WINTERIZATION OF ELECTROMAGNETIC AND GLOBAL POSITIONING SYSTEM EQUIPMENT AND SURVEYS

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This project was initiated under an agreement between Keystone Agricultural Producers and the Prairie Farm Rehabilitation Administration to develop and deliver decision support systems for sustainable agricultural resource development planning to municipal governments in Manitoba.

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This report indicates the potential to increase the detailed knowledge of resource information that can be provide to rural municipalities that will assist them in making informed decisions regarding sustainable agricultural and rural development, protecting the water and soil resource.

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Abstract

The Prairie Farm Rehabilitation Administration (PFRA) has been demonstrating the usefulness of EM/GPS Surveys for site characterization in support of a variety of agricultural related purposes. A Case Studies Report of some applications of EM/GPS Surveys in agriculture was prepared under the National Soil and Water Conservation Program and is available for PFRA- Manitoba Region. A significant limitation of this technology has been limited access to fields due to wet conditions, crops and winter. If possible, winter operation of EM/GPS equipment would greatly increase the window of time that fields are accessible for surveying.

This project involved testing EM 31 and EM 34 Ground Conductivity Meters under winter conditions to determine their operating temperature range and vulnerability to damage in cold weather and to determine the correlation between the standard summer readings and the winter readings. Once the feasibility of using the EM survey equipment in winter conditions was established the task was to design, prototype, and test any accessory equipment that would be required to conduct EM Ground Conductivity Surveys in the Winter. This involved building a protective housing for the EM 31 that could be mounted on skis or a sled and pulled behind a snowmobile. In addition, modification to the EM 34 Beam assembly was required so that it could also be towed behind a snowmobile.

The surveys that were completed were on sites that had been survey previously but in summer weather conditions. This allowed for direct comparison that the combined effect frozen soils and cold operating temperatures had on the final map results. The project clearly demonstrated the validity of conducting EM/GPS surveys in winter conditions, thereby vastly increasing the window of time which surveys can be conducted.

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1.0 Introduction

As agricultural production intensifies and diversifies, local governments and other decision makers are under pressure to make decisions on agricultural operations which must reflect sustainability in terms of environmental, social and economic issues, within local and regional areas. While resource base data is advanced enough to be useful by decision makers, the resource data is often not complete. Information obtained from Electromagnetic/Global Positioning System (EM/GPS) surveys provides decision makers with addition field level data needed to make informed decisions.

EM/GPS surveys of land have proven useful for a wide variety of agricultural related purposes. Unfortunately due to weather and crops, the time available to conduct surveys is limited. Although winter provides an additional 4 to 6 months of potential unobstructed access to agricultural land, the EM/GPS equipment has been designed to be used in warmer weather conditions. While there has been some limited use of EM equipment in the winter by others (e.g. to measure polar ice thickness), the performance of EM equipment on frozen soil is unknown. Successful winter use of EM/GPS surveys will allow for much more of the agricultural landscape to be surveyed in a much shorter time span.

2.0 Project Description and Objectives

The primary objective of the study was to determine if the equipment itself can be used safely and efficiently in winter conditions. This required considerable effort to ensure that EM meters, GPS equipment, and the people collecting the data were adequately protected. This project facilitated the testing of the EM and GPS equipment in cold winter conditions and the effect of snow cover and frozen top layer of soil on the conductivity readings. In addition, equipment was constructed to house the EM 31 and EM 34 equipment to protect it from damage while conducting the winter survey.

3.0 Methodology

The first stage of this project involved field testing of the EM 31 and the EM 34 in cold conditions. This was accomplished by using the equipment at a known calibration site under a range of typical operating conditions, with -20 Celsius set as the lower limit, and a range of snow pack thickness. The results were favorable in that the readings were similar to fall time readings, with the variation in EM 31 reading being somewhat greater then the variation in the EM 34 readings. This variation was expected to a certain degree as the shallower sensing depth of the EM 31 (6 meters) versus the EM 34 (15 meters) would indicate a higher influence in the readings due to snow and/or the frozen soil layer. While there was the option of recalibrating the EM meters to better correspond to the equivalent summers readings the decision was made not to and any required calibration would be done during the data manipulation stage.

Winter use of the EM 31 involved construction of a 14 foot protective housing and a ski/toboggan sled for pulling behind a snowmobile. The EM 31 was house in an insulated casing which was designed to protect the meter from excessive cold and to limit potential damage due to vibration and shaking during the field survey. The proto type unit was tested out with two basic configurations, one ski based and one toboggan based. In this case the toboggan based configuration was easier to manoeuver in the field, but the ski based system provided additional suspension which improved protection of the EM 31 meter. Since the EM 31 meter is very expensive to have repaired, the ski based system was deemed preferable, but some additional modifications will be required to improve stability and maneuverability.

