinder capacity beyond the measured 26 tons/hr. Nonetheless, at a grinder capacity of 26 tons per hour, seven grinders are needed to operate 14.6 hours per day (for a 302 day per year, 6 day per week schedule) to meet the 800,000 tons per year supply to the biorefinery. The daily capacity of a single grinder in this case is 378 tons. Therefore, the optimum stack size for system efficiency is 378 tons. A nominal stack size of 400 tons was broadly established as criteria for the bulk feedstock system design.

The Diamond Z 1460B tub grinders are trailer mounted units with dual axles weighing approximately 60,000 lbs. The grinders are 11’-11” wide and 33’-6” long with a maximum tub diameter of 14’. The grinders will be moved from location to location using the same Kenworth T800 3-axle day cab tractors used to haul the ground biomass to the plant. Due to the dynamics of the system, some trucks in the fleet will make one less haul than others towards the end of the shift, even though there may be an hour or more left on their shift. Some of these trucks will be available to drop their trailers at the plant and return to the grind site to move grinders to the next location. The grinders are considered oversized loads on Idaho roads and highways and will require oversized permits. An annual Overlegal Truck Permit for Commercial Vehicles in Idaho for this equipment configuration would cost $43. In addition, there would be a quarterly mileage fee of approximately $0.44/mile.

The crews will begin each workday from the main plant in Idaho Falls or one of the satellite offices in Ashton or Pocatello Idaho, where they will ride in a company service truck to the grind location. The morning crew will begin work at 6:00 am and end their shift at 2:30 pm with ½ hour for lunch. The afternoon shift will begin at 1:00 pm and end at 9:30 pm with ½ hour for lunch. The crew trucks will carry tools and spare parts necessary to do routine maintenance and repairs on site. Routine maintenance and fueling will occur during the regular shift periods. Custom fuel tanks (day tanks) with larger capacities are available for the grinders, allowing for minimization of fueling breaks. Fuel delivery for the grinders will be subcontracted to bulk fuel haulers.

The Cat TH220B telehandlers will be moved from one grind location to the next using utility trailers pulled by the crew trucks. For moves of short distances, the telehandlers may be able to drive to the next location. One trailer will be assigned per grinder team and left at the grind locations. The telehandlers have a 500 hour maintenance schedule. Minor maintenance on the telehandlers will be performed in the field or at the plant.

Experimental Data

The first grinding test configurations were designed to demonstrate performance targets of 30 tons/hour capacity, 0.25" minus particle size, and 8 ft^3 bulk density or greater for typical moisture levels (9-12%). All performance targets were assessed using the grinder screen size configuration shown in Table 8. The logistical data used to measure the performance of the first distributed grind test is shown in Table 8. Grinding configurations with bold, italicized data met or exceeded the performance targets indicated.

As indicated in Table 8, the difference between the highest (0.25" screen) and lowest (5"X7" screen) bulk density is 4.27 lbs/ft^3, but this improvement came at a capacity cost of 17.2 ton/hr and energy cost of 75.1 kWh. While the set of screen sizes are designed to reduce the nominal particle size in a range from 7.0" to 0.25", 78.4% of the straw passing through the 5"X7" screen was nominally at or below the

Table 8. Grinder configuration tests for standard straw moisture levels (9-12%).

Screen Sizes (inches)	Screen hole shape	Moisture (%)	Capacity (ton/hr)	Energy (gallon diesel/ ton)	Energy[1] (kWh)	Supersack Bulk Density (lbs/ft^3)	Particle size geometric mean (in)	Particle size standard deviation	Test Name
0.25 X 0.1875	Round	10.29	8.21	2.92	111.3	***9.72***	***0.0457***	0.103	G1
0.50 X 0.1875	Round	11.04	14.26	1.68	64.00	***8.46***	***0.0728***	0.114	G2
0.75 X 0.1875	Round	12.09	17.26	1.39	52.96	7.71	***0.0862***	0.119	G3
1.00 X 0.1875	Round	10.12	25.66	0.94	35.81	7.36	***0.0843***	0.120	G4
1.50 X 1.00	Round	8.47	25.91	0.93	35.43	***8.08***	***0.0685***	0.119	G5
5 X 7 X 1	Square	12.87	25.38	0.95	36.19	5.45	***0.139***	0.135	G13

[1] Cummins Diesel, 2005
Straw was barley, variety Harrington
All values based on typical "dry" moisture levels of (9-12%)
Grinder configuration was a tub feed with a Diamond Z forage hammer and various screen sizes.

0.25" minus particle size target. Similarly, a majority of the particle sizes produced from each grinder screen were about one order of magnitude smaller than the nominal screen size. This suggests that a majority of the material fractionates rather easily in the grinding process, while the remainder of the material requires a longer grind, and thus more energy to reach the design size. In the case of the 5”X7” screen, an additional 75.1 kWh of energy was required to reduce the remaining 21.6% of straw material to the 0.25” minus target.

The overall best configuration in terms of the established performance targets was the 1.5” screen. It had the highest production rate for the smaller screen size configurations and produced a better particle size distribution and bulk density than the 1.0” and 0.75” screens. The key to the better performance of this screen size is its larger hole, allowing the 0.25” minus particles to escape more easily, and the greater screen thickness, reducing spearing of the larger particles. The combination of these two parameters allowed the remaining larger particles to be reduced in size with a much lower burden from those particles that were at or below the target size. Thus, the 1.5” screen configuration came closest to simultaneously achieving all three production targets. At 25.9 ton/hr, it was 86% of the capacity target, at 8.08 lbs/ft^3, it was 100% of the bulk density target, and at a 0.0685 inch geometric mean particle size and 0.119 inch geometric standard deviation, 97.7% of the particles were 0.25 inch minus.

Costs

The costs presented below include capital, maintenance, ownership, fuel, twine, and labor costs . These calculations are included in the cost estimation worksheet in the Excel model.

Preprocessing (grinding):

Baling Window (hours/days/weeks)			13.3183/6/52
Labor Schedule (# shifts - hours/shift)			2 - 8
Preprocessing Costs	**Qty.**	**% Util.**	**$/dTon**
Self-Propelled Bale Loaders			
01 Caterpillar TH220B Telehandler	10	100%	$ 1.39
00 None	-	-	$ -
Grinders			
01 Diamond Z 1352L tub grinder	10	100%	$ 6.13
00 None	-	-	$ -
Total Weighted GrinderCosts			$ 7.52

Machinery costs, lifetime, maintenance schedules, maintenance costs and fuel usage were obtained from the manufacturer or local equipment dealers. The maintenance cost is for service performed by the local dealership. The salvage factor for the bale loaders is calculated from the ASAE equation for remaining value (Eq. 1.2). The salvage factors for the grinders and bale loader trailers are based on estimates from the manufacturer or dealers. The salvage factor for the field labor pickups is based on information from a local dealer, and is calculated based on a 23% yearly depreciation. Interest costs are calculated using the ASAE capital recovery equation (Eq. 1.2), and the ownership costs (for taxes, housing, and insurance) are calculated from the ASAE ownership cost equation (Eq. 1.4).

The total itemized costs for this unit operation are included in the cost estimation worksheet in the Excel model and are summarized as follows:

Preprocessing (grinding):

Capital Costs ($/yr)	$ 996,468
Operating Costs ($/yr)	$ 2,778,419
Labor Costs ($/yr)	$ 1,338,388
Total Annual Costs	$ 5,113,276
Total Capital	$ 6,848,009

12. TRANSPORTING GROUND FEEDSTOCK

Assumptions

- Average distance from grind location to plant is 47.5 miles.
- Average truck speed is 40 mph.
- Trailer capacity is 175.5 yds^3 (4,738.5 ft^3)
- Bulk density of ground straw loaded in the truck is 11.50 lbs/ft^3.
- At a grinder capacity of 26 tons/hr, the average truck load time is 70.4 minutes.
- Average truck unload time at the plant is 43.9 minutes.
- 4 trucks per grinding site.
- Trucks will operate according to the grinding schedule (302 days/yr, 6 days/wk, 16 hrs/day).
- Tractors will be fueled at the ethanol plant.
- Routine scheduled maintenance will be done by the Kenworth dealer.
- Minor maintenance will be done by the mechanics at the plant.

Equipment

Semi-Tractor; Kenworth T800 3-axle day cab
Spare Semi-Tractor; Kenworth T800 3-axle day cab
Semi-Trailer; Trinity Trailer "Eagle Bridge" 42' 2-axle, 29" side, 4' extensions
Spare Semi Trailers; Trinity Trailer "Eagle Bridge" 42' 2-axle, 29" side, 4' extensions

Personnel

68 total laborers
Semi-Tractor Driver

Materials

None

Facilities

Truck and trailer parking and a service/repair shop (mechanic's garage) will be required at the plant. This equipment and labor costs are not included in this transportation analysis.

Discussion

The main assumption associated with the transportation analysis is that the average distance from the plant to the grind site is 47.5 miles. This is based on the feedstock distribution data discussed in the Harvest section (section 3.0) above. Furthermore, the primary requirement of the transportation analysis is that the grinders do not ever wait for a truck to arrive; rather, enough trucks are included in the analysis so that a truck may have to wait at the grind site for the grinder to finish loading the previous truck. According to this analysis, 4 trucks are required for each grind site. The analysis also shows that every truck makes 3 hauls from the grind site to the biorefinery per day, and 1 of the 4 trucks for each site fleet makes one additional haul. Accordingly, 3 trucks run 14.1 hours per day, while one truck runs 18.8 hours per day. The 3 trucks that are not sent out for an additional run at the end of the day are available for either moving the grinders to a different site, or to fill in on other routes if those trucks are running behind schedule. Some trucks will carry partial loads as grinding of stacks is completed.

A well organized and efficient dispatching operation will be critical in planning the locations of the grinding operations to minimize round-trip haul times. The primary concerns with the transportation operation are maximizing the individual loads and minimizing the amount of handling of the biomass. The proposed system will use conveyors for loading in the field, and floor conveyor systems in the trailers for dumping at the plant. The Diamond Z 1460B grinders are equipped with a conveyor system that can directly load the Eagle 42’ trailers (Figure 8). The grinder will remain in a single location, being fed bales with a telehandler, and the trucks will move under the conveyor system.

The KW T800 tractors have 14,000 mile maintenance schedule and a 1 million mile rebuild schedule. The tractors are expected to accumulate approximately 90,000 miles per year. The plant will have a mechanic on duty 24/7. Minor maintenance of trucks and trailers will be conducted by a mechanic and mechanics helper during the graveyard shift.

Figure 8. Typical tractor-trailer configuration for hauling ground biomass.

Experimental Data

None

Costs

The costs presented below include capital, maintenance, ownership, fuel, and labor costs . These calculations are included in the cost estimation worksheet in the Excel model.

Machinery costs, lifetime, maintenance schedules, maintenance costs and fuel usage were obtained from the manufacturer or local equipment dealers. The maintenance cost is for service performed by the local dealership. The salvage factors for the semi-tractors and semi-trailers are based on estimates from the manufacturer or dealers. The salvage factor for the field labor pickups is based on information from a local dealer, and is calculated based on a 23% yearly depreciation. Interest costs are calculated using the ASAE capital recovery equation (Eq. 1.1), and the ownership costs (for taxes, housing, and insurance) are calculated from the ASAE ownership cost equation (Eq. 1.4).

Bulk transportation:

Average Haul Distance (miles)			47.5
Feedstock Bulk Density (lb/cu ft)			11.5
Unload Time (minutes)			43.9
Queue Wait Time (minutes)			45.4
Transport Window (hours/days/weeks)			13.3183/6/52
Labor Schedule (# shifts - hours/shift)			2 - 8
Bulk Transportation Costs	**Qty.**	**% Util.**	**$/dTon**
Tractor/Trailer Bulk Haulers			
Unit # 1: Tractor/Trailer			
01 Kenworth T800 3-axle day cab	34		
01 Trinity Trailer "Eagle Bridge" 42', 29"/4' side	68	100%	$ 9.87
Unit # 2: Tractor/Trailer			
00 None	—		
00 None	—	—	$ —
Unit # 3: Tractor/Trailer			
00 None	—	—	
00 None	—	—	$ -
Total Weighted Bulk Transport Costs			$ 9.87

The total itemized costs for this unit operation are included in the cost estimation worksheet in the Excel model and are summarized as follows:

Bulk transportation:

Capital Costs ($/yr)	$ 1,288,639
Operating Costs ($/yr)	$ 3,054,188
Labor Costs ($/yr)	$ 2,368,213
Total Annual Costs	$ 6,711,040
Total Capital	$ 11,965,758

Appendix D, contains detailed information on Idaho transportation rules and regulations.

13. WEIGHING AND ACCOUNTING

Assumptions

- The equipment required to measure and record weights of incoming trucks will be housed in the same building as the analytical laboratory at the plant. There will not be a separate scale house.
- Weighing of material in bale configuration will not be done in the field.
- All of the transport vehicles (tractors and trailers) will have tare weight certifications

Equipment

1- Rice Lake Survivor-OTR, 117’ X 11’ steel deck truck scale with pipe guide rails. This scales come with a 20-year warranty on the weighbridge and 5-years on the load cells.
1-GSE 562 programmable digital indicator with a truck I/O program and Inventory Tracking Program used for printing out reports, with a 2-year warranty.
1- Epson220 tape printer to print tickets with a 1-year warranty.
1- PC Computer
Software

Personnel

1-Receiving & Sampling Clerk per shift

Materials

None

Facilities

The scales will be located in the yard, and the electronics and accounting systems will be in the lab building and the main office.

Discussion

Feedstock value refers to the price that must be paid for biomass, standing or laying on the land, in order to purchase it from the producer (farmer or forester). While different biomass feedstocks (i.e., corn stover, cereal grain straw, sorghum stover, switchgrass, prairie grass, logging residues, forest thinnings, etc.) have different median or average values (Biomass as Feedstock, 2005), the price range for these different feedstocks can vary from less than $10/dry ton to $40/dry ton (or more in some cases) (Perlack and Hess, 2006).

The farm gate and biorefinery gate feedstock pricing structure is common place in agriculture supply systems, but can be dynamic and variable based on the farm/agribusiness (e.g., biorefinery) relationship. This feedstock supply system is based on the grower receiving partial payment for the biomass while it is in the field (estimated yield per acre), and final payment based on the feedstock weight and condition when it enters the biorefinery plant gate.

When the trucks enter the plant gate, they stop on the scales where the truck weight is recorded. The truck ID, recorded weight, etc. will be automatically stored on the scale house computer. The transaction may also be printed in the scale house. A computer system that integrates the weighing, truck ID, quality analysis, dispatching and accounting elements of the business will be used to process payment to the growers.

For approximately $7,000 per machine, load cells and data loggers can be installed on the telehandlers which would provide bale weight in the field. This option might be desirable to determine shrinkage during storage and to better manage inventories. The weight could be recorded during roadsiding operations. This option has not been included in this scenario.

Experimental Data

None

Costs

The detailed equipment costs presented below include capital, maintenance, ownership, and fuel costs. In addition, labor costs associated with this unit operation are included. These calculations are included in a cost estimation worksheet of a separate Excel model.

