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BIOMASS POWER FOR RURAL DEVELOPMENT

Quarterly Report for the Period
January 1 - April 1, 1997

James T. Cooper

CHARITON VALLEY
RESOURCE CONSERVATION & DEVELOPMENT, INC.

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INTRODUCTION

The following information summarizes the major areas of project activities accomplished during the last quarter. Activities addressing conversion technology have been geared towards gathering information and drawing comparisons to specific project needs. Of major benefit was the trip taken to Denmark by Project Manger, Edward Woolsey. The first section of this report provides an overview of his experiences and findings. As a follow up to this trip, representatives from Iowa State University and from IES Utilities will also visit some of these facilities. Their information will be included in the next report.

At the supply development level, the RC&D has been working to identify and organize producers of switchgrass. A major accomplishment has been the formation of the Prairie Lands Bio-Products group. This association will explore different business structures that energy crop producers can use to supply biomass and to effectively market their materials to the energy industry. Thus, the group will begin to interact with IES in the next few months to determine how the supplier and the utility must interact to establish a working relationship and to efficiently provide biomass as a boiler fuel. Other major areas of focus for the group will be the development and implementation of risk management strategies to overcome income loss and allow acreage increases during market development. These strategies include the development of niche markets for switchgrass, the use of CRP lands, and outside sources of cost share for establishment.

In the area of agronomic activity, the participants from Iowa State University are developing field level research techniques and establishing specific test plot sites. Details of their methods will be included in the next report. We have however included examples of GIS data layers being developed for each research and supply area. This spatial information will be linked with data gathered on agronomic characteristics to develop production models as well as environmental analysis. The report section on GIS gives more detail on the example maps provided. Actual maps provided as attachments are copies of those provided at the technical review held in February.

Finally, we have provided a summary of the status of conversion technology activities conducted by IES and Iowa State University. A more detailed report will be included in the next submission to include information on additional Danish facilities, observations from planned co-firing tests and gasifier activities at ISU.

DENMARK TRIP REPORT

Introduction

In March of 1997 Edward Woolsey, Project Manager, spent a week in Denmark. The objective of the visit was to establish contacts in the areas of large scale straw co-firing projects, medium scale straw-fired heating plants and small scale straw-fired boiler systems. The following are highlights of the visit with contacts made, and points of interest discovered.

The visit started by re-establishing Danish biomass contacts made during the past seven years. Denmark has a long history of using straw for energy. They have been recognized as world leaders in the industry.

The issues driving the Danish interest in the straw-to-energy field are lead by the Danish government in response to the will of the general Danish population. The Danish government has made the commitment to slash Danish CO^2 emissions 20% from 1988 levels by the year 2005. The Government is now considering additional reductions in those goals by the year 2030.

Additional pressure to burn straw comes from the farmers. Farmers traditionally burned excess straw in the fields after cereal crop harvests. Burning straw in this manner created large amounts of smoke due to the incomplete combustion of the material. The smoke caused public complaints and consequently a ban on open burning.

Government Structure

Unlike the U.S. utility companies, the Danish power companies are owned by the people they serve, something like our Rural Electric Cooperatives. The smaller local plants have formed themselves into six larger groups which cover the entire mainland of the country. These six companies have then formed a management group called ELSAM. ELSAM represents 2.9 million people or about 55% of the population. As a comparison, Iowa currently has 2.7 million people.

The ELSAM partnership has eleven standing committees which provide direction to the ELSAM management committees on issues. These committees include:

1. System Operation Committee
2. Network Planning
3. Accounting
4. Financial
5. Planning
6. R & D
7. Wind Power
8. ELSAM's Fuel Quality
9. Power Technology
10. Environmental
11. Combined Heat and Power

ELSAM has established a sub-group to handle all of the engineering tasks. This group, ELSAMPROJECT A/S, handles all engineering tasks for ELSAM and the six Partners that make it up. However, ELSAMPROJECT also carries out assignments for other clients on a commercial basis. ELSAMPROJECT employees 250 people which (as they advertise)

"represent a perfect mix of up-to-date theoretical knowledge and many years of practical experience gained from the design, construction, operation and maintenance of the power stations in Jutland and on Funen." *(States in Denmark)*

ELSAM and its sister company ELKRAFT jointly own a consulting engineering company specializing in services related to energy and power systems based on fossil fuels and renewable energy. This company is named the Danish Power Consult A-S. DPC provides feasibility studies, design, engineering, supervision, commissioning, operation and maintenance, training and project management.

DANISH POWER CONSULT A-S
7, Lautruphoj
DK-2750 Ballerup
Denmark
Phone +45,44,68,08,33
Fax +45,44,66,55,28

Another Danish energy agency is the Danish Technological Institute, DTI. DTI is an independent non-profit enterprise with a staff of 1,100 and an annual budget of approximately 100 million dollars (U.S.). DTI develops and disseminates information on technology progress for the benefit of trade and industry and for society as a whole. Services provided include consultancy, testing, documentation, information and training. DTI has five divisions which include:

1. DTI Energy
2. Building and Technology
3. Industry
4. Environment
5. Industrial and Business Development

DTI provides services in the following areas:

- Strategy and Structure development
- R&D
- Accredited Testing
- Accredited Calibration
- Standardization
- Teaching and Training
- Consultancy and Product Development
- Software Development

Initial contact with ELSAM and ELSAMPROJEKT was through Jens Christian Clausen, Fritz Luxhoi and Helle Junger.

Jens Chr. Clausen
Head of Mechanical Eng. Section
ELSAMPROJEKT
Power Station Engineering
Kraftwaerksvej 53
DK-7000 Fredericia, Denmark
Phone +45 7923 3333
Fax +45 7556 4477
e-mail jcc@elsamprojekt.dk

Helle Junker
R & D
ELSAMPROJEKT
Power Station Engineering
Kraftwaerksvej 53
DK-7000 Fredericia, Denmark
Phone +45 7923 3333
Fax +45 7556 4477
e-mail hju@elsamprojekt.dk

Fritz Luxhoi
Head of R & D
ELSAMPROJEKT
Power Station Engineering
Kraftwaerksvej 53
DK-7000 Fredericia, Denmark
Phone +45 7923 3333
Fax +45 7556 4477
e-mail fl@elsamprojekt.dk

These individuals were key in arranging visits to several facilities in their region. They were gracious hosts and provided excellent contacts as well as real world experience.

The Sites

In 1986 all district heating plants were required to begin operating as CHP plants. A CHP plant is a Combined Heat and Power Plant. The natural advantage of the CHP plant co-generation configuration is that it allows for an almost doubling of system fuel efficiency. The most common way to use the heat left after electrical generation is for district heating systems. Over half of the population in Denmark currently receives their hot water from district heating plants.

Natural Gas is economically the superior fuel. ELSAM was required to buy electricity from the straw-fired plants at a rate higher than competing generation sources (natural gas). The rate of subsidy was 16$/mWh for a gas fired plant. For a new straw-fired plant the subsidy rate was $40-50 per MWh. Even at this rate the plants are considered marginally competitive.

The first location visited was **Rudkobing**. Rudkobing ***(See Diagram One)*** is a 12.5 million dollar (U.S.) co-generation plant specifically designed for straw combustion. The unit produces 2.3 kW of electricity and 7 MJ/s of hot water. The system has a heat input of 10.7mW which is equal to about 3 tons of straw per hour. The hot water, used for district heating is the key to the feasibility of the system. Hot water is stored in a 2,500 m^3 insulated tank. The tank uses the natural heat gradients which are established to separate hot for warm water. The hot water storage tank allows the boiler to be operated at full capacity (most efficient) for short periods of time. The natural thermal gradient in the tank is approximately one meter wide and has a temperature range of 90 to 45 degrees centigrade. The water used is de mineralized with ammonia added and adjusted to a pH of 9.5. Hot water pipes are installed 1.9 meters deep from the plant to the hot water end users. There are no problems with this system.

Straw is brought in large bales and shredded. The grate is a sloping grate similar to a Detroit Hydra or Hyper grate system. The grate vibrates. A very tall furnace and very low

temperatures, 700c, are used, compared with traditional boilers. A lot of slagging was found, soot blowers have been used successfully. The unit has been in operation since 1990. A flu gas temperature of between 110-115C must be kept or the precipitator will not function correctly. The ESP was removed last year and replaced with a new baghouse.

The bales are the Hesston 500 kg bales, 1.2 x1.3x2.4m.. A study was completed by Elsam which determined that the Hesston bales were the most economical to produce. The bales are delivered at about $70 per ton. The range they buy from is approximately 50-70 km.

The formation of deposits on the superheater grates is dependent on the rain conditions during the year. Rain on the straw is better for the power plant but worse for the farmers due to reduced yield.

Some of the newer installations supply hot water to industries as well as hospitals municipal buildings and residential dwellings. One of the newest installations supplies hot water to a paper recycling plant. There is a rate-based pricing system causing some plants to be used as peak load facilities, optimizing the value of their running time.

The next site visited was the **Studstrup Power Station**. The individuals which conducted the tour were:

Peter Binderup Hansen
I/S MIDTKRAFT Energy Company
Chemical Engineer Ph.D.
Studstrupvaerket, 8541 Skodstrup
Denmark
Phone +45 86991700
Fax + 45 86993720
e-mail pbh@post2.tele.dk

and

Peter Overgaard
I/S MIDTKRAFT Energy Company
M.Sc. Mech. Eng. Project Manager Technology Division
Spanien 19
8100 Arhus C.
Denmark
Phone +45 86134200
Fax +45 86135654

The plant is a large facility with approximately 800 MW of total generation capacity. The facility is composed of four units.

- 150 MW P.C. unit on-line in 1968. Modified to fire straw at up to 20% on an energy basis.
- 250 MW Oil unit on-line in 1972
- 350 MW P.C. unit on-line in 1984
- 350 MW P.C. unit on-line in 1985

There have been few problems associated with the modification and operation of the unit. For an in-depth analysis of problems, please see the attached paper. (Co-Firing Straw and Coal in a 150MWth Utility Boiler; K.H.Andersen et.al.) ***(See Attachment One)*** They

estimate their coal to have 11% ash and straw to have 4-5%. The unit has a new (1995) state-of-the-art straw handling facility. ***(See Photo One)*** They have watched the fly ash impacts of the straw firing and comment that if we are firing at the 10% straw level or lower we should have no problem with the potassium levels in our ash.

For a discussion of the risks associated with straw ash, read the attached paper by Helle Junker (Decision Theory And Biofuels) ***(See Attachment Two)***

A discussion was had concerning the different ways for the facility to collect its fuel. Studstrupvaerket buys its fuel from a cooperative while a nearby facility (Granau) procures from individual farmers. The purchases from the cooperative are more expensive but have better consistency while the purchases from the farmers are less expensive but have more variation in quality.

The third place visited was the **Danish Technological Institute**. One of the institute's duties is to test small scale biomass burner/boilers and feeding systems. The individual responsible for the operation is Mogens G. Larsen.

Mogens G. Larsen
Centre for Biomass Technology
Danish Technological Institute
Teknologiparken, DK-8000
Aarhus C, Denmark

Dansk Teknologisk Institute
Postboks 141, 2630 Taastrup
Denmark
Phone +45 43996065
Fax +45 43507088
e-mail infove@dti.dk

The facility has tested, and is currently testing all biomass systems sold or manufactured in Denmark. They have test results on many different systems and fuels. Straw is one of the most common fuels tested. Straw is fed into the units by bales or pellets. The bales may be large or small, round or square. There are units which can handle any type of bale. A system was observed to be successfully operating on straw pellets. Mr. Larsen has recently completed a paper on the topic Straw Pellets As Fuel In Biomass Combustion Units. ***(See Attachment Three)***

The current straw prices are about .4 Danish crowns (7 crowns = 1 U.S. $). The fertilizer value of the straw is approximately .05 crowns. This gives the farmers reason to collect the material and bring it to the heating plants rather than combust it in the field, adding to air quality problems.

Mr. Larsen states that the small systems work well to heat air and to heat water up to 90 degrees Celsius. No companies have yet optimized the pellet stoves for straw although DTI has satisfactorily tested some of the pellet stoves using straw pellets. They find wood to run about 1% ash and straw to run about 7-8% ash. They advise that any straw stoves have easy ash removal and maybe some type of interior ash cleaning system.

It is clear that technology is not the limiting factor in the usage of straw for heat and power production. For a good overview of the Danish straw firing experience refer to ***(See Attachment Four)*** Experiences From 61 Straw-Fired District Heating Plants In Denmark. A.Evald, M.Larsen.

SWITCHGRASS PRODUCERS GROUP

Introduction

The Biomass Power for Rural Development Project 's long-term work plan focuses on the large scale use of switchgrass biomass as a fuel source for energy generation. The project's long term plan calls for 35MW of electrical power generation that will require 200,000 tons of switchgrass annually. A major challenge for the project is the need to establish switchgrass plantings for energy production prior to full development of the market for its large scale use as a biomass fuel.

In order to address the supply-related issues important to energy producers and the concerns of switchgrass producers regarding market development, the Biomass Power for Rural Development Project's short-term work plan includes the following activities.

- Develop and implement strategies to reduce producer risk and to encourage the establishment of biomass crops ahead of the proposed utility-based market .

- Create the organizational structure that will most effectively accomplish the cultivation, processing, and delivery of switchgrass, *(Panicum virgatum L.),* as a biomass feedstock for energy generation.

- Develop products and markets that will facilitate the establishment and management of switchgrass plantings necessary to support the large scale use of biomass for energy generation.

Beginning in early December of 1996, the ground work started for the formation of a producers cooperative. We have successfully organized and incorporated this entity through which the above activities will be carried out. We are now looking at defining its role as the supplier to IES utilities of switchgrass for biomass. In addition, we are outside of the direct scope of the Biomass Power for Rural Development funding, looking at ways to accomplish the following goals which ultimately support supply development.

- Evaluate and compare the variety of possible organizational structures, e.g., cooperative, corporation, and associated roles that will best enable producers to create and satisfy short and long term demand for switchgrass-derived products.

- Select and establish the type of producer organization determined to be the most appropriate to create and meet the demand for switchgrass-derived products.

- Evaluate switchgrass-derived products for niche markets including its use as a processed, e.g., pelletized, and unprocessed, e.g., baled, source of energy for residences, farms, and public facilities in rural areas.

- Develop and test market products determined to have the greatest potential in terms of supporting the large scale use of switchgrass for energy production.

Planned activities in the next few months will be designed to strengthen the producers group and to accelerate the transfer of technology related to energy crops. As the research conducted by Iowa State University is carried out, the producers will participate in the field work itself as well as the distribution and assessment of findings.

Creation of a switchgrass producers organization will provide the structure needed to help ensure the availability of an adequate supply of switchgrass of an acceptable quality for use as biomass fuel. A formal organization will: (1) contribute to a greater dissemination of

knowledge among members regarding improved techniques for establishing, managing, and handling switchgrass and, (2) provide member switchgrass producers a relative measure of risk management in the production, processing, and marketing of switchgrass. There are several alternative legal structures that may be considered for the switchgrass producers organization. These include traditional and value-added cooperatives, C and S corporations, limited liability company and nonprofit organization. This activity of the project work plan will: (1) conduct a feasibility study to determine the most appropriate legal structure(s) and associated role for the producers organization and, (2) take the necessary steps to establish the selected structure type(s).

