

MINNESOTA AGRI POWER PROJECT

Quarterly Report for the
Period July - September 1997

Minnesota Valley Alfalfa Producers

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MINNESOTA AGRI-POWER PROJECT

Instrument No.: DE-FC36-96GO10147

PROGRAM STATUS AND ACCOMPLISHMENTS

THIRD QUARTER-1997 REPORT

FOR PERIOD

01 JULY 1997 THROUGH 30 SEPTEMBER 1997

TASK 1 DESIGN PACKAGE

Subtask 1.1 Feedstock Testing

1.1.1 Alfalfa Separation Pilot Plant Testing

MnVAP's pilot plant continued to produce trial quantities of alfalfa leaf meal (ALM) product for use in University of Minnesota feeding trials. The fractionation equipment designed to produce a lower fiber and higher protein ALM has encountered operating problems under certain conditions. Problems occur as a result of rocks and other tramp materials contained in the alfalfa bales. Tramp materials require that the alfalfa be ground less aggressively, which then causes problems with drier controls. The drier is unable to produce consistent moisture in all parts of the material, with the coarser ground stem typically coming through at higher moisture and with the leaf material at lower moisture. This moisture variance, along with the coarser grind size of the material, reduces the effectiveness of the separation equipment currently installed.

Rocks and other tramp material are picked up during baling, particularly under wet weather conditions when the alfalfa needs to be raked prior to baling.

An investigation of various techniques and equipment to remove the tramp materials, including a tour of a number of operating alfalfa plants and discussions with a number of equipment suppliers, is completed. A vibrating conveyor system has been selected and the equipment is now on order. Installation of this equipment is scheduled for November, 1997.

Detailed drawings and specifications for this equipment will be presented at the meetings scheduled for November 4 and 5, 1997.

In spite of the above problems with the fractionation circuit, which increased maintenance downtime, production at the plant during this quarter totaled 15,000 tons (5,000 tons/mo.) on a 5-day/wk. Operating schedule. This production level resulted in a small operating income at the pilot plant.

1.1.2 Gasification Test Plan and Testing

Carbona issued final copies of the report on the gasification test program to all parties, including DOE, on September 9, 1997. See Attached "Final Report of Alfalfa Gasification Tests". Note: This CONFIDENTIAL report was previously distributed to the following persons: Ray Costello, Jim Spaeth (2 copies), Richard Bain, and Mark Downing.

1.1.3 Design of Gasification Plant

Carbona provided nitrogen consumption requirements for Stone & Webster's use in developing the plant nitrogen system design.

Based on the results of the gasification testing, Carbona prepared and issued a gasification plant design basis on September 17, 1997. The key information is the heat and material balance for the gasification plant which is as follows:

• Air/alfalfa stem mass flow rate	0.809
• Steam/alfalfa stem mass flow rate	0.089
• Dolomite/alfalfa stem mass flow rate	0.020
• Gasifier bottom ash/alfalfa stem mass flow rate	0.067
• Filter ash/alfalfa stem mass flow rate	0.085
• Product gas/alfalfa stem mass flow rate	1.813
• Gas cooler duty, BTU/lb of alfalfa stem	275.22
• Available condensate heating, BTU/lb of alfalfa stem	60.2

Using this design basis, Carbona prepared a new overall gasification combined cycle power plant heat and material balance which needs to be confirmed by Westinghouse and Stone & Webster. Carbona has initiated the gasification plant process design, preparing process flow diagrams, subsystem heat and material balances and process data sheets for equipment.

Westinghouse issued the following scope of supply and design basis for the hot gas filter for review by Carbona and Stone & Webster:

Westinghouse Scope of Supply

Filter vessel

- shell cylinder and cone
- head
- refractory lining (installed)
- metal alloy liners (installed)
- gaskets
- vessel instrumentation probes

Filter internals

- tube sheet
- shroud
- clusters
- ceramic filter elements and gasket sets
- fail-safe/ regenerators
- pulse pipes (sections contained within vessel head)

Pulse gas control skid

- provide independent, programmed control package, or utilize plant main control system . (To be determined)

Pulse gas compressor skid (Could be supplied by others)

Ash removal system (Could be supplied by others)

- water-cooled screw conveyor
- lock hopper system

Specifications for pulse gas control skid to vessel pulse gas piping (no piping supply)

Specifications for pulse gas compressor skid to control skid piping (no piping supply)

Spare parts (need to identify items, numbers)

