DOE/CE/15544--T10

QUARTERLY REPORT for Instrument
No. DE-FG01-9ZCE15544
INVENTION: 544

FOR: 1/1/95 to 3/31/95
GRANTEES: Don P. Froehlich
Joe A. Schumacher

PROJECT TITLE: Develop a field grid system for yield mapping and machine control

DOE PROJECT OFFICERS: Fred Hart
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Washington, DC 20585
and John Windish, PR-322.2
1000 Independence Ave. S.W.
Washington, DC 20585

PROJECT AIM: To further develop Field Grid Sense and to demonstrate its suitability for field production applications.

TECHNICAL OBJECTIVES: Build and test the Field Grid Sense system for yield mapping and machine control during harvesting. Secondly, use Field Grid Sense with chemical application equipment to demonstrate a workable in-field system.

More specifically, the operation of the patented hardware/software Field Grid Sense (FGS) system will be tested in crop harvesting to demonstrate the systems's utility and to analyze the flexibility of operation under true field conditions. Additionally, FGS will again be used with chemical application equipment - equipment that needs modification to correct one or two slight shortcomings. This action will create improved systems and establish the worthiness, efficiency and necessity of chemical application equipment that is controlled and directed via the FGS package.

D G Froehlich
4/3/95

1401
10/95

T10

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Task 1: Expand the preliminary design:

Originally FGS was used with granular chemical application equipment. A primary utility of FGS is its use with each and every phase of crop production cycles. FGS will be adapted to the harvesting phase which will require buying and then modifying crop -harvesting equipment; assembling moisture content, volume and distance sensors on a combine; and arranging the FGS package in situ on the harvesting implement.

1. Buy David Manufacturing Incorporated moisture content sensors, Lucas inclinometers, Magnavox radar distance detectors, Hall-effect sensors with fifth wheel assembly, etc. and interface components and assemble the benchtop arrangement.
2. Bench test the system and analyze the correctness of the design specifications.

STEPS OF PROGRESS FOR TASK 1:

1s1. Mr. Rod Fischer was hired as a research associate/research assistant. Mr. Stan Nielsen was hired as a research assistant and is also assisting in the areas of software and hardware system development. Rod is perfecting the sprayer manifold and employing FGS with data analysis. Stan employed Kriekging software for data smoothing and analysis plus providing a more useable operation package.

1s2. An electronic harness has been assembled. This is a remake of a previous setup plus we've added workable and available components from our departmental R & D shops. Specific sensors have been selected. Overall electronic configuration have been developed and assembled.

1s3. The combine has been specified; specifications were written and the request was forwarded in the state bid process. The combine was purchased as of 3/15/93.

1s4. Several field tests were previously performed, as described under steps 2s1, 2s2 and 2s3. Also, the software and hardware plus overall system capabilities of FGS are continuously being improved. The field tests done on borrowed equipment plus our joined efforts with Agriculture Information Technologies of Iroquois, SD have been of great benefits. The improved FGS components will continue to be bench tested and used on the purchased combine to effectively and efficiently perform field tests.

1s5. The total combine-FGS assembly is developed, and has been placed on the combine.

1s6. This task is complete.

Task 2: Use FGS on the harvesting unit under field conditions

1. Prepare the field harvester with the FGS readout and sensory attachments.
2. Make field runs in University plots, on ARS farms and in producers' fields and observe the system workability; demonstrate system feasibility. Data will be collected from automated field measurements. Collected yield data will include bushels per acre, grain moisture content, grain temperature, field slope measurements, field position, field entered. The collected information will be shown graphically in a software derived fieldmap.
3. Refine the setup and make any necessary adjustments.

STEPS OF PROGRESS FOR TASK 2:

2s1. Great progress has been made toward this task. A combine has been purchased (we've spent considerable time and have purchased the needed one); plus, we were fortunate enough to be able to use a Plant Science harvester. The electronic components with computer and FGS were placed on the machines. Further system development took place; we've added program commands.

2s2. A working arrangement was put in place that allowed us to test the FGS/harvester system. Two sites were used at the USDA/ARS farm which is located directly north of Brookings, SD.

2s3. The results of both wheat harvest and corn harvest using the system were reported - it was determined that the system offers advantages over today's farming techniques. Maps and databases of yield, grain moisture and topography were produced which could be utilized in site specific crop management toward savings of inputs. These results were presented at two separate meetings (papers filed with previous report) -

a) the SAE International Off-Highway & Powerplant Congress & Exposition in Milwaukee, WI
b) the ASAE Winter Meeting in Nashville, TN

2s4. FGS was used on the combine as a joint project with Agriculture Information Technologies for harvesting grain during 1993 and is being used in 1994.

a) The combine-FGS package was used on the SDSU/Dakota Lakes Research Unit at Pierre, SD on 9/30/93 thru 10/20/93. A profile of field data is attached.
b) The combine-FGS package was used on Agriculture Information Technologies research unit at Iroquois, SD.

For both studies, GPS monitoring along with yield and moisture were recorded and post processed with soil and nutrient data maps. Also, at both sites comparisons will be made between yield monitor types. This info is being analyzed and summarized. Presentations were made in March.