While outside the scope of the immediate project, the development of switchgrass-derived products for niche markets will nonetheless support feedstock scale-up activities. The availability of markets for switchgrass products will, at a minimum, help offset the costs and risks associated with the planned steady increase in plantings. It is expected that certain niche products and markets will develop as financially attractive complements to the large scale production and use of switchgrass for energy generation. Potential energy related products and markets that have been identified include switchgrass-derived fuel for residential, on-farm, and rural public facility use. Non-energy related products and markets identified include the use of switchgrass as a mulching material at construction sites, a component in the fabrication of fiberboard and paper, livestock bedding, and production of the chemical furfural used in the manufacture of plastics. The producers group is seeking assistance to: (1) conduct a feasibility study to determine the relative potential for success of alternative products and niche markets and, (2) initiate product development and test marketing for the alternative(s) determined to possess the greatest potential for success.

Copies of the Articles of Incorporation and ByLaws for Prairie Lands Bio-Products, Inc. follow.

IOWA NONPROFIT ARTICLES OF INCORPORATION OF PRAIRIE LANDS BIO-PRODUCTS, INC.

TO THE SECRETARY OF STATE OF THE STATE OF IOWA:

The undersigned, acting as incorporator of a corporation under the Iowa Nonprofit Corporation Act, Chapter 504A of the Code of Iowa, adopts the following Articles of Incorporation for such corporation:

ARTICLE I - NAME

The name of the corporation is PRAIRIE LANDS BIO-PRODUCTS, INC. It is organized under Chapter 504A of the Code of Iowa.

ARTICLE II- CORPORATION EXISTENCE

The corporate existence of this corporation shall begin on the date the Certificate of Incorporation is issued by the Secretary of State of the State of Iowa and shall continue perpetually thereafter unless dissolved as provided by law.

ARTICLE III - PURPOSES AND POWERS

The corporation is organized exclusively for agricultural and horticultural purposes within the meaning of Section 501(c)(5) of the Internal Revenue Code, as amended. The primary purposes of the Corporation are to promote the development of agriculture and the general

welfare of those who are involved and are dependent directly on agriculture; to promote the development of legumes, grasses, forage, trees, shrubs and other plants as commercial crop; to develop markets for such crops; to educate farmers and others involved in growing such crops; and to promote an economic climate favorable to such development; and to perform all such other activities legal within the State of Iowa as are related to these stated purposes.

The corporation shall not participate in or intervene in (including the publishing or distributing of statements) or contribute to any political campaign on behalf of (or in opposition to) any candidate for public office.

Notwithstanding any other provisions of these Articles, the corporation shall not conduct or carry on activities not permitted to be conducted or carried on by any organization exempt under Section 501(c)(5)of the Internal Revenue Code, as amended.

As a means of accomplishing the foregoing purposes, the corporation shall have all of the general powers set forth in Chapter 504A of the Code of Iowa, and as it may hereafter be amended. These general powers shall be exercised exclusively for the attainment of the purposes of the corporation set forth in this Article.

ARTICLE IV - NO PRIVATE INUREMENT

No part of the net earnings shall inure to the benefit of any director or officer of the corporation or any private individual (except that reasonable compensation may be paid for services rendered to or for the corporation affecting one or more of its purposes). No director or officer of the corporation, or any private individual shall be entitled to share in the distribution of any of the corporate assets on dissolution of the corporation.

ARTICLE V - DISSOLUTION PROVISIONS

Upon the dissolution of the corporation, the Board of Directors shall, after paying or making provisions for the payment of all of the liabilities of the corporation, dispose of all of the remaining assets of the corporation exclusively for the purposes(s) of the corporation set forth in Article III hereof in such a manner or to such organization or organizations operated exclusively as charitable organizations which would then qualify under the provisions of Section 501(c)(5) of the Internal Revenue Code, as amended, as the Board of Directors shall determine. Any such assets not so disposed of shall be disposed of by the District Court of the County in which the principal office of the corporation is then located, exclusively for such purposes or to such organization or organizations as said District Court shall determine which are organized exclusively for such designated purpose(s).

ARTICLE VI - INITIAL REGISTERED AGENT AND REGISTERED OFFICE

The address of its initial registered office in the State of Iowa is RR 3, Box 116A, Centerville, Appanoose, County, Iowa 52544, and the name of its initial registered agent at such address is: James T. Cooper.

ARTICLE VII- INITIAL BOARD OF DIRECTORS

The number of directors constituting the initial Board of Directors of the corporation is five (5). The number of directors may be changed by the Board of Directors upon the adoption of Bylaws for the corporation and by any subsequent amendment to the Bylaws adopted by

the Board of Directors. The names and addresses of the persons who are to serve as the initial directors are:

Name	Address
Donald E. Clark	RR 2, Box 167, Centerville, IA 52544
Loren Eddy	Rt #4, Box 87, Centerville, IA 52544
Edward D. Robinson	Box 25620, Rt. #1, Albia, IA 52531
John E. Sellers, Jr.	RR #3, Box 249, Corydon, IA 50060
Jim Schweizer	Rt #1, Centerville, IA 52544

ARTICLE VIII - MEMBERS

The corporation shall have members. The designation of membership classes and the qualifications and rights of the members of each class shall be as set forth in the corporation's Bylaws.

ARTICLE IX - EXEMPTION OF PRIVATE PROPERTY

Consistent with ¶504A.10l of the Code of Iowa, the private property of the directors, officers, employees and members of the corporation shall be exempt from all debts, obligations and liabilities of the corporation of any kind whatsoever and directors, officers, members and other volunteers of this corporation shall not be personally liable in that capacity for a claim based upon an act or omission of the person performed in the discharge of the person's duties, except for a breach of the duty of loyalty to the corporation for acts or omissions not in good faith or which involve intentional misconduct or knowing violation of the law, or for a transaction from which the person derives an improper personal benefit. If Iowa law is hereafter changed to mandate or permit further elimination or limitation of the liability of the corporation's directors, officers, employees, members and volunteers, then the liability of the corporation's directors, officers, employees, members and volunteers shall be eliminated or limited to the full extent then permitted.

ARTICLE X INCORPORATORS

The names and addresses of the incorporators:

Name	Address
Donald E. Clark	RR 2, Box 167, Centerville, IA 52544
Loren Eddy	Rt #4, Box 87, Centerville, IA 52544
Edward D. Robinson	Box 25620, Rt. #1, Albia, IA 52531

ARTICLE XI AMENDMENTS

These Articles of Incorporation may be amended at any time and from time to time provided by the Code of Iowa, but no amendment shall be adopted which deprives the corporation of tax exempt status under the Internal Revenue Code of 1986, as amended.

Dated this _____ day of _____. 1997.

IN TESTIMONY WHEREOF, we hereunto subscribed our names on this _____day of ____, 1997.

_____
Donald E. Clark

_____
Loren Eddy

_____
Edward D. Robinson

IOWA NONPROFIT CORPORATION BYLAWS OF PRAIRIE LANDS BIO-PRODUCTS, INC.

ARTICLE I. OBJECTIVES

The Prairie Lands Bio-Products, Inc. (hereinafter called the "Corporation") will conduct its activities to promote the purposes for which it was organized as set forth in the Articles of Incorporation. No part of the net earnings of the Corporation shall inure to the benefit of or be distributable to its directors, officers or other private persons, except that the Corporation shall be authorized and empowered to pay reasonable compensation for services rendered and to make payments and distributions in furtherance of the purposes and objects set forth in the Articles of Incorporation. The Corporation shall not participate in, or intervene in (including the publishing or distribution of statements) any political campaign on behalf of any candidate for public office. Notwithstanding any other provisions of these Bylaws, the Corporation shall not carry on any activities not permitted to be carried on by a corporation exempt from federal income tax under Section 501(c)(5) of the Internal Revenue Code (or the corresponding provisions of any future United States Internal Revenue Law).

ARTICLE II. MEMBERSHIP

Section 2.1. Requirements of Membership Any person interested in assisting with the stated Objectives of the organization may become a member. Upon completion of required Application for Membership and payment of the required annual dues; provided, however, that members at the time of the adoption of these Articles, will continue as members as long as in good standing and the payment of required annual dues.

Section 2.2 Classes of Membership. the membership of this organization shall be of only one class:

1. Regular Single Voting Member -- Person 18 years or older will be entitled to one vote.

Section 2.3 Membership Year. Membership year shall begin on the first day of January in each year and end on the last day of December of the same year.

Section 2.4 Membership Dues. The dues shall be established by the Board of Directors at the annual meeting of the corporation. Full annual dues shall be payable for any portion of a membership year.

Section 2.5 Termination of Membership. Payment of Annual Dues -- Membership is automatically terminated if annual dues are not paid as established under these Bylaws; renewal dues become delinquent on January 1 of each year, after which time membership service will be discontinued without further notice being required. Membership terminated only for non-payment of annual dues are subject to automatic reinstatement upon payment of annual dues, provided, however, the member has remained in good standing as established in Article II, Section 2.1 of these Bylaws.

ARTICLE III. OFFICES

Section 3.1. Principal Office. The principal office of the Corporation in the State of Iowa shall be located in the County of Appanoose. The Corporation may have such other offices, either within or without the State of Iowa which the Board of Directors may designate or as the business of the Corporation may require from time to time.

Section 3.2. Registered Office. The registered office of the Corporation required by the Iowa Nonprofit Corporation Act, Chapter 5O4A, Code of Iowa, to be maintained in the State of Iowa may be, but need not be identical with the principal office in the State of Iowa, and the address of the registered office may be changed from time to time by the Board of Directors.

ARTICLE IV. BOARD OF DIRECTORS

Section 4.1. General Powers. The business and affairs of the Corporation, including the control and disposition of its property and funds, shall be managed by its Board of Directors. The Board of Directors shall have sole authority to establish methods of contributions, accept or reject contributions, or to provide for qualifications or levels relating to contributions which in its sole discretion deems necessary; subject to applicable legal requirements.

In accepting gifts, bequests, and devises it is the intention that the directors will manage the affairs in such a manner so as to comply with the meaning of the terms and limitations of the Articles of Incorporation and these Bylaws so that such actions will not jeopardize the federal income tax exemption of this Corporation pursuant to the provisions of Section 501(c)(5) of the Internal Revenue Code of 1986 as now in force or as may be amended.

Section 4.2. Number, Tenure and Qualifications. The number of directors of the Corporation shall be five (5) and each shall serve for a term of one (1) year. After this initial period, the Board of Directors will be chosen by election by the membership at its annual meeting.

Section 4.3. Regular Meetings. A regular meeting of the Board of Directors shall be held without other notice than this Bylaw immediately after, and at the same place as, the annual meeting of members. The Board of Directors may provide, by resolution, the time and place, either within or without the State of Iowa, for the holding of additional regular meetings without other notice than such resolution.

Section 4.4. Special Meetings. Special meetings of the Board of Directors may be called by or at the request of the President or a majority of the directors. The person or persons authorized to call special meetings of the Board of Directors may fix any place, either within or without the State of Iowa, as the place for holding any special meeting of the Board of Directors called by them.

Section 4.5. Notice. Notice of any special meeting shall be given at least five (5) days previously thereto by written notice delivered personally or mailed to each director at his or her personal or business address. Such notice shall be deemed to be delivered when deposited in the United States mail so addressed, with postage thereon prepaid. Any director may waive notice of any meeting. The attendance of a director at a meeting shall constitute a waiver of notice of such meeting except when a director attends a meeting for the express purpose of objecting to the transaction of any business because the meeting is not lawfully called or convened. Except as otherwise provided in these Bylaws, neither the business to be transacted at, nor the purpose of, any regular or special meeting of the Board of Directors need be specified in the notice or waiver of notice of such meeting.

Section 4.6. Quorum. A majority of the number of directors shall constitute a quorum for the transaction of business at any meeting of the Board of Directors but if less than such majority is present at a meeting a majority of the directors present may adjourn the meeting without further notice.

Section 4.7. Vacancies. Any vacancy occurring in the Board of Directors and, to the extent permitted by law, any directorship to be filled by reason of an increase in the number of directors may be filled by election by a majority of the then sitting directors of the Corporation. A director so elected shall serve the unexpired term of his or her predecessor in office or the full term of such new directorship, as the case may be.

Section 4.8. Presumption of Assent. A director of the Corporation who is present at a meeting of the Board of Directors at which action on any corporate matter is taken shall be presumed to have assented to the action taken unless his or her dissent shall be entered in the minutes of the meeting or unless he or she shall file his or her written dissent to such action with the person acting as the secretary of the meeting before the adjournment there or shall forward such dissent by registered mail to the Secretary of the Corporation immediately after the adjournment of the meeting. Such right to dissent shall not apply to a director who voted in favor of such action.

Section 4.9. Informal Action by Directors. Any action required to be taken at a meeting of the directors, or any other action which may be taken at a meeting of the directors may be taken without a meeting if a consent in writing, setting forth the action so taken, shall be signed by all of the directors entitled to vote with respect to the subject matter thereof. For purposes hereof, facsimile signatures shall be adequate to show consent.

Section 4.10. Resignation and Removal. Any director may at anytime resign by serving written notice thereof on the remaining directors. Membership on the Board of Directors may also be terminated by passage of a removal resolution of the Board of Directors after any director has missed more than three consecutive board meetings.

Section 4.11 Compensation. Directors shall serve without compensation, except reasonable expenses may be paid. However, to the extent deemed necessary by the Corporation, the Corporation may retain the services of a director other than in his or her capacity as a director and the director may be compensated for services so rendered as the Board of Directors may from time to time deem appropriate.

ARTICLE V. OFFICERS

Section 5.1. Officers Appointment and Term of Office. The officers of the Corporation shall be a President, a Vice President, a Secretary and a Treasurer. They shall be elected annually at the first meeting of the Board of Directors held after the beginning of

the fiscal year. Each officer shall hold office until his or her successor shall have been duly appointed and shall have qualified or until his or her death or resignation.

Section 5.2. Vacancies. A vacancy in any office because of death, resignation, removal, disqualification or otherwise, shall be filled in accordance with the provisions of these Bylaws with respect to the original appointment to such office.

Section 5.3. President. The President shall be the principal executive officer of the Corporation and subject to the control of the Board of Directors, shall in general supervise and control all of the business and affairs of the Corporation. He or she shall, when present, preside at all meetings the of Board of Directors. He or she may sign, with the Secretary or any other proper officer of the Corporation thereunto authorized by the Board of Directors, any deeds, mortgages, bonds, contracts, or other instruments which the board of Directors has authorized to be executed, except in cases where the signing and execution thereof shall be expressly delegated by the Board of Directors or by these Bylaws to some other officer or agent of the Corporation, or shall be required by law to he otherwise signed or executed; and in general shall perform all duties incident to the office of President and such other duties as may be prescribed by the Board of Directors from time to time.

Section 5.4. Vice President. In the absence of the President or in the event of the President's death, inability or refusal to act, the Vice President shall perform the duties of the President, and when so acting, shall have all the powers of and be subject to all the restrictions upon the President. The Vice President shall perform such other duties as from time to time may be assigned to him or her by the President or by the Board of Director

Section 5.5. Secretary. The Secretary shall:

a) Keep the minutes of the Board of Directors' meetings in one or more books provided for that purpose;

b) See that all notices are duly given in accordance with the provisions of these Bylaws or as required by law;

c) Be custodian of the corporate records;

d) Keep a register of the post office address of each member of the Board of Directors which shall be furnished to the Secretary by such member; and

c) In general perform all duties incident to the office of Secretary and such other duties as from time to time may be assigned to him or her by the President or by the Board of Directors.

