EVALUATION OF THE SUITABILITY OF GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY IN THE ENERGY RESOURCES CONSERVATION BOARD

BY

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ABSTRACT

EVALUATION OF THE SUITABILITY OF GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY IN THE ENERGY RESOURCES CONSERVATION BOARD

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completed in partial fulfillment of the requirements of the degree of Master of Environmental Design

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A case study approach is used to evaluate the suitability of Geographic Information System (GIS) technology in the Energy Resources Conservation Board (ERCB). The project is approached in two pieces with the first portion covering the ERCB organization and GIS technology in the organizational setting. The second portion discusses the application of a PAMAP GIS to a problem in a specific department.

Five key factors are used to evaluate the suitability of GIS technology in the organization: type of organization, location within the organization, computer hardware and GIS software, data types and amounts, and the type and size of problems to be addressed. The research methodology, conclusions and recommendations are based upon these five factors.

The final conclusions and recommendations are broken into two time periods, short-to-medium and medium-to-long term.[1] In the short-to-medium term, this report suggests the installation of PC-based desktop GIS workstations. Over the short-to-medium term the Data Processing Department should monitor station use and provide information and demonstrations to other departments not using the technology.

Nearing the end of the short-to-medium term, the other departments not using GIS technology should have had sufficient exposure to determine if they would like to switch to GIS technology. Thus, the various departments can determine if they wish to continue to support the current technology, or to switch to GIS. At the beginning of the medium-to-long term, additional GIS PC-based workstations could be acquired. Based on the level of interest in the new technology, the Data Processing Department could determine if they should phase out the current large-scale information systems in favour of an independent network of PC and Unix-based workstations.

Key Words:

Geographic Information Systems, Energy Resources Conservation Board, Information Systems, Evaluation, Suitability, GIS Case Study, Crown of the Continent Region, Elk Movement Patterns and Monitoring

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[1] The short-to-medium term is defined as one to five years. The medium-to-long term is defined as five to ten years.

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CHAPTER ONE: PROJECT INTRODUCTION

1.1 THE PROJECT

The intent is to determine if a Geographic Information System (GIS) is an appropriate technology in limited or widespread use for the Energy Resources Conservation Board (ERCB). This project studies the ERCB organization and the environmental planning capabilities of a GIS for a defined portion of the Crown of the Continent region from within the ERCB organization.

There are five factors that need to be considered when evaluating the appropriateness of GIS technology for a particular organization. [1] These five factors are the type of organization, the location within the organization, computer hardware and GIS software, data types and amounts, and the type and size of problems to be addressed. Each factor will be addressed in this document.

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[1] This is a slight modification to the three components that are discussed by P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986), 7. The author submits that both data and applications are an integral part of an information system and should be considered.

1.2 THE PROBLEM

The problem is to determine if a GIS is a useful tool for environmental planning within the complex regulatory setting of the ERCB organization.

CHAPTER TWO: PROJECT OBJECTIVES AND METHODOLOGY

2.1 OBJECTIVES

This project was carried out under contract to the Energy Resources Conservation Board (ERCB). During its five month time period, it was overseen by various ERCB departmental representatives. The objectives of this project were developed through consultation with Advisory personnel from the ERCB and MDP Committee members.

The specific objective of the ERCB in this study was to determine if GIS technology would serve a useful role within its existing information system complex and if so where and how should it be implemented.

The specific objective of this research was to evaluate whether GIS technology is appropriate in the ERCB given the highly technical regulatory environment in and for which the ERCB operates.

2.2 ANALYSIS METHODOLOGY

A case study approach is used. As in many case study approaches, by breaking the problem down into several manageable pieces, each influencing factor can be studied. Then the case as a whole is reviewed and recommendations are given. [2] In this project, a number of factors are studied within the ERCB organization including organization structure, existing information needs and information systems, and the mandate of the ERCB. Then a GIS pilot project is run for a specific ERCB department. The environmental planning capabilities of the GIS case study are defined by this department.

2.2.1 LITERATURE SEARCH

This project began in January 1991 with an extensive literature search on the topics of: Geographic Information System(s), Geographical Information System(s), GIS, Geomatic(s), Photogrammetry, Environmental Planning, Land Information Systems, Information Systems, Management Information Systems, Decision Support Systems, Spatial Analysis, Cartographic Modelling, Computer Hardware and Trends, Operating Systems, Organizational Analysis, Organizational Behaviour, Organizational Innovation, Organizational Structures, Organizational Management, and the Energy Resources Conservation Act, the Oil and Gas Conservation Act and other associated ERCB legislative Acts.

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[2] J. Zeisel, Inquiry by Design: Tools For Environment - Behaviour Research (Cambridge: Cambridge University Press, 1988), 65.

2.2.2 ANALYSIS OF DEPARTMENT INFORMATION NEEDS

A series of informal discussions were held with various department managers and Board members. These discussions took place over a period of nine weeks beginning in November 1991. The objective of these discussions was to gain an understanding of the current and predicted information needs and processes within the ERCB.

The department managers were questioned about the information requirements of their departments relative to particular types of data, including computer data and data handling as they relate to the current and future mandate of the ERCB. The ERCB Board members were questioned about the changing mandate of the ERCB. The results of the various discussions were generalized for the ERCB as a whole.

2.2.3 ANALYSIS OF ERCB INFORMATION SYSTEMS

The ERCB information systems were investigated over a seven week period beginning in November 1991. These investigations involved direct liaison with a number of staff members from the ERCB Data Processing Department. The current information system configurations were applied to the results of the discussions with the department managers to determine information deficiencies in the existing ERCB information systems.

2.2.4 ENVIRONMENT PROTECTION DEPARTMENT CASE STUDY

The GIS case study revolved around the use of a PAMAP Technologies GIS [3] loaded onto an IBM-compatible personal computer and operated from within the Environment Protection Department. A personal computer platform was chosen to conform with the author's existing GIS experience and to demonstrate the capabilities of GIS on a desktop. The case study used digital data from a number of sources including the Government of Alberta Land Related Information System (LRIS), the ERCB energy-industry database, and Dr. Luigi Morgantini from the University of Alberta. The case study was run over a two month period beginning in February 1992.

The background for the Environment Protection case study was gathered during various discussions held with Department personnel and several "Crown of the Continent" stakeholders. [4] These discussions began in October 1991. They involved attendance at Crown of the Continent Society meetings, going on tours and field trips and speaking with representatives of various interest groups represented in the Crown of the Continent wilderness area in southwest Alberta.

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[3] PAMAP Technologies Corporation, Victoria, British Columbia.

[4] For a more in depth discussion of the "Crown of the Continent" please see Appendix II.

2.3 PROJECT EVALUATION METHODOLOGY

As noted earlier, this project is logically broken up into two portions.

2.3.1 EVALUATION OF THE ORGANIZATION AND THE TECHNOLOGY

The first portion of this project was simply a generalization and compilation of data gathered from within and about the ERCB organization. The interpretation of this data was used in determining the overall appropriateness of GIS technology for the ERCB.

2.3.2 EVALUATION OF THE GIS CASE STUDY

The Environment Protection Department case study was evaluated on feedback from department personnel involved in this project. Since the GIS case study involved only the Environment Protection personnel, this simplified the evaluation process. The resulting interpretation of the feedback went into the final conclusions and recommendations in Chapter Ten.

2.3.3 DETERMINATION OF THE FINAL RECOMMENDATIONS

The final recommendations given in Chapter Ten are based upon the results of both sections of this project. The overall appropriateness of GIS technology for the ERCB organization and the specifically defined needs of the

Environment Protection Department. Both sets of conclusions go into determining the final recommendations to the ERCB.

CHAPTER THREE: DEFINING A GEOGRAPHIC INFORMATION SYSTEM

3.1 INTRODUCTION

The term Geographic Information System has been applied to a number of different computer-based information systems. Each of these deals with "spatially-disparate" data and has a variety of capabilities. [5] The difference in capabilities between a Land Information System (LIS), Computer Assisted Design (CAD) system and an Automated Mapping/Facility Mapping (AM/FM) system are considerable. However, all of these systems have been labelled as geographic information systems at some point in time.

Understandably, this has resulted in considerable confusion among GIS technology users. [6] To date, this confusion has not been corrected. This document will provide a list of characteristics that are essential to a true GIS. The characteristics given are a compilation of several noted by various respected GIS professionals. [7] [8] [9] [10] [11] [12] The

[5] H. Scholten and M.van der Vlugt, "A Review of Geographic Information Systems Application in Europe", Geographic Information Systems: Developments and Applications, ed. L. Worral (London: Belhaven Press, 1990), 14.

[6] I. Bracken and C. Webster, "Towards a typology of geographical information systems", International Journal of Geographical Information Systems Vol.3, No.2, (1989) 137.

[7] H.D. Parker, "The Unique Qualities of a Geographic Information System: A Commentary", Photogrammetric Engineering and Remote Sensing Vol.54, No.11 (November 1988) 1547.

[8] H. Scholten and M.van der Vlugt, "A Review of Geographic Information Systems applications in Europe", in Geographic Information Systems: Developments and

resulting listing of characteristics will serve as a definition of a GIS for the purposes of this document.

3.2 HISTORICAL DEVELOPMENT OF GIS

The concept of thematic overlays seems to be one of the first stages of development of GIS. [13] For many years, American landscape architects used a specialized technique of studying "mono-disciplines" of landscaping. They overlaid mylars, each with a unique set of elements (e.g. vegetation types). This process allowed for the study of multiple variables through the integration of data onto "one" map. [14] [15]

Based on this technique, a number of computer programmes appeared that performed the same process. The

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Applications, ed. L. Worral (London: Belhaven Press, 1990), 13-17.

9 D.J. Cowen, "GIS versus CAD versus DBMS: What Are the Differences?", Photogrammetric Engineering and Remote Sensing Vol.54, No.11 (November 1988) 1551-1554.

10 I. Bracken and C. Webster, "Towards a typology of geographical information systems", International Journal of Geographical Information Systems Vol.3,No.2, (1989) 137-139.

11 S. Aronoff, Geographic Information Systems: A Management Perspective (Ottawa: WDL Publications, 1989), 40.

12 P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986),pp. 7-9.

13 This historical discussion is not intended to be the final word on the history of GIS. Its main purpose is to give the reader a general idea as to where the current form of GIS originated.

14 S. Aronoff, Geographic Information Systems: A Management Perspective (Ottawa: WDL Publications, 1989), 32.

15 R. Revel, "Preplanning Resource Developments: Science, Economics and Planning", University of Calgary, 1985, 3

programmes were faster and could deal with an increased level of process complexity. As a result, during the 1960s and early-1970s, several new techniques were derived for even more advanced spatially-related analysis.[16]

The Harvard Graduate School of Design Laboratory for Computer Graphics began to experiment with "GIS" during the 1960s. It developed a number of computer-based mapping analysis packages that were functionally crude relative to systems available today. However, the programmes generated sufficient interest to continue development. This was especially true for spatial analysis applications. Up to that point, spatial analysis had been hindered by the extensive number of variables involved.[17] The computer was an appropriate platform for the intensive numeric calculations involved in spatial analysis.

A number of related disciplines pursued the use of computers for spatially-related research. Cartographers needed to produce higher quality maps. Surveying and photogrammetry disciplines desired accurate spatial measurements from maps and photographs. Geographers employed spatial analysis using thematic maps and the interpolation of point data to produce three dimensional surfaces. Remote

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[16] S. Aronoff, Geographic Information Systems: A Management Perspective (Ottawa: WDL Publications, 1989), 4.

[17] P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986),pp 4-7.

sensing interests worked on the analysis of remotely-sensed images for vegetation and landform classification.

From these related interests, there appeared to be two main trends in the application of computers to mapping. One was the automation of existing tasks with an emphasis on producing higher quality maps in less time. The second was the use of computers for spatial analysis. [18]

In North America, the first "operational" computer-based, "GIS" systems were developed in the mid-1960s by the Government of Canada (Canada Geographic Information System - CGIS) and the State of New York (Land Use and Natural Resources Inventory - LUNR). [19] Each encompassed a number of thematic layers including agricultural land, soils, forestry, wildlife and geology.

By the late 1970s, there had been a considerable investment in and development of "GIS" applications. This was largely concentrated in North America and primarily involved large corporations, academic institutions and governments. The interest was not on high quality graphic output but rather on enhanced, computer-based spatial analysis. The aim was to produce "a powerful set of tools for collecting, storing, retrieving at will, transforming,

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[18] P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986), 6.

[19] S. Aronoff, Geographic Information Systems: A Management Perspective (Ottawa: WDL Publications, 1989), 32.

and displaying spatial data from the real world for a particular set of purposes. This set of tools constitutes a 'Geographical Information System' (sometimes a Geographic Information System - sic)." [20]

During the 1980s, several changes to computer hardware caused the interest in GIS technology to rapidly accelerate. The downsizing of computer components and the advent of the personal computer resulted in the increased utility of a GIS. [21] Many GIS tools that once resided on mainframe and minicomputers could now be easily managed on a desktop or portable computer.

Along with miniaturization, the capabilities of computer hardware have increased. The graphics capability and overall processor speed of many current desktop personal computers easily exceeds that of the large mainframe and minicomputers of the 1960s, 1970s and early 1980s. [22]

In conjunction with these rapid changes, there has been a considerable decrease in hardware price per performance

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[20] P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986), 6.

[21] A personal computer could be defined as any IBM-compatible, Intel chip-based computer or any Apple computer. However, for the purposes of this document, unless specifically noted, the term personal computer will refer exclusively to IBM-compatible, Intel chip-based computers.

[22] This is based on the changing levels of performance as measured in Millions of Instructions per Second (MIPS) which have increased significantly over this time period.

measure. [23] A straight forward graphics terminal linked to a mainframe computer cost upwards of $10,000 in the late-1970s and early 1980s. The mainframe or mini computer running the terminal would have cost well over $250,000. The same (or better) level of graphics and computer performance is now available in a personal computer costing less than $2500. [24]

This price-for-performance decrease was the primary reason for GIS to migrate to the personal computer platform. [25] It also caused a rapid increase in the number of computer users. As well, easier access to the personal computer has encouraged the application of computers to a wider variety of problems. This is witnessed in the role change from the very first computers which were designed to be adding machines. As the capabilities of the computer improved, it was applied to a wider range of problems.

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[23] The common measure of performance has been the number of instructions per second that the unit could process. The current average personal computer can perform well over three million instructions per second. Performance measures have been changing during the last five years in order to consider other areas such as mathematical floating point operations.

[24] Noted during a lecture on Canadian Business Ventures (Business 301) at the University of Alberta, Faculty of Business, Fall 1988 in which the founders of Myrias Supercomputers (formed in Edmonton in 1980 by professors from the University) discussed the reasoning for their choice of parallel configured microprocessors. The rapidly declining costs and very large scale integration of the microchip makes it easy to incorporate into parallel configurations at a low cost.

[25] GIS has operated on large computer installations for many years. The migration noted here was the start of GIS on the personal computer. Since that time, a number of newer GIS packages have developed on the personal computer platform.

This "power to the people" movement has continued to broaden as computer hardware has continued to drop in price. As well, the associated capabilities of personal computer software have expanded.[26] Invariably, as the hardware improves, the software develops to use the new capabilities. GIS has not been an exception to this process. It has developed with the rapidly expanding personal computer market. Due to the rapidly developing capabilities and low cost, GIS was never as popular on large computers as it currently is on the desktop personal computer.

3.3 CURRENT GIS SITUATION

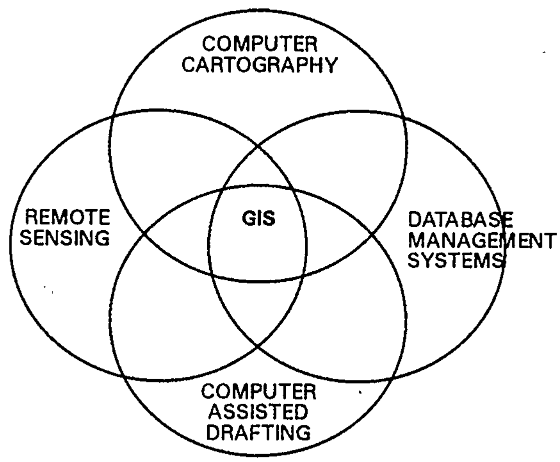
GIS seems to have become the analysis toolbox of the 1990s. For several reasons, GIS has been the recipient of a number of the spatial analysis tools developed during the 1960-1980s (See Figure 1). The primary reasons for combining these tools being the common graphical nature and spatial referencing. The resulting combination of spatial tools has improved the overall capability of GIS and it has allowed the software vendors to save money on development costs.

This amalgamation of tools has served to further enhance the popularity of GIS. With access to a wider variety of analysis tools, GIS users are encouraged to tackle a variety of new problems. Notably, this has caused

[26] C. Gooding, "Client-Server networks combine best of PC's, central mainframes", The Financial Post December 13 1991, 17.

some problems when the users don't understand the tools and inappropriately apply them. However, this is not a problem that is exclusive to GIS as many knowledgeable users of statistics will attest.[27]

FIGURE 1: THE HISTORICAL BASIS OF GIS



SOURCE: GEOGRAPHIC INFORMATION SYSTEMS, VOLUME 1, MacGUIRE ET AL, 1991, PAGE 13.

Throughout the late-1980s, GIS software vendors have been enhancing their products to take advantage of the rapid improvements in computer hardware technology.[28] Recently, this has become a complaint of the largest group of GIS users[29] which feels that GIS vendors should be listening to

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[27] G.L. Baskerville, "GIS and the Decision-Making Process" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 3-5.

[28] G.L. Baskerville, "GIS and the Decision-Making Process" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 4.

[29] Currently the largest group of GIS users is the basic or beginning user.

the largest user group to define new directions for product enhancements. [30] [31] [32] [33]

The Groups desire is to have the vendors simplify the use of existing GIS features before enhancements are added. This researcher feels this is the wrong direction to go for GIS enhancements. For GIS technology to continue to develop it needs to broaden its application through enhanced tools and capabilities. This is rarely achieved through limiting product enhancements and devoting development dollars to easier to understand interfaces. In addition, information system purchasers generally choose a system based upon current and potential application needs. [34] The user group complaints are about a system giving them too many potential applications for their information system dollars. As a result, a "pyramidal" hierarchy of user demands has

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[30] J. Dangermond, "Development and Applications of GIS" in GIS Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 101.

[31] G.L. Baskerville, "GIS and the Decision-Making Process" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 3-5.

[32] C.J. Davey, "Other Costs And Limitations of Geographic Information Systems" in GIS/SIG 91: Proceedings of The Canadian Conference on GIS held in Ottawa, Canada March 18-22, 1991 (Ottawa: Energy, Mines, and Resources Canada, 1991), 834-845.

[33] J. Dangermond, "Where is the Technology Leading Us?" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 11-15.

[34] J.A. Senn, Information Systems in Management, fourth edition (Belmont, California: Wadsworth Publishing Co., 1990), 646-683.

developed. The few proficient GIS users at the top and a large group of beginning or part-time GIS users at the base.

Currently, the main thrust of new applications for a GIS comes from these proficient users. [35] If the proficient users are given new features, they will find ways to use them. To date, it would seem the vendors have invariably listened to the needs of the proficient GIS user. The results have been very successful with GIS rapidly growing in popularity. However, the vendors will have to decide how to deal with the complaints of the basic users. Either way, GIS is heading into the 1990s as a robust tool with a plethora of features potentially applicable to an increasing range of problems. [36]

3.4 DEFINING A GEOGRAPHIC INFORMATION SYSTEM

If this project is to evaluate GIS planning capabilities, it is critical to define a GIS. Unfortunately, GIS is not easily classified by a simple definition. In the strictest sense, a GIS is a computer-based information system capable of assembling, storing, editing, manipulating, displaying and outputting geographically-

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[35] J. Dangermond, "Where is the technology leading us?" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 13.

[36] J. Dangermond, "Where is the technology leading us?" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 13.

referenced spatial information. [37] However, that definition does not actually differentiate a GIS from any other spatial information system.

As noted, there are four "major" information system groups that deal with spatially-disparate data. Each consists of five primary components: the computer hardware, the software, the data, the organizational context in which the system functions and the type of problems it addresses. [38] Each of the four systems has the capability to input, store, manipulate and output hardcopy data. In addition, each might operate on similar computer hardware and may even reside within a similar organizational context.

It is the capabilities of the software, the type and use of the data and the problems it addresses that differentiate these various information systems. Given the scope of this project, it is not appropriate to elaborate on the characteristics of each of these systems. A better definition must be given that will describe the capabilities of the GIS. [39]

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[37] Geographic Information Systems, pamphlet, United States Geological Survey, United States Department of the Interior, United States Government, 1991

[38] This is a slight modification to the three components that are discussed by P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986), 7. The author submits that both data and applications are an integral part of an information system and should be considered.

[39] D.J. Cowen, "GIS versus CAD versus DBMS: What are the differences?", Photogrammetric Engineering and Remote Sensing, Vol. 54, No. 11, November 1988, 1551.

3.4.1 KEY FEATURES OF GIS

A GIS is a computer-based information system that deals exclusively with geographically-referenced spatial data. All elements from simple lines, points, and polygons through to extensive database records or three dimensional surfaces are geographically-referenced. All referencing occurs within a specified geographic map projection and within a global setting.

Geographic referencing is the first essential feature of all GIS analysis. The analysis uses spatial referencing as the source of measurement. Based upon these measures, a GIS can determine magnitudes of spatial change. The differing results can be displayed with the original input feature maps.

Another essential feature of GIS is the extensive use of graphics. A GIS is a graphics driven tool. It can import, create, edit, manipulate, display, or print graphics. All aspects of the system revolve around the display and manipulation of graphics. It is this extensive use of graphics that makes the GIS powerful.

A third essential feature is the variety of tools available in a GIS. There are many graphical drawing packages, numerical spreadsheet, statistical and database packages available. Each has its own collection of specific features. The GIS combines many of these features plus more into one package to perform varied analysis on spatial data.

The fourth essential feature is the capability to handle different types of information. The GIS can display and manipulate varied types of data. Regardless of whether the data is textual (eg a textual river name), graphical (eg a line, a point, or a polygon), a database (eg a database file with any number of records or fields), or a surface of individual points (eg a three dimensional surface created from elevation values). Any and all varieties can be displayed and analyzed individually or collectively from the same database.

The fifth essential feature of GIS is topology. Topology is the major differentiating feature between GIS and any other spatial data information system. Topology is defined as the juxtaposition of features, or the spatial relationship between features. A GIS establishes topology as the stepping stone to analysis. Establishing topology allows the GIS analysis tools to consider the characteristics of surrounding features within spatial data. No other information system deals with topology. [40]

In summation, three key features make the GIS unique from other spatial information systems. These features are:

[40] H.D. Parker, "The Unique Qualities of a Geographic Information System: A Commentary", <u>Photogrammetric Engineering and Remote Sensing</u>, Vol. 54, No. 11, November 1988, 1547.

1. the ability to assemble a comprehensive set of socially, economically, environmentally, and politically relevant data into one location and be able to view and analyse it in any relevant combination. A GIS is a very effective integrator of data;

2. the ability to have all GIS data geographically and topologically-referenced to all other existing data sets or maps. All data sets or maps can be used individually or together for any display or analysis and the results will be applicable to any and all maps;

3. the ability to objectively simulate actions on a data set and graphically view the results on a map. This ability to visualize scenarios without impacting or incurring extensive project costs enhances preplanning.[41]

3.5 KEY PROBLEMS WITH GIS

Like statistical analysis, there are problems that can develop through the inexperienced or improper use of GIS. Many of the GIS analysis functions rely on the computer software and results are assumed to be correct. This is especially so when the user addresses the GIS through a simple to understand user interface. The user does not necessarily see the buildling blocks going into the analysis. A lack of understanding is one way to develop incorrect results.

In addition, when operators make decisions regardless of the quality of data used in the analysis further problems

41 R. Revel, "Preplanning Resource Developments: Science, Economics and Planning", The International Association for Impact Assessment Conference, Calgary, Alberta, September, 1985

may arise. The extreme variations in input map scales and accompanying detail along with the actual data quality can influence the results significantly. Decisions could be made based on polygons that are not actually there. This problem arises primarily when using small scale maps for decisions that require a larger scale and the accompanying extra detail.

Notably, these are not problems exclusive to GIS since statistical analysis suffers from similar incorrect procedures and data sets that are too small to be reliable. In addition, many of these problems can be overcome through a better understanding of data and procedures on the part of the GIS operator.

3.6 DEVELOPING TRENDS IN GIS DURING THE NEXT DECADE

The author submits that operating systems will drive the changes in computer software over the next decade. This is a reversal from the past decade which was computer hardware driven. [42] Computer hardware and software purchases will be less unique. The choice of computer hardware will be based on the desired processing speed and the available funding for the purchase. The choice of available software will be defined by the choice of operating system. [43] [44]

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[42] L. Ramsay, "New operating systems enter fray", The Financial Post, December 13 1991,13.

