University of Alberta

Development and Use of Archaeological Predictive Models in the Oilsands of Northeastern Alberta

by

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Abstract

This thesis uses Historical Resources Impact Assessment reports and interviews with archaeological consultants to analyse the development and use of predictive models in the Oilsands region of northeastern Alberta. While these models have resulted in the discovery of hundreds of prehistoric archaeological sites, closer scrutiny shows that flaws exist in the models make-up. This occurs especially when previous site location data are used because the previous survey methods used to locate sites, have been biased towards waterways and raised terrain features. Therefore, areas other than those considered to have high potential for archaeological resources have been neglected. By neglecting low and moderate potential areas, the results cannot be critically evaluated. This research recommends that post-impact assessments or monitoring of the area during developments could improve our understanding of low and moderate potential areas.

When we are dealing with history, theories are worthless...A theory is only valuable if it has the ability to predict futures outcomes. But history is the record of human action-- and no theory can predict human action.

From Timeline
by Michael Crichton, 1999

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Chapter One

Introduction

The boreal forest of northern Alberta was, and continues to be, an area of intense human activity. Currently, annual oil and gas sales in this region exceed $38 billion dollars per year (http://www.alberta-canada.com 2003). Tar sand mines, seismic lines, pipelines and access roads scatter the landscape making no area untouched by human activities. This presence of people was no different in the past. Literally hundreds of historic and prehistoric sites, spanning thousands of years, have been recorded. Estimates of the earliest occupations date back to the Early Prehistoric Period in the Alberta cultural-historical sequence (12,000 to present). Ironically, most of these sites have been recorded due to recent industrial development. Most of the expense of archaeological studies in this region has been paid by the private industry, which is primarily oil and gas.

In Alberta, cultural resource management (CRM) has provided almost all of the information reflecting the diverse and intense occupation of this region. Archaeological surveys have been done in this region for nearly 35 years. However, surveying is often difficult. Archaeologists must find their way through dense vegetation with limited or just plain little surface visibility. Even when subsurface tests are dug, tree roots encumber excavation. In addition, archaeologists must contend with muskeg, which makes many areas impassable in the summer months and adds to the logistical difficulties of site discovery. All this adds to the expense of surveying in this region of the boreal forest. Therefore, many of the areas that have been surveyed are known to have high potential for sites such as the mixed terrain features, described as trending ridges, knolls or nodes, that characterise the landscape. With so many field seasons to be accounted for the sample should be representative of the overall site distribution and/or site density, but in general it is not.

Over the years many different site discovery techniques have been employed in this area. Given the difficulties in surveying, determining the distribution pattern through predictive models is desirable. Predictive models can be used to describe trends in archaeological site locations by predicting where and to what degree sites may exist. Or as the oft-quoted definition by Kohler (1988) states, a site predictive model is a:

> … simplified set of testable hypotheses based either on behavioural assumptions or on empirical correlations, which at a minimum attempts to predict the loci of past human activities resulting in the deposition of artefacts or alteration of the landscape. (Kohler 1988, cited in Woywitka 2002)

Predictive models are often derived from anthropological theory, which is derived, in part, from ethnographic data. If the theory and ethnographic data are correct, then predictive models could be a useful tool for conducting surveys and estimating site distribution. However, the models that have been used in the study area have not been critically evaluated. Indeed, models may instead reflect biases or assumptions embedded in archaeological practice.

Predictive models eliminate certain areas from archaeological concern by defining zones of high, moderate and low potential for the discovery of archaeological remains. Today, many archaeologists working outside of academia, such as archaeological consultants, use predictive models in order to decide whether or not an area should be surveyed.

CRM is the first and last defence against the loss of heritage resources. The current political and economic climate in the province of Alberta appears to be development at any cost. Sometimes this "cost" includes the loss of non-renewable heritage resources such as archaeological sites, palaeontological remains, historical buildings, among other things. Oil and gas is the most profitable industry in this province, especially in northeastern Alberta where over one-third of all the oil and gas wells drilled and a large portion of the Oilsands occur. In fact, the boundary of the study area roughly coincides with virtually all large-scale oil and gas development and makes this a particularly vulnerable region for the loss of archaeological resources (Figures 1 and 2).

The scale of these developments is massive: Lease 13, owned by Shell Canada, is an area of approximately 202 000 hectares and the Aurora mine being developed by Syncrude Ltd., is approximately 24 000 hectares. Given the intensity and the scale of developments in the region, there is a need to understand archaeological resources in this area and collect as much information as possible before it is destroyed. One way that this can be achieved, is through the analysis of methods used to discover heritage resources such as predictive models. While this area is economically important today, it is also rich in cultural material and is one of the major contributors to our understanding of boreal forest adaptations of past peoples.

The aim of this thesis is to demonstrate how survey methods in the Oilsands region of northern Alberta have developed since 1973 and to assess the success of the current methods, which use predictive models to divide the survey region into high and low potential zones. Data were collected from the Historical Resource Impact Assessment (HRIA) reports as well as the archaeologists working in this region to illustrate weaknesses in the current methods as well as provide an interpretation of why these weaknesses may occur.

Predictive Models in Archaeological Research

Predictive models spawned from settlement pattern studies of the 1950s and 1960s. Following this, the 1970s became preoccupied with the ecological and environmental context of archaeological sites (Dalla Bona 1994; Williams et al. 1973; Plog and Hill 1971). Archaeological surveys began to rely on specific environmental variables to predict site locations. In addition, as government policies developed, management practices became more competitive and hence, more cost efficient. Consulting archaeologists were looking for a more cost effective way to plan and execute site surveys. Therefore, while consultants were using site predictive strategies intuitively, there was still no means of formalizing the criteria used in models. Concurrently, developments in mapping technology facilitated database generation and made the information stored in maps more easily accessible. The combination of these factors opened the door to the development of site predictive models by making it more explicit and allowing the operation of a geographic information systems (GIS). While not all consultants working in the study area currently use GIS-based models, there is a trend to do so because GIS is digital and results can be easily transferred into databases and final reports. The principles for non-GIS and GIS-based models are similar because all models use environmental proxy indicators to assess the archaeological potential of an area. Below is a summary of GIS based models currently applied to archaeological research.

GIS

Our knowledge of spatial relationships is traditionally stored in maps. GIS is a tool for mapping and therefore, spatial analysis. GIS uses spatially referenced data to analyse the earth. First developed in Canada in the early 1980s, it wasn't long before archaeologists began to recognize its potential, and began to use GIS for data management and simple mapping exercises. More recently, GIS has become integral to more complex spatial analyses. The CRM industry uses GIS for cost-effective management and planning around potentially significant archaeologically sensitive areas. GIS now occupies a firm niche in archaeological research and practice (Woywitka 2002). However, its relationship with archaeology as a discipline is somewhat precarious because, like any new tool, there are still many problems to be addressed (see Kvamme 1999). There are two types of spatial analyses that will be discussed within the context of archaeological predictive models: site predictive models and cultural landscape models. These two types of spatial analyses also represent the two main approaches to GIS in archaeology. Site predictive models use inductively derived data while cultural landscape models use deductively derived data. Both use our understanding of the spatial distribution of sites and artifacts in order to predict where other sites may occur. While the tools and technology to develop such models have advanced rapidly, the methodology for prediction is still being improved.

Archaeological predictive models attempt to describe trends in archaeological site location in order to predict where and to what degree more sites may exist. Warren (1990) defines three essential components of a predictive model: information, a method, and an outcome.

Information is the data from which the model is derived; it can be in one of two forms (Warren 1990). The first types of data are derived from theories that explain human relationships with the environment. The second data type is derived from empirical observations from maps or the results of previous archaeological survey. These two types of information lend themselves to two types of site predictive models.

Deductive models begin with theories that predict human behaviour and synthesize information about human land use (Dalla Bona 1994). While they may account for a greater range in human behaviour, they fall prey to changing interpretations and theoretical frameworks. Inductive models are derived from data in a database and known site inventory and are therefore subject to any biases present in the original data. Some models use a combination of these methods (Dalla Bona and Larcombe 1996; Hamilton 2000). Inductive and deductive approaches in predictive models will be discussed in more detail later.

The second element of predictive modelling is the method used to translate the information into a prediction (Warren 1990). With the advent of computer technology methods of archaeological site prediction have become very complex. Most models employ some sort of statistical method such as multiple regression or discriminant function analysis. Related to both types of statistical analyses is a group of procedures called probability sampling, which uses the laws of statistics to predict the probability that each area is a member of one of two mutually exclusive and exhaustive groups: site presence or site absence (Warren 1990: 92). This method was used in the 1970s to avoid human bias during sampling but proved to be less successful in finding sites (Conaty 1979).

Finally, the result of any statistical analyses provides an outcome. Warren (1990) describes four types of outcomes: nominal, ordinal, interval, and ratio scales. Nominal predictions parcel groups or classes, which have no assumed relationship, into categories. Ordinal predictions rank groups or classes in relation to one another. For example, an ordinal relationship defines one group as more likely to contain a site than another group. In both nominal and ordinal classifications we cannot measure the magnitude of difference between the different groups or classes. Interval-scale predictions can organize the data into ordered groups as well as measure the difference between them (e.g., size/weight). However, an interval-scale lacks an absolute zero. A measure of magnitude with an absolute zero is found in ratio-scale predictions. Together these results provide numerical data from which patterns and their spatial relationships can be assessed.

Site predictive models and cultural landscape models represent the two types of spatial analyses used in predictive modelling. Each type of model is derived from different types of data based on opposing theoretical approaches to predictive modelling. Models in the Oilsands study area generally fall into the first category; however, the second category is becoming more widely accepted as a possible approach.