Section 5.6. Treasurer. The Treasurer shall.

a) Have charge and custody of and be responsible for all funds and property of the Corporation;

b) Receive and give receipts' for monies due and payable to the Corporation from any source whatsoever, and deposit all such monies in the name of the Corporation in such banks, trust companies, or other depositories as shall be selected in accordance with the provisions of these Bylaws;

c) Compile and distribute annually to each director a report of the activities of the Corporation, including a statement of receipts and expenditures; and

d) In general, perform all of the duties incident to the office of Treasurer and such other duties as from time to time may be assigned to him or her by the Board of Directors. The Treasurer may be required to give a bond at the expense of the Corporation for the faithful discharge of his or her duties in such sum and with such surety or sureties as the Board of Directors shall determine.

Section 5.7. Resignation. Any officer may at anytime resign by serving written notice thereof on the Board of Directors. Such resignation shall take effect upon receipt thereof or at any later time specified therein; and, unless otherwise specified therein, acceptance thereof shall not be necessary to make it effective.

Section 5.8. Removal. Any officer may be removed by the Board of Directors whenever in its judgment the best interests of the Corporation will be served thereby. Any officer holding the position of President, Vice President, Secretary or Treasurer shall automatically be removed if the individual holding the subject office is no longer a member of the Corporation's Board of Directors due to death, resignation or removal.

Section 5.9. Assistants, Acting Officers, and Executive Director. The Board of Directors or any officer, duly authorized by the Board of Directors, may appoint any person to act as assistant to any officer, or to perform the duties of such officer whenever it is impractical for such officer to act personally, and such assistant or acting officer may perform all the duties of the office to which appointed as assistant, except as such power may otherwise be defined or restricted by the Board or the appointing officer.

The Board of Directors is hereby explicitly authorized to, in its discretion, appoint a full or part-time Executive Director to assist each of the Corporation's officers in the conduct of their duties and the business of the Corporation. An officer or director of the Corporation or any other person may serve as Executive Director. The Executive Director shall manage the regular business and affairs of the Corporation and shall have other such powers and duties as the Board of Directors shall specify.

Section 5.10. Salaries. The President, Vice President, Secretary and Treasurer shall serve without compensation, except that reasonable expense shall be paid. However, to the extent deemed necessary by the Corporation, the Corporation may retain the services of the President, Vice President, Secretary and Treasurer other than in their capacity as such officers and they may be compensated for services so rendered as the Board of Directors may from time to time deem appropriate.

The salaries of all assistant officers and acting officers, including Executive Director if appointed, shall be fixed from time to time by the Board of Directors.

ARTICLE VI. INDEMNIFICATION

Section 6.1. Indemnification. Except for any prohibition against indemnification specifically set forth in these Bylaws or in Chapter 504A, Code of Iowa, at the time indemnification is sought by any member, director, officer, employee, volunteer or agent of the Corporation, the Corporation shall indemnify any person who was or is a party or is threatened to be made a party to any threatened, pending or completed action, suit or proceedings, whether civil, criminal, administrative or investigative (other than an action by or in the right of the Corporation) by reason of the fact that he or she is or was a member, director, officer, employee, volunteer or agent of the Corporation, or is or was serving at the request of the Corporation as a member, director, officer, employee or agent of another Corporation, partnership, joint venture, trust or other enterprise (such serving as a member, director, officer, employee or agent of the Corporation or at the request of the

Corporation referred to herein as "serving on behalf of or at the Corporation's request"), against expenses (including attorneys' fees), judgments, fines and amounts paid in settlement actually and reasonably incurred by him or her in connection with such action, suit or proceeding if he or she acted in good faith and in a manner he or she reasonably believed to be in or not opposed to the best interests of the Corporation, and with respect to any criminal action or proceeding, had no reasonable cause to believe his or her conduct was unlawful. Their termination of any action, suit or proceeding by judgment, order settlement, conviction, or upon plea of nolo contendere or its equivalent, shall not, of itself, create a presumption that the person did not act in good faith and in a manner which he or she reasonably believed to be in or not opposed to the best interests of the Corporation, and, with respect to any criminal action or proceeding, had reasonable cause to believe that his or her conduct was unlawful.

Section 6.2. Indemnification: Further Provisions. If a member, director, officer, employee, volunteer or agent of the Corporation has been successful on the merits or otherwise in defense of any action, suit or proceeding referred to in Section 6.1, or in defense of any claim, issue or matter therein, he or she shall be indemnified against expenses (including attorneys' fees) actually and reasonably incurred by him in connection therewith. Any other indemnification (unless ordered by a court) shall be made by the Corporation only as authorized in the specific case upon a determination that the indemnification of such person is proper because he or she has met the applicable standard of conduct set forth in Section 6.1; such determination shall be made:

a) By the Board of Directors by a majority vote of a quorum consisting of directors not parties to such action, suit or proceedings, or

b) In a written opinion by special independent counsel selected by the Board of Directors by a majority vote of a quorum consisting of directors not parties to such action, suit or proceedings, or

c) If the requisite quorum of the full Board of Directors cannot be obtained through disinterested directors, in a written opinion by special independent legal counsel selected by a majority vote of the full Board of Directors in which directors who are parties may participate. Expenses incurred by defending a civil or criminal action, suit or proceedings as authorized in the manner provided in this Section 2 upon receipt of an undertaking by or on behalf of such person that such person is proper because he or she believes in good faith that he or she has met the applicable standard of conduct set forth in Section 6.1 and that such person will repay such amount unless it shall ultimately be determined that he or she is entitled to be indemnified as authorized herein. The indemnification and advancement of expenses provided herein shall not be exclusive of any other rights to which those seeking indemnification or advancement of expenses provided herein shall not be exclusive to any other rights to which those seeking indemnification or advancement of expenses may be entitled under any provision in the Articles of Incorporation or Bylaws, any agreement, any vote of members or disinterested directors, or otherwise, both as to actions in the person's official capacity entitling the person to indemnification and advancement of expenses under these provisions and as to actions in other capacities concurrently held by those seeking indemnification or advancement of expenses. However, no person shall be provided indemnification by any provision of the Articles of Incorporation or Bylaws by any agreement, or otherwise, for any breach of a duty of loyalty to the Corporation or its members, for any act or omission not in good faith or which involves misconduct or knowing violation of the law, or for any transaction

from which the person derives an improper personal benefit. The indemnification provided herein shall continue as to a person who has ceased to be a member, director, officer, employee, volunteer or agent and shall inure to the benefit of the heirs, executors, personal representatives and administrators of such a person. The Board of Directors shall have power to purchase and maintain insurance on behalf of any person who is or was serving on behalf of or at the Corporation's request against any liability asserted against him and incurred by him in any such capacity or arising out of his or her status as such, whether or not the Corporation would have the power to identify him or her against such liability under the provisions hereof.

ARTICLE VII. CONTRACTS, LOANS, AND DEPOSITS

Section 7.1. Contracts. The Board of Directors may authorize any officer or officers, agent or agents, to enter into any contract or execute and deliver any instrument in the name of and on behalf of the Corporation, and such authority may be general or to specific instances.

Section 7.2. Loans. No loans shall be contracted on behalf of the Corporation and no evidences of indebtedness shall be issued in its name unless authorized by a resolution of the Board of Directors. Such authority may be general or confined to specific instances. The Corporation shall make no loan to any officer or director of the Corporation.

Section 7.3. Checks Drafts Etc. All checks, drafts or other orders for the payment of money, notes or other evidences of indebtedness of the Corporation, shall be signed by the Treasurer or such other officer or officers, agent or agents of the Corporation and in such manner as shall from time to time be determined by resolution of the Board of Directors. Three signatures shall be required for business obligations or expenditures over one (1) thousand dollars ($1,000) -- less than one thousand dollars ($1,000) shall require one (1) signature of any of the officers

Section 7.4. Deposits. All funds of the Corporation not otherwise employed shall be deposited from time to time to the credit of the Corporation in such banks, trust companies or other depositories as the Board of Directors way select.

ARTICLE VIII. WAIVER OF NOTICE

Whenever any notice is required to be given to any member or director of the Corporation under the provisions of the Articles of Incorporation or under the provisions of the Iowa Nonprofit Corporation Act, a waiver thereof in writing, signed by the person or persons entitled to such notice, whether before or after the time stated therein, shall be deemed equivalent to the giving of such notice. For purposes hereof, facsimile signatures shall be adequate to show consent for such waiver.

ARTICLE IX. FISCAL YEAR

The fiscal year of the Corporation shall begin on the first day of January in each year and end on the last day of December of that same year.

ARTICLE X. SEAL

The Corporation shall have no corporate seal.

ARTICLE XI. AMENDMENTS

These Bylaws may be altered, amended or repealed and new bylaws may be adopted by a majority vote of all members of the Board of Directors at any regular or special meeting of the Board of Directors provided that a minimum of thirty (30) days notice in writing of the character of the proposed alteration, amendment or repeal is given to all members of the Board of Directors.

ARTICLE XII. COMMITTEES OF THE BOARD OF DIRECTORS

Section 12.1. General. The President, with the Board of Directors' concurrence, may establish and appoint standing and special committees as shall be deemed desirable for the endeavors of the Corporation. A standing or special committee shall limit its activities to the accomplishment of those tasks for which it was appointed and shall have no powers, except those specifically conferred by action of the Board of Directors. Upon the completion of the task(s) assigned to any special committee, the special committee shall be discharged.

Section 12.2. Committee Membership. Persons who are not directors or officers of the Corporation may be appointed to serve on standing or special committees. All standing or special committee members shall serve at the pleasure of the Board of Directors. The Board of Directors shall review and re-appoint persons to membership on all standing and special Committees at the Board of Directors' annual meeting.

Section 12.3. Meetings. All committees shall meet at such time and place as designated by the chairperson of the committee and as often as necessary to accomplish their duties.

IOWA STATE UNIVERSITY - AGRONOMIC ACTIVITY

Geographic Information System (GIS) Component - Biomass Power For Rural Development Project

The geographic information system (GIS) developed for the project is being used to create field level data layers. This information is being gathered and processed for land owners who are participating in the project as switchgrass producers. Field level data will enable the GIS to be used to analyze project-related issues such as the environmental impacts of land use changes to switchgrass production, e.g., reduction in soil loss when compared to row crop production, and evaluate the switchgrass yield potential of land resources, e.g., soil types, and alternative management practices, e.g., timing of harvest.

Enclosed with this report is a series of sample GIS products, e.g., maps ***(See Attachment Five)*** and the associated database, for one of the fields that is being used to produce switchgrass for the project. Specifically, these products include:

- Field boundaries and location provide the legal description of the field's location as well as the field's physical relationship to other features of interest, particularly roads, water bodies, and other fields that are, or may be candidates for, participating in the project.

- Soil mapping units present within the field provide the basis for a wide range of field level soil related interpretations to be performed. These interpretations can be made with existing soil mapping unit specific data, e.g., slope, or newly generated soil mapping unit based attributes, e.g., switchgrass yield.

- Soil mapping unit based interpretations performed and illustrated as map products include land capability class and corn suitability rating from existing data and potential soil loss and switchgrass production potential from data gathered during the course of the project. The former data is part of the Iowa Soil Properties and Interpretations Database. The later information was based on estimates of soil loss under a corn/bean cropping rotation and use of known yield potential for tall introduced grasses as an index of switchgrass production potential.

- Participant field statistics database presents the information used to create the GIS map products. The field statistics database contains the information that drives GIS analysis. The database can be used to accommodate and incorporate into GIS assisted analyses all of the field level information of interest to the project including existing data, e.g., soil mapping units, land use, as well as newly created data, e.g., fertilizer rates, switchgrass yield.

The GIS is also being used to create regional data layers of interest to the project. This information will be used to perform and illustrate the results of region level analyses. Project related analyses will include the modeling of field level data on a regional basis. Specifically, these analyses can examine such issues as the potential water quality impact of land use changes to switchgrass production in the Rathbun Lake watershed and total estimated switchgrass yield potential for land in the four county Chariton Valley RC&D area. Sample regional level GIS products included with this report are maps of the soil associations in the Rathbun Lake watershed and soil mapping unit based land capability class interpretation for the Rathbun Lake watershed in Lucas County.

CONVERSION TECHNOLOGY STATUS

IES Industries - Design Study Status

On Friday, March 7, 1997, Conrad Anderson met with Professor Ken Ragland of the University of Wisconsin in Madison to discuss progress on the co-firing tests at the MG&E's Blount Street Station. One of Professor Ragland's Phd. Students, Jeff Hoerning, demonstrated a particle combustor in his lab that can be used to measure the ignition time, temperature and ash constituents of switchgrass stems of varying length and geometry. The next round of tests are scheduled for the week of April 7, 1997.

On Thursday, March 20, 1997, Alan Teel, Gary Walling, Jerod Smeenk, Doug Alexanders (OGS Plant Manager) and Conrad Anderson met with Charles Steinman and Jim Vogt of John Deere at the OGS Plant Site to discuss various switchgrass harvesting, handling and storage options and the siting of switchgrass handling facilities at the plant site.

R.W. Beck developed a preliminary design for the on-site switchgrass handling facilities at OGS. ***(See Diagram Two)*** We have requested technical specifications and price quotes for most of the equipment shown on the attached diagram.

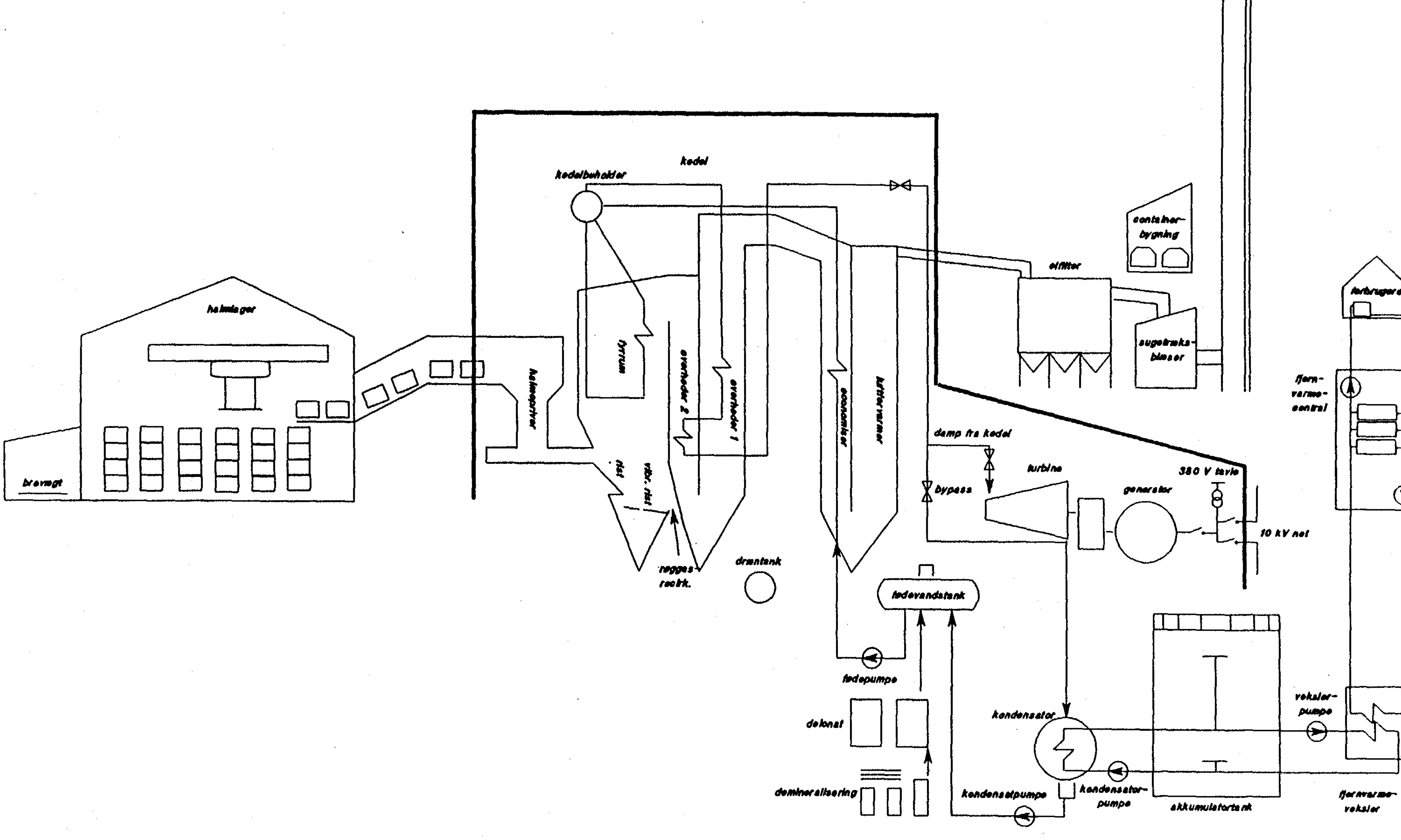
Iowa State University - Engineering Department Status

Work this quarter is concentrating on selecting a new design for a fuel handling system. As detailed in previous progress reports, the original feeder fabricated for the gasifier has performed satisfactorily for waste seed corn but has been unable to feed switchgrass in a sustained fashion. A surge hopper suitable for switchgrass is being designed and two different fuel preparation systems being evaluated for purchase or construction.