Equipment transportation carriages and erection frames

Specifications for filter Maintenance Rig

Equipment drawings and data

Manuals and training (installation, operation, maintenance)

Site supervision support (installation, startup, inspection, maintenance, operating data evaluation)

Design Basis

Filter System Operating and Design Conditions

- inlet fuel gas flow and conditions (composition, temperature, pressure) - minimum, nominal, maximum
- inlet particulate flow - minimum, nominal, maximum
- inlet particulate properties (composition, size distribution, permeability, bulk density, flow properties)
- ambient conditions - minimum, nominal, maximum
- pulse gas type(s) (recycled fuel gas, nitrogen, others)
- pulse gas supply conditions (composition, temperature, pressure)
- maximum acceptable filter outlet pressure fluctuation during pulse event
- cooling water conditions (pressure, temperature)
- plant operating histogram (time distribution of inlet gas temperature and flow)

Filter Design Constraints (possible)

- equipment design life
- maximum vessel dimensions and weight
- vessel support approach

- component lifting provisions
- inlet/ outlet pipe locations, orientations
- explosion-proof equipment requirements
- equipment redundancy requirements (e.g., pulse valves)
- pressure relief requirements
- special instrumentation required
- special material-of-construction requirements
- special gas or ash sampling provisions
- equipment inspection and QA requirements
- available space envelop for ash removal system (if Westinghouse designs this system)

Filter Performance Requirements (possible)

- maximum flange-to-flange pressure drop
- maximum fuel gas flange-to-flange temperature drop
- maximum vessel skin temperature (at specified operating conditions and ambient conditions)
- maximum outlet gas dust content and size distribution (turbine and environmental requirements)
- maximum pulse gas flow rate
- maximum pulse gas delivery power consumption
- ceramic filter element life
- ash drain cooling temperature

Interfaces

- fuel gas supply pipe and flange sizes
- fuel gas inlet nozzle loads
- clean fuel gas outlet pipe and flange sizes
- clean fuel gas outlet nozzle loads
- ash outlet pipe and flange sizes
- ash outlet nozzle loads
- pulse gas supply pipe and flange sizes
- pulse gas inlet nozzle loads
- pressure relief interfaces (if required)

Maintenance Approach

- capability for in-vessel inspection and maintenance is designed into the filter (maintenance internals)
- special maintenance provisions (e.g., head access platform)
- capability for external maintenance (removal of internals into frame) is still required

Filter Requirements for Plant Design

- startup limits and procedure
- operation control limits and procedures
- normal shutdown limits and procedures

- emergency shutdown limits and procedures
- installations and maintenance procedures

1.1.4 Combustion Testing

Westinghouse is preparing the combustion turbine test plan. Preparations for the testing at the University of Tennessee facility were identified and are currently being carried out. The testing is scheduled for November, 1997.

Gas turbine performance calculations and other technical materials will be presented at the project status meeting on November 4, 1997. Such materials will be formally submitted to DOE as an attachment to this quarterly report upon request.

1.1.5 Alfalfa Leaf Meal Product Tests

Alfalfa leaf meal (ALM) is a critical co-product to the economics of the alfalfa biomass energy system. Research is being conducted to characterize the nutritional value of ALM in dairy, beef and turkey diets and to provide an estimate of the economic value of alfalfa leaf meal to livestock.

All of the feeding trials with the exception of combined products (livestock feed products that include ALM and other commodity ingredients) containing ALM have been completed. A summary report on feeding trials and an economic analysis of results is presented below. The University of Minnesota Technical Report is attached. The University of Minnesota will issue a summary report in November 1997.

Summary Report Feeding Trials and Analysis:

Introduction - Task I was responsible for evaluation of the alfalfa leaf meal (ALM) product which would be produced by the MAP Project as a potential livestock feedstuff. The economic importance of the ALM to the overall viability of the MAP Project was demonstrated in the original feasibility study conducted in 1993/94 and jointly funded by USDOE, EPRI and NSP. In that study it was calculated that ALM would have a market price for use by dairy farmers of \$100 to \$125 per ton. This price was dependent on crude protein (CP) content of the ALM and current market price of major competing feed ingredients such as corn and soybean meal. Potential increases in value of the ALM of \$35 to \$60 per ton for use as dairy feed were projected if CP content could be increased from 23% to 30%, and if the bypass protein value of the ALM was increased. In the recently completed research we have examined the nutrient composition of ALM produced by the MnVAP alfalfa processing facility and its feeding value in dairy, beef, and turkey enterprises. From these performance results we have calculated new estimates of the potential economic worth of ALM for livestock production.