Site Predictive Models

Site predictive models use inductively derived data. Empirical observations such as site location or landscape characteristics are inventoried using environmental and other types of maps. Then, using relational and spatial software such as GIS, the inventory of information can be positively or negatively correlated with one another in order to determine if a relationship exists between a spatial location (i.e., an archaeological site) and a range of environmental variables, thus creating environmental 'proxy' variables for site locations (e.g., Hobbs and Nawrocki 2003; Kvamme 1985). For example, potential decreases as distance from water increases. These models assume that hunter-gatherers settled near key environmental resources and that the present environment can serve as a surrogate for past environments. This process helps the planning and management process because, by knowing the proxy variables that are likely to contain sites, such areas can be recognized and either surveyed to locate potential sites or the consultant can recommend that the area be avoided so that no disturbance activity is allowed to occur. However, we still do not understand the causal relationship between proxy variables and site location.

It has been observed that knowing the spatial distribution of sites is nothing more than an inventory of archaeologists' reconnaissance activities (Hamilton 2000). This suggests that the current distribution of sites and their locations merely reflect where development has occurred and therefore, where consultants have been required to look. For example, Figure 3 represents the location of all archaeological sites in Alberta and clearly shows a straight line in Southeastern Alberta of sites found during a survey for a pipeline. It is highly unlikely (if not impossible) that prehistoric peoples dispersed themselves in a strictly linear fashion. Instead, this site "distribution" is the result of the limits of the survey area required by a pipeline development. Therefore, the spatial distribution of sites is not a variable that can be measured because it reflects the artificial boundaries of the survey area. If a predictive model uses a spatial distribution of sites, then the model itself may be biased. Circular reasoning is one of the major critiques of models in the study area and will be dealt with in the context of the models and methods applied in the Oilsands region.

Cultural Landscape Models

Cultural landscape models are derived by the use deductively data. These models attempt to translate social and ethnographic theory into cartographic representation (Gaffney and van Leusen 1995). Synthesizing the social, environmental, and geoarchaeological data into a map would be ideal (Friesen 1998). The deductive approach used in cultural landscape models contends that the spatial distribution of archaeological sites is a reflection of human behaviour, not a product of the physical environment. Many feel that ethnographic information, coupled with the archaeological interpretations of settlement and subsistence patterns, would improve the prediction of heritage resources (Hamilton 2000; Friesen 1998; Church et al. 2000; Llobera 1996, Malasiuk 1999). By combining the two data sets, the cultural landscape approach may represent a more holistic interpretation of the archaeological record. However, this type of model would require exceptional ethnographic and palaeoenvironmental data that are currently not available and therefore remains only a theoretical possibility.

I have shown how sampling can affect the distribution and therefore, interpretation of the spatial distribution of the archaeological record and that this in turn affects our predictive capabilities. There are inherent biases in the methods that remain to be reckoned. This is especially true in Alberta where models have been applied in large areas of the boreal forest.

The use of predictive modelling strategies

The use of predictive modelling in archaeology has stimulated both excitement and criticisms over the past thirty years, especially with new and rapid advances in GIS (Church et al. 2000; Dalla Bona 1994; Kohler 1986; Kvamme 1999). Much of the excitement stems from its potential in CRM for planning, cost-reduction, and training. As a planning tool, predictive modelling can help to visualize landscapes and help in selection of sample areas, thereby deciding where to allocate time and money to survey. As a training tool, predictive models supply a visual resource, which illustrates large-scale survey strategies of archaeology to the client. Models can also assist industries to avoid developing in areas with high archaeological potential. The benefit to this is two fold. First, it helps protect archaeologically sensitive areas, thereby preserving a dwindling supply of sites, and second, by manoeuvring around these archaeologically sensitive areas, known as "red-flags" (Altschul 1990), they can avoid the sometimes costly process of archaeological survey and excavation.

While few would argue the benefits of predictive modelling during the planning stage, many are wary of the suggestion that models can or should be used in place of archaeological survey for several reasons. First, predictive models are generally framed within an environmental determinist perspective. Models use environmental data as proxy variables to identify favourable settlement locations. This can be problematic because environmental proxies do not always correlate with site locations. Also, the databases of environmental data can be plagued with data deficiencies (see Hamilton 2000; Kvamme 1999). For example, feature locations may be imprecisely plotted or errors may be introduced when a map is digitised. Secondly, it is still unclear to what degree of accuracy predictive models can be applied (Church et al. 2000; Ebert 2000). It is unknown how many sites we are missing and therefore creates a false sense of security in locating cultural resources. Also, for models to predict accurately a full range of sites, the sample group must be representative. Models based on biased samples could continue to miss predicting an activity location whose associated environmental characteristics do not occur in the selective sample of locations surveyed. The result is an overrepresentation of some types of sites and an under-representation of others. This leads to an unbalanced view of the different activities conducted by a group of people over time and space.

There are two major causes for misrepresentative sampling groups. The first pertains to site visibility. The second is the bias created by intuitive sampling methods. Site visibility is restricted in the boreal forest by the density of the vegetation, low surface visibility, site formation processes, and many other environmental factors that are beyond the scope of this thesis. Problems related to intuitive sampling will be discussed later in the context of the Oilsands region.

Despite the shortcomings of predictive models, they appear to help archaeologists to concentrate their efforts and to locate sites with a greater degree of success than probabilistic random sampling. Also, due to the economic and statutorial constraints in CRM archaeology, predictive models continue to be applied. Therefore, we require an understanding of predictive models, how they were developed and how they are applied the particular study region in archaeology. For example, this thesis considers how improvements can be made in the method by understanding the development of biases within the model, where they come from, and how they are engrained within the broader archaeological culture.

Chapter Two

Context

Before looking at the archaeology of the Oilsands of Northern Alberta. it is useful to describe the environmental context, the cultural context and the usual types of artifacts recovered in this region. The majority of the Oilsands developments lie north of Fort McMurray on the east side of the Athabasca River (Figures 1 and 2). Most generally, this region is situated in a boreal forest environment where prehistoric peoples were hunter-gatherers and where currently, there is an abundance of archaeological activity. There are environmental and cultural aspects that provide context for this research. Both will be discussed in past and present terms.

Northern Alberta: The environmental setting

The environment of the Oilsands region plays a key role in the use of predictive models. The boundaries of the study area lie north of Fort McMurray and south of McClelland Lake. It is limited to the east by the Steepbank and Firebag rivers and to the west by the Athabasca River. The entire region is contained within the boreal forest and the area was chosen because there has been a large degree of Oilsands development and therefore, a history of the application of archaeological survey methods.

The boreal forest is defined as a nearly continuous belt of coniferous and deciduous trees across North America and Eurasia. The forest is an assortment of successional and sub-climax plant communities responsive to varying environmental conditions. The study area lies in the Mid-Boreal Mixedwood Ecoregion of the Boreal Forest region, which covers approximately thirty percent of the province of Alberta, and is defined by its vegetation, climate, and soils (Strong and Leggat 1992). The forest composition is dominated by needleleaf, coniferous (gymnosperm) trees such as the evergreen spruce (*Picea*), fir (*Abies*), and pine (*Pinus*). Deciduous trees found include larch or tamarack (*Larix*) and alder (*Alnus*), birch (*Betula*) and aspen (*Populus*).

Vegetation varies with topographical features. The drier, elevated features support jack pine and trembling aspen while wetter, less elevated features tend to support other coniferous trees (Henry 2002). Associated with intermediate levels are white pine and communities of spruce/tamarack. Bogs (muskeg) occur in the lowest areas, which are poorly drained, glacial depressions where sphagnum moss forms a spongy mat over ponded water. Growing on this mat are species of cottongrass and shrubs of the heath family, while black spruce and larch frequently ring the edge. Thick muskeg deposits occur all over this region in low, saturated areas. This is a recent process caused by climatic warming during the Holocene (Zoltai and Vitt 1990). Although the modern landscape is drier, muskeg continues to cover much of this region.

The climate is subarctic with long, severe winters (mean temperatures are below freezing for over half the year) and short summers (50 to 100 frost-free days). Also common are a wide range of temperatures between the minimums of winter and maximums of summer (Henry 2002).

The most significant feature of this region is the Athabasca River, which begins in the Rocky Mountains near Mount Columbia (elevation 3747 metres) and flows northeast for 1,400 kilometres until it drains into Lake Athabasca (elevation 208 metres). The river cuts through Holocene and Pleistocene sediments including the Lower Cretaceous Clearwater Formation sandstones, the McMurray Formation (Oilsands) as well as the Upper Devonian Waterways Formation limestones (Norris and Carbone 1973). East of the river are gently rolling outwash plains that contain directionally oriented, raised features formed during the last glacial recession. It has been suggested that these features are a result of the Lake Agassiz flood.

The Athabasca River valley was changed into its current form at the end of the Pleistocene in a catastrophic flood (Fisher 1993; Smith and Fisher 1993; Fisher and Souch 1998; Teller et al. 2002). Evidence for this are the poorly sorted imbricate boulder gravel deposits, the presence of eddy bars and rhythmites, and the lack of glaciolacustrine sediments in the Muskeg River area. This flood may be the result of the rapidly drained Glacial Lake Agassiz, which spilled over its shorelines in northwestern Saskatchewan, into the Clearwater River valley and west into the Athabasca valley. Following this, the water then flowed northward into Glacial Lake McConnell, through the Mackenzie system and into the Beaufort Sea (Fisher 1993, 2003; Smith and Fisher 1993). While there is still much debate on the subject, there is evidence to suggest that it was an intense flood that lasted a few months occurring around 9900 BP (Smith and Fisher 1993). Following the initial flood event, water began to recede exposing and creating a series of shorelines. No studies have been done on the nature of the landscape at this time but due to the flood, water levels would have been high thereby creating a landscape full of embayments, lakes, and river terraces as well as high ridges and knolls. As the water began to recede, more land became available for the hunter and gatherers of this region.

The most visually significant aspects of the recent landscape are the recent anthropogenic changes. Seismic lines, pipelines, oil sand mines, as well as the secondary features required for these facilities such as roads, refinery plants, camps and town and dump sites, and borrow sources for gravel fill scatter the landscape leaving few pristine areas.