[43] J. Udell, "OS/2 2.0: A Pilgram's Journey", Byte Magazine, December 1991,pp.47-48.

There will be fewer unique computer platforms available than there are today. [45] Operating systems, such as IBM's OS/2, Microsoft's Windows NT and the new relatively universal version of Unix, will be platform independent. All of the computer hardware platforms in the market will be able to run OS/2, Windows NT or Unix. In addition, each will potentially run each others application software. [46] This will make the choice of a computer even easier. The choice will be based less on operating system and more on the speed of the computer hardware. [47]

Despite this apparent universality of operating systems, each group of vendors is trying to make their operating system foremost in the various computer markets. Each vendor is trying to gain a larger percentage of market

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[44] This is partially the case now with a choice between the MacIntosh computer and the IBM - compatible computer. These are largely hardware defined differences based upon different technologies. This prediction states that hardware will be a smaller consideration. The operating system will define the application software.

[45] Platform is a term that refers to specific computer architecture configurations. Generally, platforms are defined by operating systems. Thus, a Unix platform is a computer architecture that uses the Unix operating system. Currently, there are an IBM-compatible platform, an Apple MacIntosh platform, a variety of Unix platforms, and various minicomputer and mainframe platforms.

[46] Notably, Unix will operate on multiple computer architectures as demonstrated in the efforts of SCO over many years. However, Unix will not mimic other operating systems and allow application software from a variety of operating systems to be run in separate windows.

[47] J. Udell, "OS/2 2.0: A Pilgrim's Journey", Byte Magazine, December 1991, 46.

share. [48] There are a number of interests trying to make Unix the main operating system. Others, such as IBM and Apple, are trying to develop entirely new standards such as PowerOpen which is based upon a new hardware architecture. [49] Only time and market demand will determine which will hold the major share of the market.

Many of these developments will benefit GIS users and vendors. GIS software is very numeric intensive and benefits from the presence of an extensive amount of computer memory and processing speed. Therefore, GIS users and vendors can only benefit from improvements in computer hardware and operating systems.

The recently developed Reduced Instruction Set Chip (RISC) computer hardware is such an example. A RISC computer combined with the Unix operating system is currently the fastest individual platform for GIS work. [50] [51] As well, the price of the basic RISC platform is now equivalent to a high-end IBM-compatible personal computer. [52] Over the next

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[48] L. Ramsay, "New Operating Systems Enter Fray: Appetite for faster, powerful computing opens doors for new players", The Financial Post, 13 December 1991, 13.

[49] K.M. Sheldon, O. Linderholm, and T. Marshall, "The Future of Personal Computing", Byte Magazine, February 1992, pp. 96-98.

[50] This is based upon a number of dicussions I have had with GIS vendors and as well upon information supplied in computer magazines regarding personal workstation performance.

[51] For the purposes of this document, these will be referred to as Unix-boxes.

[52] For the purposes of this document, a "high-end" IBM-compatible computer is one based on the Intel 80486 chipset.

decade, it would seem logical that the major GIS market growth should be in the low-end, RISC-based, Unix-box market.

Currently, the largest installed base of GIS users is in the personal computer market. However, this may change with the decreasing price and increasing availability of optimal computer platforms like the RISC system. The only way for the personal computer market to remain the largest GIS market will be through new hardware and operating system standards. The development of the Intel 80586 computer chip and IBM's OS/2 operating system may be such standards required to maintain the growth of the personal computer market.

There are two new operating systems in the personal computer market. One is developed (IBM's OS/2) and the other (Windows NT) is still in the development phase. OS/2 has been touted as technically superior to Windows NT. [53] However, very few GIS vendors will likely move to OS/2 because of the uncertainty during its launch, poor support during its early releases, numerous problems with the early releases and uncertain future due to IBM's recent interest in a whole new operating system called PowerOpen. Many GIS

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[53] J. Udell, "OS/2 2.0: A Pilgram's Journey", Byte Magazine, December 1991, 47.

vendors will move to the Windows NT operating system to tap the large installed base of Windows 3.XX users. [54] [55]

The obvious beneficiary of these changes in operating systems and computer hardware is the computer user in the form of increased speed and fewer hardware and software limitations. These changes will provide for better memory management, better graphics capabilities and overall speed improvements on existing or new hardware. [56] These are major benefits to the GIS user.

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[54] J. Udell, "OS/2 2.0: A Pilgram's Journey", Byte Magazine, December 1991, 47.

[55] E. Ullman, "News Microbytes: NT, SCO Desktop Previewed on R4000", Byte Magazine, December 1991, 42.

[56] J. Dangermond, "Development and Applications of GIS" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 101.

CHAPTER FOUR: GIS WITHIN THE ORGANIZATION

4.1 INFORMATION SYSTEM PERSPECTIVE

A GIS is a decision support system (DSS).[57] Its role within the organization is largely, although not exclusively, problem-oriented. The data used in a GIS may originate from a number of sources within or outside the organization. Yet, its focus is on specific areas or problems that have arisen. In most cases, GIS does not have an ongoing process role like other information systems. However, its role can span long time periods if the problem being studied is not limited temporally. It can fulfill archiving, trend-analysis and other specific roles while addressing problems.

A DSS uses unique methods of information retrieval, manipulation and generation to serve its role. It consists of three main parts, the interface, model subsystem, and data subsystem. It performs a number of "what-if" functions, sensitivity testing, goal seeking, varied analysis and simulations. The variety of applications is dependent upon its sources of data. This is the most common role that a GIS plays within an organization.

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[57] J.A. Senn, Information Systems in Management, fourth edition (Belmont, California: Wadsworth Publishing Co., 1990),pp. 539-540.

4.2 GIS WITHIN THE EXISTING INFORMATION SYSTEM

4.2.1 GIS SYSTEM NEEDS DEFINE CONFIGURATION

The chosen GIS configuration obviously depends upon the organizational requirements. The fulfillment of those requirements will help to define the overall use and potential success of the GIS installation. [58] The organizational requirements include factors such as data needs with regard to security of data, access to data and frequency of data change. The factors include hardware needs with regard to the speed of hardware processing unit, size of database, ease of access to that and other data on this and other systems and the budget available for hardware purchase. The factors also include the potential needs to use existing corporate databases and/or to involve large numbers of company personnel.

As late as 1985, many GIS installations were confined to "controlled-computer" situations within large organizations. These included organizations with large data processing departments and faculties at academic institutions. [59] [60] The primary reason for computer system

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[58] R.H. Lamont, "Avoiding Surprises in Selecting and Setting Up a Geographic Information System" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),71.

[59] D. Tomlin, "GIS: Micro to Mainframe" in GIS Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),97.

[60] R.H. Lamont, "Avoiding Surprises in Selecting and Setting Up a Geographic Information System" in GIS

confinement was due to the purchase, maintenance and operating costs of the hardware required to operate most of the available full-featured GIS packages. [61] In most cases, the GIS "operators" were data processing personnel. Any analysis performed was largely restricted to specific problems which could justify the cost of operating and maintaining the computer hardware.

Due to the cost, confined location, and restricted access, many early GIS systems were limited to strategic planning roles. The infrequent and important nature of strategic planning made it one of the few applications that could justify the cost. For several reasons, this pattern has changed. As noted, the cost and size of computer hardware have declined considerably. The result has been a relocation of much of the computer hardware throughout the organization. As the cost of implementing, maintaining and operating computer hardware drops, the role of GIS within organizations is becoming more practical. GIS is becoming more of a spatial data management tool. [62]

Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),71.

[61] J.L. Smith and S.P. Prisley, "The Ultimate Compromise: Situating GIS in the Organizational Hierarchy" in GIS Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),47.

[62] J.L. Smith and S.P. Prisley, "The Ultimate Compromise: Situating GIS in the Organizational Hierarchy" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),49.

In addition, the number of computer literate people is increasing. There is less of a need to control and operate the computer hardware and software with specialized computer personnel. In fact, many of the lower levels of an organization hierarchy are more productive if given direct access to the computers. This is different from having data processing departments controlling access to a system. [63] If the GIS user and operator were one and the same person, the time and cost involved in its use would decline. There would be fewer people involved, less time explaining the problem and more time working on it.

The overall performance and data security of current personal computers easily exceeds that of the large computer installations of the 1960-1980 period. This has allowed for better analysis, graphics, speed, data reliability and ease of use in personal computers. The result has been an overall improvement of computer software use, including GIS.

4.2.2 CURRENT GIS HARDWARE OPTIONS

When purchasing hardware there is the option to have a single large computer with low cost terminals or to have any

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[63] J.L. Smith and S.P. Prisley, "The Ultimate Compromise: Situating GIS in the Organizational Hierarchy" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),49.

number of stand-alone or networked personal computers (or Unix-boxes) each operating relatively independently. [64] [65]

Previously, in situations where data control was desired or frequent data updates occurred, the large computer with terminals option was generally more adviseable. [66] This was due to the fact that operating systems for large computer installations were better able to control data access and data security.

The networked or stand alone personal computer option was most appropriate where individual users had a number of problems to study and data was infrequently shared. [67] In situations where the data was shared, it would be posted to a central location on a network where common access was available or transferred by floppy diskette media. Unfortunately, the early networks of personal computers were prone to varying problems. As a result, early personal

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[64] R. Menes and M. Sondheim, "A Chicken in Every Pot...and a GIS on Every Desk" in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 135.

[65] A terminal in this case could mean a personal computer on a network connected to a large computer facility or a simple large computer graphics terminal.

[66] J. Mostert, "Technology: The GIS Framework" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 107.

[67] User, for the purposes of this document, is defined as the individual that actually devises the problem or case study that is to be studied on the GIS. An example might be a forester who has no computer expertise but has been told to make use of the GIS facilities. The forester will devise the problem and an operator, as defined earlier, will input and manipulate the actual data on the GIS.

computer networks were very unreliable and unsuitable for critical data-controlled GIS installations. [68]

There are a number of advantages and disadvantages to each type of GIS installation. Large computer GIS installations are very appropriate when large amounts of data will be manipulated, stored and analyzed. Also, if there is an intent to extensively share the resulting data within the organization, it would be more appropriate to consider an large computer installation. [69] The main disadvantage to a large installation is the high cost for purchase, installation, operation and maintenance.

The networked personal computer is becoming more popular in situations requiring large computer GIS installations. [70] Networking technology has improved considerably and the cost of a network of personal computers is considerably less than a large computer installation. Also, using a network of personal computers means there is less likelihood of the computer becoming overloaded with too

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[68] A. Miller, "GIS in a Networking Environment" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 131.

[69] J. Mostert, "Technology: The GIS Framework" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 107.

[70] A. Miller, "GIS in a Networking Environment" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 131.

many terminals. Each personal computer has its own processor and the network is only used to share data.

As well, new operating systems for the personal computer may make the personal computer an even more likely platform for large scale GIS analysis. New operating systems will have better memory management and data manipulation capabilities similar to that of large computers.

The choice of computer platform for a GIS installation has to consider several factors including the existence of an organization-wide information system, the age and capabilities of that existing information system as it relates to GIS system needs, the need to have organization-wide access to the GIS data, the required analysis to be performed on the GIS, the amount of data to be transferred in the GIS, the number and location of operators using the system, the number of operators sharing data and the budget to implement the GIS installation. In most cases, organization-wide GIS is not necessary and the personal computer or Unix-box will fulfill most organizational needs in a GIS platform.

4.3 ORGANIZATIONAL CONTEXT

The hardware and software of a GIS govern the way in which the data is processed. It does not determine whether the GIS will be used effectively. In order to be effective, the GIS needs to be placed in an appropriate organizational context. [71] The success of a GIS within an organization is heavily dependent upon the level of acceptance of new technology. If there is resistance to that new technology and this resistance is not managed, the new technology will likely not succeed. [72]

There are three main reasons for organizational resistance to the implementation of a new information system. [73] First, there are people-oriented reasons that involve individual resistance to change in existing formal and informal relationships and potential changes in the distribution of personal power. Second, there are systems-oriented reasons that involve the improper choice, installation or configuration of the system such that the system works haphazardly, improperly, or is difficult to use. Third, there is the interaction of these two factors which may involve any variety of permutations, such as the improper use of the new system based on personal resistance to change.

There are a number of guidelines to be considered and/or implemented in order to avoid the resistance to

[71] P.A. Burrough, Principles of Geographical Information Systems for Land Resources Assessment (Oxford: Clarendon Press, 1986), 10.

[72] J.A. Senn, Information Systems in Management, fourth edition (Belmont, California: Wadsworth Publishing Co., 1990),pp. 802-808.

[73] J.A. Senn, Information Systems in Management, fourth edition (Belmont, California: Wadsworth Publishing Co., 1990), 803.

change. The most effective way to avoid resistance is to involve all potential users in the actual design, configuration and implementation process. As well, it is important to set up one person as an agent to promote the system before, during and after the implementation. Further, let the proposed users and managers have direct impact on the system chosen by demonstrating that their input is taken seriously. In addition, educate the users throughout the implementation process in the hopes of managing resistance due to misunderstanding. Then, make sure that the users can see the final system contributing positive changes to the organization. Finally, make sure that they can see the system benefitting all of the people involved. [74]

The implementation of an information system should involve many steps that can be measured as the process continues. By having many small implementation steps, this allows for the potential of many small successes along the implementation timeline. It is important for the participants to see early and continuing success from their own efforts. With continued visible success, the project implementation obstacles look smaller and are more easily overcome.

GIS is no exception to this process. If anything, it requires more of an effort to smooth the implementation

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[74] J.A. Senn, Information Systems in Management, fourth edition (Belmont, California: Wadsworth Publishing Co., 1990),pp. 808-810.

process because it can potentially cross several existing organizational boundaries. Its use of graphics, mapping, textual and database information could well extend the implementation impacts over larger areas than a standard information system. [75]

Obviously, the overall extent of the impacts depends upon the organizational structure and the size of the proposed GIS configuration. If graphics, mapping, textual information and database information is handled by a single department, the impacts could be small. If these services are each in a different department, the impact could be widespread.

The implementation of a GIS will involve a number of steps and requires a number of factors to be in place before the system can actually provide useful data. The first step requires the hardware installation and arrangement. The second step involves the software installation and checking. The third step is the data installation which may continue for many years depending upon the proposed data needs and goals of the system. Throughout this process, training of personnel must be ongoing. The goal is to have the system able to provide example results shortly after installation.

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[75] J.C. Antenucci, "Sign Up or Sign Off: Gaining and Maintaining Support for GIS" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),pp. 25-27.

This entire implementation process can vary considerably depending upon the size of the installation and the nature of the organization. [76] Obviously, it is easier to install a small scale, personal computer GIS system because the impacts of change are smaller. Only one department or one group of system users will be influenced which will simplify the whole implementation process. However, a smaller installation does not negate the need to educate potential users or to manage the potential impacts. Even a small installation can create resistance to change. All of the previously discussed factors must be reviewed in every case.

Just like any other major organizational change, an information system change must be managed from start to finish. It is important to establish an appropriate organizational context for a new information system. By involvement, education and an intelligent implementation process, the system should be fully accepted.

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[76] G.A. Jordan, "Making GIS Work in Forest Management" in GIS Applications in Natural Resources, ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991),36.

CHAPTER FIVE: THE ENERGY RESOURCES CONSERVATION BOARD

5.1 HISTORICAL BACKGROUND

The Energy Resources Conservation Board (ERCB) was created in the Province of Alberta in 1932 by the Turner Valley Conservation Act and was known as the Turner Valley Conservation Board. [77] In 1957, the name was changed to the Oil and Gas Conservation Board to reflect the new legislation, the Oil and Gas Conservation Act. In 1971, its powers were broadened extensively to include all aspects of energy development and transmission through the enactment of the Energy Resources Conservation Act. The name was then changed to the Energy Resources Conservation Board. It remains as such today.

The ERCB, as it exists today, receives funding from two sources. Half comes from the Energy industry through a tax levied on all barrel-of-oil equivalents (BOEs) produced within the province. The other half is a matching grant from the Government of Alberta. The Government of Alberta collects the tax levy on the BOEs and controls all of the ERCB funding. As a result, the total amount of the annual budget is not fixed and fluctuates based on projected needs and past budgets. Last years budget totalled $43 million.

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[77] F.M. Saville and R.A. Neufeld, "The Energy Resources Conservation Board of Alberta and Environmental Protection" in Canadian Journal of Administrative Law and Practice, (1989) Volume 2, pp. 287-313.

The ERCB head office and research centres are located in the City of Calgary. It also has eight field offices dispersed around the province. The ERCB has approximately 600 people at the head office, 32 at the research centres and 110 field personnel.

5.2 STRUCTURE OF THE ORGANIZATION

The organizational structure of the ERCB resembles the classic Public Administration organization model. It consists of a full-time committee or Board established to organize and direct specific efforts for a specific purpose. The Board defines policies in pursuit of specific objectives and acts as the top Board authority. [78] It establishes an administration to carry out the defined objectives in regular operations (see Figure 2).

There is a problem characteristic to this organization model. The model is based on the assumption that the Board determines policy and that the subordinate organization will be responsible for the administration of that policy. Unfortunately, this often results in a policy-administration dichotomy. The Board's policy objectives are given from a leadership perspective. The subordinate organization then attempts to interpret and implement the objectives. Throughout the implementation process the various

[78] G.H. Rice and D.W. Bishoprick, Conceptual Models of Organization (New York: Apple-Century-Crofts, 1971),pp. 149-150.

bureaucratic influences change these objectives. The results are not necessarily what was originally intended. [79]

Largely, the ERCB does not seem to have encountered this problem. However, it is at this point that the ERCB organizational form starts to deviate from the classic Public Adminstration model. The ERCB has attempted to move away from the potential dicotomy problem by appointing an executive manager-operations (EM-O) which acts as liaison between the management of the subordinate organization and the Board's objectives.

With this change, the ERCB organization begins to have the outward appearance of a corporation. As well, specific departmental roles within the ERCB deviate from the classic functional Public Administration form. In some cases, the Board closely resembles a Hybrid organizational model in which single function departments and relatively autonomous multi function divisions operate (see Figure 3). [80] [81]

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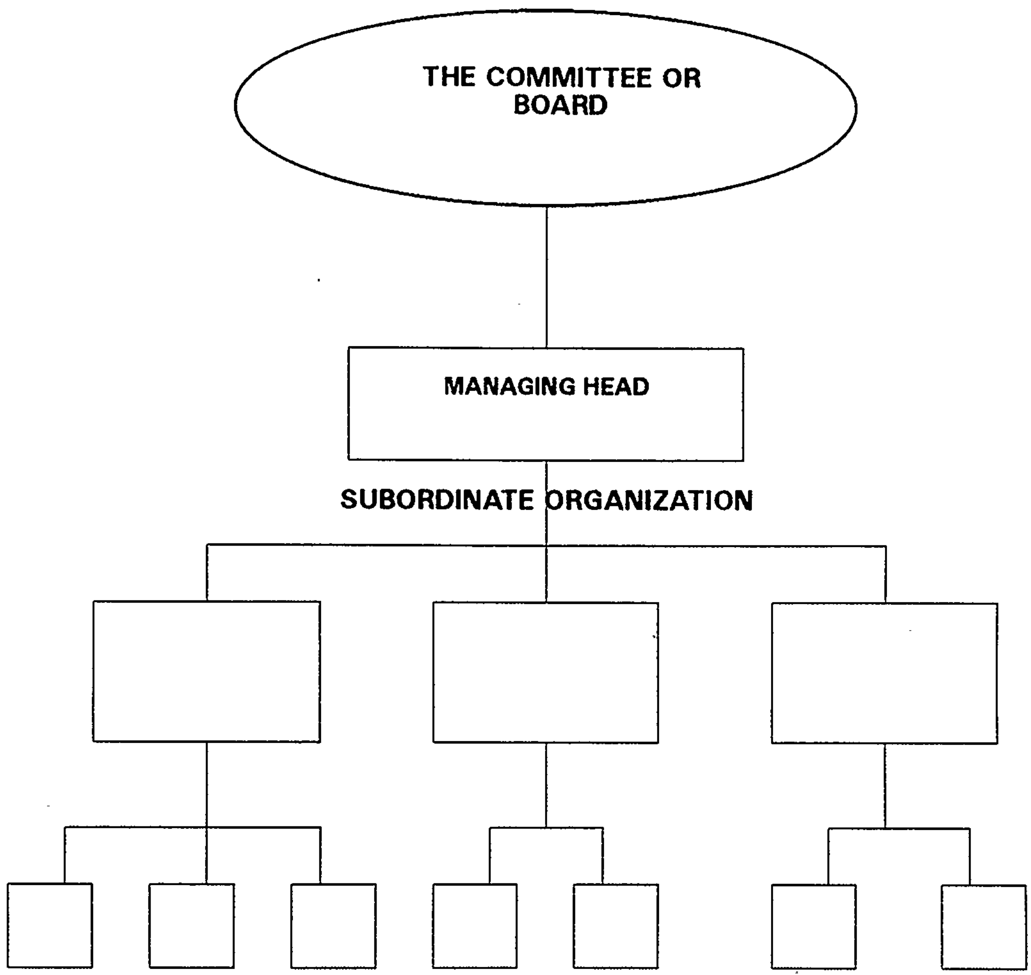
[79] H.J. Arnold and D.C. Feldman, Organizational Behaviour (New York: McGraw-Hill Book Company, 1986),pp 159-164.

[80] A hybrid structure usually contains both functional and divisional style of departments within an overall organization.

[81] J.B.Quinn, H.Mintzberg and R.M.James, The Strategy Process: Concepts, Contexts, and Cases (New Jersey: Prentice-Hall, 1988), pp.298-299

FIGURE 2: THE PUBLIC ADMINISTRATION ORGANIZATION MODEL



SOURCE: CONCEPTUAL MODELS OF ORGANIZATION, G.H.RICE Jr. AND D.W.BISHOPRICK, 1971, PAGE 158.

The Board consists of nine "division-like" line departments. Each deals with a specific aspect of the energy industry (see Figure 4). [82] The departments generally operate as separate entities very much like product divisions within a corporation. It is primarily these line departments that fulfill the Board's current legislative mandate.

There are nine other departments that fulfill a variety of support roles for line departments and Board activities. There are five single function administrative departments which deal exclusively with the bureaucratic administration. [83] There are four other departments which seem to defy categorization within either a Hybrid or a Public Administration style of organization. [84] These four fulfill a role outside of the standard line or administrative activities characteristic to the models (see Figure 5).

Another characteristic of the ERCB that is not reflected in the Public Administration model, is that a very large percentage of the ERCB staff is made up of professional and technical personnel. Very few are administrative or support staff. This stems from the

[82] These include: Oil; Gas; Pipelines; Drilling and Production; Hydro and Electric; Geology; Coal; Oil Sands; Communications; and Economics.

[83] These include: Accounting; Data Processing (which includes Graphics); Legal; Administrative Services; and Employee Relations.

[84] These are: Environment Protection; Chemical Research Laboratory; Core Research Centre; Field Offices; and the ERCB Board Members themselves.

technical role of the Board in a highly technical industry. The classic Public Administration organization model consists largely of administrators and support staff.[85] [86]

The ERCB seems to have been moulded on the classic Public Administration model. However, changes have been introduced in order to accomodate the ERCB's external environment which is the highly technical Alberta energy industry. Certain hybrid aspects of the ERCB organization structure allow for the handling of the unique characteristics of that industry.