An abstract was prepared and submitted on this work to the 1997 Biomass of the Americas Conference. It has been accepted for presentation.

DIAGRAM ONE

RUDKOBING



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container-
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sugetræks-
blæser
forbrugere
fjern-
varme-
central
veksler-
pumpe
fjernvarme-
veksler

ATTACHMENT ONE

CO-FIRING STRAW AND COAL IN A 150MWTH UTILITY BOILER

conference paper removed and cycled separately

PHOTO ONE

1995 STRAW HANDLING FACILITY

ATTACHMENT TWO

DECISION THEORY AND BIOFUELS

DECISION THEORY AND BIOFUELS

Application of decision theory for plant comparisons and assessment of technical risks

Helle Junker, M.Sc. (Mech. Eng.) Industrial Researcher
ELSAMPROJEKT A/S, Kraftværksvej 53, DK-7000 Fredericia
Telephone: +45 79 23 33 33 Telefax: + 45 75 56 44 77

Karl Erik Widell, Professor
Aalborg University, Pontoppidanstræde 101, DK-9220 Aalborg Ø
Telephone: +45 98 15 85 22 Telefax: +45 98 15 14 11

ABSTRACT

In this paper the economic potentials for co-firing and CFB (Circulating Fluidized Bed) are compared to the separate biomass-fired boiler. In the study the economic effects of superheater corrosion and costs of fly ash are compared by use of decision theory, which is not a widespread method for use in this subject.

The analysis pointed out the CFB plant type to be the best choice when comparing the estimated monetary values (EMV). The differences in EMV values were insignificant dependent on the results to come from demonstration plants and the calculations made it clear that even considering the technical risks evaluated, CFB would still be the optimal choice.

KEYWORDS

Decision Theory, Economic optimization, Risk analysis, Combustion, Biofuel, Co-firing, CFB, Separately fired bioplant, Superheater corrosion, Fly ash reuse.

INTRODUCTION

Decision theory is used mainly in general management, and - during the last years - also in engineering optimization. Traditionally, decision theory has not been widely used in technical assets management, but the following examples can be mentioned: /Douglas, 1996/ and /ELSAM, 1994/.

This work within decision theory is part of a larger project entitled: " Advanced combustion of biomass alone or combined with coal". Advanced combustion is related to power plants with steam superheating higher than 540°C. The plants investigated are: Co-firing and Circulating Fluidized Bed (CFB).

The specific part of the project focuses on ash deposits that cause corrosion in the convective heat exchangers in CFB (mainly) and reduce the heat transfer. The focus will mainly be on the thermodynamical and fluid dynamical mechanisms that form the deposits caused by co-combustion of coal and biomass (especially straw), but the investigations will also include chemical aspects of the deposits. The project will be finished in April 1997.

DECISION THEORY FOR PLANT COMPARISONS

The analysis of the above-mentioned problems is based on a marginal calculation. In the decision situation we have set up a number of choices and strategies related to:

- Co-firing
- CFB
- Separately fired Biofuel Plant

ELSAM has already decided to build one demonstration plant of each of the three types of plants. The possibilities within each plant concept set-up can be: to continue building plant types with the same technology (especially the same superheating temperature) as for the demonstration plants; to build plants with more advanced technologies (higher steam temperatures); to close the demonstration plant when the demonstration periods are finished. For Co-firing and Separately-fired Bioplant this is after two years. For CFB it is after ten years. These are the strategies it is possible to choose between for the concepts investigated.

In Figure 1 the choices are presented in a decision tree including the result of the calculation. A decision tree is a graphic technique that can be used to illustrate connections between decisions about alternative acts, where the consequences of the alternatives are uncertain. In this decision tree it is assumed, that the results from running the demonstration plants are all known before the final choice is made. In the decision tree is used conventional symbols for outcome analysis.

One could imagine a different decision tree if it has not already been chosen to build three demonstration plants. In that case it could have been evaluated whether the choice of building demonstration plants would add the extra knowledge about the technology that the knowledge is worth because of the extra costs. It could have turned out that it would be most optimal just to choose the plant type in advance and start building the necessary capacity.

THE NEED OF A COMMON BASE OF COMPARISON

The possible plants for use of biofuels that have been set up in Figure 1 differ in a number of aspects. In the following the differences are listed:

a. Power production
b. Lifetime
c. Production of district heat
d. Fired percentage of energy from biofuel
e. Thermal efficiency
f. New plants/rehabilitations
g. Equivalent hours with full production
h. Sort of biofuel (straw or wood chips)

Usually, plants are compared by net present values (NPV). In studies like this one would use the estimated monetary value (EMV) where the values are weighted with possibilities of their outcome. These values cannot be used directly in this case.

The differences related to the concepts, which are to be corrected in this comparison of the economical optimal type of plant for use of biofuel are the ones named a to c.

Power production has been compensated for as larger plants are able to produce a higher NPV just because of their size. When comparing investment with different lifetimes by NPV, a common measure is to be found. The MKA plant is a back-pressure plant and the thermal efficiency used for these calculations is as if it had been a condensing plant.

After compensating for the differences in the types of plants used for comparison, the plants will be compared by the annual EMV per MWe installed on biofuel. When this financial comparison criterion is referred to later, it is named aEMV/b.

THE TECHNICAL RISKS

The technical risks of interest in this investigation by use of decision theory are superheater corrosion and reuse/disposal of fly ash.

The risks are only evaluated for Co-firing and CFB using Separately-fired Bioplant as a reference. The technical risks for those plant types are expected to be known as the fuels are burned separately which means that the ashes will not be mixed and the superheating by the straw flue gas will only reach 450°C.

For both Co-firing and CFB it is expected that the superheater corrosion will increase when replacing coal with straw. It is also expected that for Co-firing it might not be possible to reuse the ash as it is today with coal-firing alone. The ash from CFBs cannot be used even without the use of biofuels.

The following calculations of the aEMV/b values are carried out: a) for the most likely outcome of the superheater corrosion and fly ash use; b) for the most likely outcome of the superheater corrosion and the worst case situation of the fly ash used; c) for the worst case situation of the superheater corrosion and the most likely outcome of the fly ash use.

To decide the most likely outcome of point a) possible outcomes have been set up and the probability for each outcome has been estimated. The probabilities are different for Co-firing and CFB, but within the same plant type, the possible outcomes are the same. The probabilities depend on the results of the demonstration tests. The situation "positive outcome" of the demo-tests describe a situation where the problems are equal or less than expected. For points b) and c) the most likely outcomes of one of the technical risks are combined with the worst case situation for the other one. To force the worst situation occurs the probability is set to 1.0.

RESULTS AND DISCUSSION

The results by use of decision theory include both the pointing out of the optimal choice of the type of plant when using the most likely and weighted outcomes of the technical risks investigated (figure 1) and sensitivity analysis of the importance of the technical risks (figure 2). The optimal choice of plant type using the most likely outcomes of the technical risks is shown in the decision tree in figure 1.

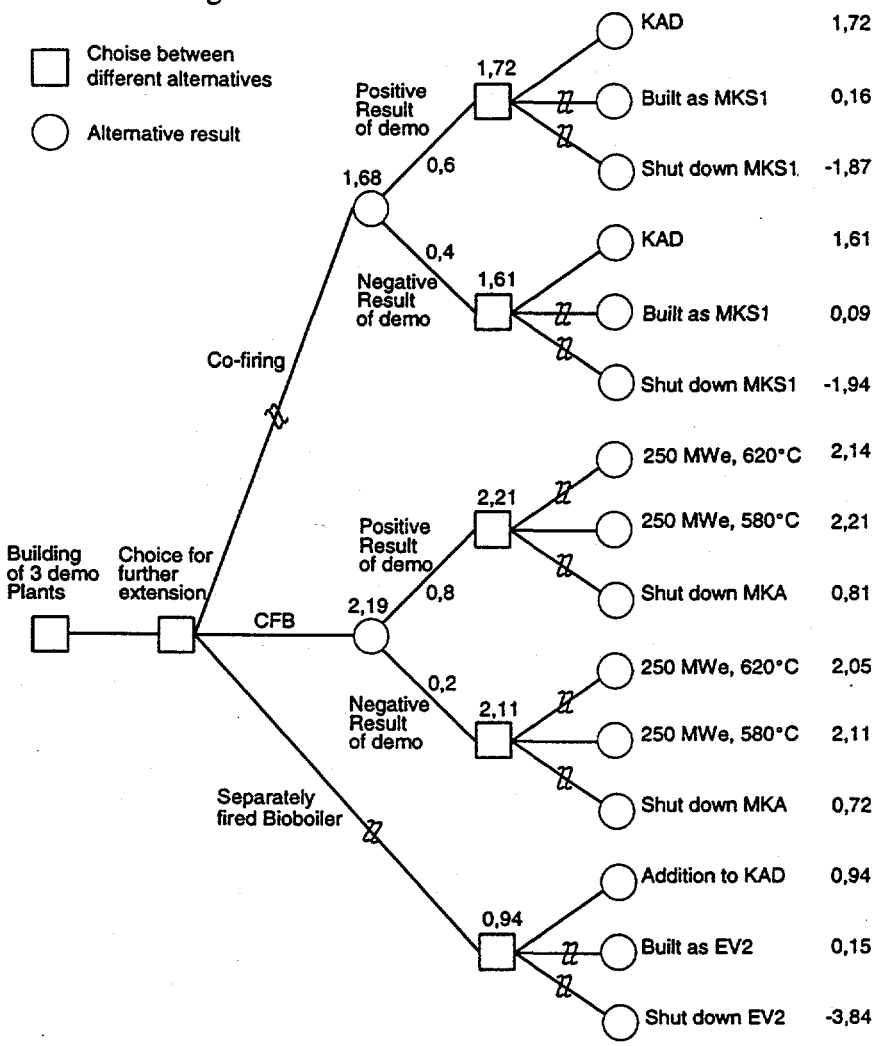

Figure 1. Decision tree with the result of the calculations using the most likely outcomes of the technical risks investigated.

As shown in the figure, both a positive and a negative outcome of the results of the demo-tests at the MKA demonstration plant point towards the same type of plant. With the assumptions used in this calculation, it is most optimal to use the biofuel in 250 MWe CFB plants with steam data as for MKA (which means superheating at 580°C). There is no increase in aEMV/b by increasing the superheating temperature as the extra costs for changing the superheaters increase faster than the expenses of fuel are reduced by using a plant type with a lower superheating temperature.

From Figure 1 it is also clear that the differences in the values depending on positive or negative outcome of the tests at the demo-plants are insignificant. Therefore the weighted values of the positive and negative outcomes are used to represent the values for the plants.

The reason why the differences are so small between the positive and negative situations it that quite a lot is already known about the rates of high-temperature corrosion from the preliminary tests at the Co-fired plant, Vestkraft unit 1 and the tests at the CFB plant, Grenaa KVV plant. Concerning the use of the fly ash, nobody really believe that the ash from co-firing can be used in the cement or concrete production no matter what the results of the demo-tests show. It can hopefully be used for landfill, but may require depositing. If it turns out to be necessary to upgrade the fly ash by one of the costly techniques, this will to a higher extent depend on whether it will still be allowed to deposit the ash at all in future, rather than on the quality of the ash.

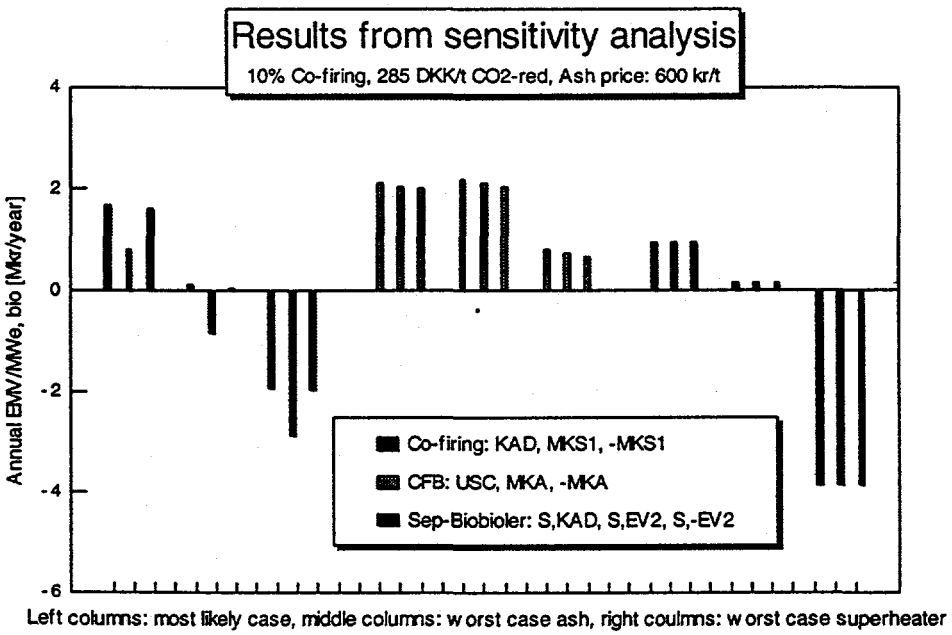

Figure 2. The result of the sensitivity analysis. For each plant type the most likely aEMV/b is shown as well as the combinations of worst case situations for the technical risks investigated.

Figure 2 shows the result of the sensitivity analysis, where the importance of the technical risks on the choice of plant type is investigated. From the figure it can also be seen which of the technical risks that can turn out to be the most costly for each type of plant.