Presented Results:

Following the pioneering work and methodology of Linsley and Bauer (1929), two 80 acre fields in central South Dakota were site specific farmed. The fields were first grided on a 200 ft by 200 ft grid, using a differential Global Positioning Satellite Receiver. Soil samples were collected (~15 subsamples within 20 ft. of grid center) and analyzed using accepted commercial soil testing analysis procedures. Geostatistical analysis was accomplished to develop iso-antecedent Nitrogen, Phosphorous and Potassium maps of the field. Only nitrogen was studied and varied in this experiment. The field was then grided into 270 ft by 270 ft field cells. These cells were fertilized with nitrogen in three different ways. A third of these cells were fertilized conventionally (100 lb/acre). The middle third were fertilized to develop yield response curves (0, 50, 100, 150 and 200 lb/acre). The last third of the plots were fertilized site specifically (yield goal 100 bu/acre) with the soil test antecedent nitrogen from the iso-maps subtracted from the recommended nitrogen amount to result in a fertilizer recommendation. Results of this study will be discussed in the poster.

2s5. The grant timeline has been extended to 11/95. Task #2 has being extended, where the harvesting system was scheduled for the 1994 harvest season. Updated hardware and software were included and tested. Results have been reported (see '1995 South Dakota NCR-180 Report' Attachment B and field maps Attachments C and D). Further analyses are being done.

Task 3: Modify present chemical application equipment to more properly dispense chemicals used in farm productivity. FGS has already been moderately successfully employed with chemical application equipment, however, present equipment has a major shortcoming in manifold design. The task is to modify the sprayer manifold, employ FGS and to demonstrate a workable system.

1. Buy sprayer and manifold, modify and assemble.
2. Assemble sprayer system with FGS package.
3. Benchtop test sprayer and prepare field system.

STEPS OF PROGRESS FOR TASK 3:

3s1. The design of a sprayer with a modified manifold has been completed. Components were specified. Mr. Rod Fischer has spent considerable time toward completing the assembly of chemical application equipment.

3s2. The sprayer system is field ready - the sprayer was used in chemical application during the spring and summer on both the ARS farm and the SDSU Agronomy lands.

3s3. The sprayer manifold and necessary system components have been connected to FGS and bench testing is continuing, plus field testing has taken place. Results were presented in March.

3s4. This task is complete.

Task 4: Test and demonstrate FGS with modified chemical application equipment.

4s1. Coordination continually occurs with the Plant Science Department and Agronomy Farms for selecting times, designating fields and locations, arranging for chemicals and laying out system operation to test and demonstrate FGS with the modified chemical application equipment. Actual field use occurred in April and May of 1993.

4s2. The sprayer, equipped with the modified manifold, was used in October on the SDSU Agronomy research units for liquid application. Results for fall tests were presented at the 2nd International Conference on Site-Specific Management for Agricultural Systems, March 28-30, 1994 in the Twin Cities.

Results:

With farm implementation of GPS Technology chemical spray rates will be varied to meet the requirements of a specific field position. This technology along with on-the-go spot spraying is replacing the common practice of applying a spray mix to a field at an average rate. Instead the spray application rate is changed on-the-go with the use of direct injection chemical units. Direct injection units hold the chemical concentrate in a factory supplied container. The carrier (water) is held in a second container. This allows the applicator to spray with minimum exposure to the chemical. When the operator is finished with a field any remaining concentrate can be returned to the manufacturer. This is a more environmentally sound practice than mixing a chemical solution with water in a single tank and having the potential for leftover spray mixture.

A significant concern when implementing this technology is the lapse time that results from the distance that the concentrate must travel from its source to the sprayer nozzles. Consequently, when the chemical injection rate changes, chemical application rates will lag by the above mentioned time offset. The poster illustrates a method to minimize the lag time error associated with a singular applied chemical (one injection system with water as the carrier). A change in the manifold system was made that enables a direct injection system to be used with reduced lag time. The system utilizes a small holding tank and uses limit switches for refilling.

4s3. Results for sprayer testing were presented at the 1994 ASME Region VII Technical Conference under the title of `An Engineering System to Vary Flow Rate and Limit Machine Lapse Time'.

4s4. System results were presented by Mr. John Oolman at the ION GPS-94 Student Paper Competition in Austin, Texas during August, 1994.

4s5. This task is complete.

Task 5: Prepare final report:

5s1. Information is being gathered and compiled to go toward the final report.

FURTHER STEPS OF PROGRESS:

A. A support arrangement involving system trials, use of equipment and a sharing of technology has been put in place. This is a great opportunity to test and demonstrate FGS in conjunction with a nationally-based company involved in crop production at the producer's level (a key company location is at Iroquois, SD approximately 55 miles from Brookings). A grant has been approved with the South Dakota Governor's Office of Economic Development via the Center for Innovation, Technology and Entrepreneurship and Ag Info Tech of Iroquois, SD.

B. An abstract had been forwarded to present FGS at the `Biostress Symposia' for April-May, 1993. Presentation was made on May 24th.

C. A new member joined our research team. Dr. Dan Humburg of the Agricultural Engineering Department of South Dakota State University has been doing research in the area of machine design and machine vision. He'll put this expertise toward possible sensory and system employment utilizing FGS and information transfer and equipment control.

D. An article was prepared for the "IMPULSE" explaining the details and progress of the project. The "IMPULSE" is an informational journal of the SDSU College of Engineering with the next issue being published late summer.

E. Mr. Jack Aellen visited our site on 7/8 - 7/9/93. The visit was an opportunity to exchange significant information plus Mr. Aellen has continued to forward additional, quite beneficial information.

F. Ag Info Tech and SDSU researchers, as a team, have forwarded a grant proposal to the Small Business Initiative Research fund.

G. Further discussion on our research, system and findings are occurring with commercial assemblers and distributors in both Sioux Falls, SD and Minneapolis, MN.

H. Mr. Joe Schumacher attended the North Central Research Committee on Site Specific Farming under the CSRS/USDA Cooperative States Research Service/Dec. 2-4, 1993 in Kalamazoo, MI.