Truck Scales Cost	$64,900	
Interest Rate	6.00	%
Annual Use	4,228	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$6,490	
General Maintenance Factor	2.0	%
Maintenance per Year	$1,298	$/yr
Total Scales Capital	$64,900	
Total Hopper Labor+Fringe+OT	$80,644	$/yr
Total Scale Maintenance Cost	$1,298	$/yr
Scale Interest Cost per Unit	$6,403	$/yr
Total Scale Interest Cost	$6,403	$/yr
Total Scale Cost	$88,345	$/yr

The equipment costs were obtained from a local equipment dealer. The lifetime and salvage factor was not provided by the manufacturer, so they were assumed as shown. A maintenance cost equal to 2% of the purchase price was also assumed.

14. UNLOADING GROUND FEEDSTOCK

Assumptions

- Truck unloading and handling operations are completely enclosed to minimize dust and moisture issues.
- Unloading operations will be conducted 302 days/yr, 6 days/wk, 16 hrs/day (two 8 hr shifts) to coincide with the grinding schedule.
- Feedstock Characteristics:
  Format: Ground offsite
  Particle Size: ¼” –
  Conveying Density: 5.2 lb/ft3
  Moisture: 15.0%
- Feedstock Delivery:
  Infeed (Receiving Rate): 6.2 trucks/hr (9.7 min), 189 tons/hr, 58,500 bu/hr
  Outfeed (Plant Feed): 95 tons/hr, 29,500 bu/hr
  Truck Unload Time: 44 min.
  Unload Pits: 4
  Staggered Unload Time: 11 min.
- Equipment Amortization:
  Equipment Life: 15 years
  No salvage value at end of life
- Maintenance Costs
  Usage Maintenance: 3% of capital per 1000 hours use
  General Maintenance: 1% of capital per year

Equipment

4 - Dump Hopper - GSI Pit Conveyor, 10’, Model 21x21
4 - Dump Hopper Conveyors – GSI Horizontal En Mass Conveyor, 20’, 20,000 bu/hr, 7.5HP Model 3220
2 - Bucket Elevator – GSI 120’ long, 40,000 bu/hr, 200 HP, Model 400P48
2 - Bin Feed Conveyor – GSI Horizontal En Mass Conveyor, 75’ long, 40,000 bu/hr, 60 HP, Model 3632

Personnel

Unloading Operator – 4/shift; 2 shifts/day; 8 operators/day

Materials

None

Facilities

There are 4 unloading pits that must be covered to protect against wind and moisture. In addition, the pit house must contain a dust collection system for dust control during unloading.

Discussion

This task involves the feedstock handling operations at the plant, and includes the feedstock handling systems from truck unloading to interim storage. The main considerations for identifying the necessary equipment are feedstock format, infeed rate, bulk density, and the angle of repose of the feedstock. The feedstock is ground off-site and delivered to the plant at a rate of 189 tons per hour. The challenge associated with this application is the low bulk density of the feedstock. The bulk density is a function of the compressive gravimetric forces on the bulk material. Since the gravimetric forces are small given the volume of material in a conveyor (compared to a truck volume or large capacity storage bin), the bulk density for sizing conveyors is very low at 5.2 lb/ft3, compared to 11.50 and 14.1 in a truck and bin, respectively. With this low bulk density, the required volumetric flow rates are very large at nearly 73,000 ft^3 per hour (60,000 bushels per hour).

The most efficient way to move large quantities of bulk material on-site is via conveyors. Therefore, conveying systems are used to transfer the feedstock from the trucks to interim storage.

In order to meet the volumetric flow rate requirements with standard conveying systems, four unloading pits with two pits feeding two separate conveying systems are needed. As the feedstock is discharged from the truck into the dump hopper, it is conveyed from the pit to a bucket elevator and then to a horizontal conveyor that feeds the storage bin. All conveyors are enclosed for dust, moisture and wind control. The horizontal conveyors are en-masse drag conveyors. The handling equipment consists of grain handling equipment, but since this equipment is designed for handling grain at 40-50 lb/ft^3, the conveyor speed analysis is currently ongoing to determine the effectiveness of these systems for this application. Certainly the motors on these conveyors are oversized for handling this light material, and perhaps there are issues such as conveyor speed, bucket configuration, etc. that will cause handling problems.

Experimental Data

None

Costs

The detailed equipment costs presented below include capital, maintenance, ownership, and electricity costs. In addition, labor costs associated with this unit operation are also included. These calculations are included in a cost estimation worksheet of a separate Excel model.

The equipment costs for unloading and handling equipment are based on 2002 prices from a local dealer; the costs shown were obtained by scaling the 2002 costs to current dollars using the Chemical Engineering indices as discussed in section 2.0. The lifetime and salvage factor was not provided by the manufacturer, so they were assumed as shown. The maintenance costs are based on rule-of-thumb estimates from a bulk handling consultant. The maintenance costs include both usage maintenance and general maintenance. Annual general maintenance costs are estimated as 1% of the purchase price. Usage maintenance costs (shown as scheduled maintenance) are estimated as 3% of the purchase price for every 1000 hours of use.

Unloading Pit Cost	$13,720	
Interest Rate	6.00	%
Annual Use	4,228	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$1,372	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$232	
General Maintenance Factor	1.0	%
Maintenance per Year	$1,056	$/yr
Total Hopper Capital	$54,880	
Total Hopper Labor+Fringe+OT	$313,819	$/yr
Total Hopper Maintenance Cost	$4,224	$/yr
Hopper Interest Cost per Unit	$1,354	$/yr
Total Hopper Interest Cost	$5,415	$/yr
Total Hopper Cost	$323,458	$/yr

Pit Conveyor	$19,376	
Interest Rate	6.00	%
Annual Use	4,228	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$1,938	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$327	
General Maintenance Factor	1.0	%
Maintenance per Year	$1,491	$/yr
Power Rating	7.5	hp
Fuel Use	5.6	kW/hr
Fuel Cost per Year	946	$/yr
Total Hopper Conveyor Capital	$77,502	
Total Hopper Conveyor Fuel Cost	$3,783	$/yr
Total Hopper Conveyor Maintenance Cost	$5,965	$/yr
Hopper Conveyor Interest Cost per Unit	$1,912	$/yr
Total Hopper Conveyor Interest Cost	$7,647	$/yr
Total Hopper Conveyor Cost	$17,395	$/yr

Bucket Elevator	$225,375	
Interest Rate	6.00	%
Annual Use	4,228	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$22,537	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$3,260	
General Maintenance Factor	1.0	%
Maintenance per Year	$14,868	$/yr
Power Rating	200	hp
Fuel Use	149.1	kW/hr
Fuel Cost per Year	25,223	$/yr
Total Bucket Elevator Capital	$450,749	
Total Elevator Fuel Cost	$50,445	$/yr
Total Elevator Maintenance Cost	$29,737	$/yr
Elevator Interest Cost per Unit	$22,237	$/yr
Total Elevator Interest Cost	$44,474	$/yr
Total Elevator Cost	$124,656	$/yr

Bin Feed Conveyor	$99,607	
Interest Rate	6.00	%
Annual Use	4,228	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$9,961	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$1,681	
General Maintenance Factor	1.0	%
Maintenance per Year	$7,666	$/yr
Power Rating	60	hp
Fuel Use	44.7	kW/hr
Fuel Cost per Year	7,567	$/yr
Total Bin Feed Conveyor Capital	$199,214	
Total Bin Feed Fuel Cost	$15,134	$/yr
Total Bin Feed Maintenance Cost	$15,333	$/yr
Bin Feed Interest Cost per Unit	$9,828	$/yr
Total Bin Feed Interest Cost	$19,656	$/yr
Total Bin Feed Cost	$50,122	$/yr

15. PLANT QUALITY ASSURANCE

Assumptions

- The company will have it's own staff and laboratory to collect and analyze samples
- A single sample will be collected from every load
- Samples will be collected in the truck unloading facility
- Results of receiving sample analysis will be used to calculate "dockage" for final payment to growers
- QA samples will be archived for 3 years
- QA Data collected will be used by the plant to "blend" the biomass being stored at the plant.
- The calibration for a Near Infrared (NIR) instrument is available for all the sample variances including crop and condition.
- 2000 sq-ft facility with fume hood, bay doors, reception area, LAN computer hookups, compressed air, room temperature dry-archiving room
- The Laboratory Manager will work an 8 hour day that overlaps both shifts

Equipment

Laboratory Equipment:

Two NIR instruments @ $90,000 each ($180,000)

Four Laboratory Balances @ $10,000 each ($40,000)

One vacuum raffle splitter @ $800

Two Wiley #4 Mills @ $15,000 each ($30,000)

One Ro-Tap II 12" Shaker @ $2,250; 10 brass sieves @ $71 each (2,250 + 710 = $2,960

Two Drying ovens @ $10K

One DL77 Graphix Titrator @ $21,200

One Rondolino DL50 Automatic Titrator (automates sample changing) @ $4,590

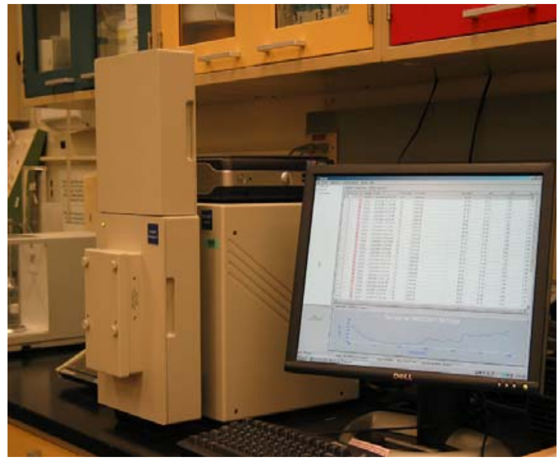
Titration supplies – Approximately $5,000 / yr

Cleaning supplies, Kimwipes, weigh pans, grinder consumable parts – Approximately $2,000 / yr

Calibration, Spares and Repairs (1% First Year Cost)

1 Standard PC with LAN capability – Dell Optiplex GX620 processor with Dell UltraSharp 2001FP 20" Flat Panel Monitor ($1,455)

Wiley Mill



Near Infrared Spectrometer

Figure 9. Laboratory equipment including a knife mill and Near Infared Spectrometer (NIR)

Personnel

The laboratory will be staffed by a full time lab manager and four laboratory technicians 6 days a week. It is anticipated that the Laboratory Manager will split his/her time between the morning and afternoon shifts. Two laboratory technicians will be assigned to each shift.

1 - Laboratory Manager
4 - Lab Technicians (2/shift)

Materials

The lab will require titration supplies, estimated to cost approximately $5,000/year. In addition to the equipment listed above, laboratory operations will also require routine expendable supplies such as cups, dishes, cleaning agents, labels, bags, boxes, cleaning supplies, weigh pans, grinder consumable parts and other miscellaneous supplies estimated to cost approximately $2,000/yr. Laboratory operations will also consume approximately $9,000 in chemicals per year.

Facilities

The laboratory facility will be located at the ethanol plant and consist of approximately 2000 sq-ft of combined office, laboratory and storage space. The laboratory space will have a standard fume hood, sample receiving and preparation areas, and sinks. In addition, the facility will need chemical storage and a source of compressed air: The facility will also require a room-temperature dry-archiving storage room.

Discussion

This Quality Assurance task is closely related to the QA sampling, testing and reporting described in section 8.0 Field Quality Assurance, but the plant QA element concentrates on sampling the ground biomass in the trucks as they come into the plant. Much of the equipment is the same and will be used for both processes. The laboratory will be staffed by a full time lab manager and four laboratory technicians 6 days a week. It is anticipated that the Laboratory manager will split his/her time between the morning and afternoon shifts. Two laboratory technicians will be assigned to each shift.

The normal test procedure will determine feedstock chemical composition using Near Infrared Spectroscopy (NIR) (Figure 9) for the following constituents: glucan, xylan, lignin, protein, acetyl, uronic acids, galactan, arabinan, mannan and structural inorganics.. This analysis task assumes that the calibration of a Near Infrared (NIR) instrument is available for all the sample variances including crop and condition. Laboratory preparation of the field samples includes grinding, weighing and cleaning; this is estimated to take approximately 5-8 minutes per sample. NIR analysis will take an additional 3-5 minutes per sample to load the sample, run the analysis and unload the sample. Data reporting and tabulation are estimated to take approximately 1 minute per sample, and archiving is estimated to also take approximately 1 minute per sample. The total time necessary for laboratory testing from receiving through archiving is estimated to be approximately 10-15 minutes per sample. If one sample is collected from every truck crossing the plant scale, 27,482 samples will be collected and analyzed each year. Assuming 12.5 minutes per sample, laboratory testing of field samples requires about 5700 hrs of lab time annually. Testing of the field samples, sample archiving and special analysis will account for the remaining hours for the four technicians.

In addition to NIR testing, some samples will be analyzed to determine buffering potential to provide critical information on dilute acid pretreatment levels when the biomass enters the refinery operation. Labor for the buffering titrations is expected to take approximately 10 minutes per sample for buffering titrations. These will occur on a limited basis, costing approximately $50/sample.

In order to calibrate the equipment in the laboratory, it will be necessary to run a wet chemistry validation. This validation process will be run quarterly, or according to observed sample variance, or other problems that may become obvious during sample analysis. This calibration process is estimated to cost approximately $1000/sample.

It is anticipated that for the first 3 years of operation, the biorefinery will want to archive samples for evaluating plant efficiency verses biomass type and origin. Each sample will occupy a volume of approximately 1 cup. Archiving is estimated to take approximately 1 min/sample

Experimental Data

None

Costs

Cost of laboratory equipment and supplies for startup operations of a QA/QC laboratory is estimated at approximately $310,000. This estimate was determined from actual equipment and materials recently purchased, and from pricing on the internet. The equipment, materials and supply prices are shown in Table 9.

Table 9. Cost of laboratory equipment and supplies

Laboratory Equipment & Supplies	**Dollars**
Two NIR instruments @ $90,000 each ($180,000)	180,000
Four Laboratory Balances @ $10,000 each ($40,000)	40,000
One Vacuum, riffle splitter @ $800	800
Two Wiley #4 mills @ $15,000 each ($30,000)	30,000
One Ro-tap II 12” shaker @ $2,250; 10 brass sieves @ $71 each (2,250 + 710 = 2,960)	2,960
2 drying ovens @ $10K	10,000

5 Coring Tool Systems- Coring tool $150 each; Honda EU2000i Portable Generator $1,080 each; and Dewalt DW138 Heavy-Duty ¾" Drill $580 each (600 + 5400 + 2900 = 8,900)	8,900
One DL77 Graphix Titrator @ $21,200	21,200
One Rondolino DL50 Automatic Titrator (automates sample changing) @ $4,590	4,590
Titration supplies – Approximately $5,000 / yr	5,000
Cleaning supplies, Kimwipes, weigh pans, grinder consumable parts – Approximately $2,000 / yr	2,000
Calibration, Spares and Repairs (1% First Year Cost)	3,055
Shelving for archiving samples	1,500
Laboratory Equipment & Supplies Subtotal	***310,005***

16. FEEDSTOCK STORAGE

Assumptions

- Plant demand is 2,286 tons/day, 95.2 tons/hr.
- There will be a 3 day (72 hours) supply (6,858 tons) of feedstock in interim storage.
- Material will be stored in concrete Eurosilos.
- Moisture content of the bulk material is 15.0% or less.
- Bulk density of the material is 14.1 lb/ft^3.
- Storage requirement is 973,000 ft^3.