This figure gives the answer to the question asked previously whether it is possible that one of the technical risks investigated can be so costly that the optimal choice would have been to choose another plant type. If the height of the columns is compared, it is clear that choosing a CFB type of plant with superheating temperatures such as MKA will be the best choice no matter the technical risks.

The results of the calculations shown in this paper are based on co-firing with 10% of the energy from straw, an income from CO_2 reduction at 285 DKK/t and an ash upgrading price of 600 DKK/t in the worst case situation. CFB plants will still be the economically most optimal type - also with co-firing of 20% of the energy from straw and with no income from CO_2 reduction.

For the set of columns that represent CFB plants, it can be seen that for these plants the columns with the worst case situation for the superheater costs are lower than the cases with the ash costs being worst case. That means that for CFB plants, the costs of the superheater corrosion can turn out to be more costly than the costs of the fly ash disposal/upgrading.

For co-fired plants the costs related to fly ash may turn out to be higher than the costs in connection with superheater corrosion. This is not surprising as large amounts of coal ash are being contaminated by the straw ash resulting in all the ash having to be upgraded.

CONCLUSIONS

In this project decision theory has been used to test the method and to focus the research on the type of plant with the highest economical potential and to solve some of the high-risk problems.

The major results obtained with regard to the method were: it was possible to use the method; it was possible to find a common base of comparison; using the method made it possible to split up the possible outcomes of the risks investigated and to set up probabilities for the outcomes.

The major results from evaluating the problem complex were: The analysis pointed out one of the plant types (CFB) to be the best choice when comparing the annual EMV/per installed effect on biofuel (aEMV/b). The difference between the aEMV/b for positive and negative outcome of the demo-tests was insignificant. The result of the calculations made it clear that the technical risks evaluated could not turn out so bad that CFB would not still be the optimal choice. For both co-firing and CFB plants the cost of the high-temperature corrosion of the superheaters is expected to be higher than the possible upgrading of the ash. For co-fired plants upgrading of the ash can make up the highest costs.

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ATTACHMENT THREE

STRAW PELLETS AS FUEL IN BIOMASS COMBUSTION UNITS

conference paper removed and cycled separately

ATTACHMENT FOUR

EXPERIENCES FROM 61 STRAW-FIRED DISTRICT HEATING PLANTS IN DEMARK

EXPERIENCES FROM 61 STRAW-FIRED DISTRICT HEATING PLANTS IN DENMARK

Anders Evald (1) and Mogens G. Larsen (2)

(1) Centre for Biomass Technology, dk-TEKNIK
Gladsaxe Moellevej 15, DK-2860 Soeborg, Denmark

(2) Centre for Biomass Technology, Danish Technological Institute
Teknologiparken, DK-8000 Aarhus C, Denmark

ABSTRACT

This paper gives an outline of the results from a study undertaken by Centre for Biomass Technology on behalf of the Danish Energy Agency with the purpose of giving detailed information on the plant design, operational experiences, investment and operational costs and other key figures for straw fired district heating systems in Denmark.

KEYWORDS

Straw firing, district heating, Denmark, experiences

INTRODUCTION

The survey is based on a comprehensive questionnaire distributed to all Danish straw fired district heating plants. The survey is complete as data was collected from all of the 61 straw fired district heating plants in operation by 1995 in Denmark. For the single plant app. 200 different data was collected.

The study gives a presentation of state-of-the-art for straw combustion technology in the range from 0.5 MW to 10 MW thermal output installed in the period from 1980 to 1995.

This paper contains due to limitations in page numbers only a few of the many data available. In (Evald, 1996) a more comprehensive description is available.

INSTALLATION AND OPERATION

The 61 plants are in sizes from 0.4 MW to 11 MW (thermal output), the average size is 3.8 MW. Figure 1 shows the size of the plants.

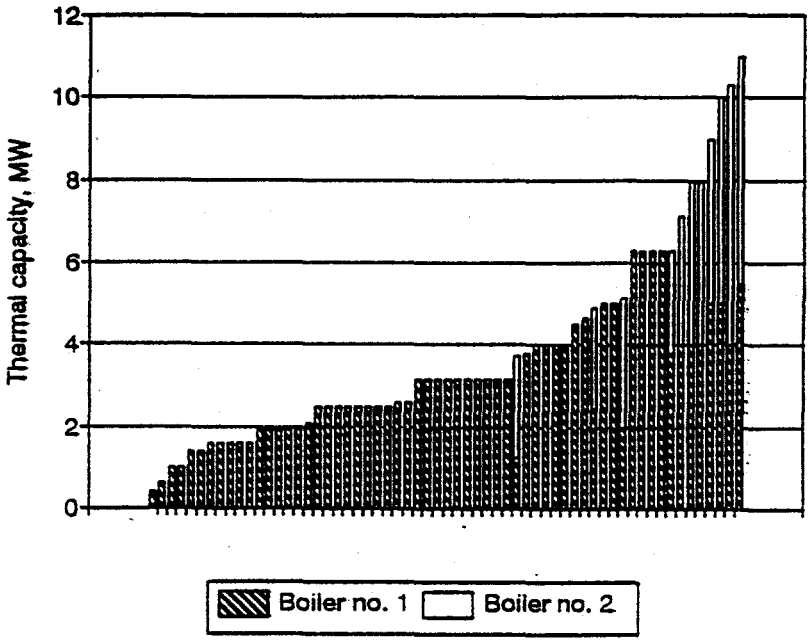


Fig. 1. Capacity of the 61 straw fired district heating plants in Denmark. Of 61 plants 11 has two boilers installed. The average boiler size is 3.2 MW.

Straw Consumption

The consumption of straw in the 61 investigated plants totals 286,000 metric ton per annum. The consumption of straw corresponds to 1360 TJ of energy based on lower calorific value (LCV) of the fuel.

Types of straw used

85 percent of the straw supplied to the various plants - more than 200,000 tonnes - comes from barley and wheat. The remainder consists of rye, rape, oats and seed corn straw. Landskontoret for Planteavl (The National Plant-growing Office) states that some 5½ million tonnes of straw were harvested in 1994, of which app. 4.2 million tonnes were barley and wheat straw. In other words, straw-fired heat-generation consumes less than 5 percent of the amount of barley and wheat straw harvested.

Plant design, handlings systems, boilers etc.

Details on plants design, straw handling, storage for straw, heat accumulators, boiler types, flue gas cleaning systems etc. are described in (Evald and Larsen, 1996)

ECONOMY

Plant costs

Information was collected regarding the cost of constructing straw-fired heating plant. Cost of construction is compared with the output of the straw-fired boiler(s) installed. The calculations are based on information received from 40 plants which burn straw without sifgnificant amounts of other fuels such as wood chips, grease sludge etc.

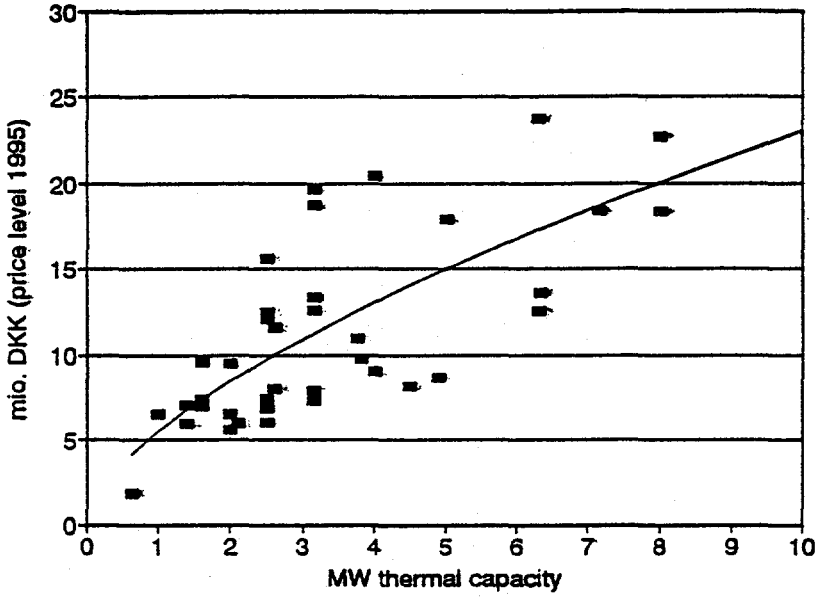


Fig. 2. Cost of construction of plant in millions of Danish Kroner (DKKm) per MW of output installed. The points on the graph show the cost of each plant, the line drawn demonstrating an approximate price formula based on a calculated average price of DKK 15m for a 5 MW unit.

The approximate cost of construction of plant = 15 * $(Q/5)^{0.62}$ million Kroner, where Q is the output of the boiler installed. 1 DKK = ECU 0.14 (May 1996). All sums are quoted exclusive of the 25 percent Danish Value Added Tax (moms).

Construction costs comprise purchase of site including site development; buildings; machinery (including installation); design and planning. Very few plants include the cost of storage tanks in their calculations. Construction costs of transmission networks and mains are not included. The prices quoted - original costs on construction of the plant and costs of reconstruction or extension accruing subsequently - are adjusted for the Danish price index level obtaining in August 1995.

Cost of straw

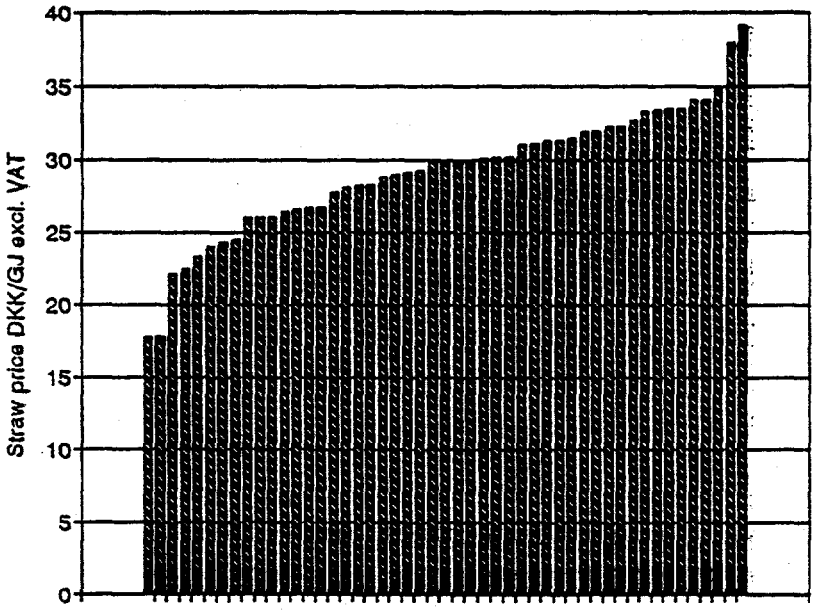


Fig. 3. Cost of straw in DKK per GJ, before Danish VAT (49 plants)

Cost of straw was given by 49 plants. The cost was calculated on the basis of the basic prices notified and the thermal value at the percentage water content corresponding to the basic price. In addition, costs are corrected for seasonal variations in the basic price. As can be seen, costs vary from DKK 17.8/GJ to 39.1/GJ, with an average of DKK 29.2/GJ.

Annual operating efficiencies

The annual operating efficiency of district heating plant is a measure of the plants production of energy over the year in relation to the energy content of the fuel burned. This study was carried out on the basis of information from 28 plants which supplied both information of consumption of straw and generation of heat. The energy combusted is determined on the basis of the weight of straw and its combustion value at the average water contents noted. Only heat generation from straw is included

Most straw-fired district heating plant show an annual operating efficiency of 80 to 90 percent. The average annual operating efficiency of the 28 plants is 84 percent.

Power consumption

Power consumption in this connection is the plants total consumption of electricity, including that used for hot water mains pumps and for generation from other fuels.

Average power consumption per MWh produced, including for pumps, is calculated to be 19.8 kWh/MWh. The minimum and maximum are 10.6 kWh/MWh and 27.9 kWh/MWh respectively. Power consumption is set in relation to heat generation, including other fuels. On the basis of

information from seven plants, electricity for operating district heating water pumps accounts for some 27 percent of the total power consumption.

Other economic information

Information of other economic data such and seasonal straw price variation, price adjustment by percentage water content etc. ia available in (Evald, 1996).

ORGANISATION ETC.

Organisation and ownership

The preferred financial construction is the limited liability co-operative (A.m.b.a.). Its go roots deep in Danish history, particularly in farming areas. The distribution is as follows:

47 are A.m.b.a.s, of which 39 are owned by the consumers and 8 by suppliers of straw; nine are municipality owned, seven of them in the east of the country, and five "other".

The latter comprise of 1 limited partnership association (Nexoe), 1 co-operative society with municipal participation (Hvidebæk), 1 special housing association (Tinggaarden) and 2 private partnership companies (Ringsted and Svendborg).

Some companies own and operate the district heating plant only: not the distribution network (the mains). The energy is paid for by the distributor, e.g. the local municipality.

Consumers

In Denmark as a whole, 45 000 consumers receive their heating supplies directly from straw-fired district heating plant. The plants report that this corresponds to 83 percent of all consumers in the areas supplied. In other words, there are still householders who could benefit from district heating. One potential category of consumers comprises people on the heating network whose property is currently heated by electricity. Unfortunately the cost of conversion to water-based heating represents a financial barrier to connection to the system.

The average number of households connected is 770. The smallest plant is Herning Municipal heating centre at Simmelkær, with 72 subscribers, and the largest is Ringsted with 4,253.

In addition, straw-fired heating plant supplies a large number of institutions such as kindergardens, schools, old people's homes, and local government offices. On the other hand business premises have not yet benefited from connection to the communal mains. Amendments to the regulations governing rebates on energy and CO_2 tax will make it more attractive for business premises to buy energy, including biomass-generated heat, for space heating etc. from the communal system.

Geographical Allocation of the Plants

The straw fired plants are distributed in the whole country, however there is a concentration in areas with the largest straw surplus.