* discussion on yield monitors
* GPS receivers and accuracy
* technology advances
* environmental issues and equipment design
* soil management and crop efficiencies
* exchange of state reports

(A summary of this meeting was published by the journal of `Farm Industry News').

I. Abstracts and presentations were delivered at the 2nd International Management for Agricultural Systems on March 28-30, 1994 in Minneapolis, MN with the University of Minnesota.

J. Presentation and discussion of project and related technologies occurred during the 43rd Annual Soil and Moisture Clinic with SD Association of SCS and SDSU in November, 1993.

K. Presentation on the project was given at the 1st Annual Biostress Poster Session on 3/11/94.

L. Mr. Joe Schumacher, Mr. John Oolman and Dr. Dan Humburg attended the SDSU/University of Nebraska "Geostatistics" workshop during May, 1994.

M. Details of our project were released to the general public/media by Dr. Gregg Carlson of the SDSU Plant Science Department with articles in the Sioux Falls Argus Leader and the Brookings Register.

N. Details and outcome statements were released with the "South Dakota Farm & Home AES Research: within an article entitled: "Global Positioning Satellites: Signals from space to the field".

O. Mr. Tim Aughenbaugh of Ag Info Tech, Iroquois, SD our commercial partner presented details and system specs at the Lake Area Tech/BASF Demo Center, Watertown, SD on August 24, 1994.

P. A second CITE grant entitled "AIT Site Specific Solutions for Economic Productivity" has been prepared, undergone on-campus review and has been forwarded. The identified amount is $77,095 (see Attachment A).

Q. System results were presented at the South Dakota Irrigators Conference via the SDSU Cooperative Extensive Service and the SD Irrigators Association on December 6 and 7 in Mitchell, SD.

R. System and field results were presented by Mr. Joe Schumacher with a presentation entitled "Site Specific Farming in the 21st Century" at the 44th Annual Soil and Moisture Clinic at Brookings, SD on November 13-15, 1994.

S. The use and continual expansion of this technology was further explained within an article entitled 'Going High-Tech On The Farm', South Dakota High Liner Magazine, Feb. 95 Issue. Mr. Tim Aughenbaugh of AIT, Iroquois, SD, our commercial partner was featured (see Attachment E).

Attachment A

RESEARCH PROPOSAL SUBMITTED TO THE GOVERNOR'S OFFICE OF ECONOMIC DEVELOPMENT

Through the Center for Innovation, Technology & Entrepreneurship
South Dakota State University
Brookings, South Dakota 57007

Title: AIT Site Specific Solutions for Economic Productivity

Principal Investigator(s): Mr. Joseph Schumacher, Dr. C. G. Carlson, Dr. D. P. Froehlich, Mr. Tim Aughenbaugh (AIT)

Department: SDSU (Plant Science), (Mechanical Engineering)

Telephone: 692-9028

Amount Requested from the Future Fund: $23,721

Cost Sharing (indicate source and amount): $53,374 (AIT)

Project Period: 1/1/95 - 12/31/95

Institutional Endorsements

Principal Investigator

Grants Administrator

Department Head

Dean

SDSU CITE Director
(605) 688-4256

Assistant Vice President

South Dakota State University
and
Agricultural Information Technologies
(AIT)

"AIT Site Specific Solutions for Economic Productivity"

A CITE Proposal Prepared by J. A. Schumacher,
Tim Aughenbaugh, D. P. Froehlich,
C. G. Carlson

Amount Requested
$23,721
Cost Sharing
$53,374

Project Period 1/1/95-12/31/95

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ABSTRACT

Agricultural Information Technologies (AIT) is an emerging company providing appropriate engineering answers to agricultural operations. AIT is making major technical exchanges throughout the agricultural industry with companies that are interested in AIT's engineering and computer expertise. Contacts include Lindsay Manufacturing, John Deere, Micro Trac and Mobile Data Communications. An important area of emphasis for AIT is site specific farming technology. Site specific farming or prescription farming is becoming practical due to the Global Positioning System (GPS). GPS is satellite technology first developed for the military that is used to precisely determine location coordinates (latitude and longitude). This technology has become available to the civilian sector for commercial use. This is an example of a very adaptable technology that has been and is being invested beyond the military. AIT has for the past three years been developing site specific products that incorporate GPS technology for agriculture. AIT believes that its expertise and products for agriculture will also be adaptable to other industries as dual use technology.

SDSU investigators have already helped this company in two ways from a previous CITE grant. The first was by providing the expertise to help test the functionality of new precision farming technologies. The second was through the development of agronomic mapping algorithms for use in site specific farming systems.

AIT and SDSU investigators propose to expand use of new precision farming tools to a 20,000 acre farm and learn on a large scale how to develop new strategies for precision farming techniques. The knowledge gained from this investigation will be of tremendous worth to AIT as it develops a product for the market. It should be seen that South Dakota agriculture as a whole will also gain as new information and techniques are learned.

AGRICULTURAL INFORMATION TECHNOLOGIES, INC.
... innovative technology for agriculture

18 October 1994

CITE Committee:

The last two years have been ones of growth and accomplishment for Agricultural Information Technologies, Inc. Our joint participation with South Dakota State University in the CITE program has played an important role in many aspects of this success.

The CITE grant enabled AIT to tap into the knowledge of SDSU personnel as we researched many aspects of new precision farming technology. SDSU expertise in data collection and analysis complemented our engineering and machinery abilities very well. Agronomic data recorded during the project will become the base on which future data of this type will be built.