Equipment

2 - Eurosilo Mechanism; ESI 15000 m3 (426,000 bu) Eurosilo mechanical & electrical
2 - Concrete Silo; ESI 100' dia. X 98' wall (72' material)

Personnel

None

Materials

None

Facilities

Two Concrete Silos, 100' diameter x 98' wall

Discussion

The plant feedstock supply system is designed to have a 72-hr supply of feedstock on hand at the plant at any given time. Therefore the plant will be storing approximately 6,858 tons of ground material.

Bulk storage is typically done in material stockpiles or in enclosed vertical silos or bins. Material stockpiles can be classified in four general categories by their shape: ring, conical, longitudinal and irregular. Ring piles are created using a circular stacker that pivots about the center of the stack. Conical piles are created by a fixed drop from above the center of the stack. Longitudinal piles are created using a linear traveling stacker or a conveyor with multiple intermediate discharges. Irregular piles are formed from non-automated equipment such as dumping from trucks and using a front-end loader for stacking and spreading. Most piles have traditionally been left uncovered, but environmental concerns of dust, contaminated runoff and odor often require covered storage.

Silo storage is generally regarded as smaller capacity and more expensive than open stockpiles, but silos have the advantage of space utilization (1/4 the footprint of an open stockpile), automation, full enclosure and less material segregation. Given these advantages, upright silos were selected for storage. However, as explained in the Experimental Data section below, the extremely high cohesive strength of the bulk feedstock causes serious flowability problems. Due to the high cohesive strength, arching and ratholing problems prevent the use of conventional flat-bottom or hopper-style silos that rely on material flowability through gravity discharge. Consequently, a Eurosilo storage system (Figure 13) was chosen for this application. With the Eurosilo system, the bulk material is fed in the top center of the silo, descends through a telescopic spout and is uniformly distributed by a screw conveyor system suspended from a slewing bridge structure.. The silo contents are built up in horizontal layers from the bottom up.

The key concept of the Eurosilo design is the reclaim mechanism. To reclaim the material, the direction of rotation of the screw conveyors is reversed. The screw conveyors feed the material to a slotted central column, As the reclaimed material is fed through the horizontal slots, it descends freely by gravity through the vertical artificial flow channel of the column. This reclaim device guarantees the reclamation of difficult, cohesive materials. Another advantage of filling and discharging in horizontal layers is the ability to blend bulk materials during in the storage process.

Enclosed, gravity discharge stockpiles are less expensive than the Eurosilo system, but if positive-discharge reclaim equipment, which is required for cohesive materials, is located in the enclosure, the costs of the two are similar. However, the Eurosilo still has the advantage of space utilization, automation and less segregation.

At a bin bulk density of 14.1 lb/ft^3, the silos must store nearly 973,00 ft^3 of feedstock. Therefore, the current design utilizes two 15,000 m3 (530,000 ft3) Eurosilos which can each hold 3700 tons of feedstock. The Eurosilo mechanism shown in Figures 12 and 13 and discussed above is purchased from ESI. The Eurosilo structure, which may consist of either a steel framing structure with an inner and outer wall or a slip-formed concrete wall structure, must be supplied by another vendor.

Experimental Data

A measure of flowability of the bulk material is the measure of the unconfined yield strength as a function of the major consolidation stress. The flowability can be represented by a flowability coefficient (ffc), defined as the ratio of the consolidation stress to the unconfined yield strength. The larger ffc is, the better a bulk solid flows (Figure 10). Often the following ranking is used:

ffc < 1 not flowing
1 < ffc < 2 very cohesive (to non-flowing)
2 < fcf < 4 cohesive
4 < ffc < 10 easy-flowing
10 < ffc free-flowing

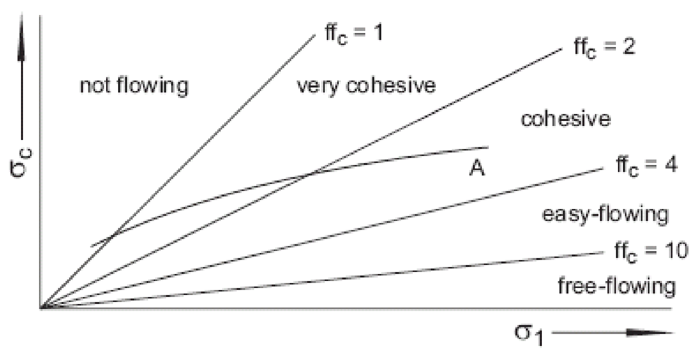


Figure 10. Unconfined yield strength dependence on the consolidation stress; lines of constant flowability.

The unconfined yield strength data for ground barley straw is shown in Figure 11. After 72-hrs of consolidation, the ffc ranges from 0.45 to 1.36, which means that this material falls within the worst flowabilty zone as defined in by Figure 10.

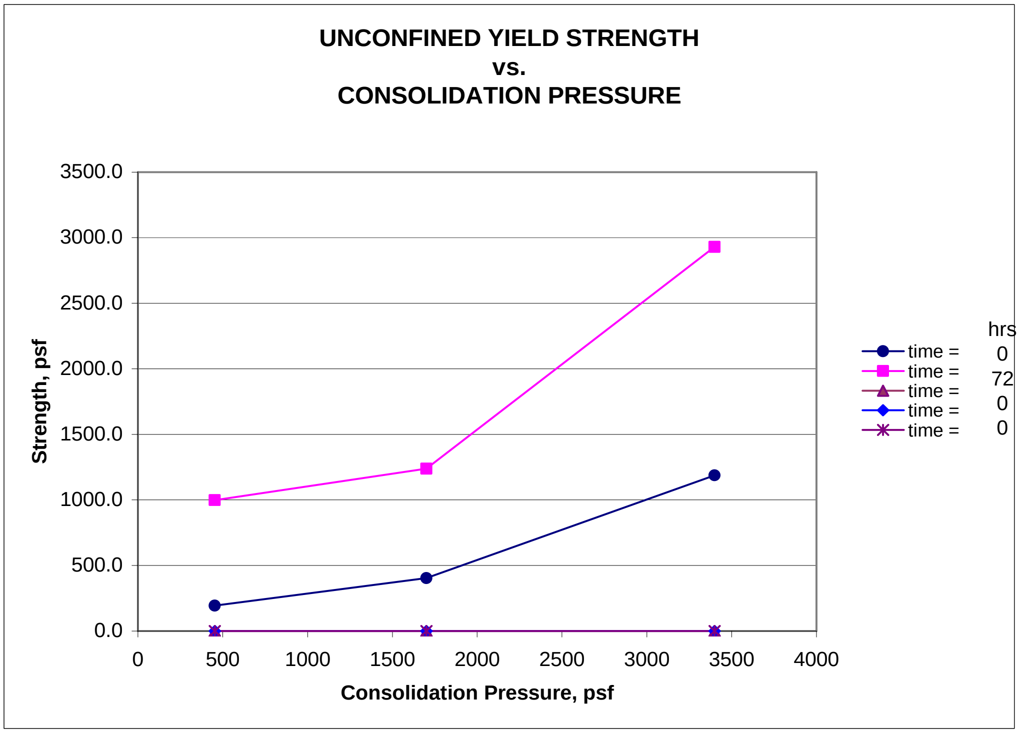


Figure 11. Flowability measurements for ground barley straw.

Costs

The detailed equipment costs presented below include capital, maintenance, ownership, and electricity costs. In addition, labor costs associated with this unit operation are also included. These calculations are included in a cost estimation worksheet of a separate Excel model.

Eurosilo Mechanism Cost	$2,307,294	
Interest Rate	6.00	%
Annual Use	8,400	hrs/yr
Life Time	30.0	yrs
Salvage Factor	0.10	
Salvage Value	$230,729	
Fuel Use		kW/hr
Fuel Cost per Year		$/yr
General Maintenance Factor	1.0	%
Maintenance per Year	$20,092	$/yr
Total Eurosilo Mechanism Capital	$4,614,588	
Total Eurosilo Mechanism Fuel Cost	$0	$/yr
Total Eurosilo Maintenance Cost	$40,184	$/yr
Eurosilo Interest Cost per Unit	$164,704	$/yr
Total Eurosilo Interest Cost	$329,408	$/yr
Total Eurosilo Cost	$369,592	$/yr
Concrete Silo Cost	$2,738,628	
Interest Rate	6.00	%

Annual Use	8,400	hrs/yr
Life Time	30.0	yrs
Salvage Factor	0.00	
Salvage Value	$0	
General Maintenance Factor	1.0	%
Maintenance per Year	$23,848	$/yr
Total Concrete Silo Capital	$5,477,256	
Total Silo Labor+Fringe+OT	$190,998	$/yr
Total Silo Maintenance Cost	$47,696	$/yr
Silo Interest Cost per Unit	$198,958	$/yr
Total Silo Interest Cost	$397,917	$/yr
Total Silo Cost	$445,613	$/yr

The Eurosilo mechanism cost was given by the manufacturer. The Eurosilo manufacturer does not build the concrete silo enclosure, but the cost shown was provided by the Eurosilo manufacturer as an estimate. The lifetime and salvage factor for the Eurosilo mechanism was not provided by the manufacturer, so a long life and minimal salvage value was assumed as shown. The lifetime of the concrete silo was assumed to be the same as the Eurosilo, but since the concrete silo is a building rather than a piece of equipment it was not given a salvage value. The annual Eurosilo maintenance cost was estimated to be 1% of the purchase price; this estimate was provided by the Eurosilo representative. Although the maintenance of the concrete silo should be minimal, we assumed the same 1% maintenance factor as was given for the Eurosilo.

17. STORAGE TO REACTOR — TRANSPORTATION

Assumptions

- Feedstock Characteristics:
  Conveying Density: 5.2 lb/ft3
  Moisture: 15.0%
- Feedstock Delivery:
  Infeed (Receiving Rate): 189 tons/hr, 58,500 bu/hr
  Outfeed (Plant Feed): 95 tons/hr, 29,500 bu/hr
- Eurosilo is capable of simultaneous fill and discharge.
- Equipment Amortization:
  Equipment Life: 15 years
  No salvage value at end of life
- Maintenance Costs
  Usage Maintenance: 3% of capital per 1000 hours use
  General Maintenance: 1% of capital per year

Equipment

1 - Bin Discharge Conveyor; GSI Horiz. En Masse Conveyor, 110'L, 30,000 bu/hr, 75 HP, Model 3232
1 - Bin Discharge Conveyor; GSI Horiz. En Masse Conveyor, 150'L, 30,000 bu/hr, 100 HP, Model 3232

Personnel

Feed Operator (1 per storage bin) – 2 Operators/shift; 3 shifts/day; 6 Operators/day

Materials

None

Facilities

None

Discussion

Feeding the reactor, either continuously or in a batch process, requires moving the feedstock from the storage bins to the "throat" of the reactor. The same handling issues exist in this operation as was discussed in the truck unloading section (Section 13.0) above. During the plant receiving hours (6 days/week, 16 hours/day) when feedstock is being delivered to the plant, the total infeed rate to the plant is 189 tons per hour, while the plant demand is 95 tons per hour. Therefore, it is necessary to send the required portion directly while putting the excess in storage. This is accomplished in the Eurosilo which simultaneously fills and discharges the feedstock using a mass flow sensor at the silo inlet that diverts the appropriate amount of the feedstock into the central reclaim column of the Eurosilo, while the remaining feedstock is sent to the fill mechanism. During non-receiving hours, the feedstock is reclaimed directly from the one or both Eurosilos. Horizontal en-masse conveyors positioned below the reclaim mechanisms of the Eurosilos to transfer the feedstock from the Eurosilos to the throat of the reactor. This conveying system is also shown in the drawing of the plant handling system (Figure 12).

Experimental Data

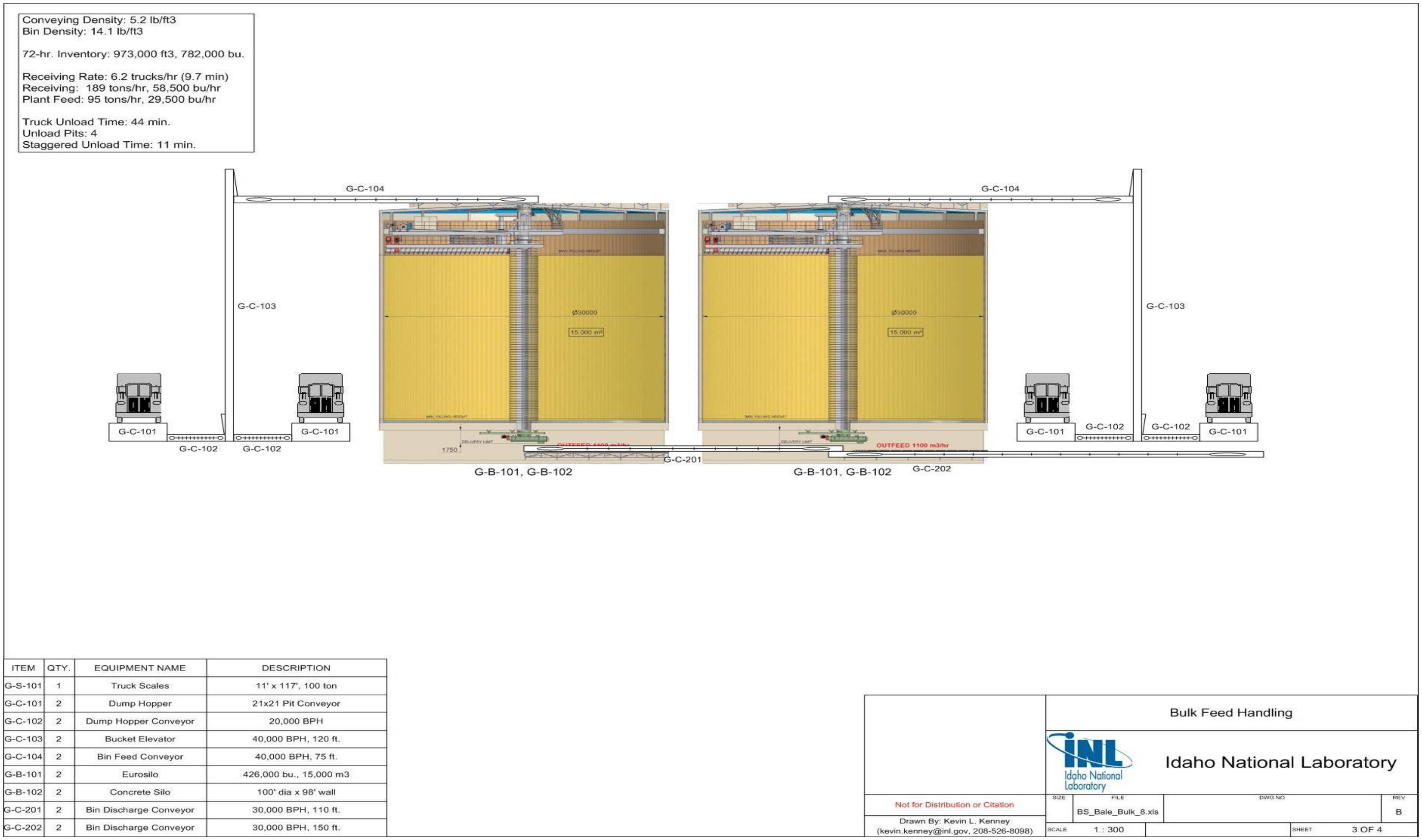
None

Costs

The detailed equipment costs presented below include capital, maintenance, ownership, and electricity costs. In addition, labor costs associated with this unit operation are also included. These calculations are included in a cost estimation worksheet of a separate Excel model.