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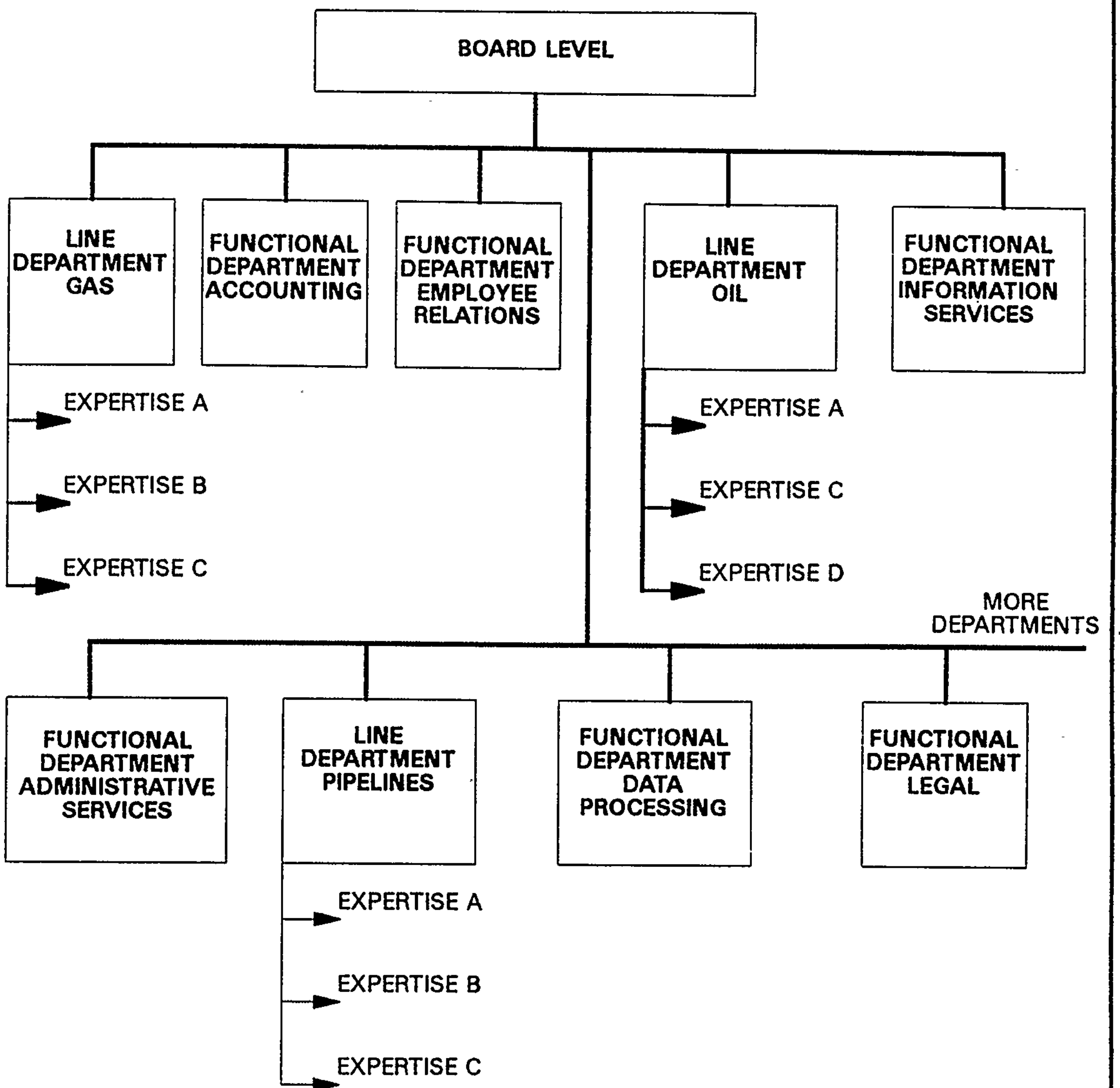
[85] G.H. Rice and D.W. Bishoprick, Conceptual Models of Organization (New York: Apple-Century-Crofts, 1971), 150.

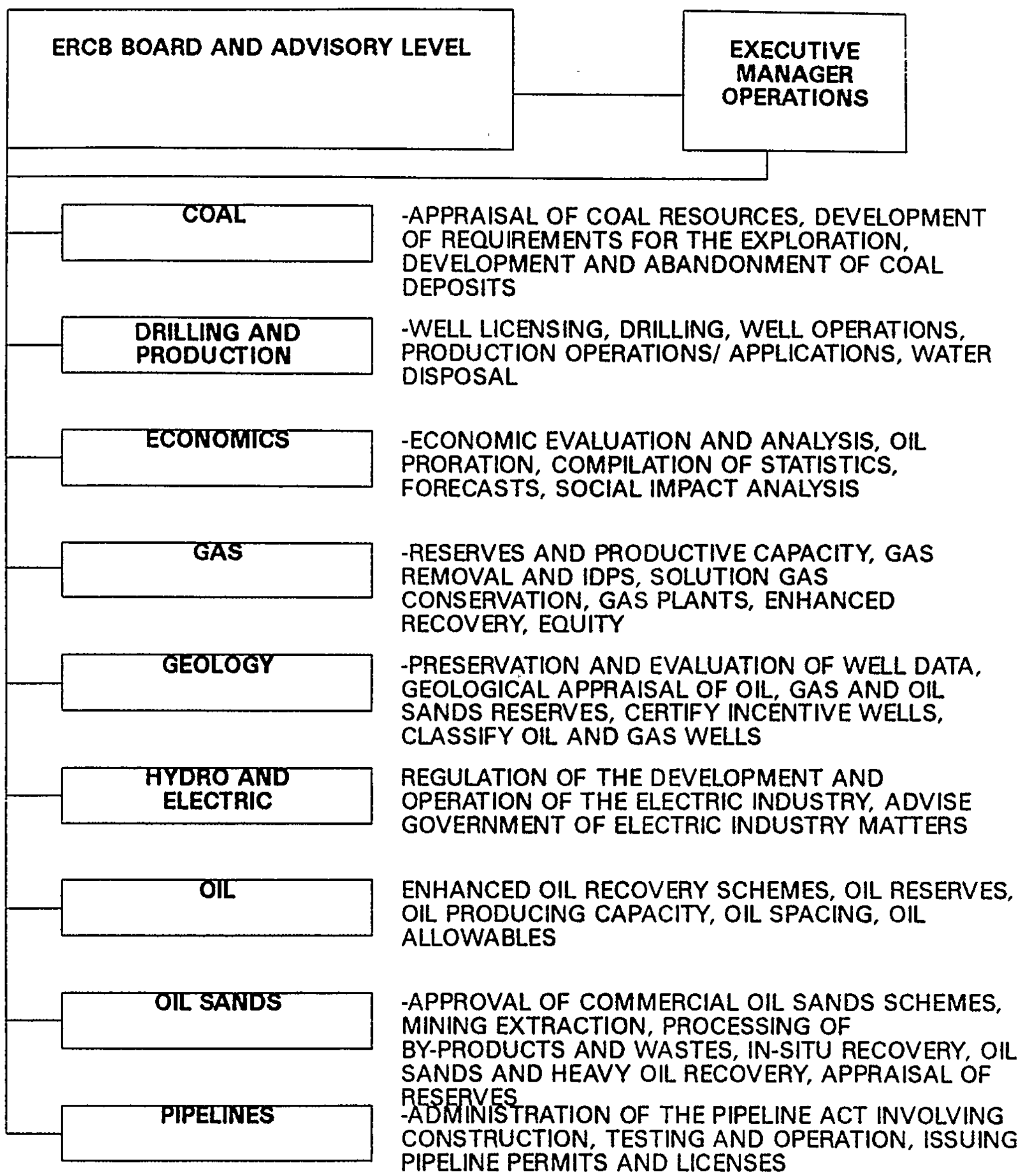
[86] In this case, the ERCB may also be called a Professional Bureaucracy as discussed by J.B.Quinn, H.Mintzberg and R.M.James, The Strategy Process: Concepts, Contexts, and Cases (New Jersey: Prentice-Hall, 1988), pp.298-299

FIGURE 3: THE HYBRID ORGANIZATION MODEL AS REPRESENTED IN THE ERCB



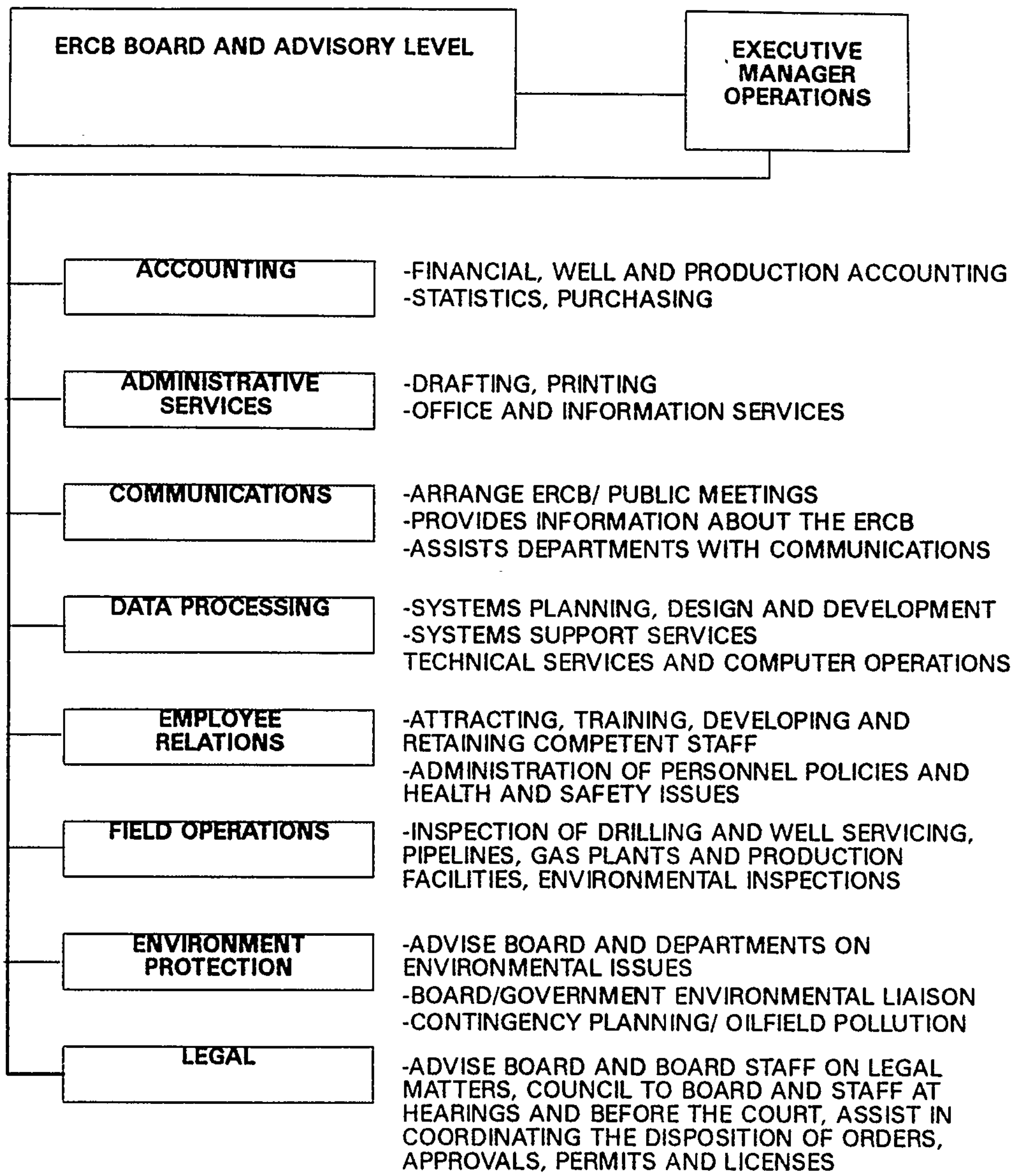
SOURCE: ORGANIZATION THEORY AND DESIGN, THIRD EDITION, R.L.DAFT, 1989, PAGE 237.

FIGURE 4: ERCB LINE DEPARTMENTS FULFILLING THE CURRENT BOARD MANDATE



SOURCE: ADAPTED FROM ERCB 1992

FIGURE 5: ERCB DEPARTMENTS FULFILLING SUPPORT AND OTHER ROLES



SOURCE: ADAPTED FROM ERCB 1992

5.3 CHANNELS OF COMMUNICATION

5.3.1 EXTERNAL CHANNELS

The nine line departments are the primary channels of communication to the industry and public. Each department deals with its own industry-related problems through a process called a "One-Window" approach to approvals. [87] This was established so that industry companies would always deal with a single line department for specific energy activities. This simplifies the effort on the part of both the industry and the ERCB and helps to control the distribution of information for a project. These external contacts by the line departments would be classified as essential in the pursuit of the current ERCB mandate.

The secondary external channels are the four uncategorized departments discussed earlier (see Footnote 76). External contacts arise during support roles to line departments and in pursuit of their own activities. [88] The external contacts made by these departments might be

[87] An example would be an oil company that wants to drill an oil well in an environmentally sensitive area. The Oil Department will collaborate with the Environment Protection Department and the Alberta Government Department of the Environment regarding environmental concerns. However, the ERCB Oil Department will control all communications with the company. The company deals with a single window in the ERCB.

[88] The field personnel have daily contact with the public and industry personnel while checking on industry activities. The Environment Protection Department deals with environmental issues brought forward by public or industry. The Board members have public and industry contact in a variety of situations including hearings.

classified as non-essential in the pursuit of the current ERCB mandate.

However, this may be changing as the ERCB mandate changes. [89] An example is the changing role of the Environment Protection Department, which is one of the four uncategorized support departments. Its role is expanding as an external communications channel due to the increasing public concern for environmental issues in energy projects. As a result, the department now has daily external contact regardless of any involvement in a specific project. Currently, the Environment Protection Department is fulfilling a number of external communication roles.

5.3.2 INTERNAL CHANNELS

The ERCB internal channels of communication are extremely simplified. The vertical channels consist of direct departmental access to the EM-O and Board level (see Figure 6). These contacts can occur at any time. Each ERCB department has equal "weighting" within the organizational hierarchy. The frequency of contact between the Board level and any one department generally depends upon the urgency of the issues involved.

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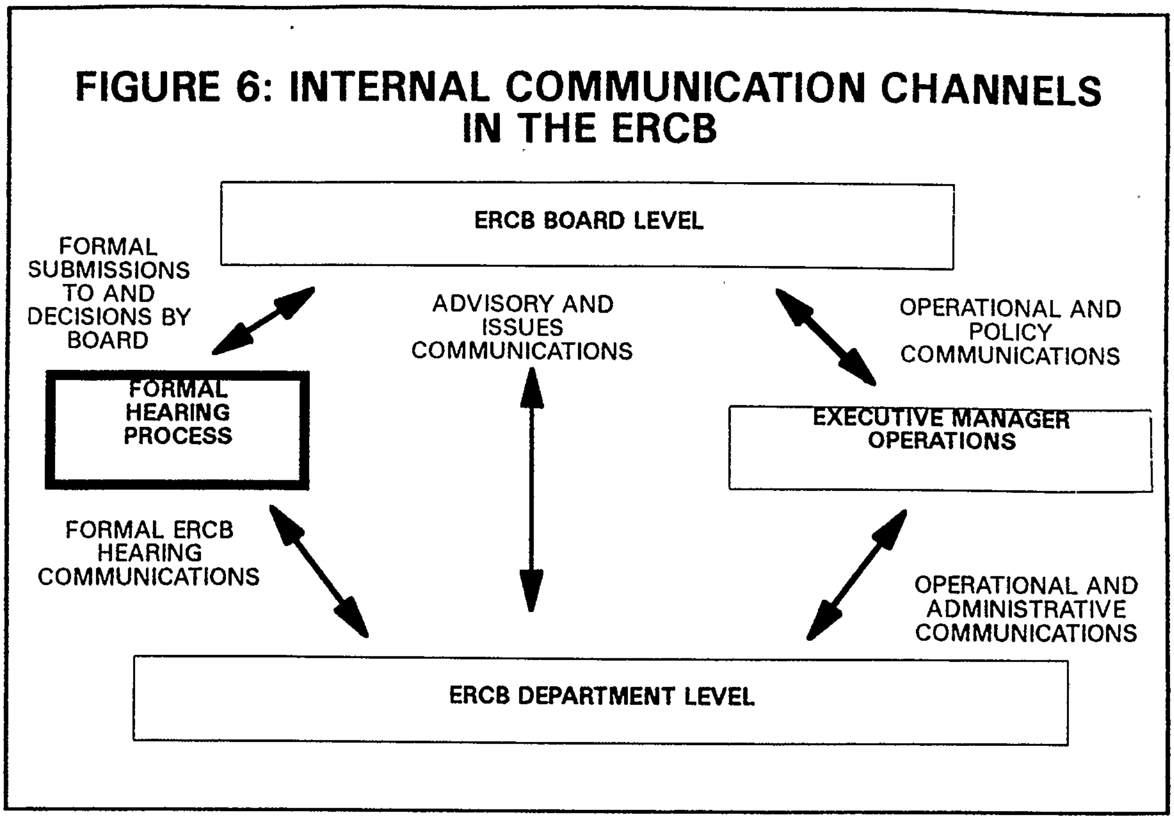
[89] The current ERCB mandate and proposed changes to that mandate will be discussed later in this chapter.



There are also a number of regular meetings that occur between specific Board members and department personnel. This stems from the assignment of specific Board members to advise specific departments. The assignment allows for regular contact between the Board and department level and a knowledgeable Board member who will support that departments efforts.

The internal horizontal channels of communication are largely case specific. The channels consist of individuals appointed within departments to collaborate with other departments on specific issues. The ERCB's One-Window approach to communications and approvals makes use of these individuals. The project-controlling line department will seek the necessary expertise in specific departments for a project. That way the controlling department gathers the necessary information internally.

These specific individuals closely resemble the "threading expertise" found in a Matrix organizational model. [90] The individuals provide expertise to any number of projects operating out of a variety of departments (see Figure 7). In some special situations, the individuals also provide their expertise to other Government of Alberta departments on a similar basis.

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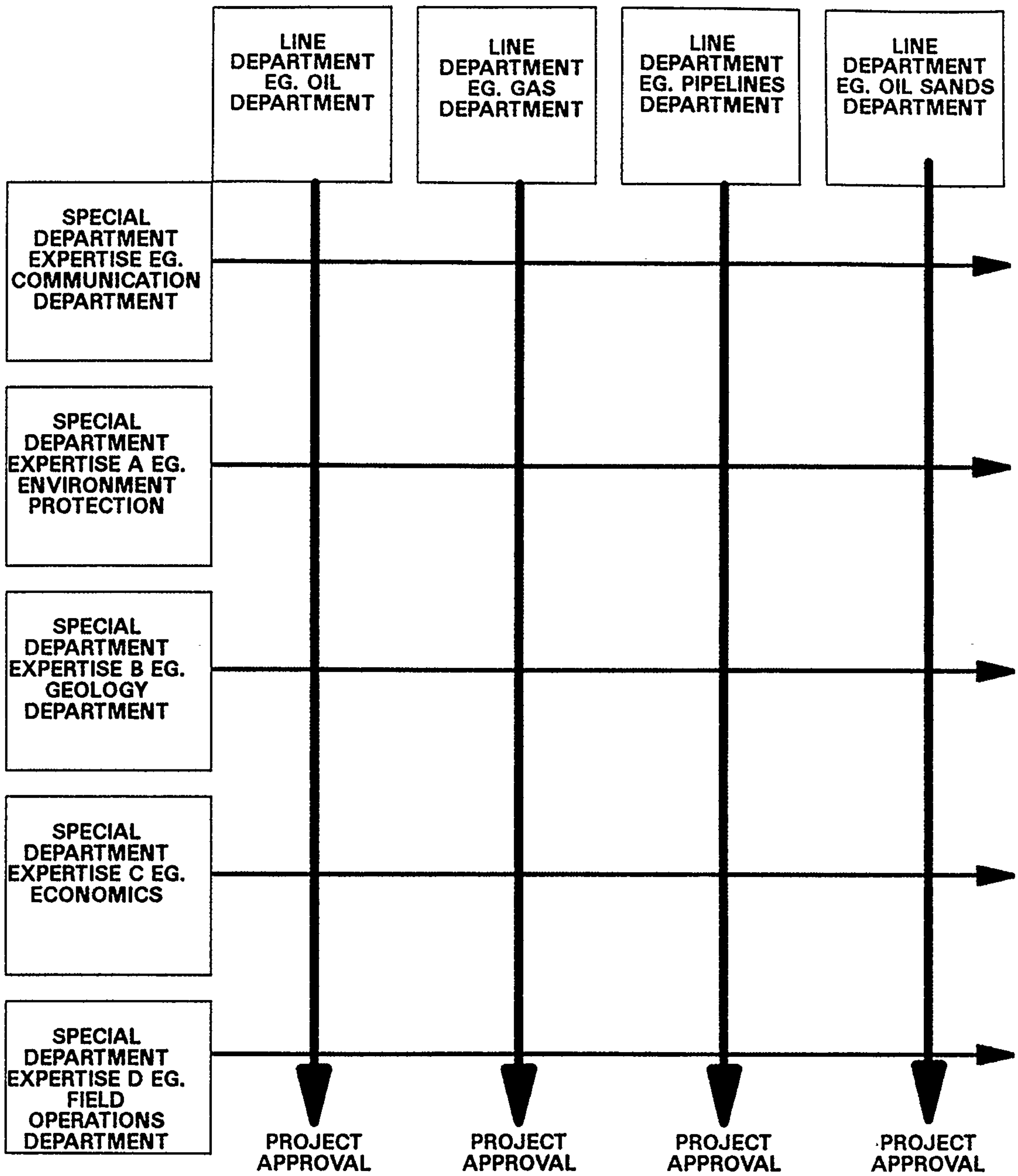
[90] R.L. Daft, Organization Theory and Design (St. Paul, Minnesota: West Publishing Company, 1989),pp. 237-245.

FIGURE 7: THE MATRIX ORGANIZATION MODEL AS REPRESENTED IN THE ERCB



5.4 CHANNELS OF AUTHORITY

The ability of an organization to function efficiently depends upon its structure of authority. [91] This is especially true for an organization which operates largely on rules of authority and the designated channels of communication. Each department within an organization functions independently. Properly designated authority gives the departmental manager sufficient control to make that portion of the organization work. [92] [93] If each department employs its specific level of authority and channels of communication, the organization should operate efficiently.

There are both official and unofficial channels of authority. Official authority, also known as legitimate or rational authority, is defined to achieve specific organizational and departmental goals. Unofficial authority, results from case specific situations where unrecognized opportunities, activities, or information can be guarded and/or controlled by specific individuals for their own benefit. This control may come about through the use of legitimate and/or illegitimate authority.

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[91] The structure of authority has also been termed control mechanisms by some authors such as J.R.Montanari, C.P.Morgan and J.S.Bracker, Strategic Management: A Choice Approach (Chicago: The Dryden Press, 1990), pp.268-292

[92] R.L. Daft, Organization Theory and Design (St. Paul, Minnesota: West Publishing Company, 1989),pp 176-178.

[93] J.B.Quinn, H.Mintzberg and R.M.James, The Strategy Process: Concepts, Contexts, and Cases (New Jersey: Prentice-Hall, 1988), pp.320-323

Rational legitimate authority is vested in positions within the organization. Since it is vested, it is openly recognized by subordinates and the authority openly flows down the organizational hierarchy. Positions higher up in the organization have higher levels of legitimate authority. The level of authority vested in any one position depends upon the level required to achieve assigned departmental and position objectives. [94]

Illegitmate or unwritten authority can differ tremendously from existing legitimate authority for it is not based upon organization level so much as access to and control of "strategic" information and/or activities. Use and control of that information and/or activity gives illegitimate authority inside and possibly outside of the organization hierarchy. It can rest in the hands of either administrative or managerial personnel and the content or basis can vary considerably. [95]

The legitimate channels of authority, within the ERCB, demonstrate that the line departments serve a key role within the hierarchy. Only the line departments and the Board level are involved in the energy industry approval process. As expected, the internal channels of authority closely resemble the organizational structure. Generally,

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94 R.L. Daft, Organization Theory and Design (St. Paul, Minnesota: West Publishing Company, 1989),pp. 399-408.

95 R.L. Daft, Organization Theory and Design (St. Paul, Minnesota: West Publishing Company, 1989),pp. 399-408.

all departments within the ERCB have a similar level of internal authority.

The external channels of authority stem from the project approval process. In the ERCB's One-Window approach, the department dealing with that aspect of the energy industry controls the project approval. Therefore, that one controlling department has a higher level of organizational authority for that specific project. The only hierarchy level that exceeds that authority is the Board. If the project goes to a hearing, the external authority shifts with the power of approval from the department level to the Board level.

Characteristic to the Public-Administration model, the Board has the ultimate decision over approvals. [96] Generally, the Board does not become involved in mundane issues. When a number of interests are involved or the project causes public concern, the ERCB will be asked to convene a formal hearing to discuss the relevant project issues. [97] In those circumstances, the line department involved acts only as the intermediary between the company and the Board. If there are information deficiencies, then

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[96] G.H. Rice and D.W. Bishoprick, Conceptual Models of Organization (New York: Appleton-Century-Crofts, 1971), pp 149-150.

[97] The ERCB Board level does not decide to hold a hearing. There is a special advisory group made up of department managers and assistant managers that decides whether there is sufficient justification for a hearing.

the line department will deal with the companies to address these deficiencies.

In the Public Administration model, internal authority stems from the "use" of a specific department and the resulting political importance within the hierarchy.[98] The ERCB is no exception to this rule. The "unwritten" authority of a department seems to stem from the strength of a specific part of the energy industry. The most active and thus strongest portion of the energy industry would seek the most approvals from the ERCB. The department in charge of that portion would potentially have more unwritten authority.

That authority applies both internally in the organization and externally in the industry. A single department performing a large number of the ERCB approvals would theoretically hold a larger percentage of the unwritten internal authority. Externally, that department would hold authority within that specific portion of the industry since it controls approvals.

This unwritten authority would stem from the extent of strategic information in daily operations. A department handling larger amounts of information should have more power within the hierarchy. For the ERCB, its product is

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[98] G.H. Rice and D.W. Bishoprick, Conceptual Models of Organization (New York: Appleton-Century-Crofts, 1971), pp 152-154.

regulatory approval. The strategic information and/or activity would theoretically be project approvals. [99] A department handling a larger number of the project approvals could potentially have more influence in the organization.