Perhaps more important than the actual agronomic data was the experience gained in site-specific data collection and equipment control. Methodology used to complete the project is currently being refined and incorporated into AIT products. Software to evaluate data as well as a monitor to collect data, utilize algorithms and techniques that resulted from the CITE grant. Development of these marketable products has directly benefited AIT as a company and will hopefully benefit the agricultural industry we serve.

Indirect benefits of our CITE participation have also proven significant. This participation led credibility to a design bid accepted by Lindsay Manufacturing Company of Lindsay, NE. Mapping and irrigation center pivot control software was developed for LMC and is currently being marketed worldwide. We have also initiated relationships at various levels with several other agricultural manufacturers with the goal of working on joint product development.

These design projects as well as our relationship with SDSU have been essential to the growth of our company. They have helped to increase resources and reduce the time required to develop sellable products. AIT has developed five innovative tools for agriculture in the last two years, tools that aid the farmer in areas of productivity, efficiency, and profitability. With the recent addition of a new office and research facility along with the hiring of two more full-time employees, we hope to be successful in bringing these products to the marketplace.

In closing I would like to give special thanks to three SDSU personnel who worked extensively on this project. Dr. Gregg Carlson, Joe Schumacher, and John Oolman went the extra mile on every aspect of the project and pushed it beyond our expectations. Their attitudes and efforts were central in making AIT's participation in the CITE program both enjoyable and productive.

Timothy A Aughenbaugh
President

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INTRODUCTION

STATEMENT OF PROBLEM AND HISTORY

'Large multinational billion dollar conglomerates such as Monsanto Co. and John Deere are entering the computer software and computer communication market in order to help farmers stay profitable. They are doing this to ensure steady markets for their own agricultural products,(agricultural equipment, Ag chemicals , irrigation equipment). The major agricultural vendors are actively seeking partnerships with one another and alliances with fledgling software developers in order to promote greater agricultural productivity. These companies are concerned that the core customer base- the U.S. farmer- be financially healthy enough to keep buying trademark agricultural products. A strong emphasis is being made on the development of computer software and hardware for precision farming utilization. "Precision Farming" is a relatively new concept in agriculture in which farmers calculate and apply varying amounts of "inputs" - fertilizers, chemicals, moisture, seeds, etc. - to match the specific needs of varying soil conditions within a field. John Deere Corporation has identified the following three critical links to the success of precision farming.

1. Mapping accurate sections within a field for analysis. Increasingly, this will be done by satellite receivers mounted on farm equipment that communicate with Global Positioning System (GPS) satellites (U.S. military technology suitable for Technology Reinvestment Projects (TRP's) within the civilian sector). GPS technology provides instantaneous position information that is used to create digital field maps (examples: yield maps, soil maps, pest maps, etc.).

2. The prescribing of exact amounts of chemicals, fertilizers and seed. This will be done by onboard processors, based on the analysis of the soil, grain and yield potential of each field section.

3. Communicating this complex field data back to traditional farm record-keeping systems. This data is used to track the financial outcome of experimenting with these new farming techniques.[1]'

Ag Information Technologies (AIT), a South Dakota Company, uniquely fits into the developing precision farming industry. AIT has for the past three years been developing and marketing agronomic site specific products that incorporates GPS and precision farming technology. SDSU investigators have already helped this company in two distinct ways from a previous CITE grant. The first was by providing the expertise to help test the functionality and user-friendliness of Agricultural Site Specific systems. The second was through the development of agronomic mapping algorithms that can be used in site specific farming systems. The focal point for development of these goals was a 160 acre research site. Last year's results from yield maps show

variable-rate application of fertilizer at 76 lbs/acre compared to conventional single rate application of 100 lb/acre saved $4.80/acre and gave the same crop yield. Estimates are that after 3-4 years of yield data an additional savings of $5.00/acre will be realized. This translates into a huge economic impact if only a fraction of the acreage in the United States incorporates site specific technology (South Dakota alone has 11,000,000 acres devoted to grain and oilseed and many more in range land).

AIT is emerging as a viable company in the agricultural industry. Highlights of the company from the past year include expansion of its headquarters near Iroquois SD with the construction of a conference and project development center. A new road now leads in directly from Highway 14 to the company headquarters. AIT designed and built the computer software and communication system for Lindsay Manufacturing Company's new AIMS control units (Automated Irrigation Management System). AIMS allows remote control of a network of center pivot systems from a computer located in an operator's office. For example, the control panel from 8 different Lindsay center pivots can be controlled and monitored from one central station via computer and radio modem.

AIT is also developing a handheld center pivot control that will regulate the speed and pressure of an irrigation system as environmental factors change (Example: As night descends and wind velocity decreases the center pivot system will speed up and apply less total water but still the correct applied rate, since evaporation will be reduced at night. It is calculated that this practice will save 1 day within an irrigation cycle of every 10 days.)

Another highlight is the development of precision farming software and hardware that will incorporate a new agronomic yield mapping algorithm developed under a previous CITE grant. Contacts are being developed with major Agricultural companies such as John Deere[2], Lindsay Manufacturing Company[3], Mobile Data Communications[4], John Deere's precision farming group has already made a special visit to AIT headquarters. John Deere officials and a related company Applications Mapping (headed by Ted Macy) again met with AIT this September inquiring about the development of a software algorithm. Lindsay officials are currently discussing variable rate irrigation application based upon site specific information with AIT. Lindsay has also issued another contract to AIT for work related to the AIMS monitor. Micro-Trac and Mobile Data Communications have tested a new yield monitor and GPS system at the farm site near AIT.