These recent anthropogenic changes, combined with flooding from Glacial Lake Agassiz have created the modern landscape, which is represented and stored in maps, air photos, and satellite images, which are then translated into the models. However, maps used in GIS programs do not discriminate between past and modern landforms; instead it is the archaeologist that must make this discrimination. Parts of the modern landscape are used to represent past features. Understandings how the present landscape features represent a paleo-landscape is part of an archaeologist's task. Observing the landscape through time and differentiating the landscape in time sequences is a skill often learned through experience in a particular region. For the preceding reasons the environment plays a key role in predictive modelling in archaeology of the Oilsands region.

Cultural Setting: People of Alberta's Boreal Forest

In J.V. Wright's seminal work *A History of the Native People of Canada* (1995), the figure showing northern Alberta is a large blank space with a question mark (Figure 4). This is true for both the time period 8,000 – 4,000 BC (Figure 4a) and for 4,000 – 1,000 BC (Figure 4b). This is not to say that there has been no research done in this area but it does give an impression of the paucity of general knowledge in the study area compared to other boreal forest areas across Canada. A summary of the cultural groups of this region can be found in the *Handbook of North American Indians: Volume 6 Western Subarctic* (Helm 1981). What we do know about this area comes from two broad sources. The first is from ethnographic studies of peoples of the boreal forest (e.g., Tanner 1979). The second source of information is related more specifically to the study area and includes specific archaeological information for this region (e.g., unpublished archaeological reports).

The first source relies on general information of how people survived within a boreal forest environment, known through ethnographic, ethnohistoric, and archaeological research. Researchers have looked at sub-arctic hunter-gatherers in considerable detail; including the archaeology (Speck 1973, Feit 1973, Fisher 1973), ethnography (Tanner 1979) and ethnohistory (Reid 1988; Hamilton 1988). Ethnographic information has been compiled for groups such as the Mistassini Cree (Tanner 1979) and ethnohistories are provided by Russell (1985) on the Western Cree. Both provide a starting point for looking at boreal adaptations. Most important for this thesis is that boreal people were highly adapted for the winter climate and generally travelled in small familial groups, thereby establishing small camps. As well, these camps were situated in different locations every year so that firewood and game were readily available.

Specific to this area, researchers have analysed kinship and economic patterns in this region for the Cree and Athapaskan people (Ives 1990). Archaeological research in this region has been done on the Bezya (Le Blanc and Ives 1985, 1986) and Nezu (Bourges 1998) sites and attempts have been made to locate and understand the quarrying of Beaver River Sandstone (Ives and Fenton 1983). A partial historical sequence for the early prehistory of the study area has been offered by Saxberg and Reeves (2003). They describe four complexes: the Fort Creek Fen Complex (ca. 9900 to 9400 BP), the Nezu Complex (ca. 9400 to 8500 BP), the Cree Burn Lake Complex (ca. 9400 to 7750 BP), and the Early Beaver River Complex (ca. 7750 to 7000 BP). Each complex is characterized by varying lithic technology at specific contour lines, which are associated with the shoreline sequences with the drainage of Lake Agassiz.

However, all other archaeological research has appeared in the unpublished archaeological reports. These reports, written by CRM consulting archaeologists, could provide an excellent source of data. They contain several examples of survey methods and the development of and use of predictive models. However, due to the constraints of the industry, which are usually economic and political, few consultants are afforded the time to answer research questions about their work or contribute to the research domain. Therefore, there is value in providing a synthesis and evaluation of how archaeology is done in the Oilsands.

Chapter Three

The Historical Resources Act

Archaeology in Alberta is governed by the Heritage Resource Protection Act (herein called the Act). Passed in 1973, the legislation contained five parts.

1) Historical Resources (generally)
2) Historical Resources Fund
3) Historic Resource Management
4) The Alberta Historical Resources Foundation
5) General

Part one defines historical resources and how they are to be treated by those who implement the Act. The second part defines the historic resources fund and part three outlines historic resource management. Part four establishes goals and guidelines for the Alberta Historical Resources Foundation and the last includes other general clauses concerning the temporary power to issue a stop work order, compensation, exemption from building codes, and fines (offence and penalty). Most clauses begin with the statement the "Minister may..." thereby leaving almost everything to the discretion of the Minister in charge of administering the Act. However, it is the Cultural Facilities and Historical Resources division that is currently responsible for the implementation and promotion of this Act. The spirit of the Act, or the intended meaning of the Act, is expressed on the website as:

> The Cultural Facilities and Historical Resources Division preserves, protects and presents Alberta's unique natural, cultural and historical resources. It does this by operating 18 provincial historic sites, museums and interpretive centres, as

> well as the Provincial Archives of Alberta; maintaining provincial heritage collections; providing assistance to community-based preservation projects; providing historical designation to significant resources; and operating the Northern and Southern Alberta Jubilee Auditoria. (http://www.cd.gov.ab.ca/all_about_us/ministry_overview/index.asp)

While the spirit of the Act is to protect, preserve, and display historical resources, the resulting policy is much more complicated. In order to understand the development of survey methods, this section will define and examine the resulting policy.

Policy and Stakeholders

The result of the Act is a process that contains many steps and several stakeholders. Most simply, in order to protect historical resources the Alberta government can require developers to verify that they will not have an impact or destroy historical resources when undertaking a new development. Figure 5 shows the general order of this process. If at each stage there is no further concern or no required action, the process is complete and the development receives clearance under provisions of the Act.

To increase economic growth, the Alberta government promotes, among other things, oil and gas development. Industries that undertake this work must acquire the proper permits and clearance from a variety of regulatory bodies including Alberta Community Development (ACD). Under the Historical Resources Act (HRA), new land developments are required to obtain clearance from ACD in order to protect archaeological sites. If the new land development is likely to cause impacts to historical resources, ACD may require that the developer do a Historical Resources Impact Assessment. The consulting archaeologist is responsible for obtaining a permit from ACD to conduct the HRIA. The methods used to conduct impact assessments will be reviewed later.

There are three primary stakeholders as well as several others that can be involved at any stage of the process. The primary stakeholders have a direct influence on archaeology in the Oilsands and thereby use the models. They are: the Oil and gas industry (land consultants, engineers and various other contractors herein grouped as industry), ACD, and the archaeological consulting industry. Other equally important stakeholders include the public, First Nations groups, academia, and other government agencies. At any point, these groups may choose to exercise interest, opinions or control over various parts of the process.

Industry groups must obtain clearance and therefore, "fund" CRM. Some industry groups do what is minimally required for clearance while others are more willing to take an interest in archaeology and support high-quality assessment studies. ACD monitors and manages the process, making sure that new developments do not proceed without proper clearance. This includes a verification of the quality of the archaeological assessments through a professional review of the resulting reports. ACD is the broker between all stakeholders.

Consultants are the individuals who deal directly with the archaeology. They are responsible for choosing and executing the sampling method in order to locate heritage resources. They must apply for a permit from ACD, which approves the sampling method, conduct the necessary assessment or fieldwork, and are responsible for the production of a report. The report is the means of communication between the consultants and all other stakeholders; however, archaeologists are hired and paid by industry. Therefore, all consultants operate as a business but are regulated by ACD. While, they work within the discipline of archaeology and therefore, have similar research interests (broadly the understanding of past peoples), their goals are different from academic archaeologists, in four ways: (1) Purpose, (2) Funding, (3) Timeline, and (4) Final Product

Firstly, unlike academics, CRM work is not framed within research questions. Instead, their work is applied and they are charged with managing heritage resources. Secondly, the Act stipulates that the development proponent pays; therefore, it is the client for whom the consultant works that provides the funding needed for this work. In the province of Alberta, this is usually primary industry such as oil and gas or forestry companies. Thirdly, although both academics and consultants are bound by the Act, the timeline available to complete an assessment or excavation of a site is very different. Consultants work within strict time constraints and must deal with the legal implications if inadequate work is done. Lastly, while the cost of producing the final report is paid for by the proponent, there is no additional institutional and financial support such as exists at universities or in government. Therefore, if the consultants choose to do further research or submit their work for peer-reviewed publication, the cost is assumed by the company itself. Thus, while consulting is an archaeological discipline it has key differences from academia.

The remaining stakeholders, such as the public or First Nations groups, may have special interests in the land development and become involved at any stage of the process. The Act and its resulting policy allow for several methods to be applied to CRM.

Responses to the requirements of the ACT

Since the Act was passed there have been many methods used to conduct an HRIA. Both probabilistic and non-probabilistic methods have been used to conduct HRIAs in the study area and different survey methods have developed or waned over time. Because survey strategies are a methodological consideration of fundamental importance to the discipline of archaeology, it is also a theoretical consideration in the discipline. Over the years sampling strategies have changed to refine sampling methods. The following is an overview of sampling methods used in the Oilsands in response to the introduction of the Act. These methods are relevant to the observations and interpretation of this thesis.

At the largest scale, archaeological survey design methods are about sampling. Archaeologists are constantly forced to sample part of a quadrat or block, a portion of a site, or a fraction of an artifact collection (Mueller 1975).

Archaeologists, as well as researchers in general, are continually making decisions about inclusion or exclusion. These sampling decisions can be made in a variety of locations including the field, based on our knowledge and experience, or in the lab or the office with access to previous research, maps, databases, and reports. There are two types of sampling strategies related to archaeological survey methods: non-probabilistic and probabilistic.