Within a large organization like the ERCB, an increasing internal influence could serve to increase the influence of departmental requests. The growth of a department within an organization is usually a good indicator of increasing internal influence. This may not indicate an increasing influence over other departments but rather an increasing influence in the organization's fulfillment of its mandate and objectives. [100] A department with increasing involvement in strategic information and/or activities should see a corresponding increase in internal influence.

This can be witnessed in the structural changes within the ERCB organization during the last twenty years. An example is the Environment Protection Department which has grown from five people in 1980 to twenty four in 1991. The influence of the department has increased. This can be easily substantiated by noting the increasing presence of

[99] This is also true for corporations in which successful product divisions receive more of the internal recognition and power. If that same division was to control a large portion of the product market, then it would have significant power in the industry.

[100] However, the increasing influence over other departments often logically follows a departments increasing influence in an organizations fulfillment of its objectives.

environment-related issues in Board hearings and the resulting decisions. [101] The Environment Protection Department is more involved in issues dealing with the Board mandate.

A department with more influence in the organization hierarchy should be able to sway information system configurations towards its own desires. This is based on the premise that a department that can use a system more has a higher justification for the system to be installed in the first place. Therefore, the system is invariably configured for that department.

In summation, the ERCB has very simple lines of authority. Ultimately, the project approval authority resides with the Board level. Otherwise, it resides with the line department controlling the One-Window of access. The author submits that unwritten power does exist but that it offers very few benefits to a department except possibly a potentially larger budget for an upcoming year. [102]

Therefore, with each department controlling its own project information, the logical organizational location for

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[101] See the following for an indication of the trend of growing influence of environment-related issues: Informational Letter IL OG-72-20; Decision Report D88-16; Decision Report D90-8; Decision Report D91-2; Interim Report 91-AA.

[102] In a normal organization, unwritten authority can be used to establish individual "power centres". Yet, the equal footing of ERCB departments and the inability to control public "use" of a specific department makes unwritten authority considerably less useful.

an information system like a GIS is at the department level. Each department that desires GIS technology for its approval process will determine how the system will fit. An organization-wide information system would have too many trade-offs (i.e. it could not meet the needs of each department) unless all of the departments wanted identical forms and amounts of data. Usually, this is not the case and each department has unique information needs.

5.5 MANDATE AND POLICY DISCUSSION

5.5.1 CURRENT ERCB MANDATE

The Board is governed partly or entirely by ten different Legislative Acts and a wide range of associated Regulations.[103] The Board has jurisdiction over any energy-related activity within the Province of Alberta. This includes all aspects of energy exploration, development, production, upgrading, transmission, and marketing. Of the ten pieces of legislation, two Acts heavily influence the Board's current activities and/or decisions. The two are the

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[103] These consist of the Energy Resources Conservation Act and Regulations, Coal Conservation Act and Regulations, Hydro and Electric Energy Act and Regulations, Pipeline Act and Regulations, Gas Resources Preservation Act and Regulations, Oil Sands Conservation Act and Regulations, Turner Valley Unit Operations Act and Regulations, Clean Air Act and Regulations, Clean Water Act and Regulations, and the Land Surface Conservation and Reclamation Act and Regulations.

Oil and Gas Conservation Act and the Energy Resources Conservation Act.

The Energy Resources Conservation Act has seven purposes:

> (a) to provide for the appraisal of the reserves and productive capacity of energy resources and energy in Alberta;
>
> (b) to provide for the appraisal of the requirements for energy resources and energy in Alberta and of markets outside Alberta for Alberta energy resources or energy;
>
> (c) to effect the conservation of, and to prevent the waste of, the energy resources of Alberta;
>
> (d) to control pollution and ensure environment conservation in the exploration for, processing, development and transportation of energy resources and energy;
>
> (e) to secure the observance of safe and efficient practices in the exploration for, processing, development and transportation of the energy resources of Alberta;
>
> (f) to provide for the recording and timely and useful dissemination of information regarding the energy resources of Alberta;
>
> (g) to provide agencies from which the Lieutenant Governor in Council may receive information, advice and recommendations regarding energy resources and energy.[104]

The Oil and Gas Conservation Act has six purposes:

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[104] Energy Resources Conservation Act (Edmonton: Queen's Printer of Alberta, 1971), c30 s2.

(a) to effect the conservation of, and to prevent the waste of, the oil and gas resources of Alberta;

(b) to secure the observance of safe and efficient practices in the locating, spacing, drilling, equipping, completing, reworking, testing, operating and abandonment of wells and in operations for the production of oil and gas;

(c) to provide for the economic, orderly and efficient development in the public interest of the oil and gas resources of Alberta;

(d) to afford each owner the opportunity of obtaining his share of the production of oil or gas from any pool;

(e) to provide for the recording and the timely and useful dissemination of information regarding the oil and gas resources of Alberta;

(f) to control pollution above, at or below the surface in the drilling of wells and in operations for the production of oil and gas and in other operations over which the Board has jurisdiction.[105]

There is no question that these Acts give the ERCB sufficient mandate to regulate energy activities. However, "non-energy" issues that arise during the pursuit of those energy activities are more uncertain.[106] Interests within the Energy Industry have questioned the ERCBs mandate to

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105 Oil and Gas Conservation Act (Edmonton: Queen's Printer of Alberta, 1970, 1979, 1984), 1970 c267 s5; 1979 c56 s2; 1984 c0-5.5 s30(6).

106 Non-energy issues are those that arise during energy activities such as environmental impacts, waste production, et cetera.

make approvals or decisions based upon issues "outside of energy" such as the environment. [107]

The ERCB has maintained a position that its approvals are based upon issues relevant to the public interest. The ERCB feels that its fundamental mandate is to ensure that energy resources in Alberta are conserved and developed in a manner that is consistent with that public interest. [108] In fact, several recent ERCB decisions have revolved around these non-energy issues. [109]

Upon close inspection, it is this protection of a broad public interest that tends to underlie many of the ERCB decisions and procedures. [110] Most of the purposes outlined above relate exclusively to energy matters. However, three are sufficiently general in order to encompass broader

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[107] P. McLaws and S. Blackman, "The Environmental Mandate of the ERCB in Well License Applications", The Newsletter of the Canadian Institute of Resources Law 28 (Fall 1989) pp 1-3.

[108] F.M. Saville and R.A. Neufeld, "The Energy Resources Conservation Board of Alberta and Environmental Protection" Canadian Journal of Administrative Law and Practice [2 C.J.A.L.P.], 294.

[109] See the following reports and letters for an indication of the trend of non-energy issues driving ERCB decisions: recent issues of the ERCBs annual report Energy Alberta, Informational Letter OG-72-20, Decision Report D86-2, Decision Report D87-16, Decision Report D-88-16, Decision Report D89-3, Decision Report D90-8, Interim Report 91-AA, Decision Report D91-2.

[110] F.M. Saville and R.A. Neufeld, "The Energy Resources Conservation Board of Alberta and Environmental Protection" in Canadian Journal of Administration Law and Practice [2 C.J.A.L.P.] pp 287-288.

public interests, such as the environment. [111] Each of these three has been extensively interpreted by the Board in a number of situations to justify decisions and/or requests. [112]

This confusion about mandate stems from the changing role the ERCB has played since its inception. Initially, the ERCB performed a highly technical role in ensuring compliance of its regulatory approvals. The approvals were based upon the technically sound development of energy resources. That technical regulatory role has continued to this day.

The ERCB still monitors technical compliance of its approvals. However, changes in this role came about when interest groups became more involved in energy activities. The industry believes the ERCB should stick exclusively to technical compliance related to energy development as it has in the past. [113] The public feels it should have more input to the development of energy projects. The Board feels it must consider public input if it is given.

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111 Purposes (D) and (E) in the Energy Resources Conservation Act and purpose (C) in the Oil and Gas Conservation Act.

112 F.M. Saville and R.A. Neufeld, "The Energy Resources Conservation Board of Alberta and Environmental Protection" in <u>Canadian Journal of Administration Law and Practice</u> [2 C.J.A.L.P.] pp 291-302.

113 P. McLaws and S. Blackman, "The Environmental Mandate of the ERCB in Well License Applications", <u>The Newsletter of the Canadian Institute of Resources Law</u> 28 (Fall 1989) pp 1-3.

5.5.2 PROPOSED LEGISLATIVE CHANGES

In 1990, the Government of Alberta made efforts to revise and update the various environment-related legislative Acts. During 1991, the Department of Environment submitted Bill 53 which was a compilation and/or revision of approximately seventeen pieces of legislation, eight of which were to be repealed upon the Bills passing.

An addendum to Bill 53 involved specific changes to certain pieces of the ERCB legislation. Bill 53, Part 13, Section 242, Subsection 3, Parts (a)(b)(c) altered the Energy Resources Conservation Act as follows:

> (3) The Energy Resources Conservation Act is amended
>
> (a) in section 1 by adding the following after clause (c):
>
> (d) "environment" means the components of the earth and includes
>
> (i) air, land and water,
>
> (ii) all layers of the atmosphere,
>
> (iii) all organic and inorganic matter and living organisms, and
>
> (iv) the interacting natural systems that include components referred to in subclauses (i) to (iii)
>
> (b) by adding the following after section 2:
>
> 2.1 Where by any other enactment the Board is charged with the conduct of a hearing, inquiry or other investigation in respect of a proposed energy resource project, it shall, in addition to any other matters it may or must consider in conducting the hearing, inquiry or investigation, give

> consideration to whether the project is in the public interest, having regard to the social and economic effects of the project and the effects of the project on the environment.
>
> (c) by repealing section 31(1) and substituting the following:
>
> 31(1) In this section, "local intervener" means a person or a group or association of persons who, in the opinion of the Board, are or may be directly affected by a decision of the Board or as a result of proceedings before it but, unless otherwise authorized by the Board, does not include a person or a group or association of persons whose business includes the trading in or transportation or recovery of any energy resource.[114]

The result is to broaden the ERCB mandate.[115] It now would include many of those issues considered by some to be technically "outside" of the ERCB mandate including issues such as the environment. These revisions will add legitimacy to past Board actions that were questioned.

As well, the public interest clause was broadened to encompass all of those issues not specifically outlined within the revised legislation. The result is a complete coverage of all possible issues that might arise now and in the future in dealing with energy development.

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114 Environmental Protection and Enhancement Act (Edmonton: Queen's Printer of Alberta, 1991), Part 13, Section 242, Subsection (3) Parts (a), (b), (c).

115 P. McLaws and S. Blackman, "The Environmental Mandate of the ERCB in Well License Applications", The Newsletter of the Canadian Institute of Resources Law 28 (Fall 1989) pp 1-3.

CHAPTER SIX: ERCB INFORMATION SYSTEMS

6.1 EXISTING INFORMATION SYSTEMS

The ERCB currently has three information systems. They are a large main database (IDMS Database), a Zycor automated mapping system (Zycor) and an Informap computer assisted drafting and mapping (Informap CADM) system. Each operates relatively independently, except for certain physical connections which will be discussed later. To gain access to the database requires access to a mainframe terminal or a personal computer on the network. Access to the other two systems requires specific graphics terminals and system expertise since both are relatively user unfriendly.

The main IDMS Database and the Zycor system reside on two large IBM-compatible mainframe computers. The Informap system currently resides on a VAX 11/780 minicomputer. The Mainframes operate the MVS operating systems. The VAX operates VMS. These operating systems have few real similarities. The main database is an Integrated Database Management System (IDMS Database). The functional split between the two platforms is: VAX-Informap - Base Map, Plot Facilities, Map Preview, IBM file to Informap Drawing File Conversion, and Pipelines; Mainframe-Zycor - Gridding, Contouring, Posting, Cross Sections, plot facilities; Mainframe-main IDMS Database- energy data.

6.1.2 THE MAIN IDMS DATABASE

The IDMS database is one of the worlds' largest energy-related databases. It consists of all drilling data, well log data, geological data, production data, workover data and reserves data for oil and gas in Alberta. It also contains oil sands and coal reserves data for the province.

For many years, this data was resident in a number of computers and filing cabinets. In the early 1980s, the ERCB moved to consolidate all of the various pieces of its energy data into a single integrated database. This was done to better manage the data and to give all departments equal access to the available data in the hope that it would be more readily used.

The existing mainframe terminals are configured for textual output only. As a result, if graphical output is desired, the data has to be downloaded to one of the two other information systems or to a personal computer (see Figure 8).[116] Currently, only the Zycor information system and personal computers are used for graphical output from the main database. The Zycor system provides hardcopy output and the personal computers provide a variety of output depending upon the user needs.

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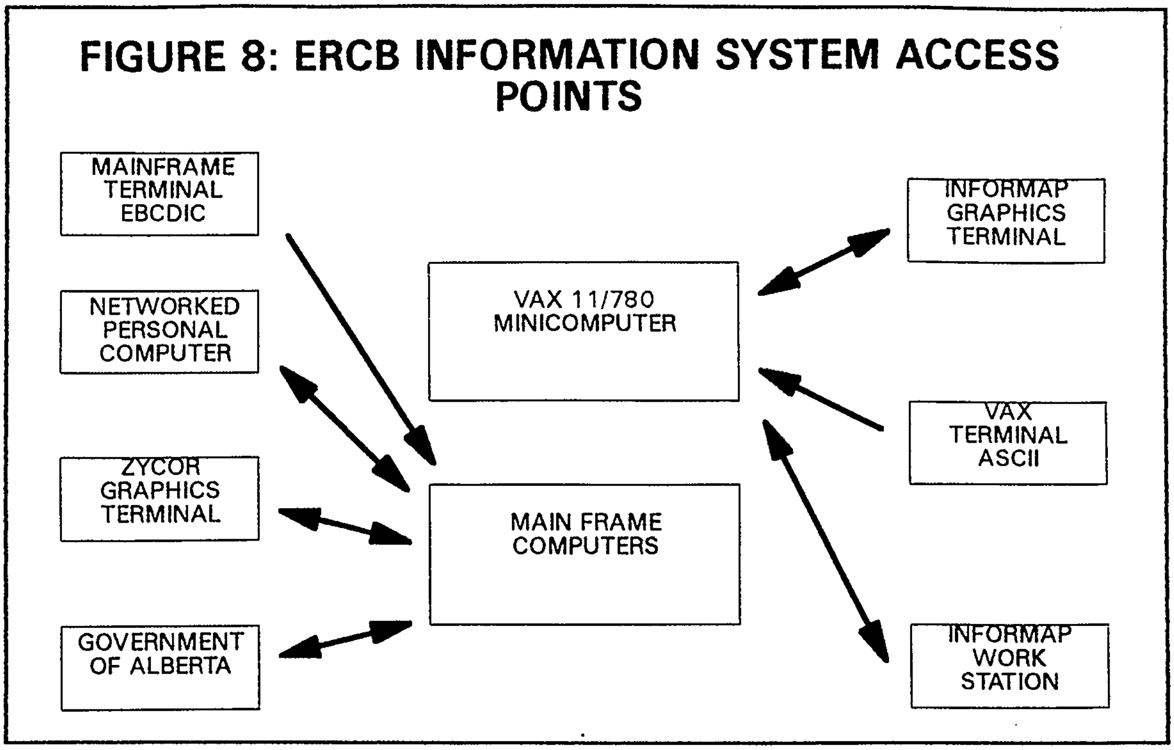
[116] In order to use the data from the IDMS Database system on another computer platform, it has to be exported as an ASCII file and reimported to the target platform.



6.1.3 THE ZYCOR AUTOMATED MAPPING SYSTEM

The Zycor system installation began in 1988 under a five year purchase plan. New modules were to be purchased and installed each year. At the end of the five year implementation, the ERCB would have its desired system configuration. Zycor's main purpose was to automate the hardcopy mapping of specific types of data residing on the main IDMS database. It was installed on the mainframe computers in order to give organization-wide access to the Zycor facilities.

Zycor is a very difficult system to learn and use. It is widely considered, within the ERCB, as very user unfriendly.[117] It is a batch operated graphics system and as a result, does not accommodate interactive queries or previews. Since it is a batch system, errors can not be discovered until the batch has run through the mainframe.

The system is heavily used by the Geology Department for contouring and gridding of IDMS Database data. As a result, much of the Zycor expertise rests within the Geology Department. Other departments that desire to use the Zycor information system either have their own personnel trained on the system or submit work requests to the Geology Department. The latter seems to be the most common.

6.1.4 THE INFORMAP CADM SYSTEM

The Informap system has been around the ERCB for more than fourteen years. The system resides on a separate computer, which is currently a DEC VAX 11/780. Informap is operated by a specialized Graphics group which is a part of the Data Processing Department. Having its own computer gives the Graphics group flexibility in system configuration. Again, either departments train their own personnel to use terminals on the system or submit work requests to the Graphics group. The latter are the most common.

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[117] This was related during the discussions held with the departments regarding information needs.

Informap originally filled the automated mapping role that Zycor currently fills, but the Informap capabilities in this role were very limited. Like the Zycor system, Informap is a difficult system to learn and specialized graphics terminals are required for its current system configuration. The current role of the Informap system is the mapping of linear elements. These include energy transmission systems of various sorts and any associated elements such as wellsites.

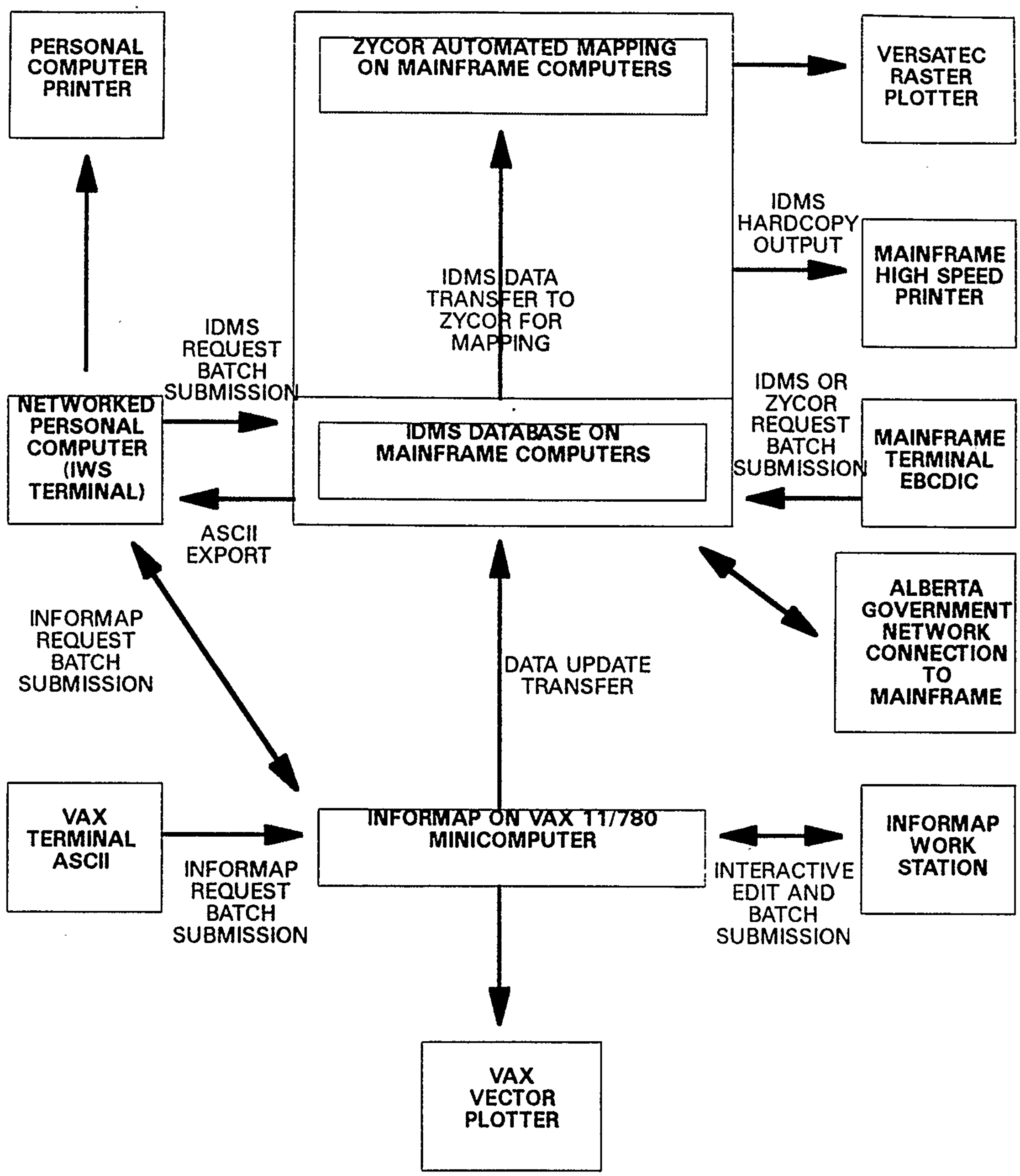
The Graphics group maintains their own database of information on the separate VAX computer. Data is sent out of the VAX system to the mainframe computers on a weekly basis in order to update the main IDMS Database. If required, bringing data back into the VAX system from the main IDMS Database is a slow, indirect process.

6.1.5 LINKS BETWEEN THE THREE INFORMATION SYSTEMS

The data links between the three information systems are indirect since there are two separate platforms and two operating systems to deal with. The Informap system on the VAX computer can transfer data to the main IDMS Database which operates on the mainframe computers with the MVS operating system. However, the data transfer path established was a work around the two relatively incompatible operating systems. Special programmes had to be developed by the Data Processing Department to allow information exchange.

A special programme was developed to output data from the VAX in large ASCII files to a network. The data is then imported into another programme which converts the data to the format required by the Zycor or IDMS information systems. A similar process is used to export data from the IDMS Database or the VAX Informap Database to personal computers on the network. The Zycor system is only able to output hardcopy data once it imports data from the other two systems (See Figure 9).

FIGURE 9: DATA PATH OUT OF THE IDMS DATABASE INFORMATION SYSTEM



SOURCE: ADAPTED FROM ERCB 1992

6.2 PLANNED INFORMATION SYSTEM CHANGES

6.2.1 ZYCOR UPDATES

The Zycor system is currently being considered for update. The developer of Zycor has informed the ERCB that it will no longer support the MVS mainframe operating system. This is despite the fact that the five year implementation plan is incomplete. As a result, the Geology Department has requested that an updated Unix version of Zycor be evaluated. If purchased, it would be placed on Unix-box workstations in the Geology Department. The Unix version of Zycor is reported to be considerably faster and more user friendly. Also, it is said to have more features than were available on the currently incomplete mainframe version. [118]

6.2.2 INFORMAP UPDATES

The current Informap hardware is very out of date. A basic desktop personal computer has more speed and power than the current VAX computer. [119] As well, considering the graphics work required of the Synercom black and white graphics terminals linked to the VAX, the system hardware is easily overloaded.

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[118] Personal Communication from Mr. Andrew Pond, ERCB Data Processing Department.

[119] A basic 80386 computer is rated at a minimum of three million instructions per second whereas the VAX 11/780 is rated at one million instructions per second.

As a result, funding has been approved to purchase a Unix multi-processor minicomputer and a number of Unix X-Windows graphical work stations. The Informap system will also be updated and enhanced to take advantage of the new computer hardware and operating system. The current Graphics group will continue to be the primary users of the Informap system.[120]

6.2.3 IDMS DATABASE UPDATES

The hardware for the main IDMS Database was recently updated through the acquisition of a second mainframe computer. It is faster than the older mainframe computer and is connected with the same networking system. As a result, any mainframe work load is shared between the two systems. With two computers, the usage is one hundred percent and forty percent on the old and new mainframes respectively.

The main IDMS Database package is the focus of a number of complaints within the ERCB. There is a great desire by departments to use the data available in the main database. However, the current IDMS system is very unfriendly and awkward to use. As a result, several ERCB departments want to see the current database package changed to a newer, more friendly relational database package.

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[120] Personal Communication from Mr. Andrew Pond, ERCB Data Processing Department.

However, a number of reasons go against the possibility of any changes in the database package over the short to medium term. [121] The IDMS Database system is now up and running full time. It has been operating as such for less than ten years. The Data Processing Department has configured itself for the IDMS data needs. As a result, organizational momentum exists in the Data Processing Department.

As well, much of the database support software has been configured to operate with the IDMS data structure. Unfortunately, the current IDMS data structure does not lend itself to an easy exchange to a new database system. Several major changes would have to be made before a new system could be running.

Also, the management of the Data Processing Department feel that the available relational database packages have not been proven to be sufficiently reliable. The question of reliability of the relational database packages and a considerable resistance to change in the Data Processing Department organization will mean the IDMS Database system will remain unchanged for awhile.

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[121] Personal communication from Mr. Lorne Fredlund, Manager, Data Processing Department.