Results - Six large batches of ALM were received from MnVAP between November 1996 and August 1997. Consistency of the ALM product was good for CP content (21.8 to 23.6%); however, fiber concentrations were quite variable (28.8 to 44.5% neutral detergent fiber). Fiber variability suggests variability in the quality of the alfalfa hay used in the preparation of ALM batches. The relatively low CP content of the ALM clearly indicates that improvements

in separation technology provides an opportunity to significantly increase the value of ALM (alfalfa leaves contain 30% CP, and stems have a CP concentration of 10%).

The overall conclusion concerning the feeding value of ALM for all livestock species tested was that ALM can be successfully fed in properly formulated diets without loss in performance. We found that ALM can replace either high quality alfalfa hay or supplemental protein normally supplied by soybean meal in diets of lactating dairy cows. Feed intake, milk production, and milk composition were all similar when ALM was incorporated into the diet at moderate levels. However, when ALM is pelleted there is an apparent limit to ALM intake. Beyond 16% of the diet, the cows began to refuse ALM pellets.

In beef cattle, ALM was evaluated in three phases of production including wintering cows, receiving steers, and finishing feedlot steers. Supplemental protein was successfully provided by ALM for wintering cows, and mature cows actually gained more weight during the winter feeding period when fed ALM compared to soybean meal. Steers newly received in the feedlot are under stress, and ALM was evaluated as a feed to encourage feed intake by these stressed cattle. When ALM replaced soybean meal in the diet, receiving steers consumed more feed in one trial; but feed intake was the same for ALM and soybean based diets in the second trial. However, efficiency of growth was less on the ALM diets in the first trial. Finally, ALM could successfully replace soybean meal in the diet of finishing steers without reducing growth rate or carcass quality traits. There was a trend toward fewer liver abscesses when steers were fed ALM, and the blend of ALM and soybean meal increased efficiency of growth.

Inclusion of ALM in replacement of soybean meal in growing tom turkey diets increased feed intake up to 7.5% ALM in the diet. At this high level of ALM, feeding efficiency of growth was reduced, probably because of the high fiber content of the ALM. The 2.5% rate of ALM inclusion significantly improved weight gain of the turkey chicks during the first 4 weeks of life. Feeding ALM to turkey breeder hens tended to increase rate of egg production and fertility, especially during the later part of the production cycle. However, egg weights and hatchability were slightly reduced when turkey hens were fed ALM. The ALM appeared to contain similar "hatchability factors" to other traditional feed sources for these unknown components.

Economics - Prediction of the economic worth of a new potential feedstuff is always difficult. Factors to consider include price of competing feed ingredients, handling characteristics of the feed, and availability. The most successful new ingredients are those that are available in large quantity on a year-round basis, can be handled by existing feed facilities on farms, and are consistent in quality. The ALM product could potentially meet these criteria; however, it must still compete against a variety of other ingredients in a marketplace driven by least-cost diet formulation. The most important competing feed ingredient to ALM is soybean meal which is the dominant supplemental protein feed in the world, and all other protein feeds are valued relative to the price of soybean meal.

University researchers performed a series of economic calculations to provide "shadow" prices of ALM for all three livestock species studied. In the case of dairy, we projected that ALM would have a maximum economic value to a dairy farmer of \$163 per ton if used to replace

high-quality alfalfa hay or \$186 per ton if used to replace soybean meal. These ALM prices are based on current feed prices, which are high, especially for soybean meal and hay. At more typical feed prices, the ALM price drops to \$130 and \$145 per ton in place of hay and soybean meal, respectively. For finishing feedlot steers, projected ALM prices ranged from \$125 to \$196 per ton depending on which other feed ingredient in the diet was chosen as the replacement feed. Wintering cow diets placed a lower value on the ALM, ranging from \$100 to \$127 per ton. In turkey diets, several methods of price evaluation for ALM were attempted. The estimated market price of the ALM varied from as little as \$45 per ton to \$127 per ton. Based purely on protein content, ALM had a projected value of \$119 per ton at today's high soybean meal prices (\$280 per ton).

It is apparent that vastly different ALM prices can be projected depending on the livestock species being fed and the assumptions used in the diet formulation process. We advise caution in making economic projections for the ALM in overall performance of the MAP Project. While soybean meal prices are quite high today, which contributes to a higher ALM price estimate in today's marketplace, more typical soybean meal prices would suggest that 23% ALM be conservatively valued at approximately \$125 per ton.