AIT is very interested in Dual Use Technology for its products and expertise. One such dual use of technology by AIT is the use of 900 MHz transmissions and GPS for use in the Automated Vehicle Location (AVL)Industry (tracking vehicles with the aid of GPS corrections via 900 MHz signals) - Mobile Data Communications which is setting up 900 MHz transmission towers throughout the country for GPS correction signals is interested in AIT's technical expertise in data transmission and equipment control

via radio modem (900 MHz signals can be used simultaneously for both data transmission and GPS signal correction). Another area of dual use technology for AIT is its site specific software and hardware that can be adapted for use in the natural resource, transportation, public utility and industrial monitoring sectors as well as the agricultural industry.

A recent highlight was the appointment of AIT President Tim Aughenbaugh to the site specific software standards committee for the Association of Ag Computing Companies[5].

A CITE grant will help foster development of precision farming technology in South Dakota as AIT forms relationships with these and other major agricultural companies. South Dakota will benefit if SDSU researchers receive a CITE grant with AIT in which to foster company growth and help AIT continue to establish a leadership position within the agricultural - site specific industries. The grant will be used to support a Graduate Research Assistant in the College of Agriculture. This person will research, evaluate and help synthesize the new technologies and methodologies that are being introduced into agricultural practices via precision farming for AIT. The grant will also be used to support AIT through the SDSU Engineering College Co-op program. SDSU Co-op and graduate students will receive valuable experience while using their technical abilities with AIT.

ANTICIPATED RESULTS

1. Develop working relationships with major agricultural companies with interests in precision farming.

2. Development and improvement of affordable site specific systems for irrigated and dry land farming. Through past AIT effort and in conjunction with its previous CITE grant, problems with the ergonomics of existing technology have become evident. One anticipated result of this project will be to ease the use and operability of precision farming technology for the general consumer.

3. Development and marketing of precision farming technologies that are agronomically, environmentally and economically desirable.

4. Continued expansion of company facilities and personnel.

5. Education of future scientists and engineers with experience in site specific applications. (Two student engineers from this project have already taken engineering positions within the agricultural industry. Also a future agricultural scientist with experience in prescription farming is nearing completion of a Master's degree with a thesis topic on Prescription Farming.)

6. Exposure of new technologies that are applicable to the South Dakota agricultural industry to student classes and interested state organizations.

CITE GRANT PROPOSAL (Approach)

The objectives of the proposed work are:

1. Ease the use and operability of precision farming technology for the general consumer.

2. Implement newly developed yield mapping algorithms into site specific software.

3. Development of computerized Ag equipment controls and software for precision farming applications.

4. Expand use of new precision farming tools to a 20,000 acre farm and learn on a large scale how to better use precision farming technologies.

5. Market new precision farming tools through various avenues such as alliances with major agricultural or GPS-GIS related companies.

STATEMENT OF WORK

The project will be centered around a 20,000 acre farm. AIT's computer software and hardware expertise along with SDSU's agronomic and engineering expertise will be used to gather information and develop new strategies for precision farming techniques collected from this farm operation.

Work agenda:

1. Combine grain samples will be taken with sample locations marked. The grain samples will be examined with NIR technology (Near Infrared Reflectance) for protein content and elemental makeup. Grain makeup will then be correlated with soil sample data. Samples will also be analyzed with a mass spectrophotometer for carbon ratios C_{13} and C_{14}. Grain makeup will then be analyzed for nutrient uptake from a given location. Costs for grain and soil analysis of location samples will be covered by a Department of Energy (DOE) grant obtained by the SDSU researchers.

2. Field yield maps for corn, sunflower, wheat, soybean and other small grains will be developed and analyzed. Maps will be analyzed to determine soil sampling areas and productivity areas within a field.

3. GPS/computer systems for use in field scouting and remote sensing of weed pressures, nutrient deficiencies and insect problems will be evaluated.

4. Improvements in consumer ergonomics for precision farming technologies will be instituted. Quick and intuitive software and hardware formats will be developed for improved data collection, data recall, and equipment usage.

SDSU's knowledge base will be put to good use as AIT develops new products for the Agricultural Industry. The knowledge and product marketability gained from field testing on a large operating farm as opposed to a single field or plot area will be of tremendous worth to not only AIT but also to the whole of South Dakota agriculture as new information and techniques are gained and implemented. Dual use of new technologies will also be implemented as site specific tools for the agricultural community can be used in other industries. It is of special note that technologies (such as GPS and infra-red technology) derived for the military will be put to civilian use (a good example of Technology Reinvestment Projects (TRPS) being applied in the public sector).

EQUIPMENT AND PROJECT REQUIREMENTS

Ag Information Technologies has available the necessary equipment and personnel to help carry out this project (a combine with the latest Micro Trac yield monitor, a variable seed planter, an automated soil sampler, fertilizer and chemical application equipment, weigh wagons, tractors, cultivation equipment, GPS equipment, farm personnel, computers, data acquisition equipment, software and electronic expertise). Consequently, the main expense of the grant will be to fund Engineering Co-op students and a Graduate Research Assistant (GRA). Co-op students from the Engineering College will work with AG Information Technologies on the technical aspects of new precision farming technologies. A GRA from the Plant Science Department will work with the Soils Science Researchers on implementing new agronomic aspects of precision farming. The remaining costs from the CITE budget will be to pay for research costs associated with analyzing information collected from the project.