6.2.4 CONCLUSIONS

For a number of reasons, there are a variety of information system changes that have been, are being, or should be undertaken. The overall approach to information system planning in the ERCB Data Processing Department is to not be "cutting-edge" in hardware or software technology. There are fewer problems associated with the purchase of proven technology but this may also mean buying hardware or software that may soon be phased out. The current ERCB mainframe version of Zycor is a case in point.

The ERCB information system user departments would like faster hardware, better software, and information systems that better fulfill their originally-proposed role. Departments are developing a sense of frustration due to the inability to use the available information as desired and the need to develop work arounds to solve the incompatibilites between the various information systems. As a result, many departments are acquiring more desktop personal computers. Each department can control the hardware and software on a personal computer and in many cases get a better quality and faster output product while using extracts of the available ERCB data.

6.3 FUTURE INFORMATION SYSTEM CONSIDERATIONS

The move of both the Zycor and Informap information systems to the Unix operating system seems to be responsive to the future. The logical next move is to choose a Unix-based main database package and transfer the data from the current IDMS system to the Unix platform. Having all information systems on a common platform and operating system lends itself to easier data transfer and management.

The Unix-based software packages overall are more user friendly than comparable mainframe packages because of the Unix X-Windows windowing environment. Therefore, the Unix versions of the existing information systems may subdue the growing ERCB "user-unfriendliness" complaints. If broad access is allowed to the new systems, the departments may be quite content with the capabilities of a new Unix system.

The RISC hardware platform and Unix software environment are very suitable for GIS technology. Many of the most popular, full featured GIS packages are available for Unix. The Unix system at the ERCB is a suitable platform if the ERCB should decide to go with an organization wide GIS. As well, the RISC hardware is easily expanded and updated if required in the future. [122]

This report suggests the transfer of the main database information to a Unix-based relational database package such as Oracle or Sybase. The common use of a single powerful platform and operating system would simplify the whole

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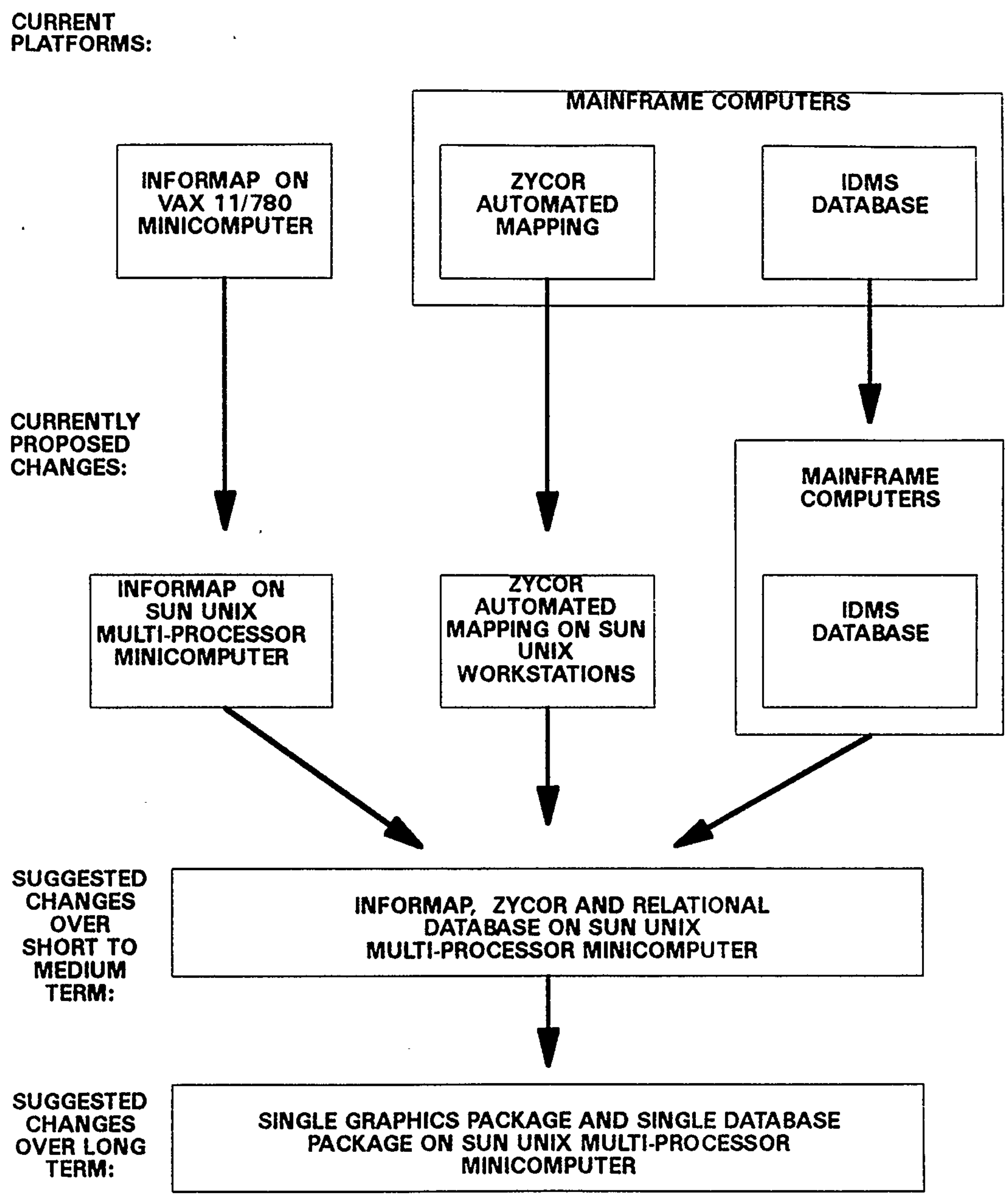
[122] All full featured GIS packages can operate on Unix and in many cases the Unix versions are considerably more powerful.

information process. Any required support software or effort would go toward a single operating system, not the current two operating systems which have very little in common and have difficulty sharing data (see Figure 10).[123]

Over the longer term the Data Processing Department should aim at merging the three existing information systems into a single graphical mapping package. A full featured GIS package or some other powerful graphics package on a Unix platform could easily serve all of the current information system needs. By bringing the mapping capabilities and database into a single powerful graphics package, this would simplify the Data Processing Department role.

[123] This is based on discussions with Data Processing Department personnel which discussed the organizational momentum in place supporting the different connections of the various operating systems and hardware configurations.

FIGURE 10: SUGGESTED CHANGES TO THE CURRENT INFORMATION SYSTEMS



CHAPTER SEVEN: ERCB DEPARTMENTAL INFORMATION NEEDS

7.1 DEPARTMENTAL INFORMATION NEEDS

More than twenty informal "discussions" were held with department managers and other key individuals within the ERCB to determine the Board's current and future information needs. [124] [125] The discussions were conducted over a nine week period and each lasted anywhere from thirty to ninety minutes. The results have been reviewed and generalized in order to determine an overall direction for information within the ERCB.

7.2 DISCUSSION RESULTS

The results fell into three main categories. First, does the ERCB require the technology or should the ERCB let the proponents deal with the technology. Second, a desire for better access to existing database information. Third, a desire for a new information system that will serve the unfulfilled purposes of the existing systems.

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124 The discussions were held with individuals from Data Processing and the Graphics Group, Gas, Geology, Environment Protection, Oil Sands, Drilling and Production, Hydro and Electric, Pipelines, Coal, Oil, Field Operations, Communications, the EM-O, and three of the five Board members.

125 Certain administrative departments were not contacted due to the difference in their information needs. The departments not contacted include Accounting, Economics, Legal, Administrative Services, Employee Relations, Chemical Laboratory, and the Core Research Centre.

7.2.1 DOES THE ERCB NEED THE TECHNOLOGY?

The first category involves a question put forward as to whether the ERCB should worry about information system technology. Should it leave the special graphics and analysis to the actual proponents? That way it was suggested, the ERCB could limit its exposure to changes in computer technology and remain unbiased in its regulatory role. The proponents would submit the completed product to the ERCB to be reviewed.

This was a unique position and only one department actually proposed this idea. It was a department that did not require special analysis or graphics on a regular basis. This researcher submits that this is not a viable option. The Board performs a number of tasks with its information systems ranging from mundane database management to confidential site analysis. As well, it undertakes a number of in-house projects to develop or improve models or data extraction. These are tasks that would be difficult to contract out since its the expertise of in-house personnel actually performing the analysis and revisions.

7.2.2 IMPROVED ACCESS TO THE MAIN IDMS DATABASE

The second category involves access to the main IDMS Database. There was a very strong desire with all departments contacted to have the main database converted to a relational format. The users wanted to be able to run real time, interactive queries on the database, not through the existing batch process.

The integrated format of the database was accepted as useful but a new database package was desired. The original premise of integrating the various databases to give better and increased access to the data was being defeated. Through the use of a tremendously unfriendly multiple menu format and batch processing, accessing the available information is a formidable task.

Some departments suggested that it might serve the ERCB better to dismantle the integrated database. A series of logical database pieces could be placed into a different format. One suggested format was to package the entire database on CD-ROM technology. [126] The CD collections could be distributed internally and sold externally. New data could be distributed on new CD's released periodically. This process could be performed in house or by a third party.

As well, CD-ROM technology can be used on several different computer platforms including desktop personal computers. The resulting sale or lease of pieces of the database on CD-ROM will increase the value added. This could help the ERCB to pay for the continued support and collection of this immense amount of information. Currently,

[126] CD-ROM technology is a compact disk identical to those for stereo sound use, but with digital computer data on the disk instead of digital musical notes.

the ERCB sells portions of the database in IDMS format to outside firms which rework the data into a more relational format and resell it to the Energy industry. This researcher feels this is a role the ERCB should fulfill and CD-ROM technology is the perfect vehicle.

There are questions about ERCB mandate in being able to sell its database to the industry. In its current role it acts as manager of the database but has very little financial return for that management. Value added resellers have established an industry based on reworking the ERCB database into more useable formats. The sale of the database is a logical step for the ERCB to take if it chooses to move to another database package.

CD-ROM technology is a perfect low cost technology for storage and sale of the database to the industry and public. CD-ROM technology is also perfect for internal use for easy low cost access to the entire database for personal computer networks. Thjis researcher that CD-ROM packaging of the database into logical pieces would be an intelligent step for the ERCB. It would also expand the options open to the ERCB regarding continuing management of the large database. Once packaged onto CD-ROM technology, the database would be free to move to any computer platform and be easily managed.

7.2.3 A DESIRE FOR A DIFFERENT INFORMATION SYSTEM

The third category involves a desire for a different information system. A system which would fulfill specific roles in specific departments. Over time, it could possibly replace all of the mixed uses of existing ERCB information system technologies. However, not all departments voiced this desire for a new system. In fact, only three showed a strong interest in a new information system.[127] The rest of the departments hoped, through the planned and proposed information system changes, that their needs would be better met with the current systems.

The three departments gave a number of reasons for their desire for change. The primary reason was to have a single information system that would access all types of information regardless of whether it was a map (or series of maps), database information, or both at the same time. They wanted access to a variety of data at all times and they wanted instantaneous access to that data. The desired data on the new information system ranged from topographic base map information, to vegetation, geology, special interest areas (such as environmentally sensitive areas), to existing ERCB database information and specific project information.

A second reason was the departments wanted to be able to perform interactive queries on the available data. They

[127] The three were Environment Protection, Drilling and Production, and Oil Sands. They all attended demos held during the Environment Protection Department case study.

wanted the new system to have a strong graphic component. The departments felt that a graphical display of data was more useful and generally easier to understand than textual forms of the same data. Using graphics simplified the running of interactive queries and planning scenarios and improved the final interpretation of the results.

The third reason involves a desire to have the new information system on a desktop personal computer. The departments main reason being that they knew how to operate a desktop personal computer and they desired a system that could be configured for their own needs. The departments did not want a system that attempted to meet everyones general needs and ended up not meeting many of their own. A well chosen desktop system can easily be configured for specific needs.

Each of the three departments expressed specific needs in a new information system. The Oil Sands Department desired an information system that gave them access to both surface and subsurface data with the capability to perform analysis on all of the available data. Much of the current oil sands data resides on the mainframe IDMS system. At present, it is brought into the Zycor system for mapping purposes and into other specialized programmes in the Geology Department for analysis.

The Oil Sands Department wanted a system that brought the three processes together. A system that allowed interactive queries, modelling, geological analysis and the capability to run planning scenarios on any amount or type of desired data. The desired complexity of subsurface analysis on geological data was not yet possible on a GIS but may be within two years. [128]

The Environment Protection Department wanted to concentrate its analysis primarily on surface data. The department desired an information system that could analyze a number of things ranging from geological modelling of groundwater, to modelling of project impacts on wildlife species, to studying plume dispersions of gas releases and the impacts. The system is to be used as an analysis tool and an archive for referral to specific types of information.

The Drilling and Production Department needs were more simple. They wanted an information system that would store, manipulate and output a variety of maps. The department regularly dealt with large numbers of different maps and it wanted to be able to plot hardcopy maps of any part and/or combination of any and/or all of the maps at any time. The

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[128] Personal communications from a number of the full featured GIS vendors during a URISA sponsored conference in November 1991 in Calgary, titled "GIS and the Energy Industry".

Drilling and Production Department needs were more archival with a simple interactive ability to peruse available data.

All three departments were very interested in the potential of GIS technology and two of the departments had already tentatively looked at GIS technology prior to my discussions with them. In fact, a GIS could fulfill many or all of their needs and it could easily be accommodated on a desktop computer.

7.3 CONCLUSIONS

In summation, this research has found a strong desire and practical justification for change in the current ERCB information systems. The information system changes currently underway could potentially satisfy some departmental information needs. However, since the changes only involve the mapping packages, the IDMS Database system is still a problem. In addition, the mapping package changes do not address the needs of the three departments searching for a new information system.

Three departments voiced an interest in GIS. All were not positive if GIS would meet their needs, but they were very interested in looking at the technology. Interestly, all three departments desired a desktop version of whatever new information system they chose. This bias seems to stem from a growing frustration with large information systems.

CHAPTER EIGHT: THE ERCB AND GIS TECHNOLOGY

8.1 BASIS OF NEED?

In evaluating whether the ERCB could use GIS technology, it is important to discuss the basis of need. Certainly, the technology can fulfill many roles in a variety of organizations. But, will it fulfill a useful role in the ERCB?

It is easy to see how a single, well chosen, GIS package could fulfill all of the roles of the existing mixture of ERCB information systems (see Table 1). However, the desire is currently not there to update all of the information systems. The new versions of the existing information systems may end up fulfilling more of their originally planned role. As a result, more departments may have their information system needs met with the new systems. The three departments which expressed an interest in a new type of information system felt something different was needed to fulfill their unique needs. Their needs and the capabilities of a full featured GIS package easily correspond (see Table 1).

So is there a need for GIS technology in the ERCB? Currently, not on a organization-wide basis. In special situations, where the data and mapping uses are appropriate, then yes there appears to be a need. The three departments discussed have shown a desire for an information system like a GIS.

No other departments have voiced or demonstrated a need for a technology with the capabilities of a GIS. In many departments, the capabilities of a GIS would far exceed the existing data and mapping needs. However, information needs are not fixed. Over time, the needs of some of these "non-GIS" departments may change and GIS may become an appropriate technology to more of these departments. On that basis, it would seem that a phased introduction for GIS would be appropriate. Give GIS to the departments that desire it now. Then over time, if other departments develop a desire and/or demonstrate a need for GIS, then give it to them (see Figure 10 Page 79 - The resulting single graphics package could be a GIS package).

Table 1: Comparison of Categorical Capabilities for Existing ERCB Projects: Current Information System Complex versus a PC-Based GIS

CATEGORICAL FUNCTIONS / PROJECT ROLES		Main Database Archiving	Database Modelling	Spatial Analysis	Complex Modelling	Interactive Query and Display	File Translate	Hardcopy Output
Gascon2 Modelling	Existing	IBM MAIN	IBM MAIN	N/A	IBM MAIN	N/C	ASCII OUT	PC
and Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Coal Bed Methane	Existing	IBM MAIN	UNIX	N/C	UNIX	N/C	N/A	UNIX
Modelling and Mapping	PC GIS	YES	SOME 3D	SOME 3D	SOME 3D	YES	VARIOUS	YES
Emergency Planning	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Database Management	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Emergency Planning	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Scenario Impact Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Hazardous Spill	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Monitoring and Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Flare Pit and Pond	Existing	IBM MAIN	N/A	N/A	N/A	N/C	ASCII OUT	ZYCOR
Database Management	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Drilling Lease Flare	Existing	IBM MAIN	N/A	N/A	N/A	N/A	N/A	ZYCOR
Pit and Pond Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Energy Transmission	Existing	INFORMAP	N/A	N/A	N/A	INFORMAP	ASCII OUT	INFORMAP
Planning Maps	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Energy Transmission	Existing	IBM MAIN	N/A	N/A	N/A	N/A	ASCII OUT	ZYCOR
Database Management	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Drilling Activity	Existing	IBM MAIN	N/A	N/A	N/A	N/A	ASCII OUT	ZYCOR
Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Production	Existing	IBM MAIN	N/A	N/A	N/A	N/A	ASCII OUT	ZYCOR
Facility Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Resource	Existing	IBM MAIN	IBM MAIN	N/A	VARIOUS	N/A	ASCII OUT	ZYCOR
Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Facility Planning	Existing	INFORMAP	N/A	N/A	N/A	N/A	ASCII OUT	INFORMAP
Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Facility	Existing	INFORMAP	N/A	N/A	N/A	N/A	ASCII OUT	INFORMAP
Decommissioning Maps	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Critical or Sensitive	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Areas Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Initial Project Scenario	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Impact Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
Post Project	Existing	PAPER	N/A	N/A	N/A	N/A	N/A	N/A
Impact Mapping	PC GIS	YES	YES	YES	YES	YES	VARIOUS	YES
3D Subsurface	Existing	UNIX	UNIX	UNIX	UNIX	UNIX	UNIX	UNIX
Modelling	PC GIS	YES	LIMITED	LIMITED	LIMITED	YES	VARIOUS	YES
Large Scale	Existing	IBM MAIN	YES	N/A	N/A	N/A	ASCII OUT	TEXTUAL
Database Management	PC GIS	LIMITED	YES	YES	YES	YES	VARIOUS	YES

Legend:

IBM MAIN = Mainframe Computer
INFORMAP = VAX CADM
ZYCOR = Zycor Automated Mapping Package
UNIX = Unix Minicomputer
PC = Exported to Personal Computer for Output
N/A = Not Attempted
N/C = Not Capable
YES = Yes Capable
VARIOUS = Many Available

8.2 RECOMMENDED ORGANIZATIONAL LOCATION FOR GIS

As discussed, the location of GIS within the organization can partly determine its success or failure. The ERCB is a large organization with a well established and substantial Data Processing Department that has almost total control over all aspects of computing on all platforms within the Board. This is a feature that has developed from the original data processing mainframe-based computing and continued through the current interest in personal computers. Therefore, GIS hardware and software would have to be purchased through the Data Processing Department.

One advantage to controlled purchasing is that it ensures an acceptable level of quality and compatability of computer hardware and software. A purchase of a GIS should also benefit from the same. Purchasing a GIS from a single vendor will help to ensure future compatibility between user departments.

The computer hardware direction in the Board seems to be for more personal computers and Unix-boxes. There is little or no desire to have a mainframe terminal if a personal computer is available. The personal computer can be configured to emulate a mainframe terminal plus fulfill a number of other roles. A mainframe terminal cannot be configured to emulate a personal computer.

The increasing use of personal computers has led to some data compatability problems. Many of the software programmes operating on large scale computer systems do not have products that operate on personal computers. Thus, translators are required but this is by no means new to the ERCB. "In-house" translators have been developed and have been in use for several years to move data amongst the various existing platforms.

This report recommends that the GIS location be as close to the user as possible. In this case it would involve GIS on the desktop in those departments that have demonstrated a need or an interest in the technology. This would mean personal computers or Unix-boxes. Either computer platform would serve the purpose as long as the control and operation of the GIS remains at the desktop level in the department with the system.[129] [130]

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[129] J. Mostert, "Technology: The GIS Framework", GIS Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 107.

[130] G.A. Jordan, "Making GIS Work in Forest Management", GIS Applications in Natural Resources ed. M. Heit and A. Shortreid (Fort Collins, Colorado: GIS World Inc., 1991), 37.

CHAPTER NINE: GIS CASE STUDY

9.1 BACKGROUND

This case study is the second part of this Masters Degree Project. It is a micro look at the "environment planning" capabilities of a GIS as defined by the interests within the Environment Protection Department at the ERCB. As noted, this department is one of the three departments interested in GIS technology. This case study will attempt to determine whether GIS technology will serve a useful role given the Environment Protection Departments needs and mandate.

Case studies serve a unique purpose in applied social sciences research. A case study is used when a researcher wants to develop an intense level of knowledge about one single, complex situation. [131] Through the delineation of boundaries, the researcher is able to control the influences on that single interest. The results from a case study do not apply to the general population. The results apply only to a specific object in a specific context. [132]

A case study is very appropriate for evaluating GIS technology since a GIS is not appropriate in all situations.

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[131] J. Zeisel, Inquiry by Design: Tools for Environment-Behaviour Research (Cambridge: Cambridge University Press, 1988) 65.

[132] B.S. Phillips, Social Research: Strategy and Tactics (New York: The MacMillan Company, 1969) 128

As noted earlier, the applicability of GIS is influenced by five factors. These are the type of organization, location within that organization, the computer hardware and software, the data used, and the problems to be addressed. The first four of these factors have been addressed in the first eight chapters of this document. This chapter considers one of the problems to be addressed by a proposed GIS installation in the ERCB's Environment Protection Department.

Case study results are reliable as far as the results apply to that one or other very similar situations. Generalizing the results causes unreliability because the number of cases observed in a case study is low. [133] Therefore, the results of this case study are valid for the purposes of this document. They apply within the context of the ERCB Environment Protection Department and its unique problems and solutions.

9.2 AREA OF INTEREST

The area of interest was entirely defined by the Environment Protection Department. This method was used in order that an area be chosen regardless of its complexity and/or any possible lack of understanding of GIS on the part

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[133] J. Zeisel, Inquiry by Design: Tools for Environment-Behaviour Research (Cambridge: Cambridge University Press, 1988) 79.

of the chooser. The department chose the area for its own reasons. This ensured an unbiased choice of study area. [134]

The department outlined an area in the southwest corner of the Province of Alberta directly north of Waterton National Park. It is part of a region often referred to as the "Crown of the Continent" (see Figure 17 - Page 148). In the department's opinion, the Crown appeared to be an area in need of further investigation. This opinion was prompted by the recent increase in energy development in that area. (For a more detailed discussion of the Crown of the Continent study region, please see Appendix II)

The study site in the outlined region was chosen using three factors: the availability of Alberta Government 1:20,000 digital base map data, the availability of Alberta Government digital Alberta Vegetation Inventory data, and the Elk locations and movements noted in Dr. Luigi Morgantinis ongoing Elk study.

These factors were chosen for two reasons, to ensure a consistent data quality as defined by the Alberta government and to again remove any potential bias by having no regard for area complexity. [135] This choice was made by personnel

[134] This might be defined as a biased choice, as far as is possible, considering the extent of oil industry activity at that time. The department knew which areas were of need of study and chose from amongst those. It is unbiased from the research perspective since the principle researcher had absolutely no input into its choice.

[135] Limiting the choice to areas where digital data is available demonstrates some bias since the choice is limited

in the Environment Protection Department. They were presented with all possible data options and a decision was made to use certain types of data based upon the type of analysis to be performed (see Figure 11).

When townships with all three types of data were located within the study area, the township legal reference numbers were added to a list. The complete list of townships was then presented to the supervising personnel of the Environment Protection Department for a choice. [136] The resulting eight townships rested on the fringe of the forest region and went as far south as the north boundary of Waterton National Park.

9.3 STUDY DATA INPUT

9.3.1 BASEMAP DATA

The Alberta government supplied the 1:20,000 base map data and vegetation data. The data purchased included six complete 1:20,000 scale position files in the IGDS file format. [137]

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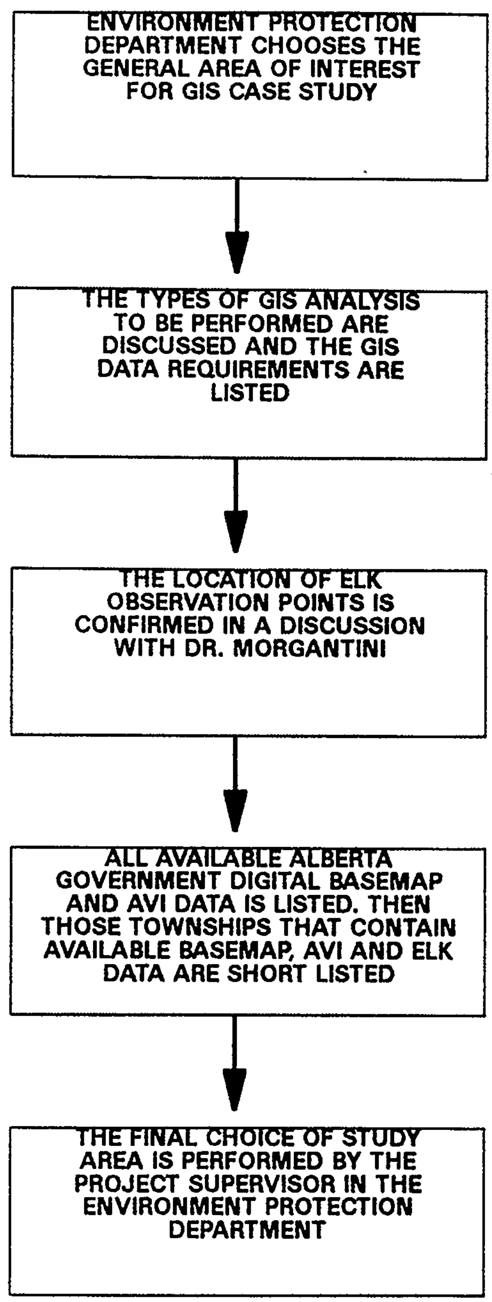
by the Alberta Government programme to create the data. However, it was felt that a consistent data quality was more important from the perspective of analysis.