Non-probabilistic sampling designs include both opportunistic and judgemental surveys. A judgemental survey is a shovel testing strategy that relies on the "judgment" of the archaeologist to choose the precise location of the shovel test. Opportunistic surveys avoid the locational prediction of judgemental sampling by using available exposures (e.g., erosional surfaces, animal burrows and trails, tree throws, cutlines, access roads, etc.) to maximize site discovery (Van Dyke and Reeves 1985). Opportunistic surveys are therefore different from judgemental surveys because they rely on previous disturbances of the landscape as opposed to the archaeologist's experience. Opportunistic sampling is usually done in conjunction with a judgemental sampling survey. Judgemental sampling is performed in areas where archaeologists feel there may be sites. For example, it is common knowledge that people tend to live near water in the boreal forest and therefore shorelines, beaches, and river terraces are likely to have sites and judgementally surveyed. A Judgemental survey is done in the field based on the archaeologist's experience and frequently relies on implicit or narrative knowledge of the ethnographic record. Sometimes knowledge of the ethnographic record is not first hand but relayed from a senior archaeologist to a junior colleague and so on. Archaeologists often use preconceived notions or "intuitive" investigation by examining areas where they have found sites in the past. While both types of reconnaissance aim to find areas that were favourable for past settlement, these expectations are not always applied systematically across the landscape. Additionally, "...few field archaeologists pay due attention to the frequency with which such 'high probability' localities do not yield heritage resources" (Hamilton 2000: 45). Therefore, there is no way to assign a probability that favoured areas yield archaeological resources. The concern is therefore not for the survey procedure so much as for "the failure of the archaeologist to provide a meaningful statement of the predictive model which structures the survey" (Dyke and Reeves 1985). In the late 1970s and early 1980s, many archaeologists attempted to avoid such biases by using probabilistic methods.

Probabilistic testing was introduced as a means to overcome the lack of scientific methodology seen in judgemental and opportunistic survey (e.g., Binford 1972; Chenall 1975; Cogwill 1975; Judge et al. 1975; Lovis 1976; Mueller 1975; Nance 1979; Plog 1978; Read 1975; Schiffer 1975; Schiffer and Gummerman 1977; Schiffer et al. 1978; Spurling 1978; Thomas 1975). Probabilistic methods were designed for statistical analysis. Samples were chosen from a known population so that inferences could be made about the parametres of that population. In this method, there are two types of populations: target and sampled. The target population defines the whole group of elements under investigation and can be limited. Definition of this group is precise so as to understand the relationship to the sampled population. The sampled group is the actual variable or entities under investigation. For example, the target population could be the landscape of a particular region and the sampled population would be comprised of the areas sampled. Many studies where this method was used would divide the survey area into ⅛-mile quadrats, and then select a percentage of the quadrats from a random number table to survey (e.g., Spurling, 1978). To do this, numbers are assigned to each quadrant and then a random number table is consulted to determine which quadrants will be tested. The quadrants would then be consistently sampled in the same area (for example, the northeast corner or the centre) for each quadrant tested. Within this framework, data can then be analysed for any statistical relationships that may exist. Theoretically this procedure eliminated any judgemental biases and because the survey was done randomly the data possessed statistical significance. Also, this method allowed the investigator to statistically extrapolate on the numbers and/or types of sites. While this allowed for statistical manipulation of archaeologists' reconnaissance activities, this process failed to account for the non-random nature of human use of a landscape.

Probabilistic sampling methods eliminate human biases inherent in other survey methods such as judgemental and opportunistic sampling. However, probabilistic sampling frequently resulted in the surveyor testing in areas of little potential (e.g. muskeg) making site discovery nearly impossible. Ultimately, the inability to account for both an archaeologist's experience and the nature of the boreal forest left archaeologists unsatisfied with random sampling. Thus, when GIS technology became more widely used in other disciplines, archaeology was quick to envision a great future for predictive models, but the initial enthusiasm of GIS was soon plagued with numerous problems that still exist today. For example, the problem explored here is the discrimination between high and low potential areas. more specifically how the distinction is made between them. To answer this we must understand what information the models use to define these regions.

The datasets that are used come from two sources (1) environmental information; i.e., physical characteristics of the landscape, and (2) the location of previously recorded sites (Hobbs and Nawrocki 2003). Though often considered to be two separate categories within a GIS model, in actuality they are not. The majority of previously recorded sites were found using judgemental and opportunistic sampling. Both of these methods are highly dependent upon the physical characteristics of the landscape. Therefore, what was defined as two separate sources of data, is actually one in the same. In addition, a number of studies (e.g., Kvamme 1999) have recognized the limitations of the environmental data used to construct a GIS model. Because elements within a GIS system must have exact coordinates imprecisely located or "fuzzy" information about environmental features and or archaeological sites (i.e., before the widespread use of GPS) make it difficult at best to assess the accuracy of the model.

Chapter Four

Archaeology in the Oilsands Region of North-eastern Alberta (1970-1989)

Canada's centennial in 1967 led to an increased awareness of Canadian historical resources (Losey 1973) and around this same time (1973) Alberta passed legislation that required industry to avoid impacts to archaeological and palaeontological resources. Also, during this time Syncrude and Suncor development projects were occurring in northern Alberta because of exploration for large-scale tar sands mines and therefore, this area became susceptible to the loss of cultural resources. Therefore, archaeologists began large-scale salvage projects (Losey 1973, Arundale et al. 1989). Prior to this time, very little work had been done in Alberta's north; indeed, "as of 1965 the vast northeast region of Alberta represented a complete void archaeologically" (Losey 1973: 11; Bonnichsen and Bryan n.d.; Wright n.d.). The lack of archaeological information was due in part to the exceedingly difficult survey conditions in the boreal forest due to thick vegetation which complicates mobility and obscures surfaces. It was also due, in part, to the difficulty in convincing researchers of the area's archaeological potential, especially in comparison to the Alberta Plains where site features are more visible. Therefore, contract archaeology began in this region in 1973.

Heritage legislation is provincially regulated in Canada and archaeologists are often hired privately by industry groups to determine the impacts their proposed development would have on historical resources. A large number of archaeological permits (63 as of 2001) have been issued in the Oilsands region of northeastern Alberta. This is due to large scale mine developments in the oil and gas industry with their attendant access roads, camps, airstrips, and highways. These surveys covered very large tracts of land and a variety of landscapes. The majority of these projects were located on the east side of the Athabasca River, north of Fort McMurray. The complete list of these permits and final reports are listed in Appendix I. The sample that was used to create the predictive models relies on these previous surveys.

The 1970s

The first survey by Losey (1973) located 31 sites in Syncrude's Lease number 17. From day one, it was assumed that "archaeological sites in forested and semi-forested areas of Alberta are very often (but not exclusively) located near water" (Losey 1973: 9)[1]. Another determining factor for archaeological potential used by Losey (1973) was the presence of so-called ecotones. Ecotones occur at the junction between one or more ecozones and were considered to have an increased archaeological potential because there was an increased diversity of plants and wildlife. Losey (1973) maintained that while these two features may help delineate culturally important areas, "archaeological potential of any given area can only be accomplished through a thorough on-the-ground archaeological survey" (Losey 1973: 10).

[1] Losey does not provide a source or justification for this statement.

Losey subsequently divided the study area into *priority classifications* (an ordinal ranking) based on the possibility for the presence of historic sites and the availability of subsistence resources. A priority 1 classification was given to areas east of the Athabasca because of its high relief. It was assumed that trending ridges were natural travel routes and were used for hunting lookouts. Priority 2 areas were less varied 'ecologically' but still important for moose habitat because many of the priority 2 areas contained the ecotones adjacent to muskeg and were therefore only accessible during the winter. Since, "aboriginal winter camps of short duration are rarely preserved in the archaeological record" (Losey 1973: 19), Losey argued that Priority 2 areas should be eliminated from further investigation. Priority 3 areas encompassed the remainder, which were areas of low relief and poor drainage.

It is unclear in Losey's report whether testing of each of the priority areas was done; it appears that only the priority 1 area were surveyed. Losey states: "the archaeological survey was conducted using the above priorities as a guide for scheduling work to be done" (Losey 1973: 25). The priority 1 area was "intensively surveyed (excluding portions of marsh and muskeg)" (Losey 1973: 3) and 28 sites were found[2]. Losey and others continued to work in this area with similar criteria for archaeological survey (Losey 1974; Losey and Sims 1974; Sims 1975; Donahue 1976). These studies, which are examples of judgemental

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[2] Due to this 'intensive' survey, it is assumed by the author this sample of sites represents the actual site distribution in this area. Sites were found, as *expected*, in proximity to water, at particular elevations and near 'characteristic' vegetation.

and opportunistic sampling designs, demonstrated that the areas adjacent to the Athabasca River were intensively used by prehistoric peoples.

In 1977, McCullough and Reeves surveyed the priority 2 areas. Their study was the first systematic analysis of the low wetlands with the rationale that "low-energy societies are closely linked to the environment in which they live" (McCullough and Reeves 1977: 13), and that this area would show variability in site distribution, type and function. Ten days were spent walking along the Beaver Creek and taking some judgemental transects through the area. Three sites (isolated finds eroding out of the bank) were found along the Beaver Creek and one trapper's cabin was located near a small tributary of the creek. There is no mention of subsurface testing.

Following this, the construction of the Alsands plant and mine site required another large survey project (Conaty 1979). This area was sampled using a probabilistic survey design as it was "the only means of retrieving data which is amenable to further statistical manipulation" (Conaty 1979: 60). The Alsands lease was surveyed using a two-stage sampling design. First, the study area was randomly divided into ⅛ square mile quadrats. Non-metric measures were used to align with township and range divisions. Secondly, thirty percent of the sample quadrats were chosen, and then, these were systematically sampled. The sampling point was selected for each quadrat using a random number table. This procedure established the location of the first test unit. Other test units were established, relative to the first, using compass bearings and a measuring tape.

Muskeg and bog environments were tested because of evidence from Glob (1971) and Wintemberg (1936) that indicated that archaeological sites might be found in these types of areas. Despite the scientific logic of this study it recovered an astonishingly low number of sites.

The 1980s

In 1980, Ronaghan continued work in the Alsands region. Under permit 80-91, which included areas proposed for a utility corridor, a townsite, and an airstrip, 59 new sites were recorded. The surveys in the utility corridor used ground reconnaissance in high potential areas as well as some subsurface testing. The method for reconnaissance of the townsite and airstrip was systematic shovel testing along cutlines and visual examination of the study area. Most of the sites were located in areas along the Athabasca River. The larger sites, defined as workshops, were located during shovel testing.