COMPANY DESCRIPTION

Agricultural Information Technologies (AIT) was founded in 1990 by Timothy A. Aughenbaugh, following graduation from South Dakota State University with an agricultural engineering degree. The company is based on a large Iroquois, SD farm (founded in the 1930's) and was formed on the premise that there is a need for greater implementation of modern electronic technology in agribusiness.

Through the development and use of systems utilizing today's computer, satellite, and control technology, agricultural operations can become more productive, environmentally sound, and cost effective. It is AIT's goal to locate, test, and develop such systems as well as to provide the knowledge base and training necessary to implement them.

In pursuit of this goal, AIT is primarily focused on three areas. The first of these is agricultural software engineering. The advent of inexpensive, fast computers has ushered in the need for user friendly, graphic-based software. AIT delivers computer programs utilizing only the latest innovative techniques in areas such as record keeping, reporting, and decision making.

Satellite positioning and tracking, which was utilized by the military in the Gulf War, is the second area of focus. AIT believes that the greatest benefit of this technology will occur in agriculture and now provides agribusiness with systems to provide guidance, keep site-specific records, and vary the application rates in real time.

Machinery automation and control rounds out the areas of focus by relieving some of the tedious aspects of repetitive agricultural tasks. AIT supplies systems in which automated sensors and controllers are used to ease the burden of tiresome chores and increase the accuracy of crop operations.

Through the integration and implementation of systems derived in these focus areas, AIT hopes to attain growth, financial strength, and technological expertise not only for itself, but also for the agribusiness industry that it services.

REFERENCES

1. PC Week , "Old McDonald had a Newton", July 1994"

2. John Deere - Chuck Studer, Marketing Director - Precision Farming Group. Moline IL.

3. Lindsay Manufacturing Company - Charlie Meese, Vice President Engineering, Lindsay NE.

4. Mobile Data Communications - Rick Engelby, President, Cedar Rapids, IA.

5. Association of Ag Computing Companies - Grant Mangold, chairman of site specific committee, editor of ag/INNOVATOR magazine, Linn Grove IA.

Attachment "B"

1995 SOUTH DAKOTA NCR-180 REPORT

Contact: Dr. Daniel Humburg
Department of Agricultural Engineering
South Dakota State University
Brookings, SD 57007
(605) 688-5658
humburgd@mg.sdstate.edu

The topic of precision farming has received widespread publicity within South Dakota this past year. Articles in newspapers and magazines statewide have followed SDSU presentations on site-specific crop management. Presentations were made during several ag Experiment Station Farm Days, the State Irrigators Conference, the Soil and Water Clinic, the State Cooperatives Annual Meeting, as well as to SDSU student classes. Topics covered at these presentations included yield monitoring, GPS technology, GPS field scouting, aerial photography and the future economic potential of these tools. There is a growing interest in combine yield monitors within the state. We currently have a small number of farmers with yield monitors installed on their combines and we expect that number to increase rapidly within the coming years.

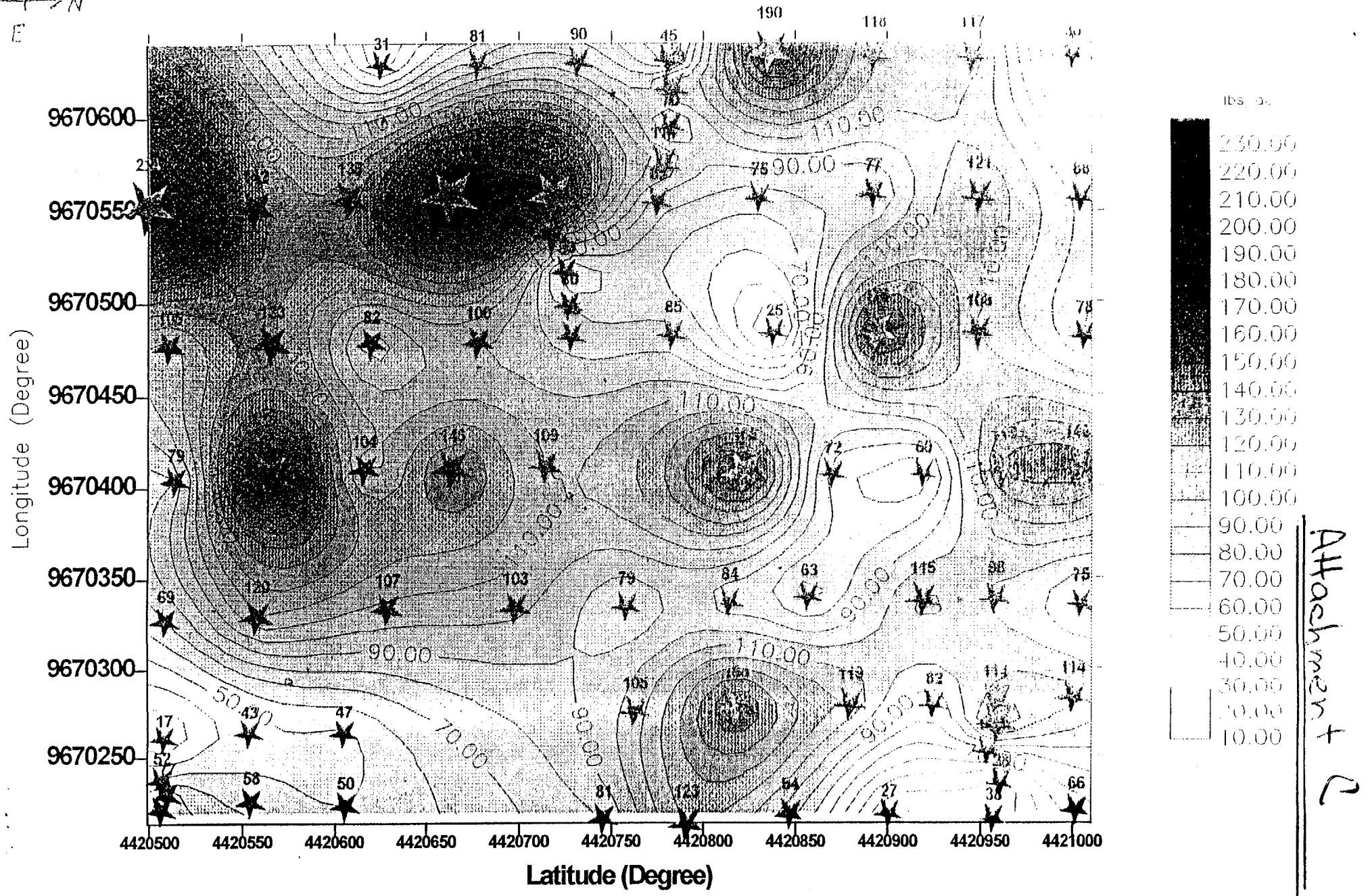
The information provided by a yield monitor is greatly enhanced when combined with location coordinates, as provided by a positioning system, for the synthesis of yield maps. With differential GPS becoming the positioning system of choice for ag applications, South Dakota faces a problem of limited access to DGPS base station correction signals. South Dakota is a large state with many remote farming locations. Presently the high costs and limited coverage of available DGPS signals limit the widespread adoption of SSCM methods. It will be interesting to see if the new wide-area North American DGPS systems can provide affordable and adequate DGPS correction signals to rural South Dakota.