Bin #1 Discharge Conveyor Cost	$116,279	
Interest Rate	6.00	%
Annual Use	8,400	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$11,628	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$2,354	
General Maintenance Factor	1.0	%
Maintenance per Year	$20,563	$/yr
Power Rating	75	hp
Fuel Use	55.9	kW/hr
Fuel Cost per Year	$18,792	$/yr
Total Bin Discharge Conveyor Cost	$116,279	
Total Conveyor Fuel Cost	$18,792	$/yr
Total Conveyor Maintenance Cost	$20,563	$/yr
Conveyor Interest Cost per Unit	$11,473	$/yr
Total Conveyor Interest Cost	$11,473	$/yr
Total Conveyor Cost	$50,827	$/yr
Bin #2 Discharge Conveyor Cost	$146,102	
Interest Rate	6.00	%
Annual Use	8,400	hrs/yr
Life Time	15.0	yrs
Salvage Factor	0.10	
Salvage Value	$14,610	
Maintenance Schedule	1000	hrs
Maintenance Cost per Schedule	$2,958	
General Maintenance Factor	1.0	%
Maintenance per Year	$25,836	$/yr
Power Rating	100	hp
Fuel Use	74.6	kW/hr
Fuel Cost per Year	$25,056	$/yr
Total Bin Discharge Conveyor Capital	$146,102	
Total Conveyor Fuel Cost	$25,056	$/yr
Total Conveyor Maintenance Cost	$25,836	$/yr
Conveyor Interest Cost per Unit	$14,415	$/yr
Total Conveyor Interest Cost	$14,415	$/yr
Total Conveyor Cost	$65,307	$/yr

The conveyor costs are based on 2002 prices from a local dealer; the costs shown were obtained by scaling the 2002 costs to current dollars using the Chemical Engineering indices as discussed in section 2.0. The lifetime and salvage factor was not provided by the manufacturer, so they were assumed as shown. The maintenance costs are based on rule-of-thumb estimates from a bulk handling consultant. The maintenance costs include both usage maintenance and general maintenance. Annual general maintenance costs are estimated as 1% of the purchase price. Usage maintenance costs (shown as scheduled maintenance) are estimated as 3% of the purchase price for every 1000 hours of use.



ITEM	QTY.	EQUIPMENT NAME	DESCRIPTION
G-S-101	1	Truck Scales	11' x 117', 100 ton
G-C-101	2	Dump Hopper	21x21 Pit Conveyor
G-C-102	2	Dump Hopper Conveyor	20,000 BPH
G-C-103	2	Bucket Elevator	40,000 BPH, 120 ft.
G-C-104	2	Bin Feed Conveyor	40,000 BPH, 75 ft.
G-B-101	2	Eurosilo	426,000 bu., 15,000 m3
G-B-102	2	Concrete Silo	100' dia x 98' wall
G-C-201	2	Bin Discharge Conveyor	30,000 BPH, 110 ft.
G-C-202	2	Bin Discharge Conveyor	30,000 BPH, 150 ft.

Figure 12. Process schematic for bulk feedstock handling and storage at the plant.

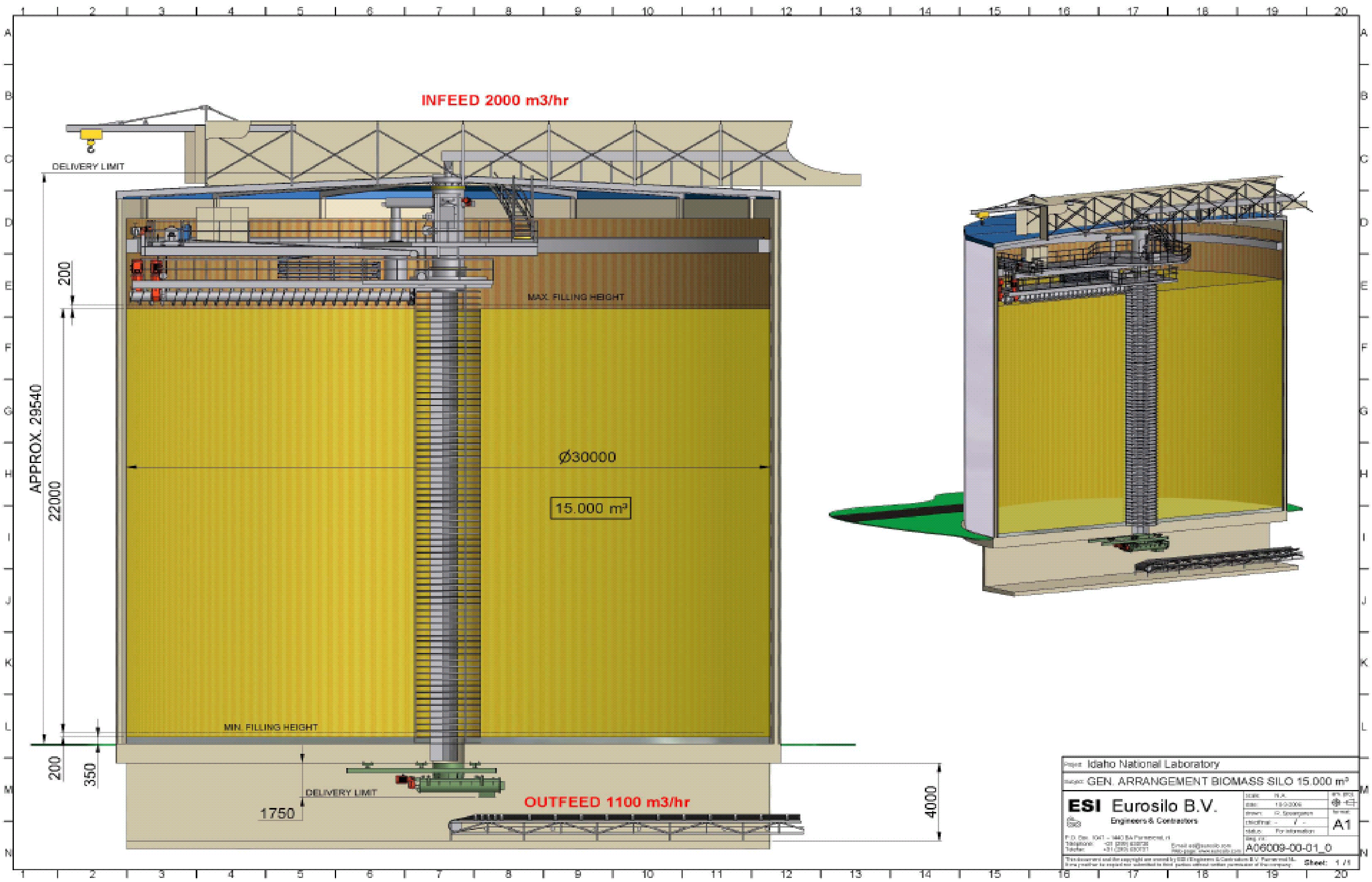


Figure 13. Eurosilo for 72-hr inventory storage.

18. MANAGEMENT SYSTEMS AND FACILITIES

Assumptions

- The bulk collection and delivery system will be an independent financial entity from the ethanol plant
- Management covers straw delivery from initial contracting with growers to delivery to the throat of the bioreactor at the ethanol plant.

Equipment

Company supplied vehicles for President/CEO, General Manager, Field Representatives
Light duty trucks for repairs and routine maintenance

Personnel

President/Chief Executive
General and Operations Manager
Secretary
Accountant
Lawyer
Human Resources Manager
Safety Manager
Electrician
Billing Clerks
Office Clerk, General
Dispatchers
Field Representatives - Straw Buyers
Mechanic
Mechanics Helper
Shift Supervisors
Laboratory Supervisor
Laboratory Technicians
Truck Weighing & Sampler

Materials

Materials in this element would include office furniture and equipment, and all other materials and supplies necessary to run a business of this type. A list of materials is presented in Appendix C-2.

Facilities

The footprint for the feedstock receiving and short term storage is estimated to be approximately five acres to accommodate all the required elements. The facility will need an office building, a laboratory building and a maintenance shop. In addition there will be a parking lot for employees and areas to park equipment. The entire facility will be fenced with an 8-foot chain link fence topped with 3 strands of barbed wire. The facility will have a main gate and 2 personnel gates. A security system consisting of cameras will provide coverage of the gates, fence line, and key work areas such as the fueling station, unloading pits and silos. Table 10 lists the assumptions behind a five acre design.

This model also assumes the facility will require 1000 kVA electrical service including a transformer, switchgear and distribution system. This will suppy the material handling systems as well as facility lighting which will include lighting for parking areas, equipment areas, open areas and work specific areas. Lighting will consist of both mast mounted lights and localized lights mounted in and on buildings.

Table 10. Footprint elements for a 800,000 ton/year receiving operation.

Element	Required Space
Employee Parking for 110 vehicles	39,600 ft^2
Maintenance Shop	3,200 ft^2
Office	3,520 ft^2
Lab	2,000 ft^2
Silos	15,700 ft^2
Fuel Depot	3,200 ft^2
Truck Unload, scales, pit, access/egress road	40,000 ft^2
Truck, trailer and equipment parking/storage	33,000 ft^2
Setback and Circulation	49,000 ft^2
Total	189,820 ft^2

Construction cost for office and lab space – Typical office space $150 sq ft Allow 100 sq ft per person. Allow 60% more space for other space such as closets, janitor space, storage, bathrooms, etc. Include conference and break rooms separately. A small lab will run about $900/sqft, and a bigger lab would be about $700/sqft

Discussion

Management of an operation of this size and magnitude can be quite variable, depending on how the company is organized and operated. For instance, if the feedstock supply operations were part of, or a subsidiary of the overall ethanol production plant, there would not be need for a president, directors, legal services, accounting, etc. However, if the feedstock supply operation were to be organized as a separate entity or company, these positions would be required. This scenario is based on the assumption that the feedstock supply operations would be a separate entity. A generalized organization diagram is presented in Figure 14.

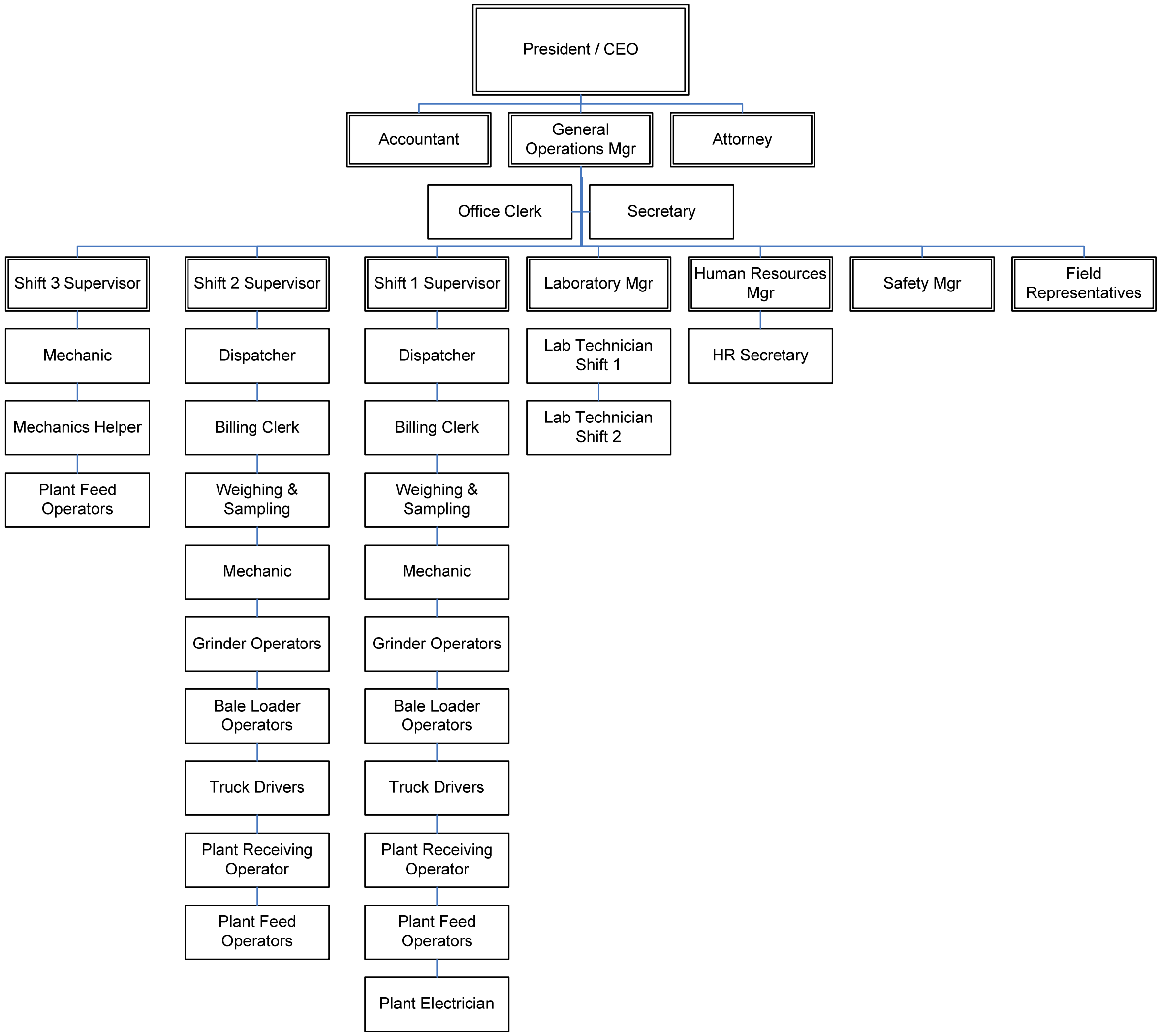


Figure 14. Generalized organization diagram for a biomass feedstock supply business.

Costs

Most of the labor rates used in the model come from the Idaho Occupational Employment & Wage Survey-2006 for the Eastern Idaho area. These labor rates are presented in Appendix C table C-1. The estimated startup cost for facilities and equipment independent of the feedstock handling, grinding and transportation cost reported in other sections of this report, is approximately $3,000,000. Additional information on facilities and materials costs used to arrive at this estimate are presented in the Appendix C, Table C-2.

19. ENVIROMENTAL CONTROLS, PERMITTING AND WASTE STREAMS

Assumptions

- Air Permits are not required for field grinding operations
- Truck unloading operations will require baghouse systems to control particulates
- Total particulate emissions will stay below 100 tons per year and the operations will receive "minor source" status
- A Stormwater Pollution Prevention Control (SPPC) plan will be required
- Waste stream permitting will be evaluated and permits may be required

Equipment

None

Personnel

Once the enterprise is operating, permitting and reporting responsibilities will primarily be handled by the Laboratory Manager

Materials

None

Facilities

None

Discussion

The unloading, transfer and storage facilities will occupy approximately five acres. In permitting an industrial operation of this type there are four major areas or waste streams of greatest importance: particulate air pollution; storm water runoff; fuel leaks and laboratory chemical waste.