Conclusions and Recommendations - The University of Minnesota researchers believe ALM could become a viable feed ingredient in the livestock industries provided that MnVAP is able to achieve and maintain favorable price, availability, and quality. Livestock performance is acceptable on diets formulated to include ALM. University researchers have detected some beneficial animal responses to ALM feeding (increased feed intake, increased weight gain, and improved animal health) under certain conditions that would potentially result in a price premium for ALM, if these benefits can be shown to be reliable. University researchers recommend that further research be conducted to verify the potential benefits observed for beef and turkeys fed ALM. Also, research in the dairy area to produce a more valuable form of ALM that incorporates improved bypass protein value and digestible energy would open a higher priced market to ALM. Finally, improvements in ALM separation technology to increase the CP content of the ALM will increase both the value of and marketing opportunities for ALM. Such an increase in protein concentration would be the most direct route to increasing the market value of ALM.

Subtask 1.2 Integrated Plant Design and Cost Estimate

Carbona provided Stone & Webster with a basis of design document listing site, plant and project design requirements. Much of the required information is not available, at this time. Stone & Webster has developed the following basis of design:

The proposed site is located in Granite Falls, Minnesota. The site is adjacent to Chippewa County Road 38, approximately 1 mile from Highway 23.

Gasification plant maximum feed capacity: 111,000 lb/hour of alfalfa stem

Potential range in alfalfa stem analysis:

Constituent, Dry Basis Weight %	Low	High
Carbon	45.3	45.8
Hydrogen	5.4	5.55
Nitrogen	2.2	2.8
Sulfur	0.1	0.22
Ash	5.0	9.2

Barometric pressure: minimum 0.94 bar ; maximum 1.04 bar

Ambient temp: min -36.7C/max 43.3C

Ambient relative humidity: min10%/max 100%

Precipitation: 700mm

Wind Pressure: 78.128 kg/square meter

Max wind velocity: 130 km/h

Typical wind direction: NW

Dust Loading: 14 micrograms/cubic meter

Site elevation above MSL: 320 m

Instrument air: 5.15 to 9.63 bara/-40C dew point

Electrical: 4160v 3 phase 60hz feed to gasification plant; Frequency Variation
+/- 5%; 250 to 4000 hp loads connect to 4160v; 75 to 250 hp loads
connect to 480v; Smaller loads are connected to 120/240 v

Cooling water: Assuming makeup for the cooling tower will be Minnesota
River water, the poorest cooling water quality would be as follows:

Total dissolved solids	3075 ppm
Total suspended solids	215 ppm
Silica	80 ppm
Calcium	445 ppm
Magnesium	255 ppm
Sodium	135 ppm
Fouling factor:	0.001 SqFt-°F/BTU (cleanliness factor of 85%)

Design cooling water piping to avoid deadlegs and keep velocities as high as possible

Stone & Webster has prepared system descriptions and flow diagrams/piping and instrumentation diagrams for the major power plant and balance of plant systems. These systems were based on overall plant heat and material balances prepared by Carbona in May and may require minor modifications once Westinghouse gas turbine performance information has been received and Stone & Webster prepares the design basis overall heat and material balances.

Stone & Webster provided Westinghouse with the following basis for development of gas turbine performance runs:

Site Elevation: 1050 feet

Turbine Exhaust Backpressure: 12 inches W.G.

Ambient Conditions:	<u>Temperature</u>	<u>Relative Humidity</u>
Max GT Output	20 to 30°F(NOTE 1)	66%
ISO	59°F	60%
Maximum	90°F	66%

NOTE 1: Westinghouse to determine temperature at which gas turbine output is maximum.

Fuel Gas Composition:

<u>Constituent</u>	<u>Volume (Mole) %</u>	
	<u>Alfagas #1</u>	<u>Alfagas #2</u>
Carbon Monoxide	10.97	12.28
Carbon Dioxide	17.91	16.32
Hydrogen	13.41	15.73
Methane	7.44	5.07
Ethylene	0.419	0.388
Ethane	1.054	0.977
Benzene	0.154	0.143
Toluene	0.066	0.066
Other Hydrocarbons	0.03	0.03
Water Vapor	14.38	13.73
Nitrogen	32.32	33.55
Hydrogen Sulfide	0.0423	0.0414
Carbonyl Sulfide	0.0047	0.0046
Ammonia	1.62	1.503
Hydrogen Cyanide	0.18	0.167