There are several projects underway at SDSU that involve aspects of SSCM. One state supported project involves the cooperation between SDSU personnel and a private company/farm to develop methods of incorporating yield history information into the fertility decision process. A site-specific normalized yield history for a field is to be combined with fertility measurements, spatially varied drainage data, and seasonal weather predictions to allow more informed decisions to be made regarding spatially applied fertilizer. Yields and fertility are currently being mapped on two 80 acre fields as a part of that study. Additional yield data for this work is being accumulated at the Dakota Lakes Field Station farms and in the study described below.

A related project supported by the Department of Energy involves a second farming operation as cooperators. SDSU's DGPS system was used on this farm for developing yield maps. Soil samples for a fertilizer banding study were taken before planting and after harvest on two fields with a 200 by 200 ft grid spacing. Yield maps and soil nutrient maps have been developed for these fields. Grain samples were also collected from the combine grain auger at intervals (approximately every 15-30 seconds) on the grid transact lines. The grain samples are to be analyzed for nutrient content this winter. This project has become one of the first attempts in South Dakota to synthesize site specific field information for analysis and archival storage and retrieval by the farm operator.

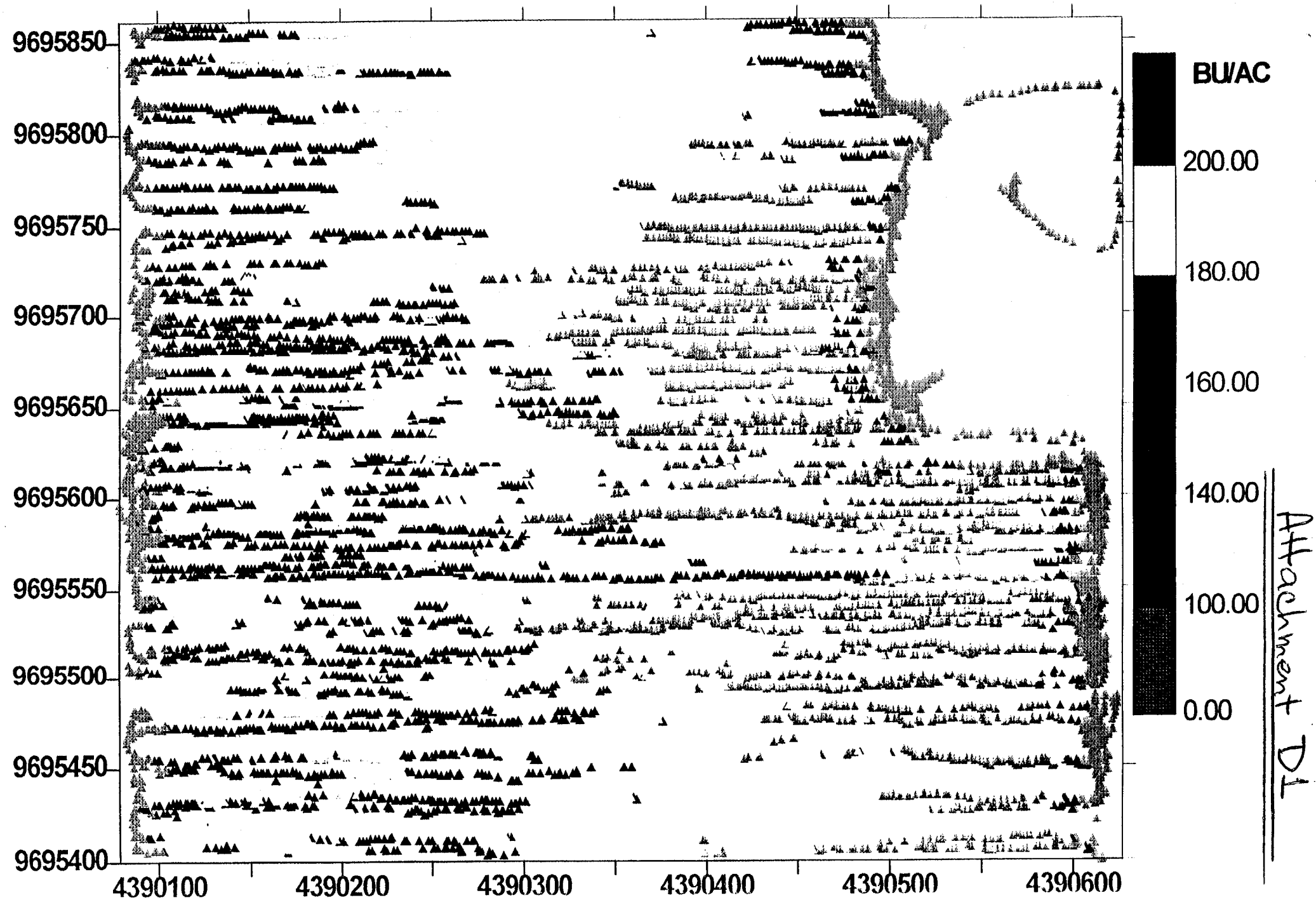
A new three-year study being conducted by the Northern Grain Insects Research Lab and South Dakota State University personnel is beginning this winter. The project will utilize a nested database consisting of topographic location, soil series, weed distributions, monitoring data for insect infestations, and nutrient requirements over the landscape to evaluate the ability of Best Management Practices (BMP) to minimize pollution and provide an economic return over entire watersheds. Site specific technology and methodology will be used throughout the project and evaluated for applicability.