In 1980, McCullough executed another large-scale project approximately 65 km north of Fort McMurray. This project consisted of 107 oil and gas well sites and 50.55 km of new access road. Of this, 80 of the core-hole drilling locations and 27.9 km of road were tested. At each drilling location, five test holes were dug, one in the centre and at four at each corner. A series of two test holes were placed at 100 m intervals along the proposed road for a total of 558 units. An additional 25 units were excavated at proposed camp locales (shovel tested along equally spaced transects) as well as 362 judgemental units in high and medium potential areas. Sixteen new sites were recorded. McCullough makes important observations regarding the methodology previously applied in this region. He states:

> The dense vegetation which is characteristic of the Clearwater Lowland obscures the ground and thereby the site surface. To overcome this visibility handicap, researchers have had to take advantage of fortuitous exposures (e.g., road cuts) or implement a subsurface testing program to expose the strata bearing cultural material. Of the 220 prehistoric sites recorded, over 83.6% were discovered in areas of extreme ground disturbance while 16.4% were discovered by a subsurface testing program. The disproportionate number of sites recorded in areas characterized by fortuitous exposures versus those found in subsurface testing programs, in part, reflects the relatively recent implementation of the latter type program. It also, in part, reflects the fact that previously disturbed areas such as roads make extensive areas visible. (McCullough 1980)

Certain locations such as riverbanks, south-facing ridges, and topographically high areas were targeted for testing. Van Dyke and Reeves (1985) excavated 7,608 shovel tests in the area on riverbanks, terraces, outcrops, knolls, ridges, sand flats, relic landforms, and aspen or spruce stands. Sample areas were selected based on previous archaeological surveys, NTS topographic maps and aerial photography. Van Dyke and Reeves (1985) first identified the attributes of probable site locations. Secondly, they looked at the maps to collect faunal and geological data. This assumed that the known archaeological material/site distribution would accurately reflect the actual distribution of archaeological resources. This is an example of how archaeologists rely on previous site data to estimate areas of archaeological potential before setting foot in the study area. Thus, the model was developed based on ethnographic analogy.

optimising models, and archaeological expectations as well as previously known sites.

In 1989, Fedirchuch, McCullough and Associates (89-52) conducted a baseline study for the OSLO (Other Six Leases Operation) project. They predicted that sites would be found only near major water sources (Kearl Lake, Hartley Creek, wetlands, and small tributary creeks as well as on dry land features within muskeg tracts), and so they concentrated on these areas of the development project.

Following these original surveys, which used judgemental sampling, predictive modelling began to develop in this region. Obviously, the sample that was used to create the predictive models relies on these previous surveys, which is why they have been discussed. Predictive modelling was applied to this region in the early 1990s. Although improvements had been made in GIS and hence the models themselves over the past ten years, the outcome remained very similar to the survey strategies used throughout the 1970s and 1980s. In my opinion, relying on previous site data to create predictive models, when the data has not been critically evaluated, leads to spurious results.

Chapter Five

Part 1: The Reports

Methods

Here I present observations from two sources to investigate the current modelling methods used in the Oilsands. The first source is the published Historical Resources Impact Assessment site reports from the Archaeological Survey, Alberta Community Development. The results of this research then led me to investigate this question further through direct questions and responses from the authors of the reports via an online questionnaire. Results from the questionnaire prompt a discussion that examines the treatment of low potential areas. Because the observations are interrelated, each data source will be presented, then the observations will be summarized and discussed as a whole.

The Reports

The first set of observations was collected from the HRIA reports. At the time that this research was done 63 permits had been issued for work in this region (i.e., Borden Block Major designation: HO) since the introduction of the Act (Appendix I and II). It was first necessary to identify which projects and reports used predictive models. As no projects before 1990 used predictive modelling, this was used as the cut-off date; 12 years worth of reports remained. However, because the project analysis and report writing takes place after an archaeological work permit is issued, some projects may take several years to complete a final report. Consequently, not all the reports were available. Of all the post-1990 reports that had been completed, those that only covered a small areal extent were eliminated since predictive models are usually applied to large tracts of land, and not to smaller parcels. The latter included projects on pipelines where the area is covered in only one or two transects. Some reports were simply missing or unavailable from the ACD archives.

Reports typically contain a section that explains about the method used in each project and how it was applied. These sections were reviewed in order to understand how predictive modelling was carried out in the Oilsands. The method section is important because the results of an archaeological assessment are dependent on the efficacy of the method used. Before presenting the details of the reports there are a few general observations that should be described about the development use and presentations of the method section in CRM reports.

Many CRM reports concentrate on the results of the assessment while the method section is outlined simply and in brief. Also, not all reports are equal. In some, there is very little detail given as to how the method was developed nor on whether or not it was effective; others are more complete. Therefore, there were no systematic criteria with which to analyse all the reports. Each report is thus considered a case study and was observed independently of another. The remaining 12 reports are listed in Table 1. Each report was reviewed and observations of their methods are outlined below.

Table 1. Final reports used for case studies.

Permit Number*	Project Title	First Author	Affiliation
95-83	Steepbank Mine	Balcom	Golder
96-72	Syncrude Aurora Project Phase I	Shortt	Lifeways
97-043	Aurora North highway and Utility and Access Corridors HRIA	Saxberg, Shortt, Reeves	Lifeways
97-107	Muskeg River Mine HRIA	Ronaghan	Golder
97-116	Aurora Mine North HRIA and HRIM	Shortt, Saxberg, Reeves	Lifeways
97-123	Project Millennium HRIA	Clarke	Golder
98-029	Fort McKay Light Industrial Use Site Project	Kowal	Altamira
98-145	HRIA Mobil Lease 36 (Kearl Lake)	Clarke	Golder
98-172	HRIA Hwy 63 Upgrade [Fort McMurray to Suncor]	Amundson	Stantec
00-045	Suncor Firebag Project	Clarke	Golder
00-118	HRIA Petro-Canada McKay River Project	Meyer	FMA
01-248	CNRL Project Horizon	Clarke	Golder

* The first 2 digits reflect the year the archaeology permit was issued while the last 2 digits are the sequential number of all permits issued for that year.

Case Studies

Permit 95-83 Steepbank Mine Project

The Steepbank Mine Project was prepared by Golder Associates (Balcom, 95-83) for Suncor Inc. Within the study area, the previous site locations of prehistoric and historic sites as well as data regarding topographic features and environmental criteria were compiled. In addition, maps were consulted to determine the archaeological sensitivity of the area. These included: 1:50 000 NTS topographic maps, air photos, and 1:10 000 maps of pedological and muskeg distribution. Golder specifically identified well-drained features such as knobs, ridges, escarpments, shorelines, benches, terraces and banks as having high potential. Using a digital elevation model (DEM) to discriminate between high areas and low areas, 1 344 hectares (ha) were classified as high potential, 634 ha were classified as moderate potential and 1 107 ha were classified as low potential for a combined area total of 3 085 ha. "Once this initial data was accumulated, a stratified archaeological site potential map was produced utilizing a GIS system" (Balcom, 95-83: 43). The development of an archaeological site potential map that is stratified into parcels of high, medium, and low potential, allowed for an enhanced sensitivity rating (Balcom, 95-83: 43). Following this, judgemental sampling was executed in areas of interest or 'high potential' in the field. The report is unclear if areas other that high potential ones were tested. The only detail available is that over nine days, five people excavated 1,154 shovel tests. This is the first example of a GIS based model being applied to this region. However, their testing scheme is similar to that applied by Ronaghan in 1981.

96-72 Syncrude Aurora Project Phase I

Field methods and sampling strategies were based on the methods of two previous surveys: the 1980 Alsands HRIA (Ronaghan 1981) and the 1984 Lease 22 HRIA (Van Dyke and Reeves 1984). In other words, testing was confined to high potential areas, meaning raised features and trending knolls or "high nodes."

97-43 Aurora Mine North Utility and Access Corridor HRIA

Field methods and sampling strategies were based on the methods of three previous surveys: the 1980 Alsands HRIA (Ronaghan 1981) and the 1984 Lease 22 HRIA (Van Dyke and Reeves 1985) and the 1996 Aurora Mine North studies (Shortt and Reeves 1997). Again, testing was confined to raised features and trending knolls (i.e., areas considered to be high potential).

97-107 Muskeg River Mine

The Muskeg River Mine project used a GIS based predictive model to divide the area into high and low potential based on the Alsands survey of 1980, which relied on terrain specific terrain features such as raised knolls. The model was based on drainage, proximity to water, and access for survey. Only high potential areas were tested, using 4 578 shovel over an area of 10 000 ha. Areas of low potential were traversed when moving from one high potential area to another and therefore, there was opportunistic survey of low these potential areas. However, these low potential areas are not discussed any further.

97-116 Aurora Mine North East Pit, Plant, Tailings and Related Facilities HRIA and Mitigation

This project used opportunistic and judgemental sampling methods. Again, high trending ridges and knolls were tested, but it is unclear if any other areas were examined.

97-123 Project Millennium

Project Millennium was one of the first projects to use two separate predictive models. The first of these was a Local Study Area Model. It was produced prior to the field assessment as a means to focus field time on high potential areas. This first model was based on vegetation communities and open water. The study area was subdivided into high (10%), moderate (13.5%), and low potential areas (75.7%). However, observations during the fieldwork prompted a revision of subdivided areas to reflect more accurately the actual potential of the areas. The second model was a Regional Study Area Model. This model attempted to asses the impact of the Oilsands development on historical resources for the entire Oilsands region, to locate areas with archaeological concern so that in future they can be avoided (Clarke 1997).

98-129 Fort McKay Light Industrial Use Site Project

The area was examined by foot and all areas were visually inspected. One hundred and sixty-seven shovel tests were excavated in judgementally sampled areas.

98-145 Kearl Lake

The HRIA for Kearl Lake used a GIS based model to define the archaeological potential of the area prior to field assessment. The model used two land-based categories (water and vegetation) and two categories based on previous archaeological assessments by Light (1997) and Reeves and Saxberg (1998). These previous surveys suggest that sites occur on raised landforms between "intervening areas of water saturated terrain" (Clarke 1998: 61). They argue that "this correlation was established by the 1980 Alsands Mine and Tailings Pond studies (Ronaghan 1981) [and that they] have been confirmed by the Archaeological Survey's work in the cleared Alsands Plant and Mine areas" (Ives 1998). Categories such as soils, slope, aspect and general elevation were not included in the model for assessment. They then proceeded to do aerial reconnaissance, which modified their original model. "Field work included pedestrian traverses accompanied by visual inspection and shovel testing of high, moderate and low potential areas" (Clarke: 1998: 61).