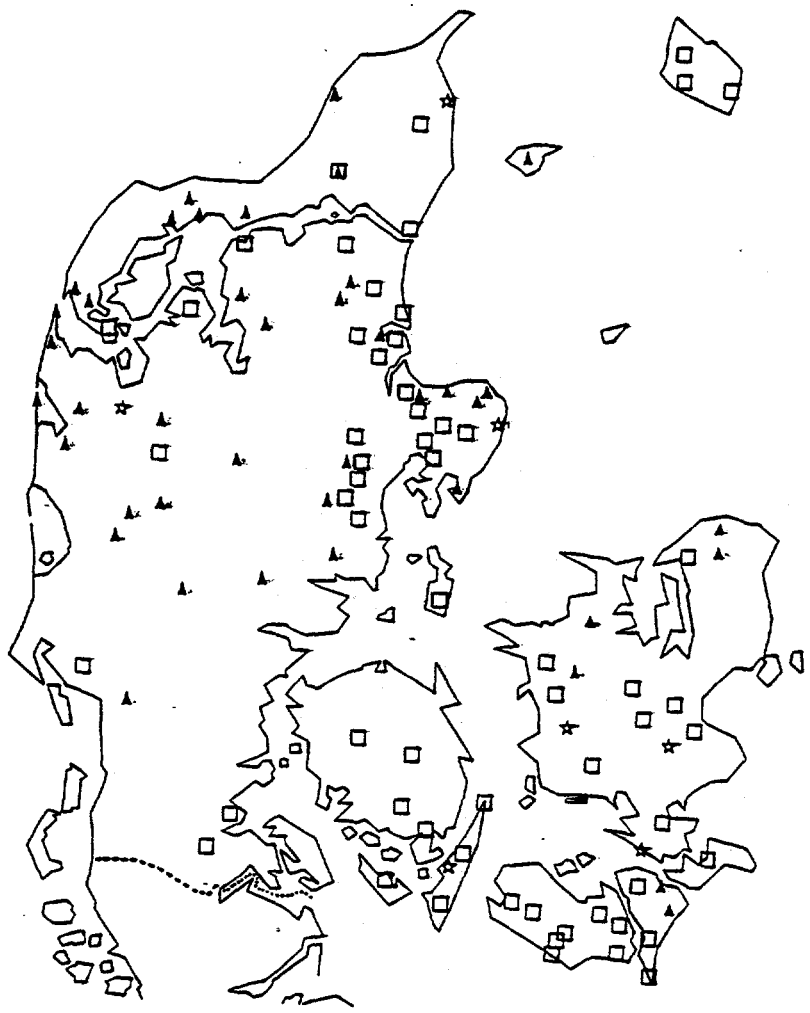


Fig. 4. Biomass-fired heating plants in Denmark. Straw-fired heating plant (squares) are concentrated in East Jutland and the islands of Lolland and Falster, and are more scattered in the rest of the country. Central and Western Jutland are completely dominated by wood chip-fired plants (solid triangles); the five-pointed stars indicate biomass-fired cogeneration plant.

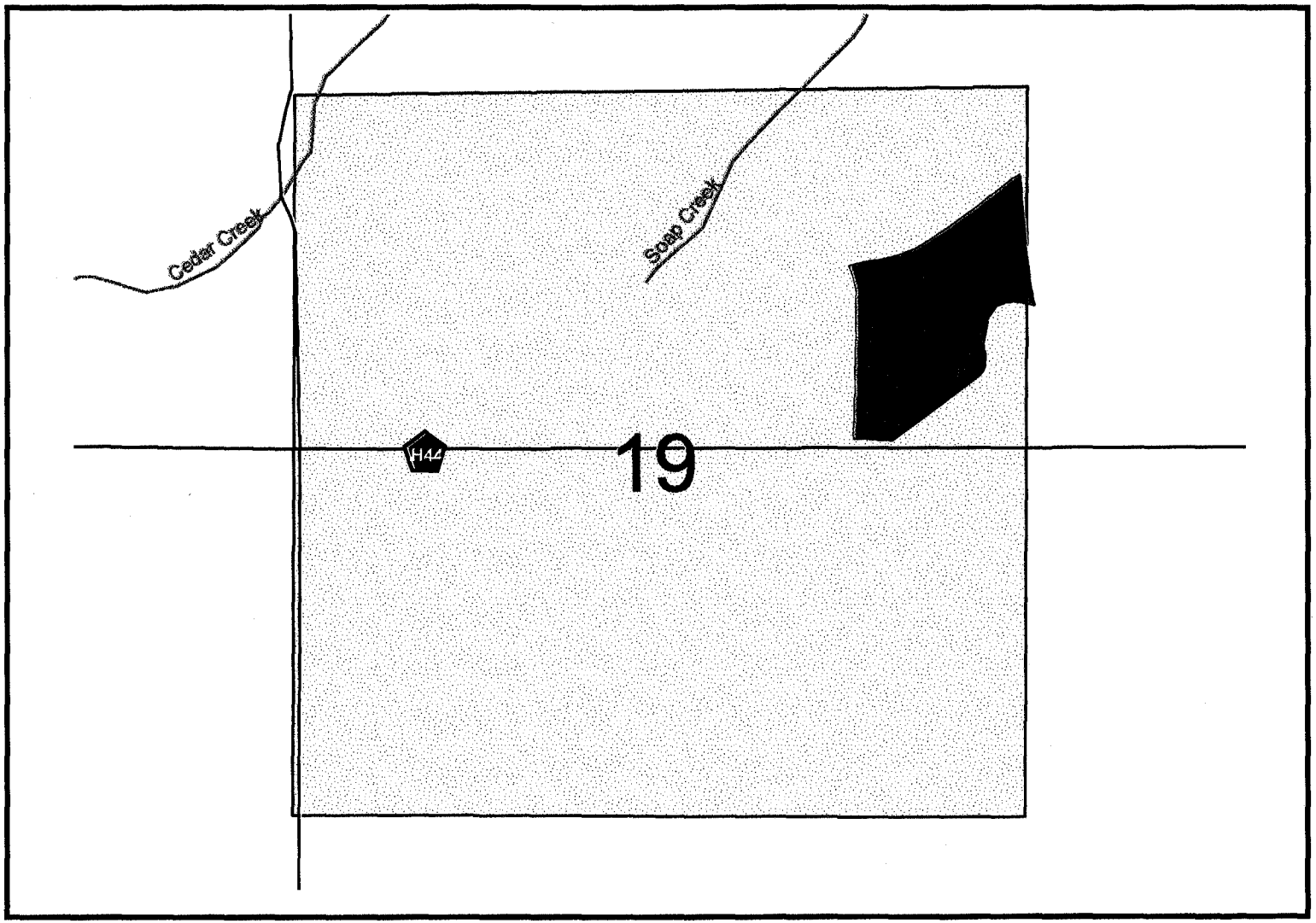
REFERENCES

Evald, Anders and Larsen, Mogens G. (1996) Straw Fired District Heating Plants in Denmark - Facts and Figures, Centre for Biomass Technology

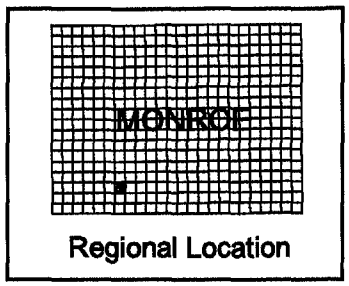
ATTACHMENT FIVE

SAMPLE GIS PRODUCTS

FIELD LOCATION
PARTICIPANT -- SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY



Participant Field
Roads
Streams
Section Boundary



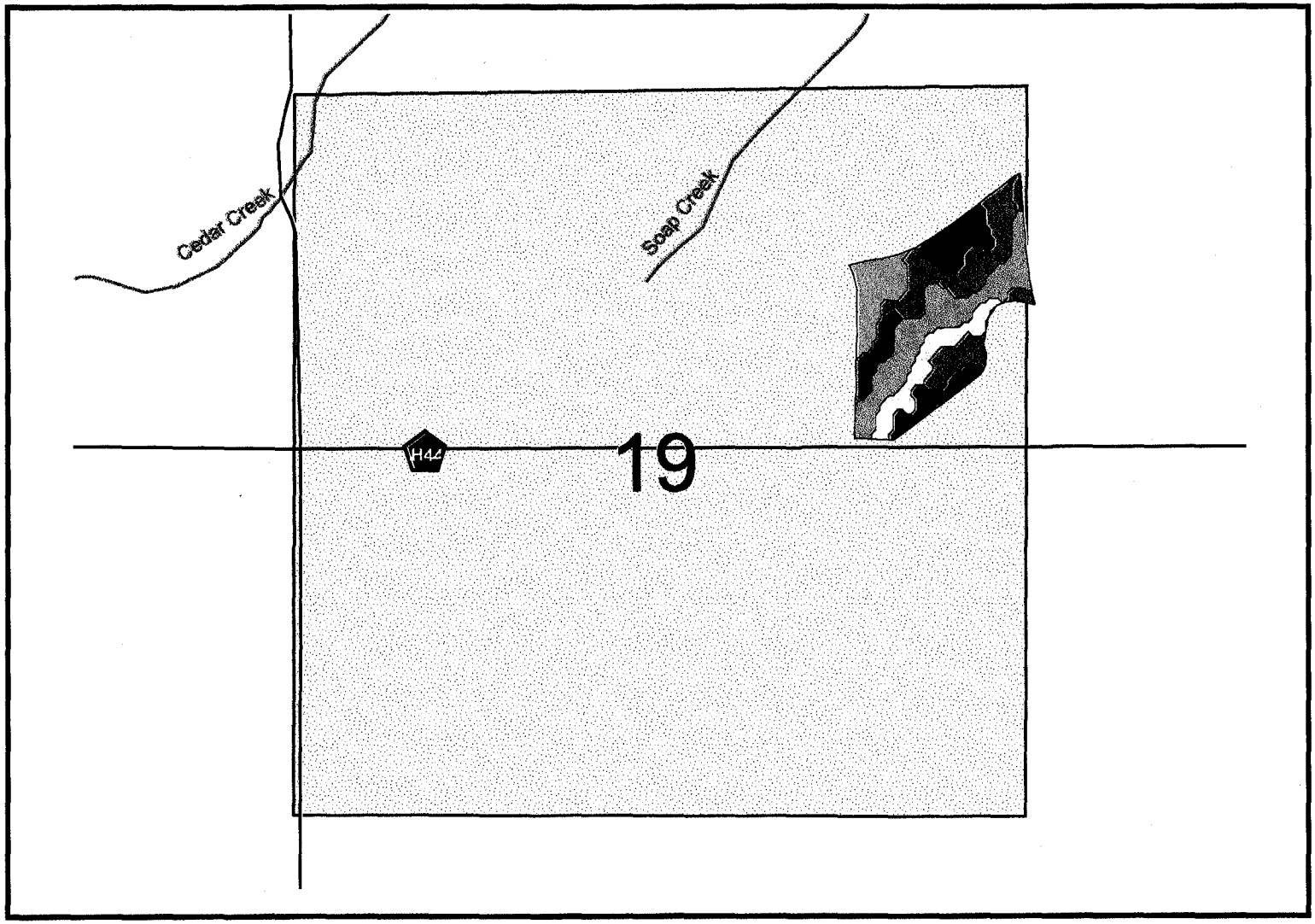
Regional Location

0.1 0 0.1 0.2 Miles

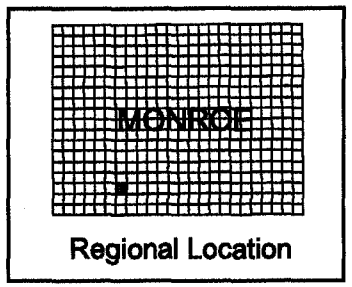
N

Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

SOIL MAPPING UNITS
PARTICIPANT -- SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY



Soil Mapping Units
- 131B
- 179E2
- 179F2
- 223C2
- 223D2
- 423D2
- 731C2
- 993D2
- Roads
- Streams
- Section Boundary

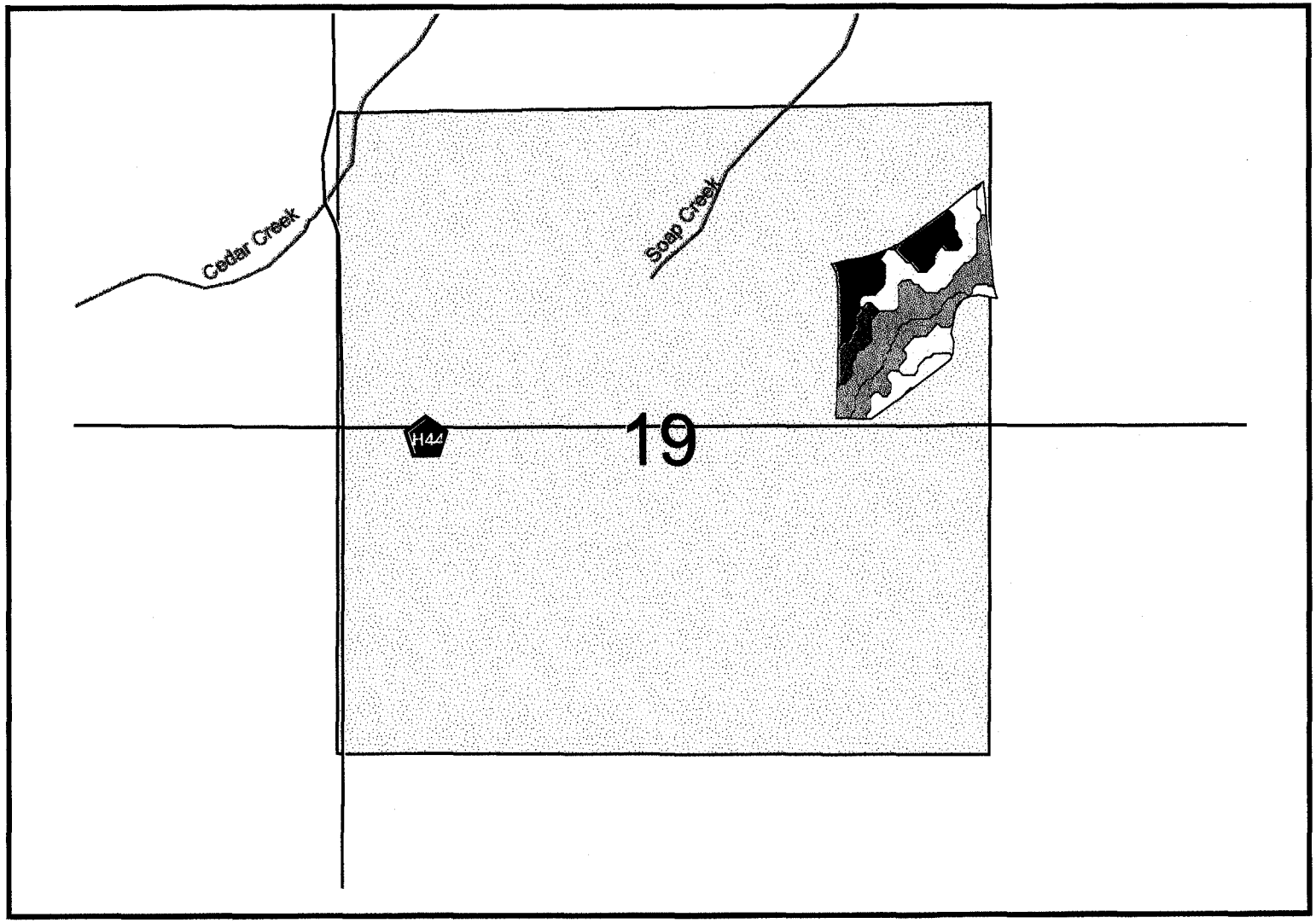


0.1 0 0.1 0.2 Miles

N

Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

LAND CAPABILITY CLASS
PARTICIPANT – SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY