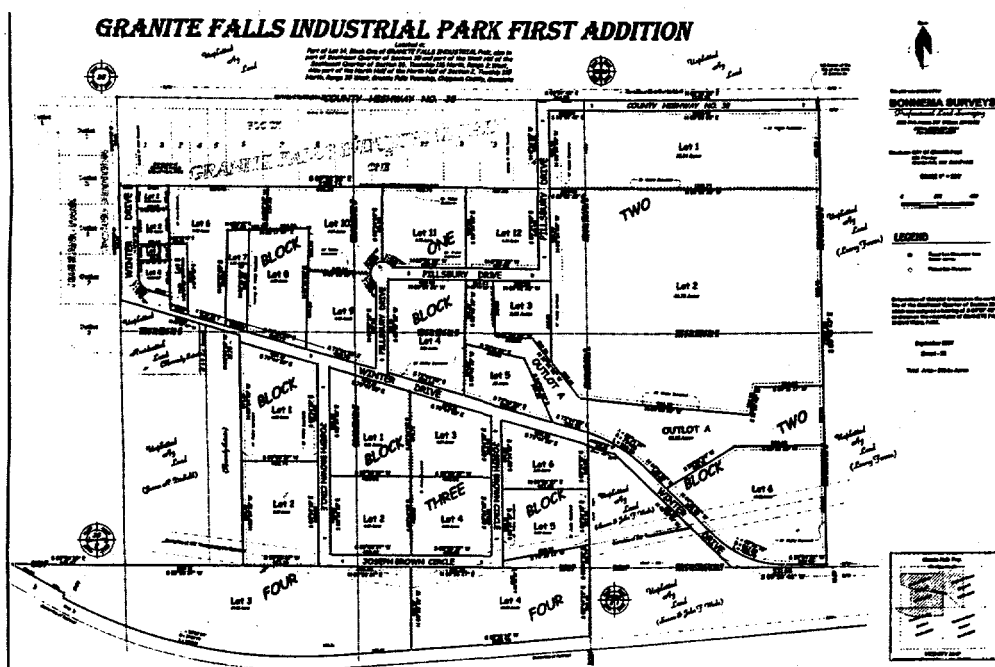
Fuel Gas Temperature: 1020°F

Gas Turbine Loads: 100% and 50%

Total number of alfagas runs: 3 ambient temps x 2 fuel gas analyses x 2 loads = 12 runs. Note: for each run, provide gas turbine output, exhaust gas flow, exhaust gas temperature and exhaust gas composition.

Also provide an ISO run with natural gas at 250°F (for the latest 251B model equipped with the MASB burner). Provide for this run normal performance data, e.g. heat input, fuel input, heat rate, output, exhaust gas flow, exhaust gas temperature and exhaust gas composition. Also provide performance correction curves for natural gas (e.g. ambient temperature, elevation and load).

The MAP gasification combined-cycle power plant is sited on lots 1 and 2 in the northeast corner of the Granite Falls Industrial Park.



TASK 2 REVIEW AND CONFIRM FEEDSTOCK SUPPLY PLAN

MnVAP continued development of the first new alfalfa processing facility. Meetings were held with economic development officials and business leaders in Marshall, Minnesota and Doland and Huron, South Dakota to determine local support for development of an alfalfa processing facility in their communities. Due to the tremendous intensity of alfalfa producers in eastern South Dakota, a number of meetings were held in and around Huron, South Dakota with farmers regarding their opportunities to participate in MnVAP and developing an alfalfa processing facility in their area.

MnVAP staff is evaluating the development of an alfalfa processing facility near Doland, South Dakota. A site was selected and staff are preparing a business plan for review and consideration by the Board of Directors.

Meanwhile discussions continue with the City of Marshall and representatives of other communities in MnVAP's production region for the development and siting of future facilities.

TASK 3 PERFORMANCE GUARANTEES AND WARRANTIES

MnVAP authorized continuation of all work under the subcontract with Westinghouse for Phase I. MnVAP is continuing discussions with United Power Association (UPA) staff regarding UPA's project role and commitments. UPA's commitment depends in part on the outcome of Power Purchase Agreement negotiations with Northern States Power.

TASK 4 SALES CONTRACTS

In production operations, MnVAP is improving the quality of the enhanced leaf meal livestock feed pellets. Markets that are likely to demand higher quality alfalfa products are being identified in order to focus leaf meal product marketing efforts.