[136] This individual was Mr. Roger Creasey who is a section head within the Environment Protection Department and was the individual in charge of this GIS Pilot study at the ERCB.

[137] A position file is a digital map file with no linework edited around lakes, rivers, towns, et cetera.

FIGURE 11: THE METHOD FOR CHOOSING THE GIS CASE STUDY DATA



The Alberta Government LRIS project has defined its own map projection for all of its digital files. This was done in order to circumvent the problem of the province being divided by a Universal Transverse Mercator (UTM) projection meridian. [138]

The Alberta Government's Modified Ten Degree Transverse Mercator (10TM) map projection causes numerous problems for any GIS user since it is an undefined and unsupported map projection. Anybody who chooses not to use the same projection has to alter the government files in order that the data will be properly located.

The choice had been made to use a UTM map projection since Dr. Morgantini's elk coordinates were in UTM. So when the Alberta Government map files were initially translated, the geographic coordinates in the map reflected an area off the west coast of the State of Washington.

This was caused by the fact that the 10TM files were being translated into a UTM map. Half of a 10TM map is negative coordinates. As a result, "shift" values were calculated, inserted into a translation table file and the translation was performed again. At that point, the files translated correctly into the formerly created map file in the Pamap GIS (see Figure 12).

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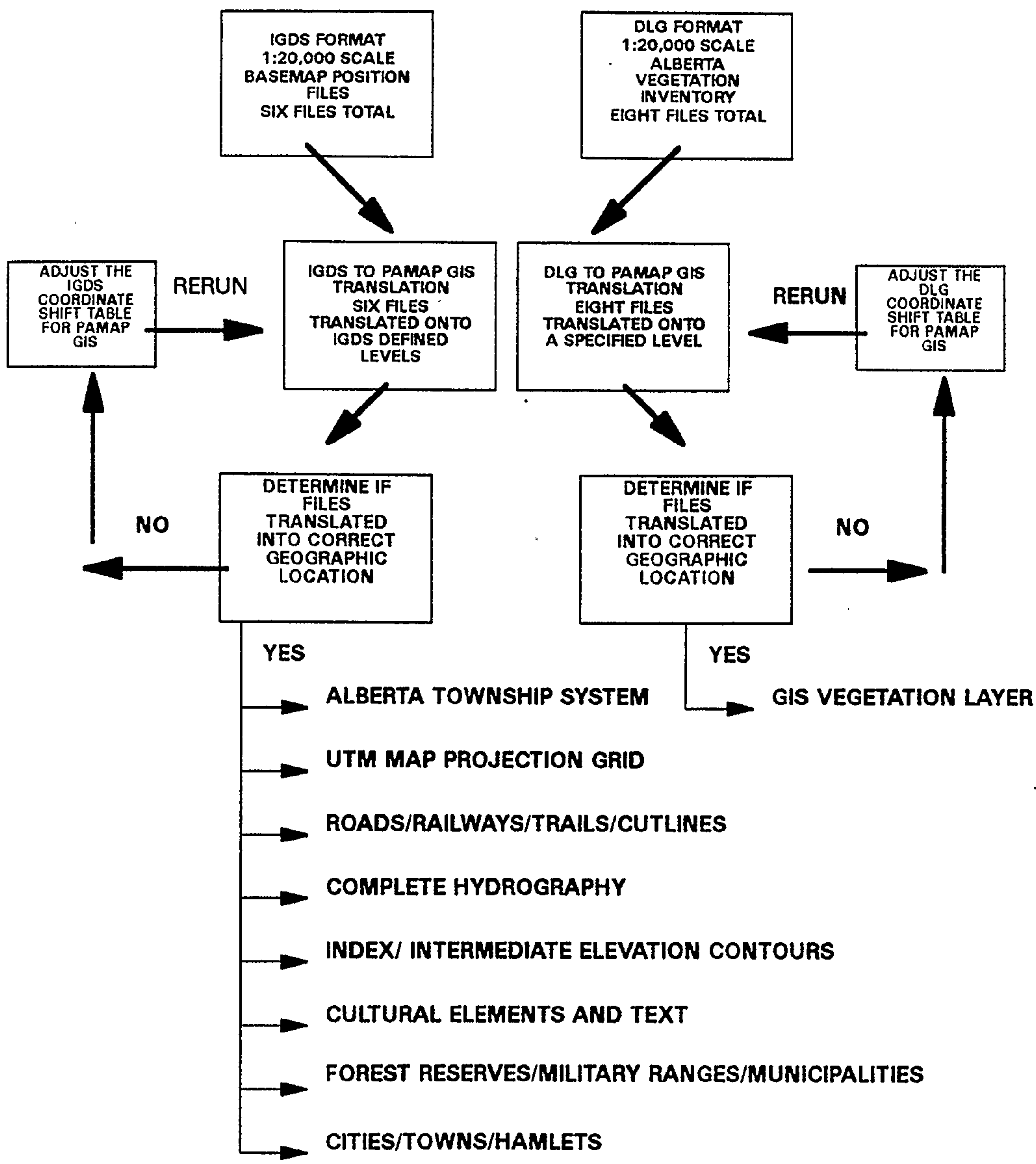
[138] The province is divided by the fifth meridian and thus, rests in UTM map zones eleven and twelve.

9.3.2 VEGETATION DATA

The Alberta Vegetation Inventory (AVI) data is produced and updated by the Resource Information Branch, again part of the LRIS division. The data purchased included eight townships in DLG file format accompanied by the respective database files in ASCII format.

The files were translated directly into two existing UTM map files. One file was a UTM Zone 11 map and the other was a UTM Zone 12 map. This method was chosen to simplify the difference in shift values required for the governments 10TM files from two separate UTM Zones. The resulting two maps were then merged into the single larger map (see Figure 12).

FIGURE 12: GIS DATA IMPORT - GOVERNMENT DATA



The government-defined vegetation polygons contained database tags which had to be "activated" through the PAMAP GIS polygon-formation process.[139] This activation creates polygons out of assorted area-enclosing vectors. The accompanying ASCII formatted vegetation information was then brought directly into the dBase IV database programme.

The resulting database files were then imported into the map file and dynamically linked to the corresponding database tags residing in the activated polygons. The resulting polygons could then be used in any sort of analysis within the system while being able to actively call on any part of the database information.

9.3.3 ELK DATA

The elk movement data came from an extensive spreadsheet maintained by Dr. Luigi Morgantini of the Department of Forest Sciences at the University of Alberta. The data was and is being generated as part of a three year study initiated in November 1989. The overall objectives of Dr. Morgantini's study are to provide baseline data on the ecology, movements and distribution of the elk herds that range between Waterton National Park and the Crowsnest Pass.

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[139] A tag serves as the link between the polygon shape defined by vectors and the database record containing any amount of information related to that polygon. Once polygonized, any point within the polygon can be queried to display all information about that area including any information residing in the attached database record.

The data was divided by Dr. Morgantini into four "seasons" and three "years" and then submitted as twelve individual spreadsheet files.[140] The divisions were defined by Dr. Morgantini based upon his direct experience of the seasonal conditions in the study area.

The resulting spreadsheet files were opened in the Borland Quattro Pro spreadsheet package and data was adjusted as required. The files were then exported as ASCII format, blank delimited files and directly imported into dBase IV once the specific fields were defined as to width, type and name.

The database files were then used along with a simple piece of dBase IV programming code which incorporates defined parts of the data into a series of GIS system commands. These command files can then be run from within the PAMAP GIS and the incorporated commands will be performed.

The observation numbers and UTM coordinates were going to be used to place database tags for a point-type database on respectively defined levels in the PAMAP GIS. Once the database tags were in place within the map file, the rest of the database data was imported (see Figure 13).

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[140] The seasonal divisions defined by Dr. Morgantini were Spring (May 01 - June 30), Summer (July 01 - Mid-September), Fall (Mid-September - Mid-December), Winter (Mid-December - April 30).

9.3.4 PIPELINE DATA

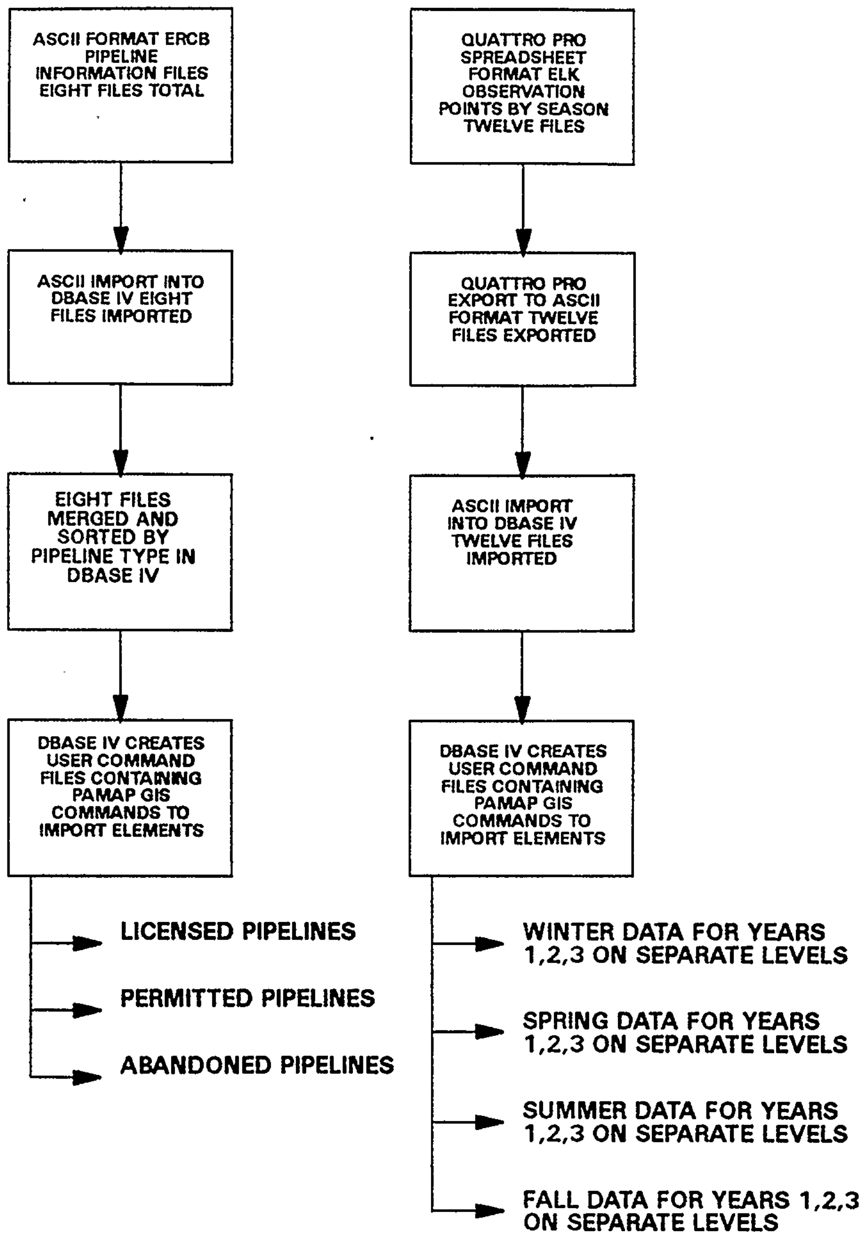
The pipeline data was extracted from the ERCB DEC VAX 11/780 computer which houses all of the energy transmission system data. Initially, the system would not export any of the data. This was a problem that was corrected over a two week period. Once corrected, the three available types of pipeline data were exported to ASCII text files. These were licensed pipelines, permitted pipelines, and abandoned and/or discontinued pipelines. The choice of data was made for the same townships that contained the purchased vegetation data.

The pipeline data was exported as a blank delimited ASCII file. So the data was directly imported into Dbase IV once the file width, type and name were defined. From there, the data was run through the dBase programme used to create system command files. The files were then run from within the PAMAP GIS and linear elements were placed by the system onto the respective levels (see Figure 13).

9.4 SIDE NOTES

As noted, Dr. Morgantini's data extends south into Waterton National Park, which is currently in the process of converting and transferring its maps to a GIS. As a result, enquiries were made as to whether Waterton's GIS data could be incorporated into this case study.

FIGURE 13: GIS DATA IMPORT - OTHER DATA



Waterton's data conversion process was not as far along as hoped. Therefore, the data was not available for use in this study. However, Waterton personnel did mention they were interested in seeing Dr. Morgantini's results incorporated into a GIS with the hope that it could eventually be transferred to their own system.

In addition, our project learned that Alberta Forestry, Lands and Wildlife had received a request from Alberta Fish and Wildlife to use Dr. Morgantini's data to study the impacts on the elk by increased road access in the Crown region. This was one aspect that the ERCB Environment Protection Department wanted to review in its own study. Enquiries were made to see if we could break the problem up into a few discrete pieces. There was no sense in duplicating the analysis.

The Environment Protection study could cover specific aspects of a larger overall study as defined by Alberta Forestry, Lands and Wildlife. However, Alberta Forestry, Lands, and Wildlife informed us that the Fish and Wildlife request is still in the proposal stage and it was uncertain if funding could be secured. As a result, we offered the results of this study in order that the same effort was not repeated.

9.5 DEPARTMENT OBJECTIVES

The Environment Protection Department went into this case study with two main objectives. The first objective was to observe GIS technology in dealing with a problem and area of their choice. They wanted to see if the technology would work for their own purposes. The objective involved a number of analyses to be performed by the GIS on the chosen data. The choice of analysis was done by Dr. Morgantini and personnel in the Environment Protection Department. It was based upon analysis that would be useful for establishing baseline information on elk movements. As well, it involved analysis that determined if existing linear developments might be influencing elk movement patterns. These results would be used by Dr. Morgantini for his project.

The second objective was to hopefully get a better idea of issues arising in the Crown of the Continent region. Much of the increased interest in the study area is energy related. Through the use of a technology like GIS, the Environment Protection Department hoped for better insight into regional management. In addition, other groups involved in the Crown region might be able to use the case study results for their purposes thus possibly improving the overall level of understanding.

9.6 RESEARCH OBJECTIVES

There was one research objective for this case study. It related to the overall question of GIS within the ERCB. How well would the GIS deal with a problem defined by a particular departments needs? The objective was to determine on a micro scale what was determined earlier on a macro scale. Does GIS work within the ERCB?

9.7 STUDY METHODOLOGY AND CONTROLS

9.7.1 GIS ANALYSIS METHODOLOGY

There were no special methods developed for this study. The GIS methods involved standard operating procedures for this type of analysis. The methods were the same as those used in other similar studies involving wildlife and linear disturbance.[141] This discussion of methodology will cover the steps taken to perform the analysis (see Figure 14).

There were three main types of analysis to be performed. The analysis included defining movement patterns for individual animals per season, year and the three years (animal movement analysis), distance from linear elements to animal observations (proximity analysis), and overlaying of animal observations over vegetation polygons (vegetation affinity analysis). Each analysis was repeated for the

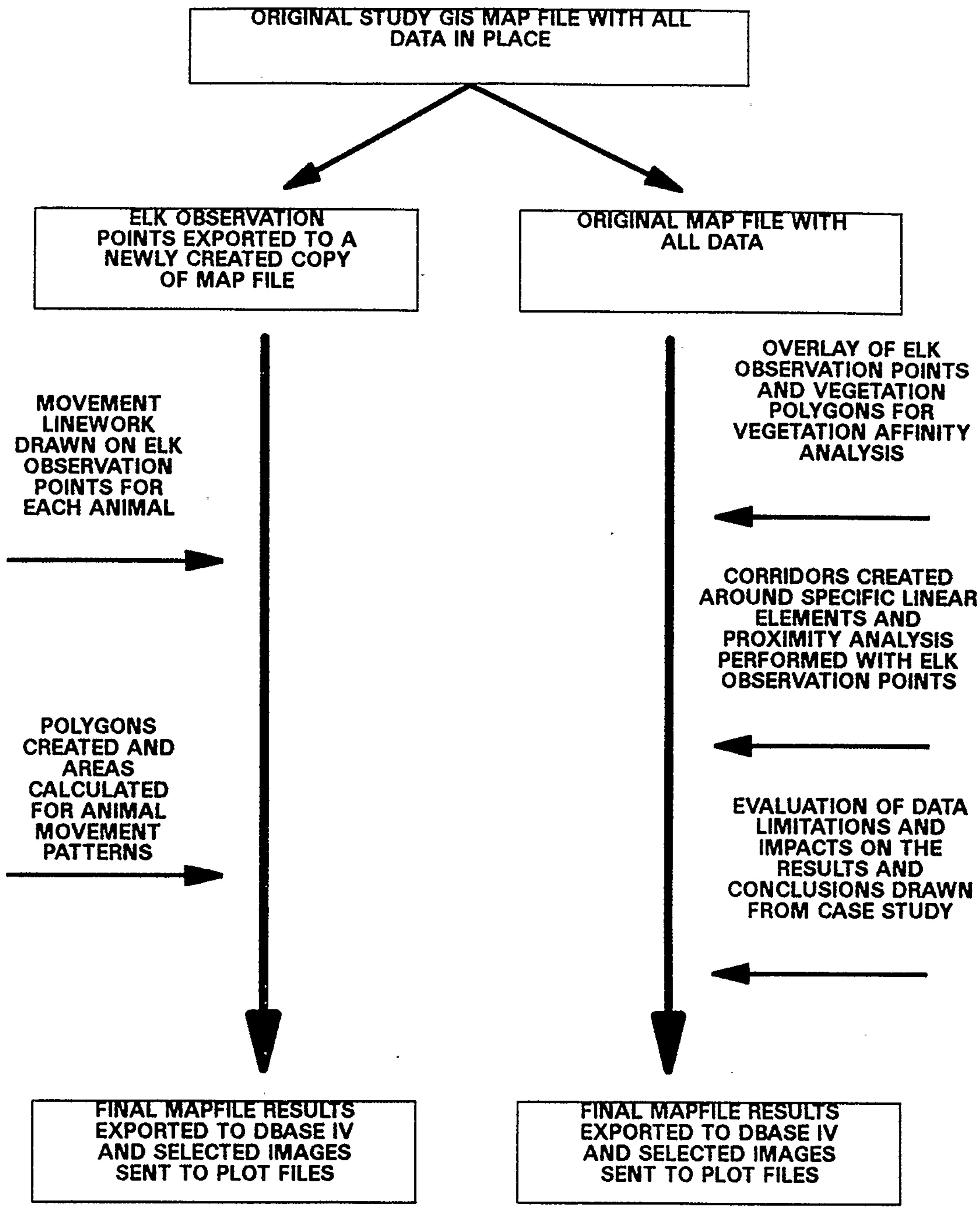
[141] For the purposes of this document, a linear disturbance is defined as a road, pipeline, powerline, or seismic cutline.

animal observations in each defined season. Then repeated for each defined year and the entire three year period.

The animal movements were defined through the connecting of observation points with lines. Only the outside points were considered for the movement boundary. Notably, this is a biologically simplistic yet visually complex method of defining an animal movement. However, this is the method that was requested by Dr. Morgantini. This was performed for each individual radio collared animal for each season, year, and the entire three year period.

The first analysis involved the distance measurement from defined linear elements and the animal observation points. This involved a number of steps. A GIS is spatially very accurate so any errors that arise are largely due to errors in the data being used. So, distance analysis is a simple process. It just requires setting the data up in the correct format.

FIGURE 14: STEPS TAKEN FOR GIS CASE STUDY ANALYSIS



All defined linear elements were converted to raster elements on a raster surface. [142] These raster elements were broadened from single lines to corridors of defined widths. [143] The system then measured all distances on the raster surface from those corridors. It measured the minimum distance and mean distance to the linear element corridor. The values were brought into the animal observation database. Each animal observation point then had two distance measurements to each linear element corridor (see Table 2).

The second analysis involved an overlay procedure. The individual animal observation points were overlaid onto the vegetation data. The point overlay programme extracted any desired information from the vegetation layer. It then placed it into defined fields in the animal observation database.

9.7.2 CASE STUDY METHODOLOGY

Two methods were used to determine the research results. The primary method to reach this objective was to question the departmental personnel involved with the

[142] A raster surface is a plane of dots with each dots represneting a single value. A whole plane of single values displays as a surface of varying values or a raster surface.

[143] The widths were defined based on the element involved: four lane highways were given a forty metre corridor; two lane highways, thirty metres; one lane gravel and unimproved roads, ten metres; truck trials, ten metres; trails and cutlines, six metres; licensed, permitted and abandoned pipelines, ten metres.

project. These personnel defined the case study and chose the data and analysis. As a result, they had expectations going into the project. If the GIS met those expectations, they would be able to provide positive feedback. After they had seen the case study results, they would know in their own mind whether GIS would be useful.

The secondary method was through observation when key departmental personnel were presented the case study results. If the case study provided useful information that was not available prior to GIS, the case study could be considered a success from the departmental standpoint. Therefore, the research results would be known.

9.8 VALIDITY OF RESULTS

The quality of data and its use is an important factor for the successful implementation of a GIS. For this study, any data problems were duly noted and each will be discussed as it relates to the required analysis.

The vegetation data was restricted to a fringe along the forest region north of Waterton Lakes National Park. [144] A large percentage of the "usable" (see below for an explanation) elk data was within the chosen vegetation data. However, not all of it so the results for some of the

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[144] This was due to the fact that the Alberta Government chose to not create digital vegetation data of the forest regions.

analysis did not apply to all of the data. [145] It was approximately ten percent of the total number of observation points during any one season. Therefore, any conclusions derived from this data should be carefully evaluated for validity.

Some of the animal movement observations were outside of the defined map area despite its considerable dimensions. [146] These animals were "lost" to the GIS as soon as they stepped off of the map. Therefore, observation data outside of the map area was not considered. Fortunately, it was less than one percent of the total data. If this was a larger percentage of the total, the validity of the results would be questioned further.

There were certain "cross-referencing" problems with the elk data. There were a considerable number of animal observation points over the three year period. [147] However, many were of limited "quality". Only the radio collared animals were given an identifying name. That name was the only feature of the gathered data that identified an observation as that of the same animal. So the animal names

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[145] The vegetation affinity analysis obviously only applied to those areas where vegetation data was available.

[146] The defined map consisted of an area greater than four 1:50,000 NTS map sheets.

[147] There were more than one thousand, three hundred points consisting largely of radio collared observations. This data was acquired over a period of three years. It tracked the movements of forty seven radio collared animals. There were also a number of visual observations of animals.

were used to define specific animal movements. The remaining elk data was of limited use on the GIS.

In defining the animal movement patterns, some animals had what was considered an insufficient number of observation points to actually define a pattern. [148] So, the movement patterns that could be defined are of questionable validity. They are also incomplete for all seasons for all three years since many of the animals had four or fewer seasons out of a possible total of twelve in which there was sufficient data to define animal movements.

There are two blank areas which have absolutely no data (see Figure 15). Its not certain whether this is due to the animals not going into the areas or collared animals not being tracked into the area. These two areas are currently undergoing the most development activity. Shell Canada is active in Area A and there is a proposed expansion of the West Castle Ski Area in Area B. There are unsubstantiated reports that elk have been seen in both areas yet surprisingly in the three years of his study Dr. Morgantini did not collect data in those areas.