<u>98-172 HWY 63 Cree Burn</u>

An HRIA was conducted for the Highway 63 upgrade from Fort McMurray to Suncor access (approximately 22 km). This area was surveyed judgementally and opportunistically. Two areas, one 4.8 km from Ft McMurray and the other up to 5 km from Suncor, were extensively examined. The remainder (12.2 km) of the area was "spot checked" at five locations between the other two areas. Twenty-seven shovel tests were excavated "near level topography that (was) moderately well drained. [They] did not test on steep slopes or in muskeg areas."

00-045 Firebag

This project encompassed 1,098 ha of land and therefore. Golder used a predictive model to define areas of high, moderate and low potential. The model was adjusted after they made aerial observations and field inspections. Areas selected for testing "were chosen on the basis of the GIS predictive model" (Clarke 2000:69). High moderate and low potential areas were visually inspected and shovel tested. "Sample selection was weighted toward the highest ranked features but also provided coverage of a reasonable number of moderate and low ranked areas. Investigations in many cases extended beyond the break in slope on the features selected, thereby providing at least some coverage of areas considered to have lower potential" (Clarke 2000:69).

00-118 HRIA Petro-Canada McKay River Project

This area (approximately 75.5 ha) was surveyed judgementally and opportunistically. Three hundred and twenty-five shovel tests were excavated in areas of limited exposure or in areas deemed to have potential for buried cultural deposits (Meyer 2000).

01-248 CNRL Project Horizon

Pre-field studies in this project did not include a GIS-based model. Instead, archaeological site records and environmental information were reviewed. Fieldwork was conducted using pedestrian transects, ATVs, and aerial survey and subsurface testing. "Visual inspection focused on landforms believed to have potential for the presence of archaeological material with special attention give to natural or man-made exposures" (Clarke 2001: 68).

Discussion

Four heritage consulting companies wrote the foregoing 12 reports: Golder and Associates, Lifeways Canada Ltd., Fedirchuk, McCullough and Associates (FMA) and Stantec. All four modelled their surveying strategy, either judgementally or with GIS, based on raised topographic features. While the criteria for high potential varies slightly for each different model implemented by each consulting company, the most common variables include proximity to water (in this case the Athabasca River and its tributaries) and vegetation type and/or elevation, as specific vegetation grows at certain elevations (particularly in this areas where you get high dry knolls etc.). All other regions were considered moderate or low potential and were generally not surveyed. Only in the Kearl Lake and the Firebag projects is there mention testing of high, *moderate* and *low* potential areas (Clarke 1998, 2000). However. Clarke also states in both reports that "areas known to have little or no potential for archaeological sites received very little investigation" (Clarke 1998:76, Clarke 2000: 69) and so it remains unclear exactly how much of the so-called low and moderate potential areas were tested. The basis for all the models used in the reports above are one or more of the following studies: Ronaghan (1981), Van Dyke and Reeves (1987), Ives (1988), and Light (1997). The problem here is that, in keeping with the limitations of the Historical Resources Act, these initial studies did not look at low or moderate potential areas. Therefore, when subsequent work is based upon them, it also fails to include these areas. The result is an unrepresentative sample within the region.

Representative samples are necessary to produce a complete picture of the cultural activities in a region. For example, the areas shown in Figures 6 and 7 were tested by Ronaghan in 1981 (Ronaghan 1981) (Figure 6) and reassessed by Unfreed in 2000 (Unfreed 2000) (Figure 7). Both Ronaghan and Unfreed tested the knolls but not the lower intermittent areas as they were considered to be of low potential. When the area was subsequently cleared for development in 2001, Kowal located numerous lithic scatters in the low potential region (Kowal pers. comm. 2002) (Figure 8). Other low potential areas were tested, and sites were found several km away from major water sources, on slopes, and others were found in topographically low areas (Kowal pers. comm. 2002). Kowal's results strongly suggest that sites may and do exist in moderate and/or low potential areas. If this is the case then the question is: *why* are areas other than high potential ones not tested?

The Reports: Part 2

To answer better the question of why low potential areas are not tested, I decided that additional information could be obtained from the authors of the reports directly. Five consulting firms agreed to discuss their written reports.

These discussions were informal and no explicit data were collected during this time[3].

The companies contacted included: Fedirchuk, McCullough and Associates, Western Heritage, Golder. Lifeways Canada Ltd., and Altamira Consulting. Based on the discussions with them it became clear that there are several external factors that influence decision making in CRM that may help to explain the exclusion of low and moderate potential areas from survey schemes. These factors are: cost, the quality of the available data sets used with GIS and an individual's ideas about archaeology and survey strategies.

Early in the discussions it became clear that much of the decision making revolves around a cost-benefit analysis. Consultants must justify their costs to the client and remain competitive within the industry. This, in turn, influences survey decisions. For example one consultant said: "Dealing with these large areas of land is difficult and as a solution to surveying the [entire] area, with little time or expenditure, models were developed." By defining low potential areas, and therefore, eliminating them from the overall testing scheme, they justify the cost of field work and the archaeological assessment. "A model is *management*, not academic research of testing hypotheses. Ideally, people would be testing the low potential (areas) to test the model." Therefore, it is not a matter of what is archaeologically possible, but a matter of business. In a similar vein, consultants

[3] Discussions took place during personal meetings with one or several consultants at a time during which notes were taken. The statements in quotation marks are interpretations (not direct quotes) of what they said.

tend to balance site significance with site discoverability. "If we can discover it [sites in low potential areas], is it of value? If it is of value, can we justify the cost?" While sites may be found in low potential areas, they may also be insignificant. Therefore, it is less important what types of sites are being found in an area but instead, to what degree the area holds potential for site discoverability. Essentially, it costs less to find sites that are easy to find; the rest are assumed to be less significant. Almost all consultants expressed cost as the rule of thumb for decision-making. "Justify it financially, justify it archaeologically. The pendulum swings between the two." While the archaeologists are aware of their lack of rigorous analysis, they are powerless. Ultimately, this suggests that the government agency is responsible to assess the validity of the approach.

The second major limiting factor when creating a model is the quality of the data sets. Consultants are aware that the data sets used in a GIS-based systems (maps, previous site locations, etc.) are fraught with errors and do not necessarily cater to archaeology. These errors include those introduced when digitizing the maps or the age of the map, and the scale of the map. However, as one consultant suggests, "This is something that is present in all GIS applications of data. Until the calibre of the data can improve, archaeologists are no worse off than anyone else." In addition, consultants are aware that prior to the use of GPS in the field, the recorded location of a previously found site could be inaccurate. Together these problems make it difficult to assess the accuracy of models.

Another interesting point that was brought up was that the consultant's general survey strategy has not been affected by the particular model being used. Consultants continue to survey in the same manner they always have. regardless of the model being used. "The survey strategy remains up to the individual archaeologist. Surveying is based on individual experience not the visualization of the model. " Therefore, areas of low potential are commonly examined or traversed during survey, but are often not tested. Testing schemes remain the same despite the introduction of the new "modelling" systems. This leads me into the final element that influences the design of the survey strategy, which is individualism.

While many of the consultants expressed similar views on a variety of issues, there remained a strong sense of individuality not only between the different consulting firms, but also between individual consultants within one firm. Each consultant has his or her idea of how to survey an area and which elements of the landscape would have been most important to past peoples. Some individuals insist that prehistoric people's subsistence was based on fishing and therefore lakeshores become the highest potential areas. Others feel that almost all sites in this region are located on elevated terrain features such as knolls. Others consider a combination of various landscape elements. Regardless. the definition of high potential areas is based on numerous elements some of which are extremely dependent on an individual's perceptions of where sites should be located. Therefore, comparing the models used by different consultants and different consulting firms is difficult at best. Discussions with the consultants on their methodology provoked an interest in these external factors controlling model development. Combined, the observations from the reports directly and indirectly led to a need for a more formal means of data collection from individual consultants. I therefore decided to use a questionnaire.

Part 2: The Questionnaire

Methods

Due to the nature of consulting work, where time is money, it was decided that the questionnaire take no more than five minutes to complete and that it could be done at their convenience in order to elicit as many responses as possible. This was accomplished by having the questionnaire available on the Internet and having an online submission. Twelve participants were contacted via email. They were informed that by completing the questionnaire they consented that the information they provided would be used for research and that confidentiality would be maintained. The results of the survey were routed through a server and then emailed to me so as to assure anonymity. Questions were in multiple-choice format except for one. The latter was a blank field where the participants could comment as much or as little as they wanted. Results from the questions were compiled into a table and are discussed below. Finally, within this discussion is an analysis of the questionnaire itself. It is these observations that will provide the basis for further discussion of predictive modelling in this region.

The following section describes each question and why it was asked.

Question 1:

Throughout your career, roughly how many months/years have you spent surveying in the boreal forest?

This questions aims to classify the experience of the participant. In other words how much "ground time" has been spent in the boreal forest. I felt this was an important variable when considering the proceeding answers. Someone with less field experience is bound to approach surveying in the boreal region differently than someone with several years experience. Also, because the responses were anonymous, this is the only question that classifies the respondents into separate categories.

Question 2:

Have your field survey strategies changed since the development of predictive models for this region?

By asking this question I wanted to know if using a predictive model altered the way in which archaeologists view the landscape once in the field or if they continue to survey an area the same way they always have. Does a predictive model alter their survey strategy?

Question 3 and 4:

What is the primary purpose of using a predictive model?

What is the secondary purpose of using a predictive model?

These two questions serve to understand the two most important reasons consultants use predictive models. In their opinion, what purpose does a model serve and in what order to the priorities fall? Is cost reduction more important than understanding archaeological questions and so on.