Elkton Nitrate Soil Test (lbs/ac)



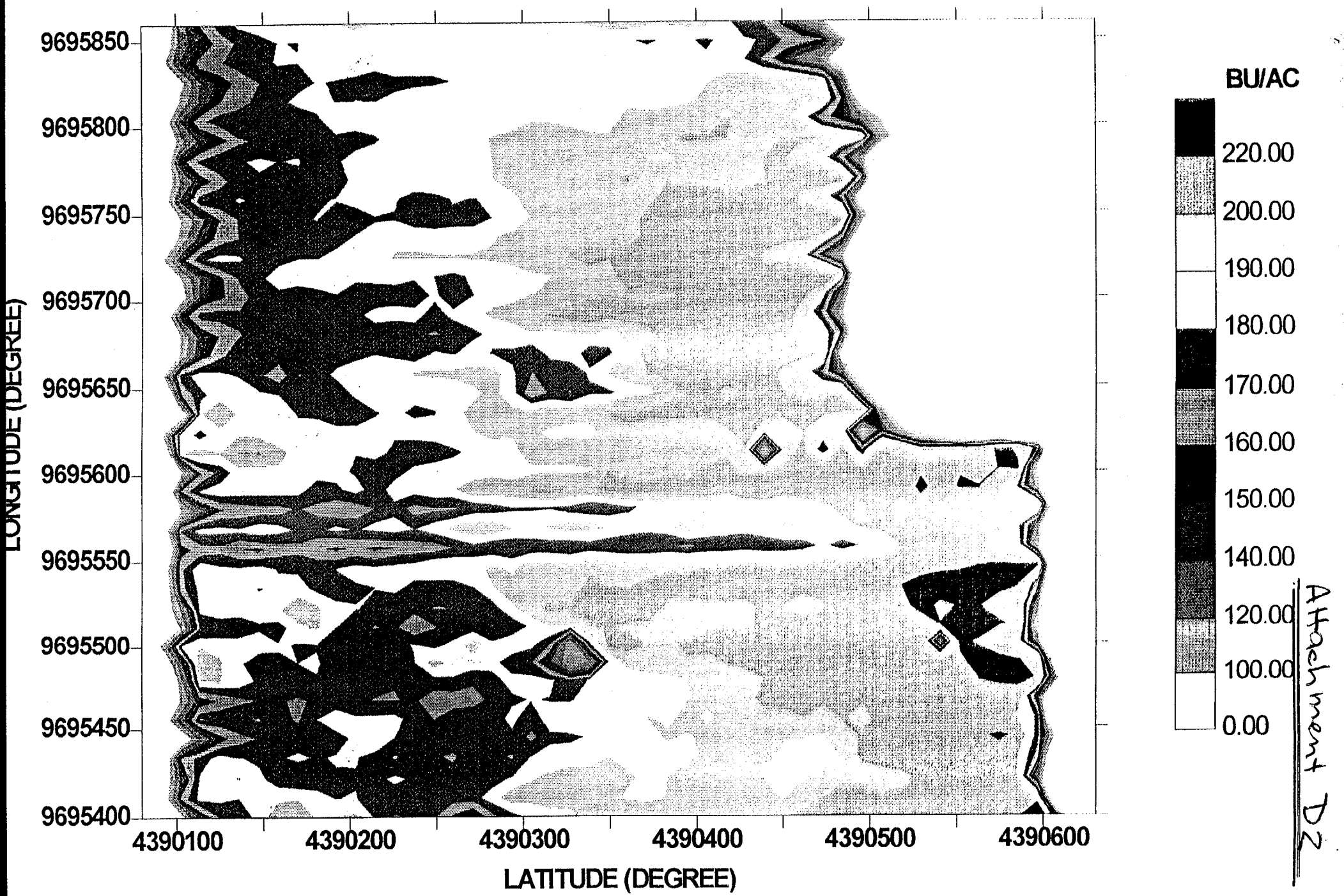
Attachment 2

Point Yield Map Differential GPS



Attachment D1

Differential GPS Kridged Yield Map



Attachment D2