The air permit is the individual permit of most concern. In Idaho there are three main categories of air permits: minor source, major source and Permit of Significant Deterioration (PSD), listed in order of increasing complexity. Because this model performs the biomass grinding operations offsite, the only air pollutant believed to be of concern is the dust generated from the unloading and transfer of the ground biomass material from truck to storage and storage to the bioreactor. These operations is expected to generate less than 100 tons per year, thus qualifying as a minor source under Idaho regulations.

The facilities will have truck refueling capabilities at an onsite fuel depot to run the fleet of trucks transporting the biomass. This fueling facility will be a 10,000 gallon above ground storage tank. Due to this and other factors, the overall facility will require a stormwater Pollution Prevention Plan. The fueling system will be required to have a secondary containment design for storm water runoff protection.

Appendix F contains a table of the key permitting requirements for a facility of this type if it were to be built in Idaho.

A list of the chemicals that will be present in the laboratory and on the site is presented in Appendix G, Table G-1. A review of the chemicals and the anticipated quantities against the reporting requirements for Idaho indicates all are below the reporting thresholds. This would be confirmed during the actual design of the laboratory space. During operations, there are likely to be some reporting requirements to state agencies, but there appear to be no environmental permitting issues with the laboratory chemicals

Experimental Data

None

Costs

Estimated cost for permits is presented in the table in appendix F

20. REFERENCES

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Patterson, Paul. 2003. Revised Straw Estimates for Eastern Idaho, personal communication (Fax 23 September 2003)

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American Society of Agricultural Engineers (ASAE) Standard, Agricultural Machinery Management Data, ASAE D497.4 FEB03.

Perlack, R., and R. Hess. 2006. Biomass resources for liquid fuels production. 28th Symposium on Biotechnology for Fuels and Chemicals. Nashville, TN April 30- May 3, 2006.

21. APPENDICES

This section contains the detailed cost summary worksheet as well as specifications for the equipment, labor rates, transportation regulations, insurance, etc., listed in this report.

Appendix A

Supply System Cost Summary Worksheet

Appendix A

Supply System Cost Summary Worksheet

This appendix contains the cost summary sheet for the unit operations discussed above for the supply system analysis.

Feedstock Supply System Cost Summary Sheet

Plant Operation Size (tons)				800,000
Plant Location				Idaho
Vehicle Length Limit (ft.)				115
Gross Vehicle Weight Limit (lbs)				105,500
State Sales Tax				5.00%
Federal Excise Tax				12.00%
Interest Rate				6.00%
Purchase Price / List Price				0.9
Cost Index Year				**2006**
HARVESTING				
Harvest Window (hours/days/weeks)				13.4951/6/6
Labor Schedule (# shifts - hours/shift)				1 -
Residue cost to grain cost (%)				0.0%
Harvesting Costs	**Qty.**	**% Util.**		**$/dTon**
Combines				
Unit #1 (Combine/Header)				
02 Combine (Extra Large Capacity)				
02 Grain Head (Extra Large Capacity)	162	100%	$	-
Unit #2 (Combine/Header)				
00 None				
00 None	-	-	$	-
Unit #3 (Combine/Header)				
00 None				
00 None	-	-	$	-
Windrowers				
Unit #1 (Windrower/Header)				
00 None				
00 None	-	100%	$	-
Unit #2 (Windrower/Header)				
00 None				
00 None	-	-	$	-
Unit #3 (Windrower/Header)				
00 None				
00 None	-	-	$	-
Total Weighted Harvesting Costs			**$**	-
Tractors	**Qty.**			**$/hr**
01 John Deere 8230 245 hp (200 PTO hp)	111		$	47.22
00 None	-		$	-
00 None	-		$	-
00 None	-		$	-
00 None	-		$	-
00 None	-		$	-
BALING				
Baling Window (hours/days/weeks)				12/6/4
Labor Schedule (# shifts - hours/shift)				1 -
Baling Costs	**Qty.**	**% Util.**		**$/dTon**
Large Balers				
01 Hesston 4910 Lg Sq 48" X 96"	111	100%	$	11.11
00 None		-	$	-
00 None		-	$	-
00 None		-	$	-
00 None		-	$	-
00 None		-	$	-
Total Weighted Baling Costs	-		**$**	**11.11**
COLLECTION				
Average Haul Distance (miles)				0.5
Square Bales - Tons				800,000
Round Bales - Tons				0
Collection Window (hours/days/weeks)				13.269/6/7
Labor Schedule (# shifts - hours/shift)				1 -
Collection Costs	**Qty.**	**% Util.**		**$/dTon**
Self Propelled Bale Hauler-Stackers				
01 Stinger Stacker 6500	48	100%	$	2.04
00 None	-	-	$	-
Loader Option #1: Self Propelled Loaders				
00 None	-	-	$	-
00 None	-	-	$	-
Loader Option #2: Tractor Mounted Loaders				
00 None	-	-	$	-
00 None	-	-	$	-
Hauler Option #1: Tractor/Trailer Combo				
Unit # 1: Tractor/Trailer				
00 None	-			
00 None	-	-	$	-
Unit # 2: Tractor/Trailer				
00 None	-			
00 None	-	-	$	-
Unit # 3: Tractor/Trailer				
00 None	-			
00 None	-	-	$	-
Hauler Option #2: Tractor Drawn				
00 None	-	-	$	-
00 None	-	-	$	-
Unloading/Stacking Option #1: Self Propelled				
00 None	-	-	$	-
00 None	-	-	$	-
Unloading/Stacking Option #2: Tractor Mounted				
00 None	-	-	$	-
00 None	-	-	$	-
Total Weighted Collection Costs			**$**	**2.04**

ID_Wheat_800kPioneer Wheat Straw				
Percent Moisture of Feedstock				15.00%
Estimated Yield (tons/acre)				1.88
Acres Harvested Annually				426,667
Feedstock Harvested Annually (tons)				800,000
GROWER PAYMENT:	$10.00 per dry ton			
FEEDSTOCK COST	**$38.43 per ton as-received**			
	$45.22 per dry ton			
STORAGE				
Avg. Tons Stored per Site				300
Annual Precipitation, in.				8.23
Storage Dry Matter Losses				5.00%
Storage Footprint at Site, sq. ft.				17,360
Min. Separation per Insurance, ft.				100
Land Rent Cost, $/acre/yr.				123.8
Management Cost per Ton				0.44
Insurance Cost per Ton			$	0.05
Storage Costs		**% Util.**		**$/dTon**
Storage Format				
01 Stack		100%	$	2.13
00 None		-	$	-
Storage Cover				
00 None		-	$	-
00 None		-	$	-
Total Weighted Storage Costs			**$**	**2.13**
BALE TRANSPORTATION				
Average Haul Distance (miles)				0
Square Bales (tons)				800,000
Round Bales (tons)				0
Transport Window (hours/days/weeks)		14/6/52		
Labor Schedule (# shifts - hours/shift)		2 - 8		
Bale Transportation Costs	**Qty.**	**% Util.**		**$/dTon**
Self-Propelled Bale Loaders				
00 None	-	90%	$	-
00 None	-	10%	$	-
Tractor/Trailer Bale Haulers				
Unit # 1: Tractor/Trailer				
00 None	-			
00 None	-	25%	$	-
Unit # 2: Tractor/Trailer				
00 None	-			
00 None	-	25%	$	-
Unit # 3: Tractor/Trailer				
00 None	-			
00 None	-	50%	$	-
Self-Propelled Bale Loader-Stackers				
00 None	-	90%	$	-
00 None	-	10%	$	-
Total Weighted Bale Transport Costs			**$**	-
PREPROCESSING (GRINDING)				
Baling Window (hours/days/weeks)				13.3183/6/52
Labor Schedule (# shifts - hours/shift)				2 - 8
Preprocessing Costs	**Qty.**	**% Util.**		**$/dTon**
Self-Propelled Bale Loaders				
01 Caterpillar TH220B Telehandler	10	100%	$	1.39
00 None	-	-	$	-
Grinders				
01 Diamond Z 1352L tub grinder	10	100%	$	6.13
00 None	-	-	$	-
Total Weighted GrinderCosts			**$**	**7.52**
BULK TRANSPORTATION				
Average Haul Distance (miles)				47.5
Feedstock Bulk Density (lb/cu ft)				11.5
Unload Time (minutes)				43.9
Queue Wait Time (minutes)				45.4
Transport Window (hours/days/weeks)				13.3183/6/52
Labor Schedule (# shifts - hours/shift)				2 - 8
Bulk Transportation Costs	**Qty.**	**% Util.**		**$/dTon**
Tractor/Trailer Bulk Haulers				
Unit # 1: Tractor/Trailer				
01 Kenworth T800 3-axle day cab	34			
01 Trinity Trailer "Eagle Bridge" 42', 29"/4' s	68	100%	$	9.87
Unit # 2: Tractor/Trailer				
00 None	-			
00 None	-	-	$	-
Unit # 3: Tractor/Trailer				
00 None	-			
00 None	-	-	$	-
Total Weighted Bulk Transport Costs			**$**	**9.87**
Plant Handling and Queing ($/dTon):			**$**	**2.54**
LABOR				
Operation	**Qty.**	**Hours**		
Harvesting	162	78,703		
Baling	111	62,602		
Collection	48	26,750		
Storage	-	-		
Bale Transportation	-	-		
Preprocessing	40	199,680		
Bulk Transportation	68	339,456		

HARVESTING			BALE TRANSPORTATION		
Capital Costs ($/yr)	$	-	Capital Costs ($/yr)	$	-
Operating Costs ($/yr)	$	-	Operating Costs ($/yr)	$	-
Labor Costs ($/yr)	$	-	Labor Costs ($/yr)	$	-
Total Annual Costs	$	-	Total Annual Costs	$	-
Total Capital	$	-	Total Capital	$	-
BALING			**PREPROCESSING (GRINDING)**		
Capital Costs ($/yr)	$	3,679,047	Capital Costs ($/yr)	$	996,468
Operating Costs ($/yr)	$	3,321,665	Operating Costs ($/yr)	$	2,778,419
Labor Costs ($/yr)	$	555,944	Labor Costs ($/yr)	$	1,338,388
Total Annual Costs	$	7,556,656	Total Annual Costs	$	5,113,276
Total Capital	$	28,495,508	Total Capital	$	6,848,009
ROADSIDING			**BULK TRANSPORTATION**		
Capital Costs ($/yr)	$	565,560	Capital Costs ($/yr)	$	1,288,639
Operating Costs ($/yr)	$	585,703	Operating Costs ($/yr)	$	3,054,188
Labor Costs ($/yr)	$	237,339	Labor Costs ($/yr)	$	2,368,213
Total Annual Costs	$	1,388,603	Total Annual Costs	$	6,711,040
Total Capital	$	7,413,024	Total Capital	$	11,965,758
STORAGE			**TOTAL CAPITAL INVESTMENT**		
Capital Costs ($/yr)	$	-	On-Farm Enterprise	$	35,908,533
Operating Costs ($/yr)	$	1,449,760	Plant-Gate Enterprise	$	18,813,767
Labor Costs ($/yr)	$	-	Total Supply System Enterprise	$	54,722,300
Total Annual Costs	$	1,449,760			
Total Capital	$	-			

Appendix B

Equipment Specifications

Appendix B

Equipment Specifications

This appendix contains the detailed specifications for the equipment listed in this report. The equipment includes:

Diamond Z 1460B Tub Grinder
John Deer 8230 Tractor
Hesston 4910 Baler
Caterpillar TH220B Telehandler
Stinger 6500
Total Truck Scales

Diamond Z 1460B Tub Grinder

Specifications:
Engine: Caterpillar Optional 1000 hp, 860 hp, or 800 hp
Weight - 60,000 lbs. – approximate;
Length - 33 ft. 6 in. (10.21 meters);
Width - 11 ft. 11 in. (3.63 meters);
Tub Diameter - 14 ft. (4.26 meters);
Screen Area - 3,960 sq. in. (10058.40 cm);
Conveyor Width, Phase I - 42 inches; Conveyor Width, Phase II - 30 inches
Hammermill & Hammers: 60 in. Hammermill 26 @ 40 Lbs. Each (Fixed); Industry's Largest Deflector Shield for Safety
Drive: Direct
Radio Remote: Standard; Self-Diagnostic
Fuel - 457 Gallons (1730 Liters) – approximate;
Hydraulic Oil- 115 Gallons (435 Liters) - approximate
Production Rates: Stumps & Logs - Up to 70 Tons or 210 Yards Per Hour; Brush & Yard Waste - Up to 85 Tons or 340 Yards Per Hour; Pallets & Construction Waste - Up to 95 Tons or 665 Yards Per Hour; Passenger Tires - Up to 1500 Tires Per Hour @ 6" Minus

Diamond Z 1460B price quote

February 23, 2006 INEL
Pat Laney PO Box 1625 2525 Fremont Ave Idaho Falls, ID 83415
Re: Quotation on a Diamond Z 1460B

Dear: Pat

The following quotation was prepared especially for INEL. The pricing is valid for thirty (30) days from the date of issue. F.O.B. Caldwell, ID. The buyer is responsible for any and all taxes, duties, tariffs and permitting expenses that may apply. Other terms also apply. All quotes in US dollars.

1460B with CAT C 27 1050 HP Engine	$ 482,553.00
(Base price includes: Radio Remote Control and Tool Box)	
Popular Equipment package options:	
Engine Enclosure and Vandalism Lock Package	$ 4,514.00

Air Compressor Pkg (13 HP, 30 Gal, 50’ 1” hose, 1” impact gun w/socket)	$ 6,471.00
UHMW on Phase I and II Conveyors	$ 3,011.00
Radial Stacking Phase II Conveyor	$ 7,823.00
Flexxaire Fan	$ 13,875.00
Fluid Coupling and Auxiliary Hydraulic Power Unit	$ 22,570.00
Containment Shield	$ 17,583.00
Hydraulic Rod Puller	$ 4,514.00
Total Price with the above options……………………………………….	$ 562,914.00

If upon reviewing this quotation, you have any questions, please contact me at 1-800-949-2383.Thank you for your interest in Diamond Z Manufacturing and our ‘Made in the USA’ products that are known around the world for durability, productivity, reliability, and ease of maintenance.