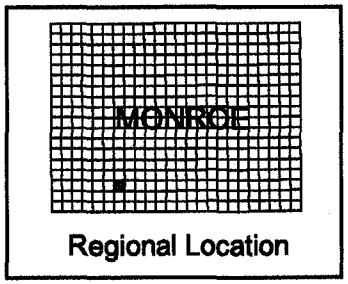


Land Capability Class
- 3E
- 4E
- 4W
- 6E
- 7E

Roads

Streams

Section Boundary



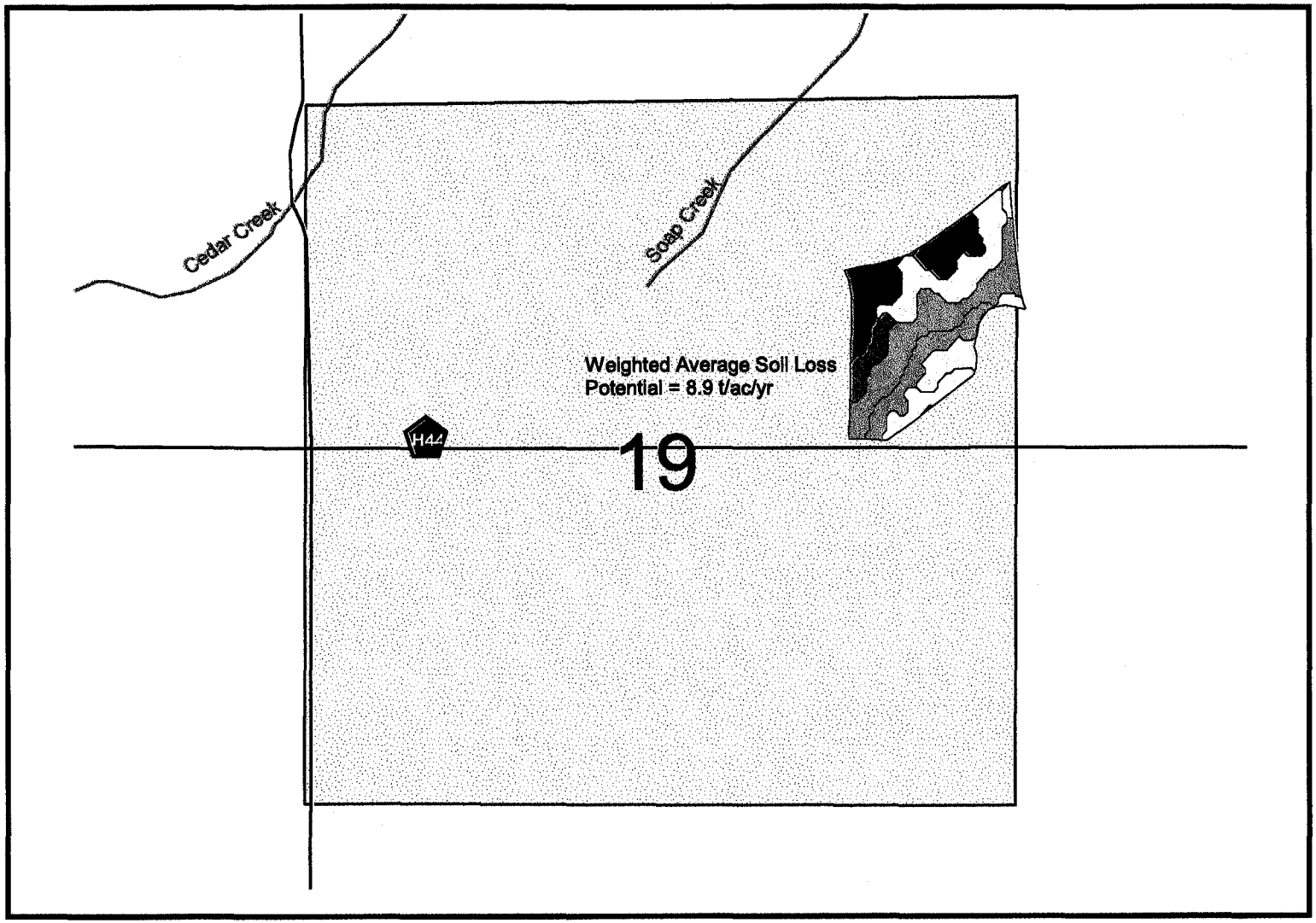
Regional Location

0.1 0 0.1 0.2 Miles

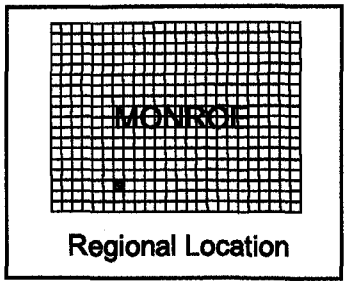
N

Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

POTENTIAL SOIL LOSS
PARTICIPANT -- SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY



Potential Soil Loss (t/ac/yr)
- 5
- 7
- 7
- 16
- 24
- Roads
- Streams
- Section Boundary



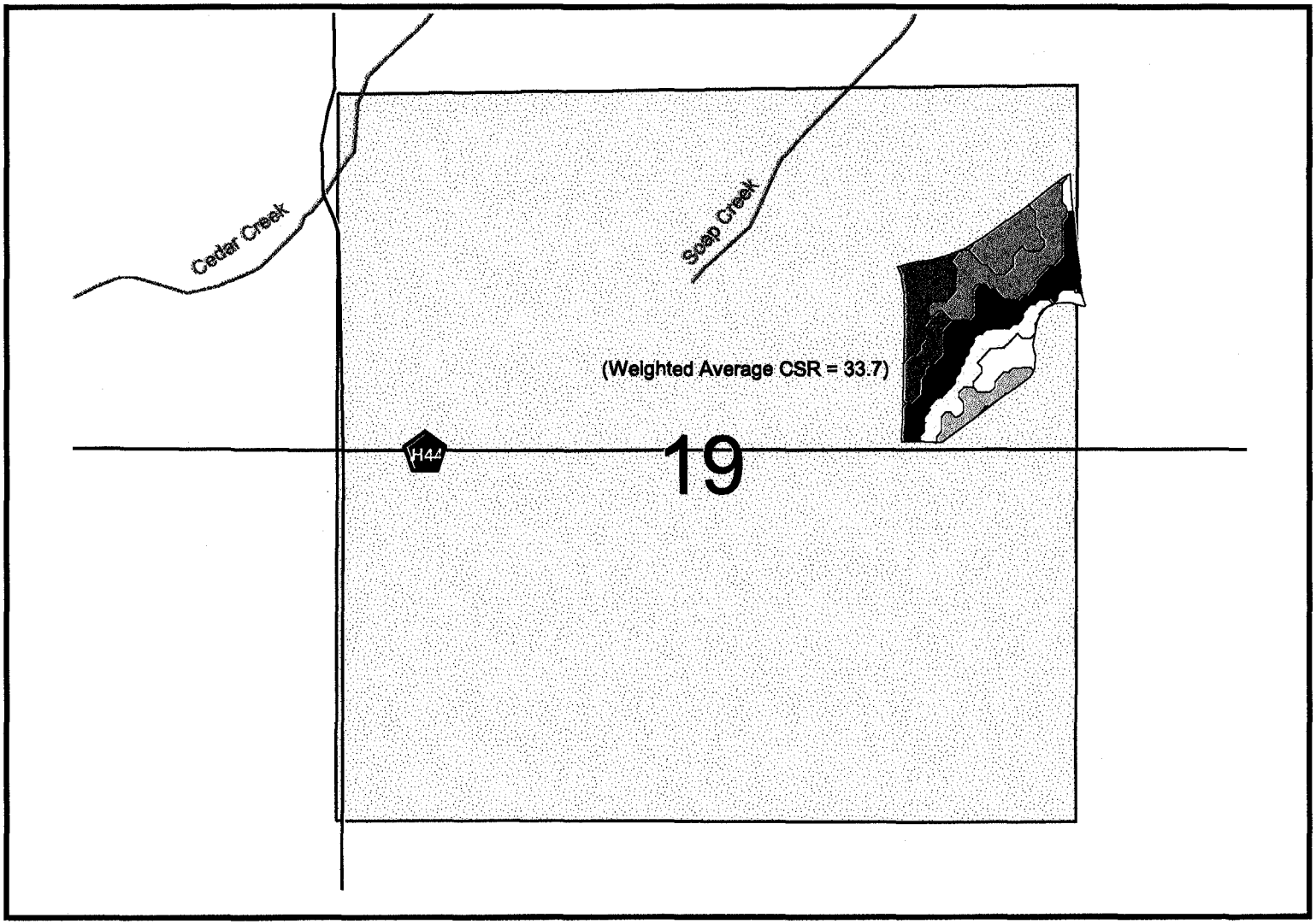
Regional Location

0.1 0 0.1 0.2 Miles

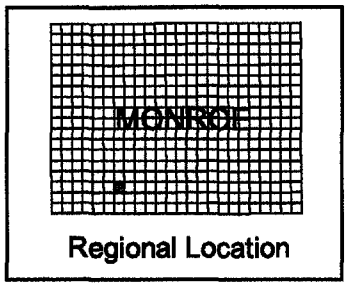
N

Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

CORN SUITABILITY RATING
PARTICIPANT – SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY



Corn Suitability Rating
- 9
- 13
- 20
- 22
- 33
- 45
- 67
- Roads
- Streams
- Section Boundary



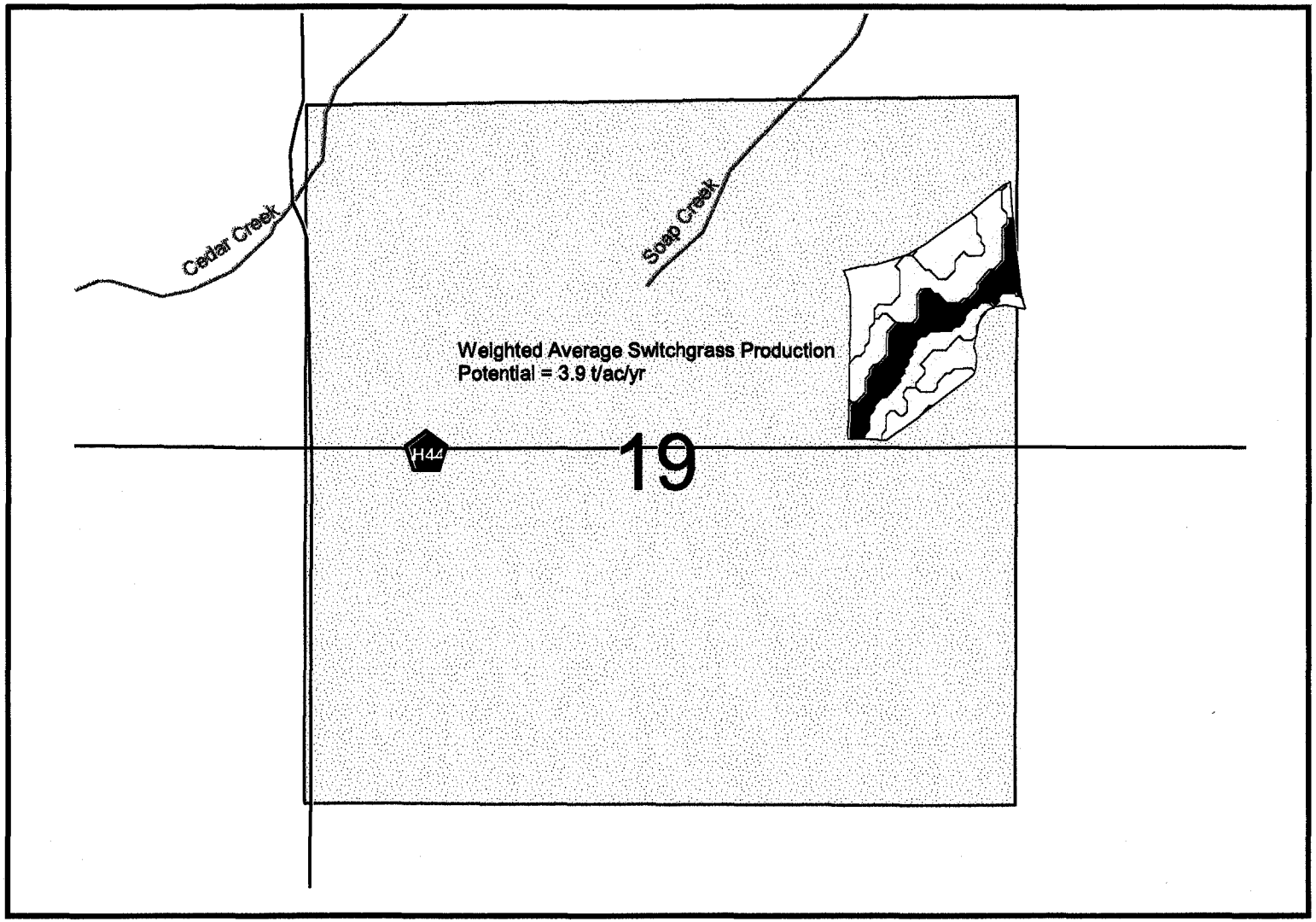
Regional Location

0.1 0 0.1 0.2 Miles

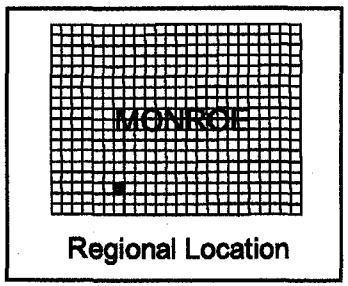
N

Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

SWITCHGRASS PRODUCTION POTENTIAL
PARTICIPANT – SWITCHGRASS BIOMASS PROGRAM
NE 1/4 SECTION 19, T71N R18W, MONROE COUNTY



Switchgrass Production Potential (Low Range) t/ac/yr
- 3.6
- 4.6
- Roads
- Streams
- Section Boundary



0.1 0 0.1 0.2 Miles

N

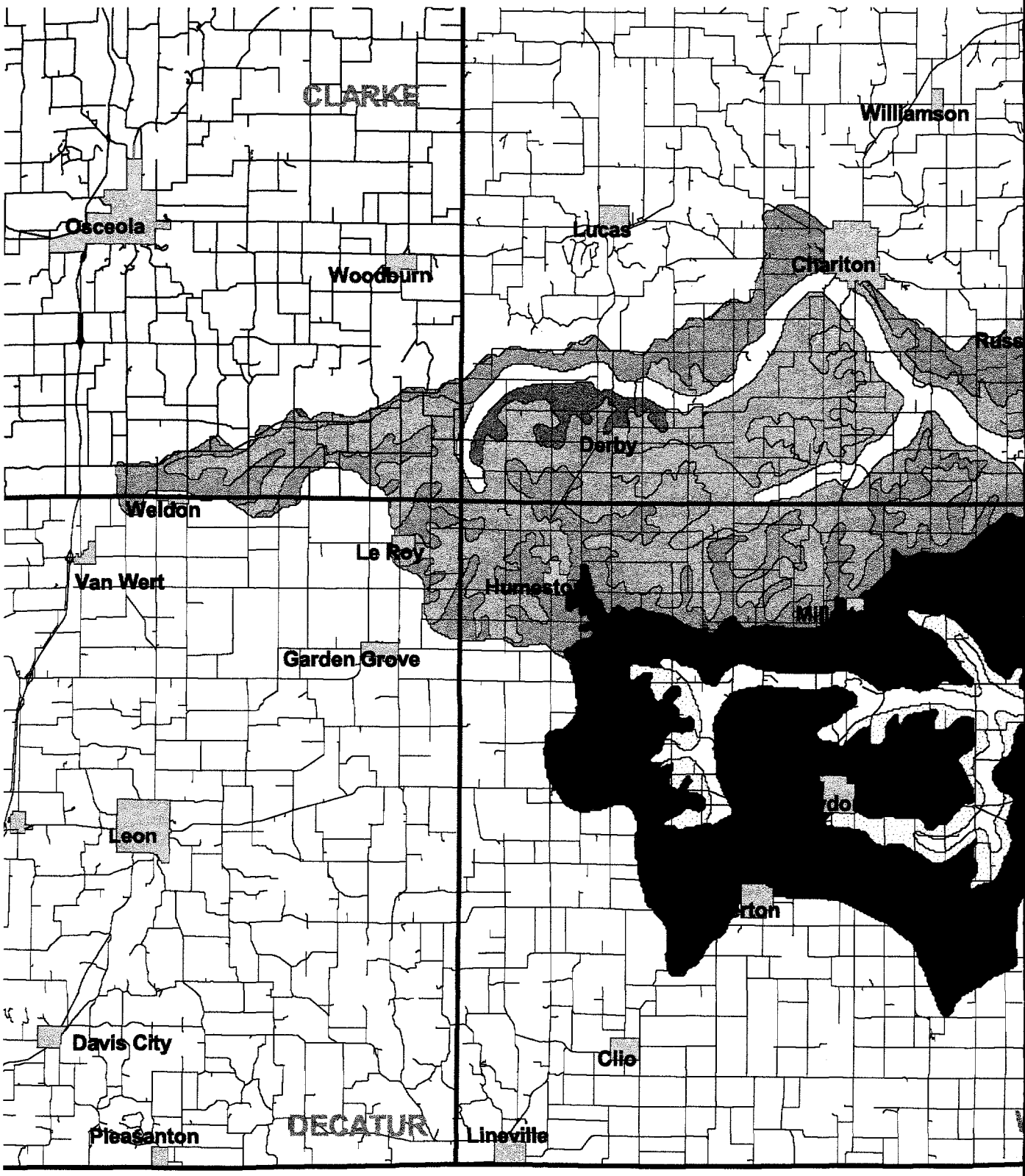
Source:
Clarke County Extension
Iowa Department of Natural Resources NRGIS
Prepared By:
Golden Hills Resource Conservation & Development
Oakland, Iowa