The EM 34 system was much more challenging to adapt to winter conditions as it involves a 40 foot beam assembly. There were several problems with this setup. The principle issue was the protection of the cables from the extreme cold. Also the actual control of the beam while being pulled behind the snowmobile created some problems. Again, two possible arrangements were considered, one with a ski based sled and a second with a toboggan based solution. Both of these designs had advantages and disadvantages depending upon depth of snow and roughness of the snow covered field.

Some limited field testing of the setups were conducted in February 2001. One problem encountered was that C cell and D cell battery life spans were greatly reduced in the cold. This was mitigated on the EM 31 by using two 6 volt motorcycle batteries temporarily wired into the battery compartment, instead of using C cell batteries. The short battery life problem was not resolved with the EM 34 as the battery configuration is more complicated. Some discussions were initiated with Geonics, who manufacture the unit, who felt a reasonable solution could be fabricated (at considerable cost of course).

The field survey involved the collection of EM/GPS data at 3 to 5 second intervals along surveyed transects that were 20 to 30 meters apart. A snowmobile, borrowed from the PFRA Morden District, was used to tow the EM sleds across the fields. On average about 2000 data points were collected on each quarter section surveyed.

A significant problem encountered was navigation in the field. During summer time surveys landmarks such as fence lines, field patterns, etc. are used to orient each survey transect. In winter the snow cover masks most of these landmarks and it is very difficult to stay oriented. For the purposes of this study a handheld GPS system was used to navigate to and from the start of each transect, but this was a vert time consuming process. There needs to be an improvement to the navigation capabilities of the GPS system used in order to better complete the surveys in an acceptable manner. In order to do a significant amount of winter EM/GPS surveys a visual field guidance system must be developed.

A second problem was the location of the vehicles in the event of a breakdown with the snowmobile. During the GPS/EM survey the operator(s) are focused on the task at hand and at times are often several kilometers from the vehicles. In the event of a breakdown the operators need to be able to quickly located the vehicles and be able to walk to them. This was addressed using the handheld GPS unit. The location of the vehicles could be stored as a waypoint prior to starting the survey and then at any time the GPS can be used to navigate back to the vehicles. Additionally, difficultly was encountered in operators having to walk back through very deep snow to return to vehicles. Over tiring and hypothermia are possible outcomes and need to be considered. This was partially addressed by the procurement of winter clothing, but snow shoes/skis should be considered.

4.0 Analysis and Discussion

The application of ground conductivity surveys conducted during the snow-free months to a variety of agricultural related activities has been established. The objective of this project was to evaluate the practicality of performing these same surveys during the winter and then the correlation between winter and non-winter ground conductivity surveys. Proto-type equipment that was constructed and tested in the field demonstrated that it is possible to perform ground conductivity surveys during the winter.

The data collected clearly correlated well with the data collected under summer conditions. This suggests that conducting EM/GPS surveys in winter conditions provides good information that can be used by producers to make decisions. Typical us of the EM/GPS maps is targeting investigations for earthen manure storage sites, characterizing soils at a construction site, etc.. Examples of uses of EM/GPS surveys are available in the Case Studies Report (see Appendix A).

The variation between winter and summer time readings in the EM 31 surveys was more pronounced, particularly in the early stages of this study. Part of the problem was determined to be the rapid decay in power available from th eight C cell batteries. In normal operating conditions the C cell batteries last between 10 and 15 hours of survey. In winter conditions this battery power decayed much quicker and was found to affect the readings. Battery decay may have been a greater problem as this was an extremely cold winter and survey operators were forced to test the equipment in temperatures below minus 20 degrees Celsius, which is beyond reasonable conditions for winter field work. In order to complete the study the power source was changed from C cell batteries to two 6 volt motorcycle batteries which included a trickle charging unit to maintain fairly constant battery power. This retrofitted power supply greatly reduced the variation found between the winter and the summer surveys. In addition, the amount of variation was much more constant and could be corrected to equivalent summer readings during post processing.

The EM 34 surveys were less affected by the frozen soil as the over all depth of the conductivity is more than double the EM 31, with very little influence by the upper meter of frozen soil. The power supply was also a problem here but the resources were not available to solve this issue as the power supply has a much more complex configuration. A possible solution was proposed by the manufactures of the EM 34 but the cost was prohibitive at the time of this study. Again the surveys were conducted in temperatures below -20 C, which is unreasonable conditions for a winter field survey. There was an excellent correlation between the winter and summer EM 34 surveys, especially during the initial part of the survey when the batteries were fresh and warm. As the survey progressed the readings tended to drift to lower numbers.

5.0 Summary and Conclusions

This project clearly demonstrated the validity of conducting EM/GPS surveys in winter conditions, thereby vastly increasing the window of time during which surveys can be conducted. While there are some minor problems that have yet to be resolved, some surveying was completed which shows the process is possible. Most of the fields surveyed during the winter were fields that had been surveyed previously during summer conditions, with the resulting maps comparing favorably

6.0 Acknowledgments

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7.0 Data Sources

The data used was collected as part of the study or had been previously been collected by PFRA as part of program support of a variety of agricultural based activities and initiatives.