John Deer 8230 Tractor

BASE MACHINE $144,733.00 2411RW 8230 Tractor Suggested List Price w/ selected options = $154,706.02 USD Feb 16, 2006 5:54:18 PM
VALUE PACKAGE CONFIGURATIONS ($1,000.00) 0811 CommandView PST Value Package Includes Codes: 0987, 1015, 1120, 1200, 2300, 2418, 2560, 2810, 3012, 5021. List Price Value of Package Options Over Base Price Equals $7,596.00.
($3,648.00 Value Package adjustment plus $3,948.00 Promotional AutoTrac Ready.)
OPERATOR STATION In Base Price
0987 CommandView Cab with ComfortCommand Seat Includes Fore-Aft and Lateral Attenuation and Lumber Support Seat.
AG MANAGEMENT SOLUTIONS No Charge
1015 AutoTrac Ready Promotion for 2006 Retail value of this option is $3,948.00 Includes Factory installation of GreenStar Ready Wiring Harness with Implement Connector, Integrated Plug-In Connectors for GreenStar Display in Cab and for StarFire Receiver in Roof, Tractor Specific Components for GreenStar AutoTrac, and Plug and Play (vehicle-side quick-coupler bracket for the StarFire receiver and GreenStar display/mobile processor mounting bracket). Requires additional components and plug-in adapter harnesses to connect GSD4 or GreenStar 2 display and StarFire receiver for a fully functioning GreenStar System. See AMS sales manual and price pages for detailed information.
TRANSMISSION In Base Price 1120 16F / 4R Speed Automatic PowerShift Transmission (42 K)
COMFORT PACKAGE In Base Price 1200 Standard Comfort Package
REMOTE CYLINDER CONTROL In Base Price 2300 Three Remote Cylinder Control Valves with Breakaway Couplers
POWER TAKE OFF $1,513.00 2418 1-3/4 1000 rpm PTO, CAPABLE of 1-3/8 540/1000 rpm PTO To field convert to 1-3/8 540/1000 rpm PTO, kit RE218639 will be required. 1-3/8 540 rpm PTO is NOT compatible with CAT 4 drawbar.
HITCH, QUIK COUPLER AND DRAWBAR $952.00 2560 15,200 Lb. Capacity 3-Point Hitch (Cat. 3/3N) and Adjustable Swinging Drawbar
HYDRAULIC PUMP $995.00 2810 85 cc Displacement Hydraulic Pump (60 gpm/227.1 lpm) Required when ordering ILS Code 5041.
REAR AXLES $188.00 3012 110 mm (4.33 In.) Diameter x 3010 mm (118.5 In.) Length with Double Taper Wheel Hubs
SINGLE REAR CAST WHEELS AND TIRES In Base Price 4279 480/80R46 In. 158A8 R1 Radial Available in Goodyear, Firestone or Titan.
Requires Dual Tire Code 4979.
DUAL AND TRIPLE REAR WHEELS AND TIRES In Base Price 4979 480/80R46 In. 158A8 R1 Radial Available in Goodyear, Firestone or Titan.

FRONT AXLES In Base Price 5021 Mechanical Front Wheel Drive Compatible with Ag Management Solutions Code 1015.
FRONT WHEELS AND TIRES In Base Price 6164 420/90R30 In. 142A8 R1 Radial Available in Goodyear, Firestone or Titan.
OPERATOR'S MANUAL In Base Price 8501 English
9109 Radio, Deere-Delco AM/FM Stereo with Weatherband, Four Speakers, Clock and Antenna Radio is Not Satellite Ready. $569.00
9066 Lights, Field Vision Xenon HID Front Lighting Package Includes 3 HID front lights and 2 roof (side-mounted) 65W halogen floodlights.
Rear HID lights must be ordered separately with Code 9059. $1,663.00
9089 Drawbar, Cat. 4 with 2 In. Pin and Heavy Duty Support, 11,000 Lb. Vertical Load Capacity Not compatible with 1-3/8 540 rpm PTO. $642.00
9012 Hydraulic Trailer Brake $639.00
9016 Fenders, Deluxe Pivoting Front for MFWD or ILS - 18.7 In. (480 mm) Wide Recommended for use with 12.4 In. (290mm) to 16.9 In. (420mm) tire widths. $979.00
9029 Cold Weather Start Kit Factory Installation of Block Heater (110V) and Ether Aid Canister and Switch. $34.00
9264 One Pair 205 kg (450 Lb.) $726.00
9988 No Brand Preference No Charge
AR243091 Single Lever (Joystick) Control Kit Attaches to Command Arm. Requires 4 tractor SCV's. $903.00
RE231703 Hydraulic Trailer Brake Kit Provides single line connection to hydraulic braking systems. Works with or without power beyond couplers. $428.00
RE219922 Antenna Mount and Wiring for Business Band Radio $105.00
RE196193 Radio, Deere/Delco AM/FM Stereo with Weatherband and Clock Excludes speakers, mounting hardware and antenna.
Radio is Not Satellite Ready. $335.00
AR254653 Transmission Hydraulic Oil Heater (110 Volts)
For IVT and PST transmission. $302.00

Hesston 4910 Baler

Quote from Pioneer Farm Equipment in Blackfoot ID for a Hesston 4910 sold in November 2005 was $85,000. It included an Auto lubrication system and a Knotter Fan each of which are about $3K options. The accumulator would be an additional $12-$13K

Hesston 4910 LARGE RECTANGULAR BALER
DIMENSIONS & WEIGHTS
Length: Without Bale Chute in (mm)....................284.5 (7230)
Length: With Bale Chute in (mm 50.5 (8900)
Height: Top of Knotter Shielding in (mm)....................124 (3150)
Height: Top of Hand Railing in (mm)....................145 (3680)
Width: Shipping, (Less Tires) in (mm) 103 (2615)
Width: With 28Lx26 Tires in (mm) 125.5 (3190)
Weight: Baler lb (kg)....................18,300 (8440)
Weight: Tongue (empty) lb (kg)....................3340 (1515)
Weight : Bale Chute lb (kg)....................250 (115)
Bale Chamber Width in (mm) 46.5 (1180)
Bale Chamber Height in (mm) 50 (1270)
Bale Length (Adjustable) in (mm)....................Up to 108 (2743)
Baler Tires ....28L x 26, 16 ply

Baler Bolt Circle Diameter in (mm)..13.2 (335)
Pickup Gauge Wheel .... 4.00x16 (2) Pneumatic w/Inner Tube
Main Drive: PTO Speed rpm... 1000
PTO Type ....ASAE Type 2, 1 3/8 IN, 21 teeth
(Optional) ....ASAE Type 3, 1 3/4 IN, 20 teeth
Drive Line Category ....ISO 8 (ASAE 6)
Drive Line Protection ....Overrunning, Slip Clutches, and Shear Bolt
Flywheel Diameter in (mm) 34 (864)
Flywheel Weight lb (kg)..535 (243)
Bearings.. Taper Roller (2)
Brake .... Direct Acting
Gearbox .... Enclosed Triple Reduction
Gears.. Spiral Bevel (1st set), Spur (2nd and 3rd Set)
Bearings.. Tapered Roller and Spherical
Lubrication ....Oil Bath
Temperature switch settings
Cast Gearbox Housing °F (°C)... 172° to 190° (78° to 88°)
Welded Gearbox Housing °F (°C)... 149° to 167° (65° to 75°)

Caterpillar TH220B Telehandler

TH220B DETAILED SPECIFICATIONS
Rated Load Capacity: 5500 lb / 2500 kg
Maximum Lift Height: 20 ft / 6.1 mm
Maximum Forward Reach: 10.5 ft / 3200 mm
Top Travel Speed: 25 mph / 40 km/h
Load at Max Height: 4400 lb / 2000 kg
Load at Max Reach: 3300 lb / 1500 kg
Engine Model: Cat 3054E
Gross Power (Basic): 99.9 hp / 74.5 kW
Gross Power (Premium): 120 hp / 92 kW
Net Power (Basic): 94.9 hp / 70.8 kW
Net Power (Premium): 117.5 hp / 87.6 kW
Maximum Torque – Basic: 300 lb ft / 410 N·m
MaximumTorque – Premium: 330 lb ft / 450 N·m
Displacement: 268 in3 / 4.4 L
Operating Weight: 14,771 lb / 6700 kg
Height: 7.4 ft / 2250 mm
Width: 7.7 ft / 2350 mm
Wheelbase: 9.7 ft / 2950 mm
Length to Fork Face: 15.6 ft / 4740 mm
Ground Clearance: 16.7 in / 425 mm
Turning Radius over Tires: 10.9 ft / 3340 mm
Turning Radius over Forks: 14.3 ft / 4370 mm
Hydraulic System
Maximum Hydraulic System Pressure: 3626 psi / 250 bar
Maximum Hydraulic Pump Flow: 28 gal/min / 106 L/min
Fuel Tank: 26.4 gal / 100 L
Hydraulic Tank: 15.6 gal / 59 L
Additional Fuel Tank: 13 gal / 50 L

Transmission Speeds: Forward – 1, 4 mph / 6 km/h; Forward – 2, 7 mph / 12 km/h; Forward – 3, 13 mph / 20 km/h; Forward – 4, 25 mph / 40 km/h; Reverse – 1, 4 mph / 6 km/h; Reverse – 2, 7 mph / 12 km/h; Reverse – 3, 13 mph / 20 km/h;

Boom Up: 5 Seconds / 5 Seconds
Boom Down: 4 Seconds / 4 Seconds
Tele In: 5 Seconds / 5 Seconds
Tele Out: 6 Seconds / 6 Seconds
Crowd Forward (dump): 3 Seconds / 3 Seconds
Crowd Backward: 3 Seconds / 3 Seconds
Combined - Up and Out: 10 Seconds / 10 Seconds
Combined - Down and In: 5 Seconds / 5 Seconds
Boom Breakout Force: 6924 lb / 30.8 kN
Bucket Breakout Force: 12365 lb / 55 kN
Drawbar Pull (Basic): 17985 lb / 80 kN
Drawbar Pull (Premium): 21357 lb / 95 kN

Stinger Stacker 6500

To:
Friday, January 27, 2006
Dear Peter:

I am excited that you have chosen to compare *Stinger!* Thank you!

Stinger Ltd. (U.S.) provides you self-propelled bale transporters and stackers for large and intermediate square or round bales. Owning a *Stinger* gives you the fastest, most productive, self-propelled bale transport/stackers in the world. A *Stinger* can *move 220 bales per hour* off of a field and/or *stack 125 bales per hour with only one person and one machine*.

Stingers have the lowest operating and maintenance cost on the market. Look at one; you will see FEW moving parts, no chains to break, no spider web of hoses to get pinched, and no complicated moving parts. What you will see is strength, durability, and extremely low maintenance. *Stinger* durability is proven by handling over 4 MILLION BALES PER YEAR.

How much does it cost, you ask? How much does it cost you when you have hay in the field and you are broken down? How much does it cost you when you have hay in the field and your current bale handler can not get the job done but a *Stinger* could? Answer those questions as you look into the sky and see a big rain coming.

Stingers retain for you the highest resale value ever. Allow *Stinger* to give you *speed*, *reduced* labor costs, *reduced* downtime, *increased* profits, and *increased* net worth.

Call me @ 1-800-530-5304. I am excited to talk to you about *Stinger*.

Sincerely,

Randy J Grover

Sales Manager

Stinger LTD "Simply The Best"

8905 Industrial Drive Haven Kansas 67543 800-530-5304

Model 6500	at $155,000 handling an average of 60 bales per engine tach hour.			
Your Est.	Number of Bales Per Year =	34,500	17,400	8,700
	Engine Tach Hours Required =	575	290	145
	Depreciation =	$7,800	$5,850	$4,435
	8% Interest =	$4,033	$4,033	$4,033
	Maintenance =	$2,850	$1,760	$1,120
	Taxes, Insurance and Misc. =	$1,750	$1,750	$1,750
	$2.00 Farm Fuel =	$8,580	$4,176	$2,088
	Labor @ $10.00 per Hour =	$5,750	$2,900	$1,450
	Total =	$30,763	$20,469	$14,876
Total Cost per Bale to Own & Operate a Stinger 4400	=	$0.89	$1.18	$1.71
	Operating Cost per Bale =	$0.55	$0.61	$0.74
Yearly Payment with Typical Financing	$23,500.00 =	$0.68	$1.35	$2.70
Total Cash Flow Cost per Bale with Typical 7 Year Financing	=	$1.23	$1.96	$3.44
Model 4400	at $115,000 handling an average of 60 bales per engine tach hour.			
Your Est.	Number of Bales Per Year =	34,500	17,400	8,700
	Engine Tach Hours Required =	575	290	145
	Depreciation =	$5,750	$4,900	$3,700
	8% Interest =	$3,022	$3,022	$3,022
	Maintenance =	$2,760	$1,800	$1,200
	Taxes, Insurance and Misc. =	$1,500	$1,500	$1,500
	$2.00 Farm Fuel =	$8,280	$4,176	$1,305
	Labor @ $10.00 per Hour =	$4,600	$2,320	$1,160
	Total =	$25,912	$17,718	$11,887
	Operating Cost per Bale =	$0.50	$0.56	$0.59
Total Cost per Bale to Own & Operate a Stinger 3400	=	$0.75	$1.02	$1.37
Yearly Payment with Typical Financing	$17,586.00 =	$0.51	$1.01	$2.02
Total Cash Flow Cost per Bale with Typical 7 Year Financing	=	$1.01	$1.57	$2.62

Truck Scales

Quote provided to INL from Adam Pereira at Total Scale Service by E-mail on 3/24/06

Total Scale Service Inc. 220 W. Yakima St. Ste A Jerome, ID 83338 Phone: 800-423-4456 Fax: 208-324-3935

To:Peter Date: March 24, 2006 Idaho Falls, ID. Quote#: 0324061AP 208-526-0373

We propose to supply and install one of the following:
-1 Rice Lake Survivor-OTR, 80' X 11' steel deck truck scale with pipe guide rails. - $ 48,400.00

OR

-1 Rice Lake Survivor-OTR, 117' X 11' steel deck truck scale with pipe guide rails. - $ 64,900.00

OR

-1 Rice Lake Survivor-OTR, 80’ X 11’ concrete deck truck scale with pipe guide rails. - $ 47,300.00

OR

-1 Rice Lake Survivor-OTR, 117’ X 11’ concrete deck truck scale with pipe guide rails. - $ 61,700.00

The above scales come with a 20-year warranty on the weighbridge and 5-years on the load cells.

<u>Included in the prices above:</u>

1-GSE 562 programmable digital indicator with a truck I/O program and Inventory Tracking Program used for printing out reports, with a 2-year warranty. An Epson220 tape printer to print tickets and it come with a 1-year warranty.

AND

<u>Total Scale Service, responsible for:</u>

1. Working with excavator in digging holes for piers.
2. Forming and placement of concrete for piers, 2-10’ approaches. (and deck.)
3. Rebar and angle iron for approach coping.
4. Help with off loading and placement of scale from factory truck.
5. Installation of scale.
6. Calibration of scale within state and federal tolerances.
7. 1 year free service. (Quarterly service of scale, a $1000.00 to $1200.00 value)

<u>Customer responsible for:</u>

1. Freight to the jobsite.
2. Provide all excavation, compaction, and back filling
3. The cost of all the concrete.
4. Provide the off loading and equipment (crane) to off load scale on to piers.
5. Rock and Blasting.
6. Permits.
7. High water table.
8. Any underground utilities.
9. Electrical, (110 Volts in the scale house or where ever it is needed.)

10. Scale house.
11. Cost of home run cable if the scale house is over 100'way from the scale.

<u>Terms:</u>

-25% down.
-65% when scale is delivered.
-All but $1000.00 due after deck is poured. (Concrete deck only)
-Balance when calibrated.

Quoted By: Adam Pereira Cell # 208-404-3996 Quote valid for (30) days.