Question 5:

What are the major limitations in predictive model development?

This question was asked in order to elicit what the consultants see as the greatest point of weakness in predictive models.

Question 6:

Could the data sets be improved?

From the relevant literature, it appears that the quality of the data sets is a major weakness in creating models. Therefore, to complement question 5, I wanted their opinion on the state of the data sets and whether there is hope for improvement of this weakness.

Question 7:

Are predictive models cost effective?

This question was asked to determine if consultants view models as a financial benefit to their clients and therefore, make them more competitive within the industry.

Question 8:

What type of sites do you think you are modelling?

This was the only question that was left open-ended so the respondent could write as little or as much as they wanted. This question was asked in order to prompt the respondent to think about what exactly they are modelling. Do models show actual site distributions, or simply reflect where previous sites have been discovered.

Question 9:

Do you agree that predictive models are effective in finding archaeological resources?

This question is straightforward and is meant to assess their opinion on the effectiveness of the technique by the results that are achieved.

Question 10:

Are predictive models accurate?

Again, this is a straightforward question to gauge their opinion on the accuracy of the technique.

Question 11:

Some people have suggested that predictive models offer a visual representation of an archaeologist's approach to surveying strategies employed in the field. In your opinion, do predictive models help non-archaeologists to understand the rationale behind the survey strategies used by archaeologists?

This question was asked to see how many individuals see a predictive model as a teaching tool. I wanted to test the idea that models are useful in consulting to teach and describe to non archaeologists our methods of prospecting.

Question 12:

To what degree does the nature of archaeology in the boreal forest contribute to difficulties in developing a predictive model (i.e., site discovery, site visibility, etc.)?

The question was asked in order to gauge to what degree environmental factors influence predictive models.

Question 13:

Do sites exist in low potential areas?

Finally, this last question aims to show how many individuals who use predictive models agree that the models are ignoring areas and losing sites.

Results

The results from the questionnaire are presented in Table 2.

Table 2. Participant responses to the questionnaire.

Participant	1	2	3	4	5	6
Q1. Years	1 to 3	1 to 3	1 to 3	>5	>5	>5
Q2. Strategies	maybe	maybe	no	maybe	yes	yes
Q3. Primary	planning	Under-standing	planning	planning	planning	Under-standing
Q4. Secondary	Under standing	planning	cost	Under-standing	cost	planning
Q5. Limitations	data	data	data	data	data	data
Q6. Data Set	yes	yes	yes	maybe	yes	yes
Q7. Cost	no	yes	yes	yes	yes	yes
Q9. Effective	agree	agree	agree	agree	agree	str. agree
Q10. Accuracy	maybe	maybe	?	maybe	maybe	no
Q11. Teaching	no	maybe	maybe	yes	yes	yes
Q12. Boreal	none	some	some	large	large	large
Q13. Low Potential	maybe	maybe	yes	yes	maybe	maybe

While 12 individuals were contacted to do the questionnaire, only six replied. Half of the respondents had one to three years experience, while the rest have more than five years. This division serves to categorize the individuals into two groups; one group has more experience in boreal forest archaeology than the other.

Questions 2 and 3 were asked in succession in order to determine what consultants felt were the primary and secondary purpose of a predictive model. Participants gave two answers for the primary purpose. Four answered planning and two answered understanding. The two individuals who answered understanding for the primary purpose answered planning for the second. There were no divisions between the two groups.

For four of the twelve questions, respondents agreed. The first of these is question five. All agreed that the quality of data sets is the major limitation in the construction of effective predictive models. In question six, everyone but respondent four answered that yes, the data sets could be improved. In question seven, all the participants except number one felt that predictive models are cost effective. In question nine, all participants agreed that predictive models are effective in locating archaeological resources.

For question eleven and twelve each group of respondents (based on their experience) had the similar answers. The group with the most experience felt that the nature of archaeology in the boreal forest region had a large impact on the development of predictive models, while the group with less experience felt it had some or no impact. In question 12, the senior group felt that models serve as a teaching tool to individuals who have less experience while the junior group felt that they may or do not.

Finally, the responses for questions 10 and 13 have mixed results. In question 10, four out of six respondents feel that predictive models are accurate, while one thinks that they are not and one responded with a question mark. For question 13, 4 out of 6 respondents agree that sites might exist in low potential areas while two say that they do.

Responses for question eight, which were an open-ended question, are listed below.

> Participant 1: Sites are not being modelled – the PROBABILITY that a site will be identified in a given area IS being modeled. AS a result, you are modelling the sensitivity of an area to whether or not a site can be found within a specific region. The regions can be ranked as those of having low potential, moderate potential or high potential for containing historical resource sites.
>
> Participant 2: Depends upon previous bias in site survey strategies across different areas of Alberta's boreal forest. Modelling process reflects maximum predictive efficiency for site location based upon statistical comparison of environmental variable associated with known sites vs. random non-site location. Models based on assumption of environmental deterministism as well as normative view of human culture. Models less effective for modelling abherrant [sic] manifestations of human behaviour or those lying outside of the economic sphere (i.e., vision quest, burial) or those site locations that are not associated with rationale [sic] human choice (i.e., kill site). Model output provides baseline view of normative prehistoric occupation of and interaction with boreal forest environments against which site outliers (i.e., sites situated within predicted low potential zones) can be identified, compared and hopefully, understood. For this reason, a model is not static and must be updated! Into perpetuity as the knowledge base and understanding of prehistoric lifeways is advanced.
>
> Participant 3: Large, permanent/semi-permanent residential sites
>
> Participant 4: Prehistoric, large scale sites such as camps, quarries etc.

Participant 5: Precontact middle to late Holocene First Nations sites

Participant 6: Early-Mid Holocene sites before formation of the modern Boreal Forest communities.

The responses to the questionnaire provided insight and qualified opinions of consulting archaeologists for the discussion that follows.

Chapter Six

Discussion

When I started this thesis my original question was where are sites not found and why? Why are low potential areas classified as such and consistently ignored? Is it truly because they contain few sites; or is it a function of some other mitigating factor such as poor site visibility or problems with GIS technology?

Low visibility along with other logistical difficulties, such as areas of muskeg, are often listed as one of the many factors that make surveying difficult and there is a plethora of articles detailing the limitations of GIS. These limitations and difficulties are compounded into predictive models. Site data are collected according to a pre-defined set of guidelines, called a predictive model. Thus, the result of a survey and hence the quality of the data collected is a consequence of the predictive model being used. Most consultants use predictive models as a planning tool in order to eliminate certain areas from the overall testing scheme, because of statutorial and financial limitations. Therefore, restrictions are not caused by the models themselves but by external factors.

Together the results from the case studies, discussions with the consultants about the reports and the questionnaire bring out important points about the development and application of predictive models in the Oilsands, which will now be discussed. There are both positive and negative elements about the current methods used. After describing both the pros and cons of predictive modelling in the Oilsands region, I will discuss my interpretation of why these methods continue to be used despite their problems and occasional lack of scientific rigour.

Cons

The most notable issue that became evident is that the sample has not changed since consulting archaeology began surveying this area in the early 1970s. Fuelled by both a lack of interest in the archaeology in this area and the lack of archaeology previously found in this region, the Oilsands area held very little promise until 1973. The initial surveys of the region uncovered an unexpected number of sites and stimulated interest about the potential for archaeological resources in this area. Later, a quarry for "Beaver River Sandstone" toolstone was believed to be located somewhere in the area (Losey 1973, 1974; Losey and Sims 1974). These initial surveys were near major waterways. Later, Ives (1981) conducted a post-impact survey, indicating that sites are concentrated on high spots, otherwise described as trending ridges or knolls; however, the final report is not yet unavailable. Since the early 1980s, surveys undertaken in this region and the models employed, have worked from these findings, looking for sites on high trending ridges and knolls. Therefore, the current methods used continue to contribute to the collection of unrepresentative samples and hence, the sample group is biased. It is this biased sample group that continues to serve as the basis for current surveys and modelling methods. Because low and moderate potential areas fall outside the selective sampling group they remain untested. Representative samples that include areas other than high potential would increase the overall value of the data that is being collected because it would improve our understanding of site distribution in the region.

A second problem is that by sampling primarily near waterways, the sample is representing areas where people lived during the summer. Ethnographic accounts of boreal forest people suggest that during the winter months people were more mobile (Tanner 1979; Rogers 1959). During the winter, the muskeg areas are frozen making the terrain easier to traverse and allowing camps to be established anywhere. As well, because of the snow, drinking water is abundant. The size of the camps also varies between the winter and the summer. In the summer, camps would have been larger and more concentrated along waterways and in open areas. In the winter, camps were smaller and distributed throughout the boreal forest to take advantage of dispersed game resources. As well, these small winter camps were located within the forest, not necessarily along waterways, for added protection from the elements. This results in a varied distribution, of smaller archaeological sites, throughout the boreal forest. By limiting the areas that are sampled to the major water sources, the emphasis shifts to summer sites as opposed to representing all sites.

The third limitation of predictive models is the current state of the data sets used to construct them. The data sets are problematic for two major reasons. Firstly, the data represent the current landscape and may not accurately represent past ones. Secondly, the resolution of the data sets is poor for the size of archaeological sites. Whereas ecoregions and large topographic features exist on a much large scale, smaller topographic features, such as the ridges or nodes that scatter the study area, exist at a scale that is unrecognizable on most maps (e.g.. NTS maps). Additionally, archaeological sites exist at a variety of scales (from a lithic scatter of 5 m^2 to a camp of several thousands m^2). Small lithic scatters found on small topographic features in the study are therefore invisible in a GIS model.