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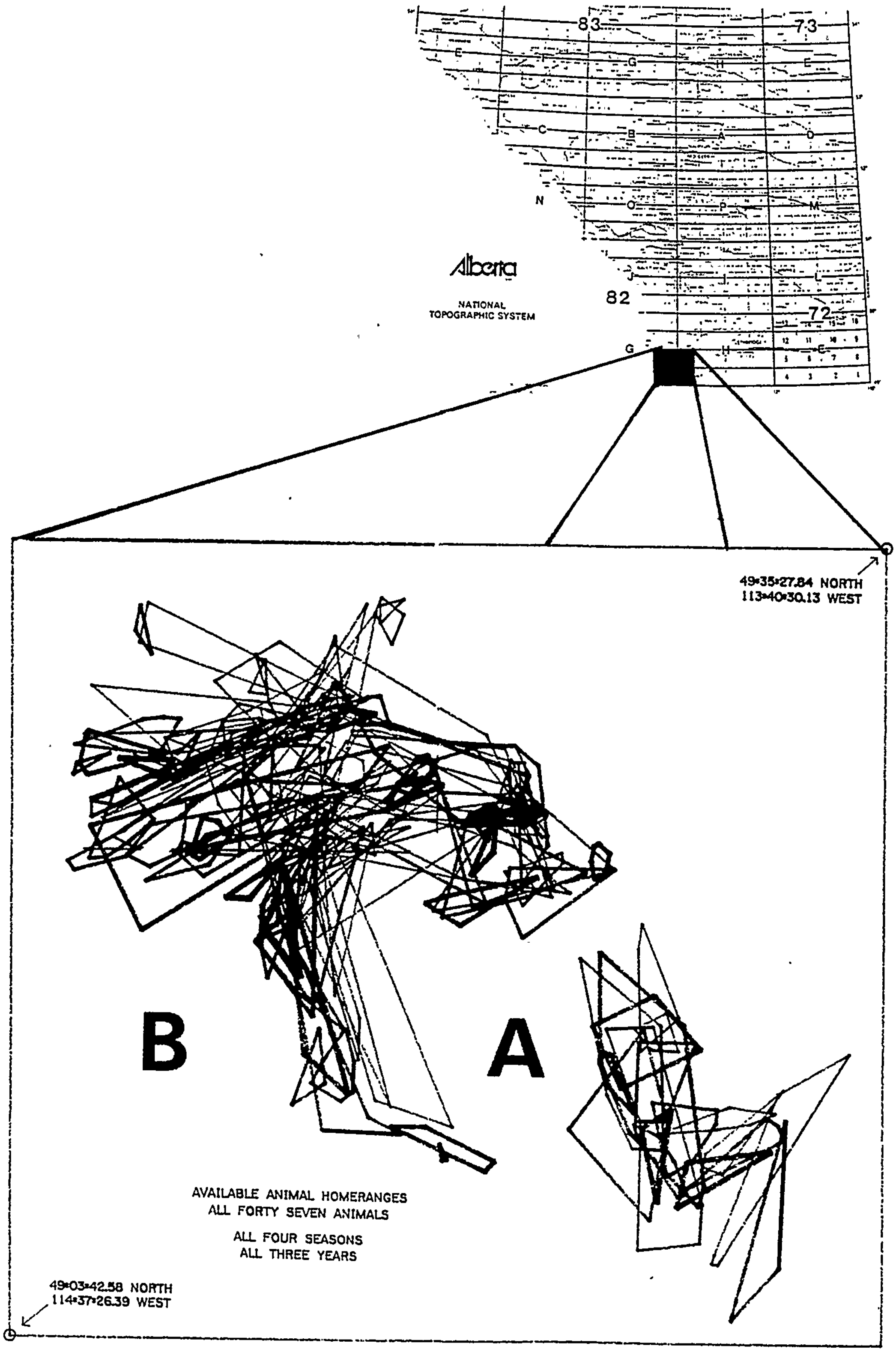
[148] Many of the animals had three or fewer observation points in many of the defined seasons. These were not even considered. The ranges were defined for animals with four or more observation points in a season. However, the validity of four to seven observation points in a season is still questionable. Less than five of the forty seven animals had more than five observation points in any one season.

FIGURE 15: MOVEMENT PATTERNS FOR ALL RADIO COLLARED ELK FOR ALL THREE YEARS



This researcher submits that for the purposes of a GIS, it would have been better served to limit data quantity and strive for data quality. Four to five animals could have been chosen to be collared from each of four to five defined regions. In addition, the collars used should have been the more expensive satellite tracking type and not the less expensive radio collars. [149]

The satellite tracking collars could have monitored animal movement for every day of every season for the entire three year period. The movements could also be compared to energy industry activities to see if there was a change in pattern. In general, the results would have been considerably more accurate and considerably more valid. However, the purpose of this case study was only to use the data, not acquire it. In addition, the use of a GIS for analysis was originally not part of the scope of the elk project. If it was, data collection methods might have been different.

Overall, the data was the main cause of questionable results and limited validity for this study. The analysis of large amounts of rambling animal observation data not

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[149] The radio collars for this project cost about $350.00 each. The estimated price of a satellite tracking collar is $1500.00 each. The forty seven radio collars used by Dr. Morgantini cost a total of $16,450.00. Sixteen satellite tracking collars would have cost about $24,000.00. That is not a large difference in cost considering the large difference in data quality and quantity. Morgantini, Personal Communication 1992

intended for spatial analysis together with accurate government digital data caused a number of difficulties. The animal data was not intended for this level of analysis and the results from the analysis performed demonstrate that. The data has to be considered as a whole and not independently in analysis situations otherwise the validity of the data falls very rapidly.

9.9 DIFFICULTIES ENCOUNTERED

There were a variety of other difficulties encountered throughout this departmental case study which limited its successful completion. In addition to the data limitations discussed in the previous section there were two main difficulties encountered.

The first revolved around limitations of the PAMAP GIS. The PAMAP GIS has difficulties when performing analysis on point observations. And, despite its many limitations, the primary data for analysis in this case study was point observations. The solution was to impose a twenty meter polygon over each point so that polygon overlays could be performed thus producing some of the desired results. Considering the level of accuracy of the animal observation points (estimated at plus or minus one hundred meters), the twenty meter polygon was probably quite flattering.

The second difficulty revolved around the hardcopy display of the GIS results. The Environment Protection Department had a small Hewlett Packard 7475A plotter capable of handling 11" X 17" paper with four pen colours. The thinnest pen nib available was 0.5" which made for a coarse and often simplistic output. The plotter had been acquired for another project and it was no longer being used. The ERCB did have two other larger plotters which were used for Zycor and Informap output. However, neither could be easily accessed by the PAMAP GIS through the information system complex at the ERCB. So, as a result, all hardcopy output is of limited quality and use until such time that the data can be reopened on a PAMAP GIS connected to a better plotter.

9.10 DISCUSSION OF CASE STUDY RESULTS

The GIS analysis results seem to display certain elk movement patterns. The intensity of animal movement data shows that the elk tend to reside in specific areas year round (see Figure 15). Any movement outside of these areas shows the common usage of two main corridors (see Figure 15). As well, the proximity analysis indicates that a large number of the collared animals remain close to cut areas including seismic cutlines and forestry cut areas (See Table 2).

Despite the limitations and problems, this case study met up to the expectations of the Environment Protection

Department. All of the individuals involved with the project were convinced by project completion that GIS would be a useful technology in their department. It was felt that it could be applied to a wide variety of problems encountered by the department. In fact, efforts were being made to possibly include the purchase of a GIS software package in the short term.

9.11 CASE STUDY CONCLUSIONS

The case study has demonstrated, on a problem defined by the Environment Protection Department, that GIS is an appropriate technology for the ERCB. Its location within the Board is dependent upon the need and desire to have the technology. However, this case study has demonstrated for the ERCB that the technology is useful on the personal computer platform.

TABLE 2: EXAMPLE DATABASE OUTPUT OF PROXIMITY ANALYSIS RESULTS -MINIMUM DISTANCE FROM ANIMAL OBSERVATION TO SEISMIC CUTLINES FOR THE FALL OF YEAR TWO

OBSERVATION NUMBER	DATE D/M/Y	ELK NAME	UTM LOCATION EAST/NORTH)	DISTANCE (METRES)
707	200990	Roger	287900,5450700	450.0000
708	200990	Annie	706500,5469400	.0000
709	200990	Maria	705800,5480900	.0000
710	200990	Pecasus	682200,5471300	.0000
711	200990		701800,5478500	.0000
712	200990	Jim Jr.	702400,5477700	.0000
713	200990	Zues	700000,5479500	777.8100
714	11090	Roger	284800,5453500	650.0000
715	11090	Annie	710800,5470700	.0000
716	11090	Jim Jr.	702800,5477900	.0000
717	11090	Maria	704000,5479000	.0000
718	21090	Mona	692700,5466900	262.1299
719	21090	Dawn	696900,5462900	.0000
720	21090	Susan	703400,5452700	6828.3999
721	21090	Minerva	684800,5481700	.0000
722	71090	Sara	709100,5477300	50.0000
723	71090	Mona	693600,5467000	.0000
724	71090	Dawn	696200,5463100	.0000
725	71090	Zues	694600,5479100	.0000
726	111090	Sara	708000,5476400	.0000
727	111090	Maria	705500,5481600	.0000
728	111090	Jim JR.	705500,5481600	.0000
729	111090	Zues	698300,5479600	1177.8099
730	111090	Minerva	678400,5482400	.0000
731	131090	Roger	285000,5452700	800.0000
732	131090	Annie	713900,5473800	.0000
733	191090	Maria	702100,5478500	948.5200
734	191090	Jim Jr.	702100,5478500	.0000
735	201090	Mona	692900,5470400	282.8400
736	201090	Susan	694500,5468700	191.4199
737	201090	Dawn	692600,5469300	332.8400
738	211090	Zues	688300,5472400	612.1299
739	261090	Roger	288200,5447900	262.1299
740	261090	Annie	713000,5471100	332.8400
741	271090	Jim Jr.	703400,5478500	.0000
742	271090	Maria	702800,5478000	.0000
743	271090	Susan	700900,5454000	4898.5200
744	281090	Sara	709800,5478000	.0000
745	281090	Minerva	686500,5484500	.0000
746	281090	Lucky	687400,5474800	.0000
747	281090	Zues	687000,5477800	70.7100

CHAPTER TEN: CONCLUSIONS AND RECOMMENDATIONS

10.1 INTRODUCTION

These conclusions and recommendations are based entirely on discussions with and feedback from a number of ERCB staff members. There were no "hard numbers" generated during this project, so these results are based entirely on this researcher's interpretations.

10.2 FINAL CONCLUSIONS

The final conclusions will be discussed in two parts reflecting the two parts of this project, the organization analysis and the Environment Protection case study. The results from the first portion demonstrate that there is a need for change in the existing information systems. The current collection of information systems have not met all of the needs of the various diverse system users. As well, there is a growing discontent in the ERCB with large organization-wide information systems on large computers. Those departments that were interested in a new information system technology would like to see it on department-based personal computers.

As well, there is a growing trend in the ERCB to choose desktop personal computers as terminals and analysis platforms. There is little desire to have a mainframe terminal since it can only display textual output from the database. A personal computer has the potential to serve a much broader role.

The data needs in the ERCB vary considerably for each department. Those departments interested in GIS technology were interested because of the capability to deal with a variety of data. The interested departments wanted an information system that would give them access to that variety of data in a graphical form.

Despite the problems encountered, the case study with the Environment Protection Department demonstrated that there is a useful role for GIS within the ERCB. This was only one case study involving a single problem but the interest shown in this pilot project was considerable and a number of departments came to see demonstrations of the GIS. They remained interested in the technology after the demonstrations and were determining new applications for GIS in their own departments.

10.3 FINAL RECOMMENDATIONS

The recommendations are broken into two time periods. This is done in order to accommodate the changes resulting from the current information system updates.[150] As well,

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[150] For the purposes of this document, short to medium term is defined as one to five years. Medium to long term is defined as more than five years.

for a number of reasons the main database will remain integrated on the mainframe computer for at least the short-to-medium term. As a result, the changes in departmental information needs over that period will determine whether GIS technology will be widely adopted within the ERCB.

For the short-to-medium term, desktop GIS technology should be acquired for the three interested departments. During the start-up period, while these departments resolve system problems, the Data Processing Department should maintain close observation. Once the systems are operating, the Data Processing Department should conduct tours for other departments to observe the systems. Over the short to medium term, the other departments should be able to observe system capabilities, problems and results.

Nearing the end of the short-to-medium term period, the various user departments should be able to decide if they wish to continue supporting the current information systems or some form of GIS. At the beginning of the medium term, additional GIS systems could be acquired and integrated with the existing systems if more systems were desired. The only caution here is to ensure that once the new systems are integrated, the current GIS users don't lose power or features due to that integration. [151]

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[151] This would occur if the GIS technology was started or moved onto a mini computer upon which additional terminals would slow the system down. If all are based upon personal computers, then this problem may not arise.

A large-scale implementation of GIS technology in the ERCB would be appropriate if the current information systems were on the way out. However, two are undergoing changes and are being updated. So GIS technology on a corporate-wide basis will have to wait until such time as all of the current users desire GIS or the current systems are phased out. The former will probably occur more quickly than the latter if GIS technology is placed in the three initial departments that desire it.

10.4 WHERE DOES THE ERCB GO FROM HERE?

The first step should be to ascertain which departments are interested in GIS technology and why, to determine if the needs can be met with the current information system updates. It is essential that department needs are not lost in the ERCB software development and evaluation process, which can be long. GIS must not be seen as a threat to the existing system supporters but rather as a specialized niche tool that will fulfill needs in specific applications.

Once the departments have been identified the funding can be secured and the evaluation period can be determined.[152] It is important to determine user needs carefully so

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[152] The current cost of a full featured PC-Based GIS workstation on a 486 computer is $15,000 to $30,000. A full featured Unix-Based GIS workstation on a Sun workstation would cost $45,000 to $75,000. A comparable GIS package on the existing mainframe computer with a single workstation would cost $50,000 to $150,000.

that the chosen system does fulfill all of the needs of the user departments. It is also important to go beyond the basic vendor demonstrations and to ask for a site key for each of the systems being evaluated. Let the departments test the systems and make their choice. The most popular system can be the one purchased and distributed for use in the ERCB.

APPENDIX 1: DIGITAL DATA SOURCES, COSTS, DETAILS

A1.1 INTRODUCTION

Publicly available digital data originates from only a few sources. In most cases, it is government agencies that have created and maintained the digital databases. Digital data is also available from private sources but, generally, in limited quantities and for specialized areas. Government agencies tend to support a number of map scales, broad land areas, map projections, and file formats as a part of their mandate. The government data is accurate to a defined precision level thus guaranteeing a consistently high level of data quality.

This discussion of digital data sources is by no means complete. It covers some of the major vendors in North America and does not discuss private sources. The scope is aimed at people in Alberta. The costs given are generic and may vary in specific cases. The only purpose of this information is to give an idea of the costs of gathering data for a GIS.

A1.2 SOURCES WITHIN ALBERTA

Alberta Forestry, Lands, and Wildlife (AFLW) is the main source of digital data of the Province of Alberta. The data is all part of the Land Related Information System

(LRIS) Project. The government has attempted to bring together cadastral, basemap, resource management, and other types of digital data for the entire province into one "gateway". Each type of data is maintained and supported by different groups within AFLW and then "mounted", for distribution, on the LRIS gateway.

Currently, only the basemap and cadastral data is available for the entire province. It is available at a variety of scales including: 1:2,000,000; 1:1,000,000; 1:250,000; and 1:20,000 basemaps; 1:1,000 or 1:5,000 cadastral municipal maps; and 1:5,000 for cadastral parcel maps. [153] The Survey and Mapping division of AFLW is in charge of basemap data. The Alberta Land Titles Office is in charge of the cadastral data.

The digital files are available as Position files (unedited linework) or representation files (linework edited around lakes. rivers, roads, and urban areas). The cost of digital data ranges from $250.00 plus diskettes for a complete 1:2,000,000 file of the entire province to $800.00 plus diskettes for a 1:1,000,000 complete file of the province to $125.00 plus diskettes for a complete 1:20,000 file of some defined 1:20,000 area in the province.

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[153] Digital Products Catalogue 1989-1990 edition (latest), Land Information Services Division, Alberta Forestry, Lands, and Wildlife, Government of Alberta,10.

These files include geo-administrative boundaries, Alberta Township System linework, all hydrography, all transportation, plus contours for the 1:20,000 files. The cadastral files are $10.00 for a 1:1,000 file and $125.00 for a 1:5,000 file. [154]

The currently available resource data includes the Alberta Vegetation Inventory (AVI), geological data from the Alberta Geological Survey, and limited data from the ERCB energy-related databases. Eventually, all of the data at the ERCB will be included along with 1:50,000 scale soils information from the Alberta Research Council, complete geological data from the Alberta Geological Survey, ecological land classification maps from Alberta Research Council and AFLW, and any specialized ecological data from Alberta Fish and Wildlife. [155]

The AVI files are available on a township basis. A single township costs approximately $120.00 and includes two files. The linework file and the accompanying vegetation database file in an ASCII format. [156] Continuous coverage of AVI data is only available for the lower half of the province at a 1:20,000 scale.

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[154] Digital Products Catalogue, 1989-1990 edition (latest) Price List, Land Information Services Division, Alberta Forestry, Lands, and Wildlife,Government of Alberta.

[155] Personal Communication with Mr. Tim Toth, editor, LRIS Newsletter.

[156] The cost of these files is approximate because the price was not permanently set when the AVI files for this

The north portion of the province, often referred to as the "green area", will not be available digitally in any quantity for a while. The budget to develop new mapping products was cut. As a result, the government is leaving the "green area" to private interests to digitize. A number of companies operating in the northern portion of the province have transformed their maps into digital. Unfortunately, these products could be difficult to obtain since the rights to the mapped areas are privately held. [157]

A1.3 OTHER SOURCES IN CANADA

British Columbia, Saskatchewan, Manitoba, Ontario, and Quebec are actively creating digital databases of their respective provincial map bases. [158] Currently, British Columbia and Ontario are well advanced in the process. Each province should be contacted individually for the formats and prices of its digital data.

The Government of Canada is also transferring its various map databases to digital format. This is being done through Energy, Mines, and Resources Canada (EMR), Statistics Canada, and Agriculture Canada. EMR provides the

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project were acquired. The AVI files for this project cost $111.00 per township.

[157] Personal Communication with Mr. Tim Toth, editor, LRIS Newsletter.

[158] It is possible that the Atlantic provinces may be transforming there map bases to digital, but this information did not seem to be available during this project.

National Atlas Information Service and Topographical Digital Maps. Statistics Canada provides Postal Code Maps, Area Master Maps, Geographic Attribute Maps, CARTLIB digital files, Statistical Maps, G-Series Reference Maps, Geocoding Maps, and Special Population Compilations. Agriculture Canada is working to make its soils information in CanSIS more accessible in digital format. [159]

A1.3.1 NATIONAL ATLAS INFORMATION SERVICE

The National Atlas Information Service, at EMR, was started following the creation of a digital atlas of Canada. This was done to expedite the production of future issues of the atlas. This is achieved by not having to continually redraft the map series. The digital products available are smaller scale maps with generalized information. Scales include 1:30,000,000, 1:20,000,000, 1:12,500,000, 1:7,500,000, and 1:2,000,000. The current price is $500.00 per map product at a set size: a 1:7,500,000 map with all layers or a 1:2,000,000 quadrant. [160]

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[159] Mapping and Geographic Products, Surveys, Mapping, and Remote Sensing Sector, Energy, Mines, and Resources Canada, Government of Canada, 1987.

[160] National Atlas Information Service Digital Products, Geographical Services Division, Canada Centre for Mapping, Surveys, Mapping, and Remote Sensing Sector, Energy, Mines, and Resources Canada, 1990.

A1.3.2 ENERGY, MINES AND RESOURCES CANADA

The Topographical Map Series is available at 1:250,000 and 1:50,000 scales. The coverage is sporadic across Canada depending upon scale. The 1:50,000 scale maps are generally concentrated around urban centres or areas of high interest. The 1:250,000 map series is said to be complete for the entire Canada land mass. Both the 1:50,000 and 1:250,000 files are available for $515.00 per map (referenced using the National Topographic Series (NTS) Codes). [161]

A1.3.3 STATISTICS CANADA

Statistics Canada has developed a number of unique mapping uses for it various forms of information. All are based upon statistics collected during enumeration. Each is a different way to look at the data. All of it is database information that can be referenced on UTM projection maps. The cost of a files can vary considerably depending upon the size of area. It can be as little as $100.00 for a small request or as large as $5,000.00 or more for a large one. Exact prices have to be determined by discussing your needs with Statistics Canada.

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[161] Digital Topographic Data Distribution Information, Topographical Surveys Division, Surveys and Mapping Branch, Energy, Mines, and Resources Canada, Government of Canada, 1987.

A1.3.4 AGRICULTURE CANADA

Agriculture Canada has had soils information available in CanSIS (Canada Soils Information System) for many years.[162] It is available in database form or as exported textual files. The information can be referenced to the NTS map series. Cost of the information depends upon the size of the area in question. Inquiries can be made at local Agriculture Canada offices.

A1.3.5 CANADIAN PARKS SERVICE

The Canadian Parks Service is also transferring its various park maps to GIS. It is allowing each of the national parks to set up a GIS system and input its respective maps. The map files include full ecological information, watersheds, management areas, wildlife units, et cetera. The information is generally available from the park for use by clients when performing mapping work for that Park.[163]

A1.4 SOURCES WITHIN THE UNITED STATES

There are two main sources of digital map data in the United States. These are the United States Geological Survey

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[162] Personal Communication with Mr. Gerry Coen, Manager of the Edmonton area Agriculture Canada office.

[163] P. Benson, "Computerization of Natural Resource Information in the National Parks of Western Region" in GIS89: A Wider Perspective Symposium Proceedings, Vancouver, March, 1989, Forestry Canada,pp. 32-34.

(USGS) and the United States Department of Commerce, Bureau of Census (BOC). As well, many of the states also have digital data available for their respective areas. The individual states should be contacted directly.

A1.4.1 UNITED STATES GEOLOGICAL SURVEY

The USGS has data for every one of the forty eight states in a variety of formats and scales. There are also a large number of indexes that reference each of the types. The data is priced on a "unit" basis and the unit cost of each product varies. The prices are generally very reasonable.

The available data are: Digital Line Graph (DLG) maps in 1:24,000, 1:100,000, and 1:2,000,000 scales; Digital Elevation Models; Land Use and Land Cover Maps in 1:100,000 and 1:250,000 scales; Geographic Names Information System maps; and Alaska Interim Land Cover Mapping Programme maps. [164]

A1.4.2 UNITED STATES DEPARTMENT OF COMMERCE

The United States BOC gathers similar information to Statistics Canada. The Bureau's main database is called

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[164] Catalogue of US GeoData, National Mapping Program, U.S. Department of the Interior and U.S. Geological Survey, United States Government, 1990.

TIGER. [165] The line and database information that is extracted is called a TIGER/Line Census file. The files contain extracts of geographic and cartographic information. The information is based on extracts of enumeration data. The U.S. Census Bureau has gone further than Statistics Canada to break its products into additional categories. The Tiger files are census data based upon the USGS 1:100,000 map series for the United States and its possessions. [166]

The TIGER/Line files are available on CD-ROM disks with each containing all of the information for one or more of the U.S. states or possessions. [167] The cost per disk is $250.00.

A1.5 REMOTE SENSING DIGITAL DATA

Remotely-sensed data in Canada is available from two sources: the recently created RadarSat International Incorporated; and from private sources. The two sources provide different types of data. RadarSat has an exclusive agreement with a number of governments to provide satellite data in Canada. [168] Private sources can provide various forms of lower altitude remote sensing from aircraft such as

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[165] TIGER stands for Topologically Integrated Geographic Encoding and Referencing system.

[166] The information discussed was provided by the U.S. Bureau of Census.

[167] stands for " Compact Disk - Read Only Memory" which is the same medium as the stereo CD-ROM technology but adapted for computer use.

[168] These include the United States, Canadian and French governments.

Side Aperture Radar images, and aerial photos. The private interests are varied enough that they won't be discussed in this document.

RadarSat can provide current images from a number of different satellites. As well, it is able to draw on large archives of past satellite images. The images are available as hardcopy films or prints and as digital files. The main satellites currently providing publicly available data are the French SPOT, and the United States' Landsats. [169]

The SPOT can provide black and white panchromatic images and multi-spectral scanner (MSS) images. The panchromatic images have a ten metre ground resolution. The MSS images consist of three spectral bands with green, red, and near infra-red, and have a ground resolution of twenty metres. The SPOT satellite has a twenty five day separation period between passes over the same area of the earths surface. The SPOT images have a sixty or a one hundred and seventeen kilometre swath width.

The SPOT data is available in its raw form or it can be geocoded. Geocoding allows for corrections to the data to account for image angle induced distortion errors as the satellite passed over an area. Panchromatic data is available for $2,500.00 raw or georeferenced for a full

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[169] The information discussed was provided by RadarSat International. Their western Canadian office is located in Richmond, British Columbia.

image. The SPOT MSS data is available for $1,950.00 raw or georeferenced for a full image.

The landsats can provide Thematic Mapper (TM) images and Multi-spectral scanner (MSS) images. The TM images have a thirty metre resolution and have seven available spectral bands, blue, green, red, near infrared, shortwave infrared, thermal infrared. The TM has a swath width of one hundred and eighty five kilometres. The MSS images have a ground resolution of eighty metres and four available spectral bands, green, red, and two near infrared bands.