MnVAP explored alternative fuel supply contract forms. While the straight price schedule is desirable because it is simpler to incorporate in business plans, prospective equity participants and financial institutions are concerned that a long-term price schedule may not appropriately price alfalfa stem in all years. They fear that the result could be windfall profits to producers or refusal by producers to deliver alfalfa stem fuel. MnVAP is continuing to work on contract terms that would be acceptable to lenders and equity participants.

MnVAP, UPA, Stone & Webster, Westinghouse, Kvaerner and Prudential Capital Group reviewed NSP's most recent power purchase agreement proposal, which was submitted to MnVAP on August 26, 1997. While this proposal was superior to past NSP proposals, there remain significant differences between MnVAP and NSP. Negotiations are continuing. MnVAP will continue to share with DOE staff all relevant correspondence.

TASK 5 SITE PLAN CONSTRUCTION AND ENVIRONMENTAL PERMITS REPORT

An air quality screening study was performed assuming the stack height will be 175 feet and using the following emission rate estimates:

	Alfagas Firing	Natural Gas Firing
Exhaust Gas Flow, Lb/hour (ACFM)	1,441,907(432,556)	1,383,827(414,158)
Exhaust Gas Temp, °F	250	220
SO₂, lb/hour	250	none
Particulates, lb/hour	< 1	negligible
NO_x as NO₂, lb/hour	125	45.4

The NO_x emission rate when firing alfagas assumes an SCR unit is required. (The exhaust gas NO_x concentration is estimated to be 365 ppm without an SCR unit in the HRSG.) The 125 lb/hour rate with an SCR corresponds to an NO_x concentration of 55 ppm (i.e. an SCR unit reduction efficiency of 85%).

The 45.4 lb/hour NOx emission rate when firing natural gas is without an SCR. If the permit requires that the SCR must be operated when firing natural gas, the NOx emission rate would be reduced to 16.4 lb/hour.

The results of the screening modeling are still being analyzed, but it appears that the plant would not cause any violations of ambient air quality standards or PSD increments.

A plan was developed to obtain site geotechnical borings to establish a basis for foundation design. A surveyor has been contracted to flag and record the boring locations and a driller has been hired to conduct the borings that are scheduled to start on October 6. Permission to do the borings has been requested from the City of Granite Falls.

The Task 5 report is currently in preparation and will be issued in November, 1997. The outline for the report is as follows:

1. Introduction

- Purpose of this Report

The purpose of this report is to present the plan for obtaining the environmental permits and approvals for the project. In developing the plan, discussions were held with DOE, EQB and other state agencies to identify the permits which would be required, to determine the information needed to prepare these permits and to identify key elements in agency procedures that would affect the schedule of activities for obtaining the permits and approvals.

- Scope of Activities under Task 5.1

2. Project Description

- Power Plant Components
- Identified Plant Sites
- Transmission Lines (Electric, natural gas, water and sewer)

- I. Electric Line Permitted by NSP

- II. Natural Gas Line - Possibly permitted by supplier

- III. Water line - permitted by MnVAP to follow existing water line possibly.

- IV. Sewer line - developed later.

3. Preliminary Identification of Potential Environmental Issues

- Air

- Noise
 - Water Supply
 - Traffic
 - Land Use
 - Remote Facility Siting
 - Ash Disposal
4. Review of Applicable Regulatory Agencies and Requirements
 5. Identification of Required Permits
 6. Review of Data Requirements to Comply with Application Requirements
 - Data Sources Accessed and Data Collected
 - Additional Data Needs
 7. Development of Permitting Schedule

TASK 6 ENVIRONMENTAL MONITORING PLAN

The results of University of Minnesota activities related to quantifying and improving the environmental benefits of alfalfa biomass energy production are described in the attached University of Minnesota Technical Report. The University of Minnesota will issue a summary report in November 1997.

TASK 7 FINAL REPORT

A quarterly report was prepared and submitted for the second quarter of 1997. Monthly reports were prepared for July, August and September, 1997.

TASK 8 PROJECT MANAGEMENT, ENGINEERING AND ADMINISTRATION

A major activity during the quarter was to prepare descriptions and budgets for work not included in the Phase I contract, but which is required to either complete preliminary engineering and develop the project capital cost/proforma or necessary to ensure that the project will meet the biomass mandate commercial operation date. This information was included in a Phase I extension proposal (denoted Phase IA) which was submitted to DOE at the end of August.