Total Scale Service, Inc. 220 W. Yakima St. Ste A Jerome, ID 83338 800-423-4456

RICE LAKE WEIGHING SYSTEMS
Commitment Beyond Measurement™
ISO 9001 REGISTERED

March 24, 2006

Appendix C

Labor and Management Related Information

Appendix C

Labor and Management Related Information

This appendix contains details on site specific labor costs. Labor rates for this scenario are based on information from the Idaho Occupational Employment & Wage Survey-2006 for the eastern Idaho region. The rates were incorporated into the excel based model used to calculate the cost of feedstock supply from the growers field to the throat of the bioreactor. Table C-1 shows the hourly rates for most of the positions that would be required to run a feedstock supply operation such as the one depicted in this report.

A site layout that covers approximately 5 acres is assumed for the feedstock delivery, handling and short term storage needs of the bioethanol plant. Table C-2 provides an estimate of the cost of the facilities and the equipment and supplies necessary to begin operations.

Table C-1. Labor rates for SE Idaho Wheat & Barley Straw supply system.

Idaho Labor Code	Labor / Personnel	$/hr	Annual Rate
	Chief Executive	*60.00*	124,800
11-1021	General and Operations Manager	*40.00*	83,200
43-6014	Secretary	*10.39*	21,611
13-2011	Accountant (1/2))	*30.00*	31,200
	Attorney (1/4 time)	*60.00*	31,200
11-3049	Human Resources Mgr	*28.58*	59,446
13-1041	Safety Manager	*22.07*	45,906
43-3021	Billing Clerk	*12.15*	25,272
43-9061	Office Clerk, General	*10.90*	22,672
43-5111	Dispatcher	*10.02*	20,842
41-4012	Field Rep. Straw Buyers	*20.66*	42,973
49-9041	Mechanic	*14.87*	30,930
49-9043	Mechanics Helper	*11.47*	23,858
47-2111	Plant Electrician	*20.99*	43,659
51-1011	Shift Supervisor	*18.90*	39,312
19-2041	Laboratory Manager	*24.10*	50,128
43-5111	Laboratory Technician	*10.02*	20,842
	Grinder Operator	*17.64*	36,691
51-8031	Receiving / Feed Operators	*11.74*	24,419
	Bale Loader Operators	*11.47*	23,858
53-3032	Truck Drivers	*13.77*	28,642

Table C-2. Estimate of buildings, equipment, materials and supplies necessary to support the feedstock supply operation.

Element	Dollars
Real Property	
Office Building ~3520 sq ft: 6 Hardwalls, 8 Cubicles, 1 Conference Room, 1 Break room @ $150/sq ft	198,000
Laboratory 20' X 30' @ $400/sqft + Office and Storage 20' X 30' @ $150/sqft	330,000

Table C-2. (continued).

Equipment / Machine Shop - 40 x 80 3200sq ft @ $70/sqft	224,000
Parking Lot - Employees	170,000
Parking Lot - Trucks and Trailers (gravel pad)	16,200
Security Fence & Systems	141,550
Lighting	96,200
Fuel Depot	100,000
Fire Protection	657,500
Electrical Load (1000kVA Service, transformer, switchgear, distribution system)	200,000
Real Property Subtotal	*2,133,450*
Plant Equipment	
Tools for Mechanic & Shop	20,000
Equipment - Mechanical Subtotal	*20,000*
Office Equipment & Supplies	
Desktop computers 13 @ $1,000	13,000
Laptop Computers 7 @ $2,000, + docking stations 7 @ $400	16,800
Laser Printers 2 @ 600	1,200
Radios -50 @ $200	10,000
GPS Units 5@150 (One for each straw buyer)	750
Cell Phones 27 @ 100	2,700
Fax Machine / Scanner	896
Desk Calculators (printing with USB Capability) $143 ea	572
Copy Machine (Xerox copy Centre 133) $5300	5,300
Desk Phones (ATT 945 4 line system) $134 ea	2,278
Postage Machine ($40/month Lease)	480
File Cabinets (4 Drawer Laterals 42x19x53) $1007 ea	16,112
Office Supply Cabinet (36x24x71) $597 ea	1,791
Time Card System (ES1000)	600
Projector (computer) HPVP6310 $986	986
Television and VCR (for Training) $450	450
Bookshelves (4 shelve 34x12x59) $234 ea	2,340
Desks - 15 @ $780	11,700

Table C-2. (continued).

Computer Table 8 @ $300	2,400
Desk Office Chairs 15 @ $400	6,000
Guest Office Chairs 9 @ $ 150	1,350
Conference Room Table 1 @ $900	900
Conference Room Chairs 8 @ $350	2,800
Office Supplies	10,000
Break room Table 3 @ 200	600
Break room Chairs 15 @ 200	3,000
Break room Refrigerator	600
Break room Microwave	150
Accounting Software	2,500
Schedule & Dispatch Software	1,500
Office Equipment and Supplies Subtotal	*119,755*
Laboratory Equipment & Supplies	
Two NIR instruments @ $90,000 each ($180,000)	180,000
Four Laboratory Balances @ $10,000 each ($40,000)	40,000
One Vacuum, riffle splitter @ $800	800
Two Wiley #4 mills @ $15,000 each ($30,000)	30,000
One Ro-tap II 12" shaker @ $2,250; 10 brass sieves @ $71 each (2,250 + 710 = 2,960)	2,960
2 drying ovens @ $10K	10,000
5 Coring Tool Systems- Coring tool $150 each; Honda EU2000i Portable Generator $1,080 each; and Dewalt DW138 Heavy-Duty ¾" Drill $580 each (600 + 5400 + 2900 = 8,900)	8,900
One DL77 Graphix Titrator @ $21,200	21,200
One Rondolino DL50 Automatic Titrator (automates sample changing) @ $4,590	4,590
Titration supplies – Approximately $5,000 / yr	5,000
Cleaning supplies, Kimwipes, weigh pans, grinder consumable parts – Approximately $2,000 / yr	2,000
Calibration, Spares and Repairs (1% First Year Cost)	3,055
Shelving for archiving samples	1,500
Laboratory Equipment & Supplies Subtotal	*310,005*

Table C-2. (continued).

Software	
GPS Software	1,500
Lab Software	3,500
Dispatching and Scheduling software	2,500
Maintenance Software	500
Accounting and Bookkeeping Software	1,500
Other software	1,200
Software Subtotal	*10,700*
Vehicles & Field Equipment	
General Manager - 3/4 Crew Cab Truck	40,000
Field Rep 1 - 1/2 Ton Truck	28,000
Field Rep 2 - 1/2 Ton Truck	28,000
Field Rep 3 - 1/2 Ton Truck	28,000
Field Rep 4 - 1/2 Ton Truck	28,000
Field Rep 5 - 1/2 Ton Truck	28,000
Plant Manager - 1/2 Ton Truck	30,000
Mechanic Truck - 1 Ton Truck	50,000
Plant Service Truck #1 - 1/2 Ton	22,000
Plant Service Truck #2 - 1/2 Ton	22,000
Plant Service Truck #3 - 1/2 Ton	22,000
Snowplow Attachment 2 @ $1100	2,200
Vehicles Total	*328,200*
Total	2,922,110

Appendix D

Transportation

Appendix D

Transportation

This appendix contains details on site specific (Idaho) transportation regulations. The majority of the information came from the Idaho Department of Transportation.

Idaho Transportation Rules

The following table is from the Idaho Department of Transportation http://www.itd.idaho.gov/dmv/Poe/bridgekl.htm

Weight Limits, up to 80,000 lbs for all commodities on non-interstate system routes

Legal Allowable Gross Loads						
Maximum Load in Pounds Carried on any Group of Two or More Consecutive Axles						
	Column K	Column L			Column K	Column L
Distance in feet between first and last axle of any group of consecutive axles	Vehicles with Three or Four Axles	Vehicles with Five or more Axles		Distance in feet between first and last axle of any group of consecutive axles	Vehicles with Three or Four Axles	Vehicles with Five or more Axles
Single Axle Weight	20,000	20,000		28'	66,000	70,950
3' thru 12'	37,800	37,800		29'	66,000	71,500
13'	56,470	56,470		30'	66,000	72,050
14'	57,940	57,940		31'		72,600
15'	59,400	59,400		32'		73,150
16'	60,610	60,610		33'		73,700
17'	61,820	61,820		34'		74,250
18'	63,140	63,140		35'		74,800
19'	64,350	64,350		36'		75,350
20'	65,450	65,450		37'		75,900
21'	66,000	66,330		38'		76,450
22'	66,000	67,250		39'		77,000
23'	66,000	67,880		40'		77,550
24'	66,000	68,510		41'		78,100
25'	66,000	69,150		42'		78,650
26'	66,000	69,770		43'+		80,000
27'	66,000	70,400				

IDAHO LEGAL WIDTH, HEIGHT AND LENGTH

WIDTH (including load)	8 FT 6 IN
HEIGHT (including load)	14 FT
LENGTH	
SINGLE MOTOR VEHICLE	45 FT
TRAILER OR SEMITRAILER**	
OTHER THAN NATIONAL NETWORK	48 FT
NATIONAL NETWORK	53 FT
MOTOR VEHICLE AND ONE OR MORE TRAILERS EXCEPT AS NOTED.*	75 FT
DOUBLE TRAILERS	
OTHER THAN NATIONAL NETWORK	61 FT OF TRAILERS (OR 75 FT OVERALL)
NATIONAL NETWORK*	68 FT OF TRAILERS
DROMEDARY TRACTOR	
STINGER STEERED**	75 FT
NON STINGER STEERED	65 FT
AUTO OR BOAT TRANSPORTER	
STINGER STEERED**	75 FT
NON STINGER STEERED	65 FT
SADDLEMOUNT COMBINATIONS	75 FT
TRUCK TRACTOR WITH STINGER STEERED** POLE TRAILER OR LOG DOLLY CONNECTED BY A REACH OR POLE	75 FT
OVERHANG	
FRONT OF ANY VEHICLE	4 FT
FROM CENTER OF LAST AXLE	15 FT
LEFT FENDER OF PASSENGER VEHICLE	0 FT
RIGHT FENDER OF PASSENGER VEHICLE	6 IN

* OVERALL length not restricted to 75 feet.

** Stinger Steered: A truck tractor semi trailer combination where the kingpin is located 5 feet or more to the rear of the centroid of the rear axle(s).

PROCEDURES FOR OBTAINING IDAHO OVERLEGAL PERMITS
http://www.itd.idaho.gov/dmv/poe/OverLegalPermitProcedures.htm

Idaho law requires that the owner/operator obtain an overlegal permit or establish intent to obtain an overlegal permit by contacting the Overlegal Permit Office before moving a vehicle on the highways.

The headquarters Overlegal Permit Office is located at the main building of the Transportation Department at 3311 W State St in Boise. An overlegal permit may be obtained by phone, mail, fax, or in person at this office.

101. INFORMATION TO BE FURNISHED BY APPLICANT. Any application for an overlegal permit shall provide for the submittal of all pertinent information required to establish the necessity of the proposed movement and the requisite to an engineering determination of the feasibility of the proposed movement. The following information shall be furnished:

01. Name. Name of owner, operator, or lessee of vehicle or vehicles concerned.
02. Description of load. Manufacturer, model number, etc.
03. Identification of vehicles. License number, if registered, otherwise serial number, unit number.
04. Weight. Licensed capacity of vehicles subject to registration, if overweight is involved.
05. Axles. Number of axles, spacing between axles, number and size of tires.
06. Gross Weight. Gross weight, distribution of weight, overall dimensions.
07. Route. Point of origin and destination, preferred route by road number.
08. Start Date. Date of movement and days required.
09. If House Trailer. License number if privately owned.
10. Insurance. Evidence of insurance, if required.
11. Necessity. Necessity for movement.
12. Special Instructions. Special instructions regarding address to which permit is to be sent and any other pertinent information.
13. Signature. Signature of applicant.

Telephone the Overlegal Permit Office at 208-334-8420, or within Idaho dial 1-800-662-7133 Toll Free.

300. PERMIT FEE ACCOUNT PROCEDURES.

01. Permit Fee Account. To establish a basis for the issuance of special permits on other than a cash basis, the permittee may guarantee permit fees by posting a surety bond. The bond shall have a minimum value of one thousand dollars ($1,000) or be equal to the value of permits required by the permittee during any three (3) consecutive months, whichever is greater.
02. Bond Requirements. Surety bonds for this purpose shall be furnished by a bonding or insurance company licensed to do business in Idaho. Applications to establish permit fee accounts shall be obtained from and filed with the Maintenance Section along with the required bond.

IDAHO STATE HIGHWAY SYSTEM

PILOT / ESCORT VEHICLE & TRAVEL TIME REQUIREMENTS

AUGUST 2005

ROUTE COLOR CODE	WIDTH OF LOAD	PLACEMENT & NUMBER OF ESCORT(S)	TRAVEL ON FRIDAYS AFTER 2:00 PM	TRAVEL ON SATURDAY OR SUNDAY	DAYLIGHT TRAVEL	TRAVEL 24 HOURS PER DAY	HOLIDAY TRAVEL
	8'-07"– 10'-00"		NO	NO		YES	NO
	10'-01"– 12'-00"	F 1	NO	NO	YES	NO	NO
	12'-01"– 12'-06"	B 2	NO	NO	YES	NO	NO
	8'-07"– 10'-00"		YES	YES		YES	YES
	10'-01"– 12'-00"		YES	YES	YES	NO	NO
	12'-01"– 14'-00"	F 1	YES	YES	YES	NO	NO
	14'-01"– 14'-06"	B 2	YES	YES	YES	NO	NO
	8'-07"– 10'-00"		YES	YES		YES	YES
	10'-01"– 15'-00"		YES	YES	YES	NO	NO
	15'-01" & OVER	R 1	YES	YES	YES	NO	NO

KEY:
- F = Front Escort
- R = Rear Escort
- B = Front & Rear Escort

BLACK CODED AND INTERSTATE ROUTES – LOADS IN EXCESS OF 10' WIDE, 100' LONG OR 14' 6" HIGH MAY NOT TRAVEL AFTER 4:00 PM ON THE DAY PRECEDING A MAJOR HOLIDAY. TRAVEL MAY BE RESUMED AT DAWN ON THE DAY FOLLOWING A MAJOR HOLIDAY.

http://www.itd.idaho.gov/dmv/poe/pilot.pdf

ROUTE CAPACITY MAP

BASIC ALLOWABLE UNIT WEIGHT

DECEMBER 2005

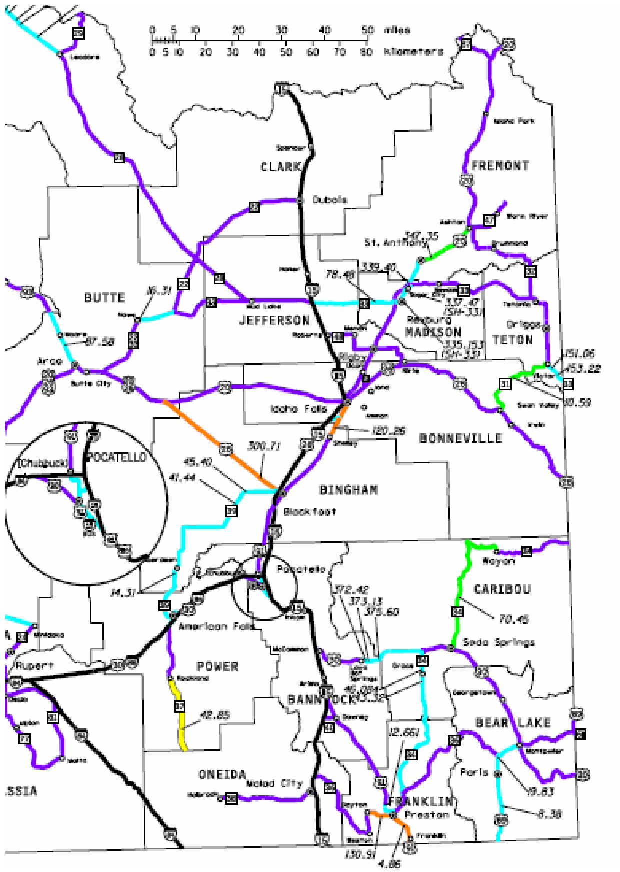
SINGLE AXLE	33,000 LBS	30,000 LBS	27,000 LBS	25,500 LBS	24,000 LBS	22,500 LBS	POSTED
TWO–AXLE TANDEM	56,000 LBS	51,500 LBS	46,000 LBS	43,500 LBS	41,000 LBS	38,000 LBS	BRIDGES
THREE–AXLE TRIDEM	70,500 LBS	64,500 LBS	57,500 LBS	54,500 LBS	51,500 LBS	48,000 LBS	

Maximum allowable loading for any combination of two or more consecutive axles is determined by axles and axle spacings. See the following charts for the maximum weight levels for route traveled.