Participant Field Statistics

Field #	Producer's Name	Operator	Location of CRP Tract	County	Acres
1	W.J. McEniry	Tom Teno	NE 1/4 Sec.19 T71 R18W	Monroe	35.2
Soil Mapping Unit	**Acres**				
131B	9.0600				
179E2	4.1500				
179F2	3.2500				
223C2	2.1900				
223D2	3.0800				
423D2	6.9100				
731C2	4.1300				
993D2	2.4100				
Total	**35.2000**				
Land Capability Class	**Acres**				
3E	13.1900				
4E	12.4000				
4W	2.1900				
6E	4.1500				
7E	3.2500				
Total	**35.2000**				
Soil Mapping Unit	**Corn Suitability Rating**				
131B	67				
179E2	33				
179F2	13				
223C2	22				
223D2	9				
423D2	13				
731C2	45				
993D2	20				
	Weighted Average CSR = 33.7				

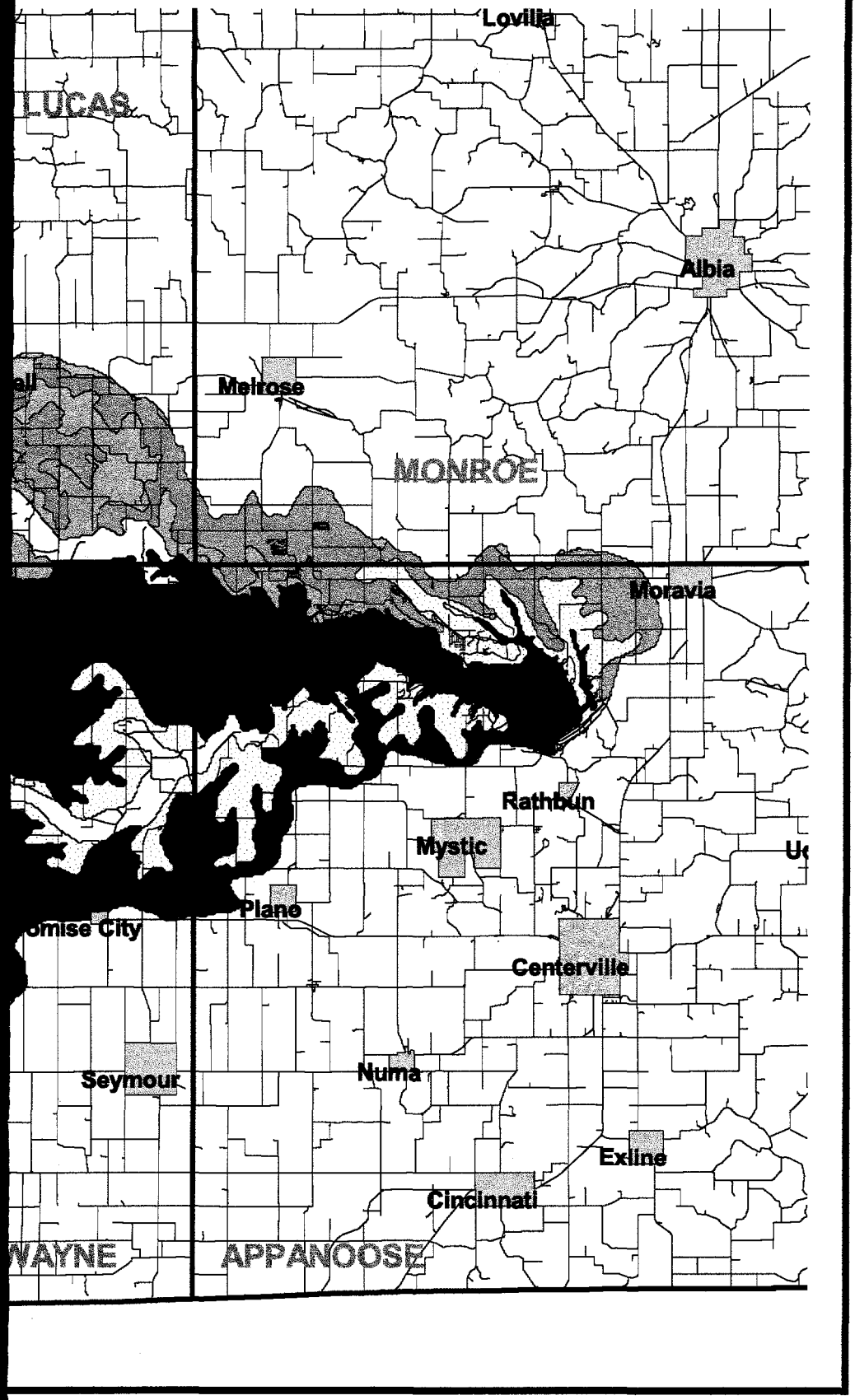
Soil Mapping Unit	**Switchgrass Production Pot.**				
131B	4.6				
179E2	3.6				
179F2	3.6				
223C2	3.6				
223D2	3.6				
423D2	3.6				
731C2	3.6				
993D2	3.6				
	Weighted Avg. Potential = 3.9				

RATHBUN LAKE WATERSHED S



Source: Iowa Department of Natural Resources NRGIS
USDA Natural Resources Conservation Service
Chariton Valley RC&D

SOIL ASSOCIATIONS



LEGEND

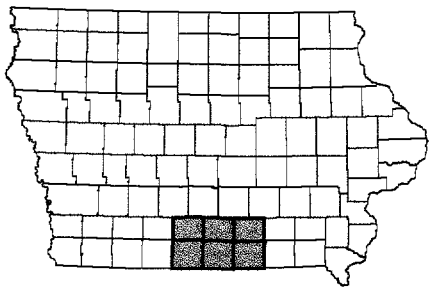
- County Boundaries
- Cities
- Roads

Soil Associations

- Armstrong-Gara
- Gara-Armstrong-Pershing
- Grundy-Haig-Arispe
- Lamoni-Shelby
- Lindley-Shelby-Clarinda
- Lindley-Weller-Keswick
- Nodaway-Lawson-Colo
- Seymour-Edina-Clarinda
- Water

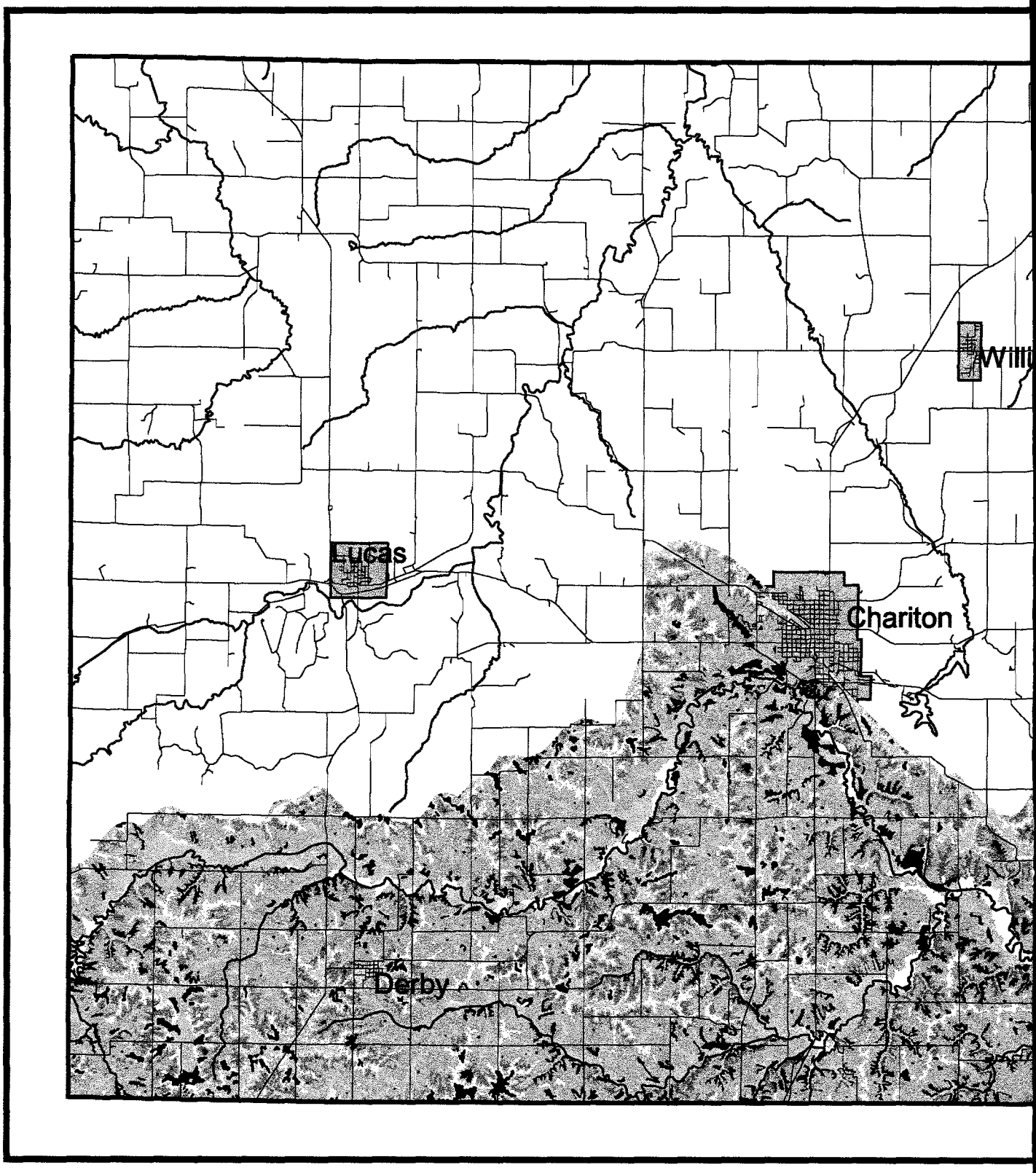
N

1 0 1 2 3 4 5 Miles



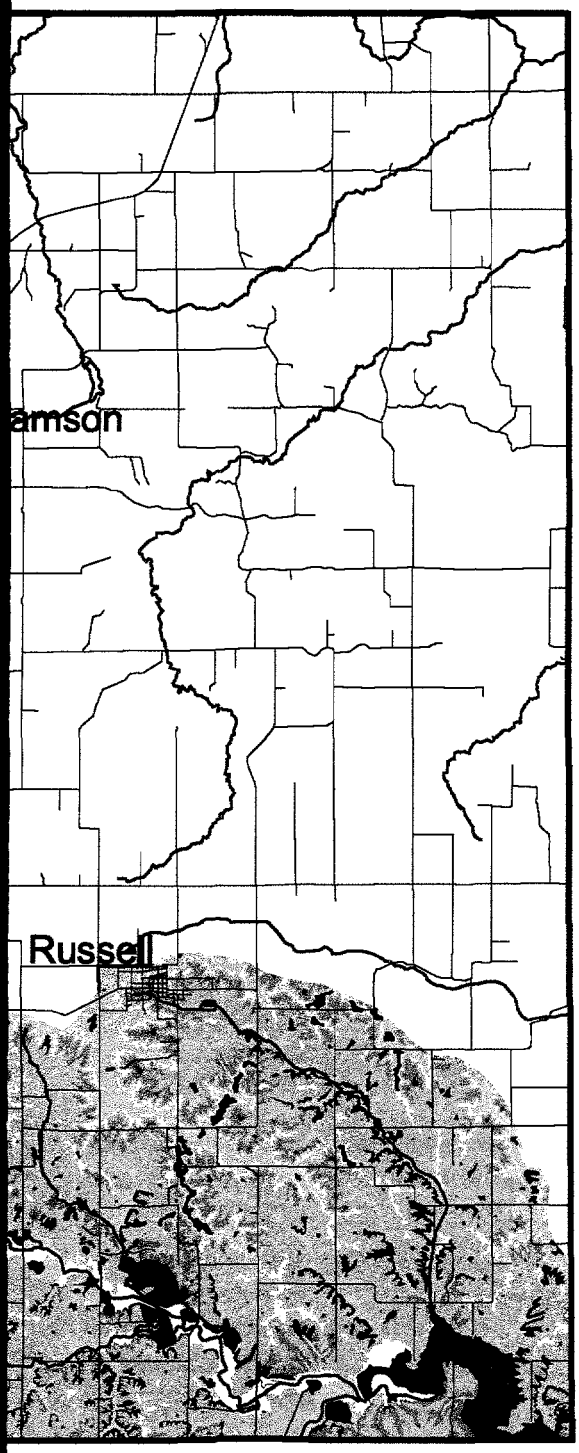
Golden Hills Resource Conservation & Development, Oakland, Iowa

RATHBUN LAKE WATERSHED LAND CAPABILITY CLA



Source: Iowa Department of Natural Resources NRGIS
Iowa Cooperative Soil Survey Digital Soils

SS -- LUCAS COUNTY



LEGEND

- County Boundary
- Lucas County Roads
- Major Streams

Land Capability Class -- Rathbun Lake Watershed

- Not Classified
- 2E
- 2W
- 3E
- 3W
- 4E
- 4W
- 5W
- 6E
- 7E
- Cities

1 0 1 2 3 4 5 Miles

N

Golden Hills Resource Conservation & Development, Oakland, Iowa

Rathbun Lake Watershed -- Lucas County LCC Statistics

Land Capability Class	Acres
Not Classified	2042.7000
2E	9662.4000
2W	17380.1000
3E	30755.5000
3W	2531.7000
4E	17042.4000
4W	5630.7000
5W	2770.3000
6E	5052.8000
7E	1983.9000

DIAGRAM TWO

PRELIMINARY DESIGN FOR ON-SITE SWITCHGRASS HANDLING FACILITY

Chariton Valley Biomass Project
Proposed On-Site SWG Handling Facilities

4/4/97
chvons1.ppt