The Landsat TM and MSS data can also be in raw form or georeferenced. Three band TM data is available for $2,350.00 for a raw or georeferenced full image. [170] Seven band TM data is available for $4,450.00 for a raw or georeferenced full image. MSS data is available for $895.00 for a raw full image and $995.00 for a georeferenced full image.

A1.6 OTHER SOURCES

As noted earlier, data is also available from private firms. The data is either already available in digital form or the company is willing to transfer it to digital form for a client. This form of digital data is considerably more expensive than purchasing comparable data from government

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[170] There are a variety of three band mixes already available for specific functions or a unique three band mix can be defined for an additional charge.

sources. As well, the data quality may be questionable depending upon the practices of the company offering the service.

If government data is not available, it makes more sense to create the data yourself. You only need access to the required facilities and the time and patience to do the work yourself. It is less costly and the data quality is dependent upon your own methods.

APPENDIX 2: CROWN OF THE CONTINENT STUDY REGION

A2.1 INTRODUCTION

The "Crown of the Continent" region is defined partially through biological attributes, partially through visual attributes, and partially through anthropogenic features. It is primarily the latter that makes the potential of singular management of the Crown region difficult.

The region potentially spans one Canadian provincial border and one international border (See Figure 19). Logistically, this makes the development of a unified management plan rather difficult. Getting the two national governments and the three state/provincial governments to agree would require a great deal of effort. Especially in the case of ecological management of an area as diverse as the Crown.

I state that the Crown "potentially" spans these areas because it has not been "officially recognized" as a region. Official boundaries have not been designated despite the region having long been considered an "ecologically-unified" region by biologists. Yet even their suggested boundaries differ. [171]

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[171] Personal Communication from Mr. Roger Creasey of the ERCB who has been attending Crown of the Continent Society meetings since its inception. Through these

Currently, there are separate initiatives in Alberta, British Columbia and Montana attempting to raise the overall awareness of the region. In two cases they are trying to influence regional management plans. In Alberta, it is the Crown of the Continent Society of Alberta(COCS) and the Castle-Crown Wilderness Coalition (CCWC) which is a member of COCS.

In British Columbia, it is the West Kootenays Environmental Society. It is considering the formation of an Akamina-Kishanena group which will more directly deal with Crown region initiatives. They are interested in forming a multi-interest group structure similar to COCS.

In Montana, it the United States Government Services in charge of Glacier International Peace Park and the Flathead National Forest containing three separate wilderness areas. Various groups are involved with government efforts to actively manage the Crown region in Montana.

Of these initiatives, the Alberta and the Montana groups appear to be the most organized. [172] The Montana initiative is well developed and was almost to the point of initiation. It was shelved when the allocated government

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meetings, a number of differing boundaries have been suggested.

[172] Of the six possible groups, which include Alberta, British Columbia, Montana, Idaho, Washington state, and Wyoming, Alberta and Montana are the most organized. None of the other states or Bitish Columbia have well organized groups dealing exclusively with interest in the Crown region.

funding was relocated to the Gulf war expenses in 1990-1991. It is uncertain when this initiative will be back on track. [173]

In Alberta, the Crown of the Continent Society was formed by various interest groups in the region. Each of the major interest groups has a representative on the Board of Directors. [174] The Society sets out to positively influence as many regional management decisions as possible through the input from as many of the regional users as possible. [175] Giving voice to a single well developed position, which is itself based upon many varied interests, could give the Society a high level of credibility. However, it is still in the process of sorting out organizational details since its official inception as a society in May 1991.

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[173] Personal Communication from Mr. Roger Creasey at the ERCB who was in contact with various individuals in the Montana area regarding the Crown region.

[174] The Society has broken its Board of Directors up into interest group seats. Each major group has to appoint its own individual(s). The Boards current configuration is: Conservation/ Environmental groups - one seat currently held by the Castle-Crown Wilderness Coalition representative; Hunting and Fishing organizations - one seat currently held by the Alberta Fish and Game Association representative; Agriculture and Ranching interests - one seat; recreational interests - two seats with one currently held by the snowmobilers association; Native organizations - two seats; Waterton Biosphere Association - one seat; Industry (Resource developers) - one seat; Municipal Government(Cardston, Pincher Creek, and Crowsnest Pass) - three seats; Oldman River Regional Planning Commission - one seat; Alberta Government - one seat; Federal Government - one seat; Canadian Parks and Wilderness Association - one seat; plus three members elected at large from the general membership that resides within 100 kilometres of the southwest corner of the province of Alberta.

A unique aspect of the Crown region is that the Waterton Lakes National Park and surrounding area was recognized as a unique biosphere. The United Nations Man and the Biosphere programme officially recognized it as such in 1990. Where "a biosphere reserve is an internationally designated protected area managed to demonstrate the value of conservation". [176] The Waterton Lakes National Park, as a biosphere reserve, is managed in co-operation with the Canadian Parks Service. The Waterton Lakes National Park is a large portion of the northeast section of the Crown region (see Figure 16).

As noted earlier, part of the problem with managing the Crown region is the fact that, biologically, it does not stop at the border. Unfortunately, it the lack of extensive baseline, biological information which makes it difficult to define, and justify "borders" for the Crown region. [177]

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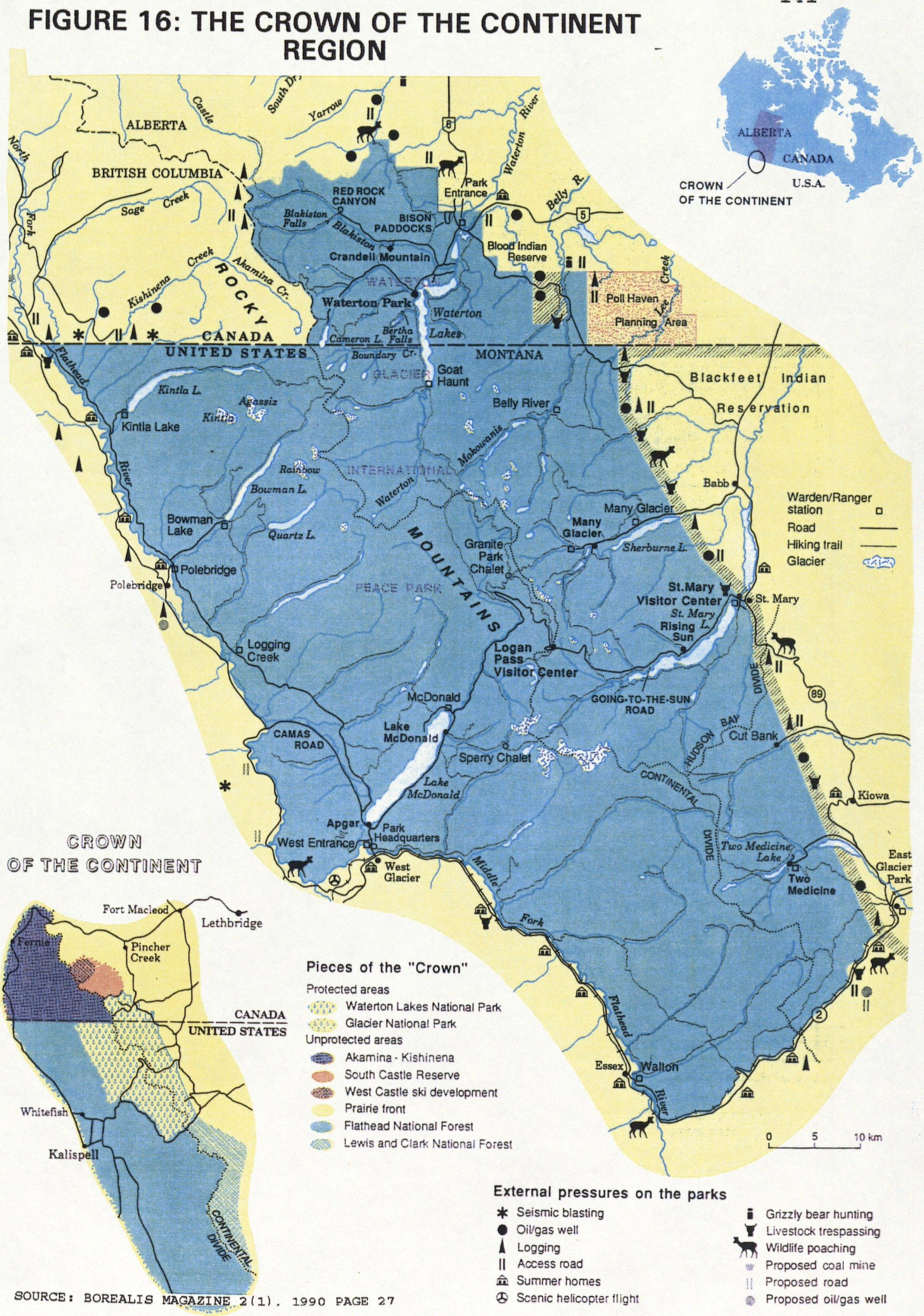
[175] Crown of the Continent Society Statement of Mission, Values, and Objectives. October 1 1991.

[176] H. Eidsvik, "Canada in a Global Context" in Endangered Spaces: The Future of Canada's Wilderness ed. M. Hummel (Toronto: Key Porter Books, 1989), pp. 36-37.

[177] This was obvious at one of the COCS meetings attended as the various interest groups defined "their" boundaries. Each partially agreed with the others and then added additional interpretations.

FIGURE 16: THE CROWN OF THE CONTINENT REGION



SOURCE: BOREALIS MAGAZINE 2(1), 1990 PAGE 27

A2.2 PHYSIOGRAPHIC CHARACTERISTICS

The Crown of the Continent is geographically classified as part of the Rocky Mountain physiographic system. [178] A large portion of this physiographic system is the Cordilleran ecoprovince in which the Crown region entirely resides. This ecoprovince stretches from the Coast ranges of British Columbia to the eastern slopes of the Canadian Rocky Mountains and south into Idaho, Montana, and Wyoming.

In Alberta, this ecoprovince consists primarily of mountainous terrain stretching between the Kakwa area and Waterton Lakes National Park. This ecoprovince consists of three ecoregions: Montane of the Rocky Mountain Foothills ecodistrict; and SubAlpine and Alpine of the Rocky Mountain ecodistrict. [179]

The climate of the ecoprovince is determined by two major factors: physiography and its interaction with the major air mass systems. [180] The northwest-southeast trending mountain ranges significantly affect the three main air masses that move through the ecoprovince. The continental and lower level air masses are the Arctic air moving northwest to southeast through the valleys and the Great

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[178] E.B. Espenshade, Jr.,editor, Goodes World Atlas, 16th Edition (Chicago: Rand McNally and Company, 1984), pp. 80-81.

[179] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 48.

[180] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), pp. 47-48.

Basin air travelling southeast to northwest from the central United States. The third and main upper level air mass is the Pacific air travelling southwest to northeast over the mountains. The large majority of the ecoprovinces' precipitation comes from this latter air system. [181]

A2.3 ECOLOGICAL CHARACTERISTICS

The ecoregions are defined primarily by elevation and the resulting unique levels of precipitation and occurrence of vegetation types. The Montane climate and vegetation are primarily in the foothills and larger valleys in the Crown region (see Figure 17). It is bordered elevationally by the Aspen Parkland and Fescue ecoregions below and the Subalpine above. The Montane ecoregion is distinguished from surrounding ecoregions by the occurrence of Douglas fir and Limber pine or Lodgepole pine and/or Aspen stands with a secondary succession to White spruce. [182]

The climate fluctuates more than the other two Cordilleran ecoregions. This is primarily due to the protection of the valleys and resulting decreased impact of Arctic air masses and increased impact that warm chinook winds will have during the year. Thus, the Montane ecoregion

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[181] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 48.

[182] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), pp.48-50.

has the highest average winter temperatures of any forest ecoregion in Alberta. In addition, strong westerly winds tend to move any snow from west slopes to east slopes where it will often remain, relatively shaded, all winter. [183]

The Montane ecoregion comprises the most important wildlife habitat in the Cordilleran ecoprovince. The grasslands are critical wintering areas for ungulates due to the lower snow levels and chinook conditions. [184]

The Subalpine climate and vegetation are primarily between 1,525 metres and 2,175 metres altitude in the Crown region (see Figure 18). These elevational boundaries decline with increasing latitude but the span between the lower and upper boundaries remains fairly consistent.

The occurrence of Engelmann spruce is the predominant indicator of the Subalpine ecoregion. The coniferous forests dominate the ecoregion with the exception of warm sites where deciduous trees will grow. [185] The forests are characterised by open canopy and where exposed, the vegetation growth is retarded by cold winds and poorly developed soils.

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[183] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 50.

[184] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 54.

[185] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 55.

The Subalpine ecoregion is characterised by snowy, cold winters and cool, wet summers. Increased amounts of snow and rain are due to the influence of the moist Pacific air masses. A high proportion of the ecoregions's precipitation comes from this easterly flowing uplift. [186]

The temperature variations tend to be the reverse of the elevationally lower Montane ecoregion. [187] The Subalpine ecoregion is colder during the day and warmer during the night. The cooler days are due to increased elevation over the Montane. The warmer nights are primarily due to cold air drainage down into the valleys. The open areas of the Subalpine ecoregion serve as feeding areas in the early spring when ungulates and bears move out into the more open, higher elevation areas. [188]

The Alpine ecoregion occurs above the climatic forest-line in the Rocky Mountains. This is defined as that point where continuous forest growth stops and isolated patches of tree begin (see Figure 19). The vegetation varies depending upon the soil development and substrate conditions, protection from wind, exposure to sunlight, availability of moisture, and resulting snow protection. Thus, glaciers do

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[186] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 55.

[187] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 57.

[188] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 59.

not support any growth and rock fields support low shrubs and lichens. [189]

The seasonal temperatures are the coldest in the province of Alberta. The precipitation level is thought to be equivalent to or greater than the Subalpine ecoregion but very little data exists. The ecoregion is characteristically windy and the wind serves an important role in the distribution of vegetation. The wind helps to move snow to protected areas where vegetation can more easily survive. The snow protection helps to decrease the dessication of vegetation when the ground is frozen. [190]

The ecoregion is populated with wildlife, including ungulates and bears, during the mid to late summer monthes when similar plant species at lower elevations are less nutritious. [191]

All of this is part of what makes the Crown of the Continent unique. The three ecoregions together could be characterized as self sustaining for wildlife. The wildlife can move between elevations (and thus ecoregions) depending upon the seasons and the weather conditions. However, if one

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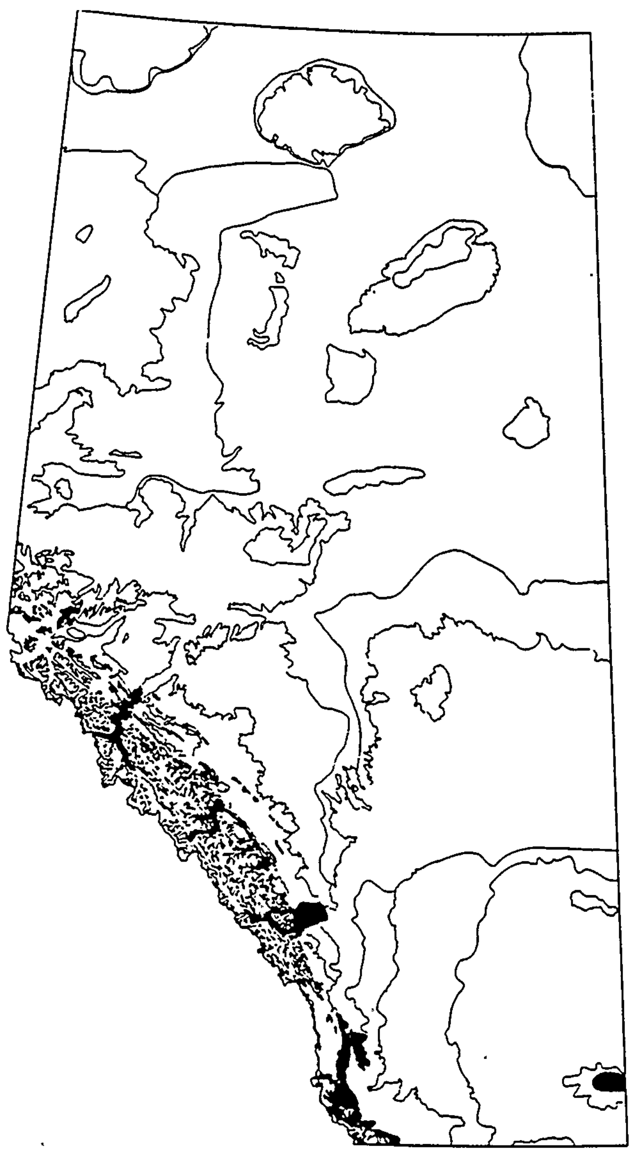
[189] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), pp. 59-62.

[190] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 62.

[191] W.L. Strong, Ecoregions and Ecodistricts of Alberta (Final Draft: Alberta Forestry, Lands, and Wildlife, 1991), 66.

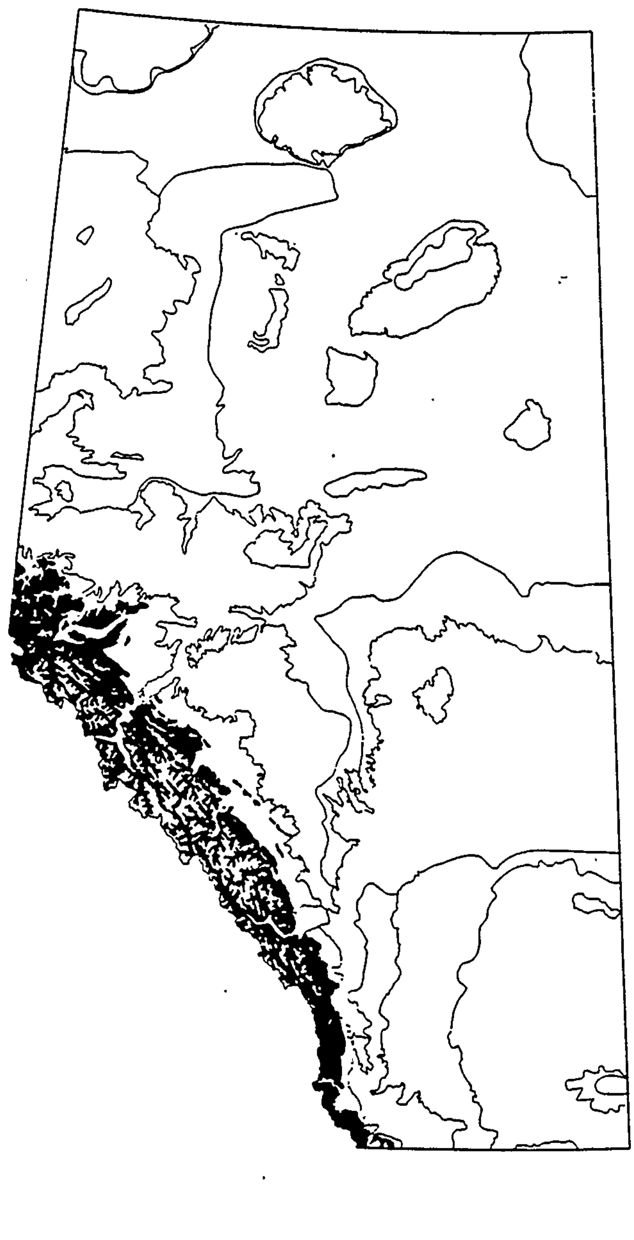
of these ecoregions was permanently changed, it may adversely influence the area capability to sustain the varied wildlife. A result may be the wildlife turning even more to man influenced areas such as crops for food.

FIGURE 17: LOCATION OF THE MONTANE ECOREGION IN THE PROVINCE OF ALBERTA



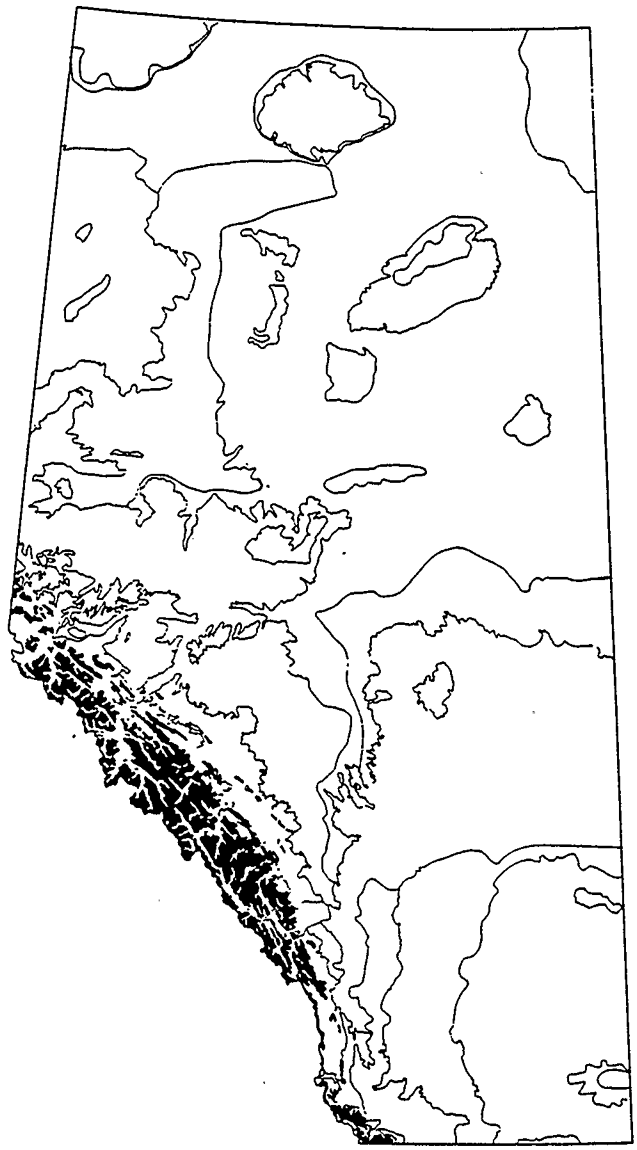
SOURCE: ECOREGIONS AND ECODISTRICTS OF ALBERTA, W.L. STRONG, 1991, PAGE 49

FIGURE 18: LOCATION OF THE SUBALPINE ECOREGION IN THE PROVINCE OF ALBERTA



SOURCE: ECOREGIONS AND ECODISTRICTS OF ALBERTA,
W.L. STRONG, 1991, PAGE 56

FIGURE 19: LOCATION OF THE ALPINE ECOREGION IN THE PROVINCE OF ALBERTA



SOURCE: ECOREGIONS AND ECODISTRICTS OF ALBERTA, W.L. STRONG, 1991, PAGE 60

A2.4 CURRENT ACTIVITIES IN THE CROWN REGION

Currently, there is a fair amount of interest in the Crown region. In Alberta, Shell Canada has discovered a number of fairly large gas wells. As well, a large magnetite deposit was discovered on the northeast fringe of the Crown region. This is all combined with the continuing forestry activities.

In British Columbia, there is an extensive amount of forestry activity. A number of tracts of land in the area are cut by U.S. forestry companies. Apparently, the area has been extensively cut already and there is pressure being placed on the B.C. government to create a park or wilderness area in the valley before it is totally ruined. [192]

In Montana, the Crown area is being continually encroached on from the south by forestry companies. The Flathead National Forest is already extensively used by forestry companies. The three wilderness areas in the forest help to protect critical areas on the south end of the Crown region. Without these, the south boundary of the area would

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[192] Personal Communication during a COCS meeting which was attended by individuals from the East Kootenay Wilderness Society. They were attempting to set up a group in the Akamina-Kishenena area of B.C. which makes up a large portion of the northwest portion of the Crown region. They wanted to see what the Alberta "Crown initiatives" were about.

more likely be drawn at the south edge of the Glacier International Peace Park. [193]

A2.5 ALBERTA'S CROWN OF THE CONTINENT SOCIETY

The Crown of the Continent Society of Alberta was officially created in May 1991. It was set up to help preserve a unique ecological area widely known as the Crown of the Continent. Through a locally based cooperative approach the society hopes to help preserve the area through wise management and restoration of the natural environment. By attempting to bring all interest groups together to one table, the desire is to develop a well thought out plan to maintain and improve the environmental state for future generations.

For its first year, COCS spent a great deal of time in determining its mission, values, and objectives. Through out this process, COCS has developed a clear and concise direction which will add to the credibility of the organization. However, the society is still trying to decide if it will be an information source, an advocate for a position on issues, or both. The most logical would be both as long as the society can continue to encourage the various interest groups and government involved to continue to sit

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[193] Personal Communication by Mr. Roger Creasey at the ERCB during a discussion about the various boundaries "proposed" for the Crown region.

on its Board of directors. If it loses people, its credibility may suffer.