- RED – POSTED BRIDGES – SINGLE TRIP PERMITS ONLY ARE ISSUED FOR RED ROUTES
- YELLOW – YELLOW OVERWEIGHT CHART
- **ORANGE – ORANGE OVERWEIGHT CHART**
- GREEN – GREEN OVERWEIGHT CHART
- **BLUE – BLUE OVERWEIGHT CHART**
- PURPLE – PURPLE OVERWEIGHT CHART
- BLACK – BLACK OVERWEIGHT CHART

ALL BUSINESS ROUTES ARE PURPLE EXCEPT AS NOTED BELOW:

SH–13B MP 0.70 – KOOSKIA – ORANGE
I–15B MP 0.424 – INKOM – BLUE
US20B MP 348.11 – ST. ANTHONY – YELLOW
SH33S MP 97.72 – REXBURG AREA – YELLOW
I 84B MP (RP) .118 – CALDWELL – BLUE
I 84B MP (RP) .150 – CALDWELL – BLUE
I–90B MP 0.056 – POST FALLS AREA – BLUE
I–90B MP 3.86 – SILVERTON – BLUE
I–90B MP 61.21 – WALLACE – BLUE
I–90B MP 0.234 – MULLAN – BLUE
I–90B MP 0.456 – MULLAN – BLUE



http://www.itd.idaho.gov/dmv/poe/route_cap2.pdf

Appendix E

Insurance

Appendix E

Insurance

This appendix contains additional details on Idaho site specific insurance costs. Early in the project, some insurance companies in the SE Idaho area were contacted to obtained general information on insuring a business that would supply 800,000 tons of wheat and barley straw to a bioethanol plant located in Idaho Falls, Idaho. The table below is a summary of the information they provided..

Option 3 Bulk Grind and Haul Insurance Estimate

	$'s / Year	$'s / ton
Total Insurance ($'s/yr)	**307,831**	**0.385**
Property Subtotal	4,024	0.005
Equipment Subtotal	10,335	0.013
Vehichles Subtotal	92,592	0.116
Liability Subtotal	32,772	0.041
Workers Comp Subtotal	128,108	0.160
Straw Subtotal	40,000	0.050

Property			
Office Building - $198K		839	
Laboratory Building - $330K		2,078	
Machine Shop Building - $224K		1,107	
	Subtotal	*4,024*	
Straw			
State Farm 800,000 tons @ $40K/Yr ($.05/ton)		40,000	Note 1
Starley Leavitt 800,000 tons $170K/Yr ($.21/ton)			Note 2
	Subtotal	*40,000*	
Equipment			
Grinders - 8 total		9,010	
Telehandlers - 8 total		1,325	
	Subtotal	*10,335*	
Vehicles			
KW Tractors - 35		68,915	
3/4 Ton Pickups - 9 total		6,264	
1/2 Ton Pickups - 8 total		5,568	
Trinity Trailers - 25 total		11,425	
Siems Trailers - 4 total		420	
	Subtotal	*92,592*	
Liability		32,772	
	Subtotal	*32,772*	
Workers Comp Coverage			
5 Mgt & Supervisors		2,184	
5 Salesmen		1,331	
3 Engineers/Professional		2,038	
6 Administrative		524	
2 Lab Techs		503	
50 Truck Drivers		74,325	
16 Laborers I		30,468	
8 Laborers II		10,372	
5 Laborers III		6,363	
	Subtotal	*128,108*	

Note 1: State Farm 3-16-05 Based on revolving inventory up to 800K tons, $25-40K/year
Note 2: Starley Leavitt - $170,000 based on $30/ton values and 800K tons

Appendix F

Faciltiy Permitting

Appendix F

Faciltiy Permitting

This appendix contains a list of permits and applications that would typically be associated with a business of this type in Idaho.

FACILITY PERMITTING TABLE

Permit Type	Requirement	Agency	Format/Req'd Info	Prep Time	Typical Review Time	Project Timing	Est. Cost [1]	Analysis
EIS	NESHAP	EPA		>1 Year	>1 Year	Prior to starting construction	N/A	Not required. Only in cases of public funding or use of public lands.
Air Quality Construction Permit	IDAPA 58.01.01.200 et al – requires a permit to construct be issued for any stationary source, prior to commencement of construction.	EPA/IDEQ	Contents of the permit application are described in IDAPA 58.01.01.202. Two basic parts – IDEQ application forms and descriptive support documentation. A general list of application follows: Site information, plans, descriptions, specifications, and drawings showing the design of the stationary source, facility, or modification, the nature and amount of emissions and the manner in which it will be operated and controlled. Estimates of ambient concentrations of criteria and toxic pollutants based on the applicable air quality models. Must demonstrate compliance with: 1) all applicable local, state or federal emission standards; 2) national ambient air quality standards (NAAQS); and, 3) applicable toxic air pollutant carcinogenic increments and toxic air pollutant non-carcinogenic increments.	Approximately 30 days including air modeling, internal reviews, etc. Note that this assumes the facility design is set. Changes in facility design and operations will delay the completion of the application. Assumes plant will not be a major facility.	Regulatory timeframe is 30 days for a completeness review and then 60 days for technical review (IDAPA 58.01.01.209. Delays may occur if additional application data is required by the IDEQ. Assumes plant will not be a major facility. (Backlogs in Idaho have created review times up to 6 months)	Permit to construct must be received prior to commencement of construction (defined as physical on-site construction activities which are of a permanent nature (IDAPA 58.01.01.006.20). Note that there are other regulatory options for minor sources that may allow construction before a permit to construct is issued.	IDEQ just implemented permit application fees. Assuming plant is a minor source, fees are as follows: Application Fee: $1,000 Processing Fee: $5,000 Preparation Est. $15,000 to $50,000	Based on our experience with other malting facilities in Idaho the plant can be designed to ensure that it is considered a minor source (synthetic) which greatly simplifies the construction and operating permits.
Air Quality Operating Permit	IDAPA 58.01.01.400 et al – Assumes the facility will be a minor source (synthetic) and therefore need a Tier II Permit.	EPA/IDEQ	No separate application will be required, the PTC application is comparable and will be used (compare IDAPA 58.01.01.202 & 58.01.01.402). Note that a Tier II operating permit application is required for existing sources. The IDEQ will issue a Tier II Operating Permit for the facility at a later date.			Prior to starting commercial operation		Assume that the facility will be a minor source (synthetic) and therefore not be required to have a Tier I Permit.
Drinking Water Connection	City Code, Section 8-4-11	City of Idaho Falls	Simple permit with expected consumption, address etc.	1 day	2 weeks	Prior to connection	$750 - $1,000	Service connection fee and meter agreement required.
Fire Service Connection	City Code, Section 8-4-40	City of Idaho Falls	Detailed plans of fire service piping, pumps, etc. in plant.	1 week following design completion	2 weeks	Prior to connection	$2,000 - $4,000	All fire service connections between water mains and property lines shall be installed and maintained by City at expense of the Owner.
Water Rights	Idaho State Law	IDWR	Standard form indicating ownership, location, quantity etc.	1 day	1 month	Prior to well drilling	$3,000	May not be required
Proof of Beneficial Use	Idaho State Law	IDWR	Test following commercial operation showing actual quantities used versus quantities asked for.	1 week following full operation	1 – 2 weeks	After commercial operation	$1,000	May not be needed depending on restrictions placed in water right.
Well Construction Permit	IDWR Policy	IDWR	Standard form and submittal of design drawings for well construction, lining, pumps, tanks etc. Must comply with state standards.	1 week	1 – 2 weeks	Prior to well construction	$1,000	Always required but not complicated.

Permit Type	Requirement	Agency	Format/Req'd Info	Prep Time	Typical Review Time	Project Timing	Est. Cost [1]	Analysis
Waste Water Discharge	Idaho Falls Ordinance 2223 & 2357, 12/22/99 Section 8-1	City of Idaho Falls	Simple permit with description of discharge type, quantity and timing, if any. Design detail of connection.	1 week once design parameters are established.	2-4 weeks	Prior to connection	$1,000	Very detailed requirements in City Code. Nature of effluent influences application process, i.e. – whether or not pre-treatment is required etc.
Stormwater Pollution Prevention Plan (NPDES)	Clean Water Act (33 U.S.C. 1251)	EPA	Notice of Intent (NOI), 1-page permit application. Stormwater Pollution Prevention Plan (SPPP) detailing engineering controls during construction.	NOI - 1 day, SPPP – 1 week after basic design is established	NOI - N/A SPPP – 2-4 weeks	48 hours prior to start of construction	$2,000	Required on all sites of 5 acres or more.
Sewer Connections	Idaho Falls Ordinance 2223 & 2357, 12/22/99 Section 8-1	City of Idaho Falls	Simple permit with description of discharge type, quantity and timing, if any. Design detail of connection.	1 week once design parameters are established.	2-4 weeks	Prior to connection	$1,000	Covered by wastewater permit.
Spill Prevention (SPCC)	40 CFR, Part 112	EPA/IDEQ	Standard template. Includes site description, materials description, design and operational controls to prevent spills from reaching waters.	2 weeks	2 months	Required prior to commercial operations	$5,000	
Waste Management Commercial Waste Landfill Waste	 City Code 8-6-10 Variable	 City of Idaho Falls Landfill Operator	 Simple request for service for commercial waste service. Variable	 1 day Variable	 1 week Variable	 Prior to starting service Prior to starting service	$1,000 - $10,000	Commercial waste is a simple contract with City Sanitation Department. Landfill material depends on quantity and nature of waste and is negotiated with landfill operator.
Planning & Zoning/Land Use	City code 10-3-1, Ordinance 2224	City of Idaho Falls	Description of property, use and impacts including traffic, number of employees and visual impacts both during construction and operations.	1 month	1 month or more depending on community reaction	Prior to starting construction	$2,500 - $10,000	
Construction Impacts	City Code	City of Idaho Falls	Contained in Planning and Zoning application			Prior to starting construction	Included above	This area will be covered in the Planning & Zoning approval process.
Easements	State Law	Landowners				Prior to starting construction	Unable to estimate	Public Right of Way is governed by City Ordinance, 8-7-5.
Building Permits	City Code	City of Idaho Falls	Numerous standard forms with design drawings as supporting documentation.	2 weeks following development of sufficient design detail.	2 weeks	Prior to starting construction	$4,000	
Siting & Utilities	City Code 8-5-5	Idaho Falls Power	Plans showing conformance to IFP standards, Uniform Building Code, Fire Codes, etc.	1 week after sufficient design detail is established	1 –2 weeks	Prior to connection	$3,000	
Railroad Spur								
Construction in navigable airspace	49 CFR Part 77	FAA	Plans showing location of construction, height above ground. FAA Form 7460-1.	1 week after final design is established	30 days	30 days prior to construction	$1,500	Only required if any part of construction is >200' tall.
Access to highway								
Runoff/grading	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Covered by NPDES Permit

Notes:

1 Cost are estimated based on typical scenarios. Many items can vary considerably depended on complexity or permit request, amount of coordination with granting agency and other issues.

2 Construction projects in Idaho Falls are covered by Idaho Falls Code of Ordinances, which has adopted by reference the following standard codes:

- Building Code – Uniform Building Code (International Conference of Building Officials)
- Administrative Code – Uniform Administrative Code (International Conference of Building Officials)
- Mechanical Code – Uniform Mechanical Code (International Conference of Building Officials)
- Electric Code – National Electrical Code (National Fire Protection Association)
- Fire Code – Uniform Fire Code (International Fire Code Institute)
- Energy Code – Model Energy Code, 1986 Edition (Council of American Building Officials)
- Building Conservation Code – Uniform Code for Building Conservation (International Conference of Building Officials)
- Each referenced code has local modifications described in City Ordinances. CH2MHILL will ensure all referenced ordinances are followed in the design of the plant buildings and equipment, including third party equipment from Seginsa.

Appendix G

Laboratory Chemicals

Appendix G

Laboratory Chemicals

This appendix contains a list of chemicals that would be used in the quality assurance and laboratory testing of the feedstock supply.

Table G-1. Laboratory chemicals, concentrations, quantities and waste classifications.

Chemical	CAS No	Chemical State	Concentration	Use / day	Haz Waste?	SARA 313 ?	CERCLE RQ/TPQ (lbs of pure substance	Comments
Sodium Hydroxide	1310-73-2	Liquid	10N	25ml	Y, if pH>12.5	N	1000	
Hydrochloric Acid	7647-01-0	Liquid	1N	10ml	Y, if pH<2	N	5000	
Sulfuric Acid	7664-93-9	Liquid	72%	25ml	Y, of pH<2	N	1000/1000	Non-aerosol form
Hydrogen Peroxide	7722-84-1	Liquid	5-10%	50ml		N	1000/1000	Regulated at 52% and greater
Hexane	110-54-3	Liquid	100%	1L		Y	5000	
Acetonitrile	75-05-8	Liquid	10-50%	1L	Y, if discarded	Y*	5000	
Lead Nitrate	10099-74-8	Liquid	1-3N	1L		Y*	10	*as a Pb compound
Lead Carbonate	598-63-0	Solid		5g		Y*		*as a Pb compound
Ethyl Acetate	141-78-6	Liquid	100%	1L	Y, if discarded	Y	5000	
Methanol	67-56-1	Liquid	100%	10ml	Y, if discarded	Y	5000	
Lime	1305-78-8	Liquid	100%	50g				Not Regulated
Ethanol	64-17-5	Liquid	100%	1ml				Not Regulated
Glycerin	56-81-5	Liquid	100%	10ml				Not Regulated
Ammonia	7664-41-7	Liquid	100%	10ml		Y	100	
Helium	7440-59-7	Gas	100%	N/A			Compressed Gas	Not Regulated
Hydrogen	1333-74-0	Gas	100%	N/A			Coompressed Gas	Regulated under 112r, 10,000 lbs
Compressed Air		Gas	100%	N/A				Not Regulated
Sodium Hypochlorite	7681-52-9	Liquid	32%	5ml			100	