Finally, it remains to be seen as to whether or not models will help to improve our understanding of a region. For example, various reports state that a Beaver River Sandstone quarry must be located somewhere in the Oilsands area. Yet, to date, no one has located exactly where this toolstone was mined (Fenton and Ives 1982, 1984, 1990). Despite this, assessments continue to collect millions of artifacts of Beaver River Sandstone (Ball, pers. comm. 2003; Saxberg, pers. comm. 2003). Models may serve as a useful tool for identifying archaeological sites and therefore, collecting more artifacts. But what is the use in expending energy to develop models if they do not provide new perspectives on the archaeology of the region? Models can predict site discoverability and allow for the most items to be collected as possible. But is the endless collection of Beaver River Sandstone debitage necessary or useful? In the spirit of the Act it is necessary to protect as many cultural resources as possible. However, I would like to argue that our goal as archaeologists is also to understand what is being collected. Collection for collection's sake defeats the goal of improved heritage resource management and adds nothing new to the understanding of a region.

Pros

Although they do not necessarily result in a new understanding of archaeological site distribution and human behaviour, models appear to have many benefits for the consulting community. The most notable is planning. Most respondents agreed that this was the primary role of predictive models. It allows a visual overview of the landscape. When dealing with large areas consultants are forced to select a sample area to survey, as the whole impact area could not possibly be addressed in the time that is allotted and a complete survey is not required by the government anyway. By increasing their ability to plan better their costs are reduced. All consultants agreed that cost held the greatest weight for decisions about sampling and procedures. Therefore, any tool that can make the survey more efficient will reduce cost for a project. Because consulting operates as a business and is not supplemented by grants, they must bear in mind that they are ultimately providing a service to customers and the larger public. As with any business there is competition for clientele. Several consultants place a bid for a project, which includes a budget for the estimated cost of the project. Therefore, a smaller project budget is likely to win the bidding process. Budgets submitted with the bids are usually close to the actual costs. However, there are instances when archaeologists find something unexpected that can increase the cost of a project. While some clients will agree to budget changes, others may not. In this situation models enable a more accurate prediction of the overall potential of the area allowing the archaeologist to better adhere to their initial estimates. Planning and cost reduction were the most important aspects of models for consultants.

The second positive element to creating predictive models for projects is that GIS provides a common language. The oil and gas industry uses GIS and most of their maps are in a GIS or digital format. By using the same format as the client, transfer of information is easier. In this way consultants can promote understanding of the basic concepts behind the survey methods, making models an effective means to communicate or teach the client the survey process as it presents a visual idea about archaeology. It can also serve as a teaching tool for new archaeologists or consultants who are unfamiliar with the area. By having a visual representation of the difference between high and low potential areas, an individual can see how the landscape is divided and which areas will require more intensive survey.

Another positive aspect of predictive models is that they are "expert" designed, meaning that the models used in this region have been planned by individuals who have experience surveying in this area. Attributes that are important when doing the fieldwork are incorporated into the model, such as proximity to water. This is why some of the respondents felt that their survey strategy remains the same. Even though consultants are aware that sites exist in low potential areas, due to statutorial and financial limitations they continue to survey areas where they expect to find sites.

It is important to note that models designed for forestry in Alberta are showing certain flexibility that is lacking in oil and gas models (Gibson pers. comm. 2003). Compared to the mass destruction of the land incurred by oil and gas companies, forestry companies must protect their livelihood and thus the landscape around it. To do this, many forestry companies have 100 year (or longer) plans designed to protect their resource. Long-term plans to protect heritage resources are being included in some of these plans. Therefore, models dealing with forestry cut blocks are open to improvements and likely to change as more is learned about the resource area. In addition, the forestry industry employs alternative methods of harvesting that will not impact archaeological sites, such as cutting in the winter when the ground is frozen. In the Oilsands industry, surface resources are irrelevant, instead they use the landscape once to mine the resource. Because Oilsands developments do not preserve the landscape, updating the model is futile. Oilsands models are one-time models vs. the forestry models, which are part of the overall protection of a surface resource.

Now that I have discussed some of the problems and benefits of predictive modelling in the Oilsands region I would like to offer an explanation for the current state of affairs. Why have models taken on such a role? And is there possibility for change? There are four factors that are beyond the control of consultants:

a) the nature of the boreal forest

b) nature of the technology and GIS

c) the Historical Resources Act

d) relationships between the various stakeholders surrounding CRM archaeology and archaeology in the Oilsands.

Both the nature of the boreal forest and the nature of GIS technology were discussed earlier and therefore, their impacts on modelling will be briefly summarized here. The fourth and last influential factor constitutes a large group of people with often conflicting interests, goals, and care for heritage.

The nature of the boreal forest makes predicting site distribution a difficult task. The composition of the environment makes surveying difficult, as site visibility is very poor; the majority of sites are subsurface, unlike Plains archaeology where there are often highly visible features such as tipi rings. Also, the way in which prehistoric people lived in the boreal forest is not as well known. Reliance on topographic features based on vegetation type is one of the few constraints that are reliable and consistent. These elements create a challenging environment in which to locate archaeological resources.

The nature of GIS technology is also a difficult problem to overcome. The data sets are not geared towards archaeology and the tool is limited in what it can perform. We cannot expect the technology to solve archaeological problems. GIS is a method and a tool; models are not results. The methods that employ this technology can only be as good as the data sets they are based upon. If data sets are identified as being one of the major problems then there is a danger in relying on it completely.

The manner in which people survey an area, (i.e., their survey strategies), affect the quality of the data that are collected. For example, random sampling that was done in the late 1970s did not produce a greater site inventory. This method later proved unreasonable due to its total disregard for the experience of the archaeologist. While survey strategies can be a new venue for people to experiment with new field methods they often must consider the potential loss of resources. Analogous to random sampling in the 1970s, predictive models are the new trend in CRM.

CRM often faces different problems than do academic pursuits because it is applied. CRM has a strong business element; the term "management" itself is a government and business term. CRM must not only manage the cultural resources, but consultants are in a sense managers of the relationships between industry and government policy. Their primary responsibility is not to create new knowledge but to maintain the relationships that are mandated by the Act.

Conclusion

The Oilsands region of northeastern Alberta has undergone numerous impacts as a result of intense resource developments. Impacts to the surface affect the archaeological sites that may be present. In order to manage the loss of heritage resources, numerous survey methods have been applied by archaeologists in this region. This thesis has discussed the history of methodological developments in the Oilsands since the Act was passed in 1973. When the Act was passed, the area represented an archaeological void. Therefore, at first, archaeologists only surveyed in areas of highest potential such as near water. As they began to find more and more sites, new methods were applied to the study area. For example, shovel testing became a common practice. Later, one of two survey methods (or a combination of both) were used, non-probabilistic and probabilistic, both of which were flawed in some way. Non-probabilistic methods were flawed because they were based on an individual's experience, which is highly variable and non-reproducible. To overcome this flaw, probabilistic testing was used, but it proved to be an unreasonable means of testing in the boreal forest because the method relied heavily on statistical frameworks, which ultimately failed to consider the non-random human qualities of site location. With pressure from academia and the governing agency, probabilistic testing was abandoned. Most recently, predictive models, many of which use GIS, are being used to identify areas of high potential. By limiting testing to high potential areas, less time is spent in the field and surveying costs are reduced. While this method has many benefits for the consulting industry, there are still aspects predictive modelling that could be improved.

This thesis has shown that problems exist with the development of predictive models in the Oilsands region, especially when using GIS. Most notable is the fact that models are based on a biased sample set. This was done by reviewing previous archaeological investigations and methods used in the study area. Results show that inherent problems of the predictive models used are due, in part, to circular reasoning. For example, the data sets used to create models include previous site locations. However, these site locations were found because they fit preconceived notions of where sites *should* exist, confirming notions of site location. But because no attempt was made to test areas in which sites were thought not to exist, the previous site location data is not representative. In this way, the new models developed for the Oilsands region did not critically evaluate the data they were using when constructing GIS models to predict site location. As a result, the majority of surveys in this region have concentrated on the small elevated terrain features and waterways thereby excluding all other environmental regions from the overall testing scheme. The biased site location data is then compounded with the numerous other problems that plague GIS based models.

To resolve this problem, the answer seems simple: improve the sample set by testing in areas other than high potential. However, this research has also shown that this solution is far from simple because many consultants find it difficult to incur new costs. It is not possible to require a proponent to pay for an assessment in an area where there is little potential to find sites. By reviewing the case studies and discussing these issues with consultants who work in the study area (i.e., the questionnaire), it is clear that these problems are due to a lack of time and/or money. Like probabilistic testing, it is likely that the pressure required to force the resolution of this problem must come from academia and the governing agency.

Academics remain divided on the issues of predictive modelling. There is a plethora of articles relating to problems associated with predictive modelling and the application of GIS. However, the topic persists within the academic literature and continues to be applied in many research projects. Therefore, it seems that GIS predictive modelling is a method here to stay.

It remains unclear what position the governing agency will take on the issue. Currently, ACD gives clearance to development projects based on the current standard of work being done.

As a solution to the biased site location data and other problems presented in this thesis, I suggest a two-fold solution. First, there must be a critical evaluation of the method by testing in areas other than high potential, for example by archaeologists employed by government or academia. By testing in such areas and recording the results, the sample set will become more complete. Even if a small percentage of areas other than high potential are tested, the results will contribute to the overall understanding of the sampling strategies used in the study area. Secondly, testing of areas other than high potential is possible with the use of post-impact assessments and active monitoring by archaeologists when the surface resources are cleared. Monitoring is a cost-effective way of gathering information about areas other than high potential. Often such areas are difficult to shovel test, therefore monitoring enables a quick visual reconnaissance of the area. In this way archaeologists can get a better picture of where sites in this area occur and alter future methods if they do not agree.

As oil and gas developments continue to increase in the Northern Alberta Oilsands region, more archaeological resources will be destroyed. The Alberta government predicts oil and gas development to continue at an equal or greater rate (see http://www.alberta-canada.com/oandg/pdf/oilsands_oct2003.pdf). Therefore, it is not a matter of *if* heritage resources will be destroyed; instead it is now a matter of at *what rate* they will be destroyed. As the future of our non-renewable resources looks bleak, we can only hope that we are doing the best that we can to preserve what little we have left of archaeological heritage in this province. Protection of heritage resources is possible when there is an awareness of methodological problems and a strategy to revise the methodology.

Figure 1. Map of Alberta displaying the study area

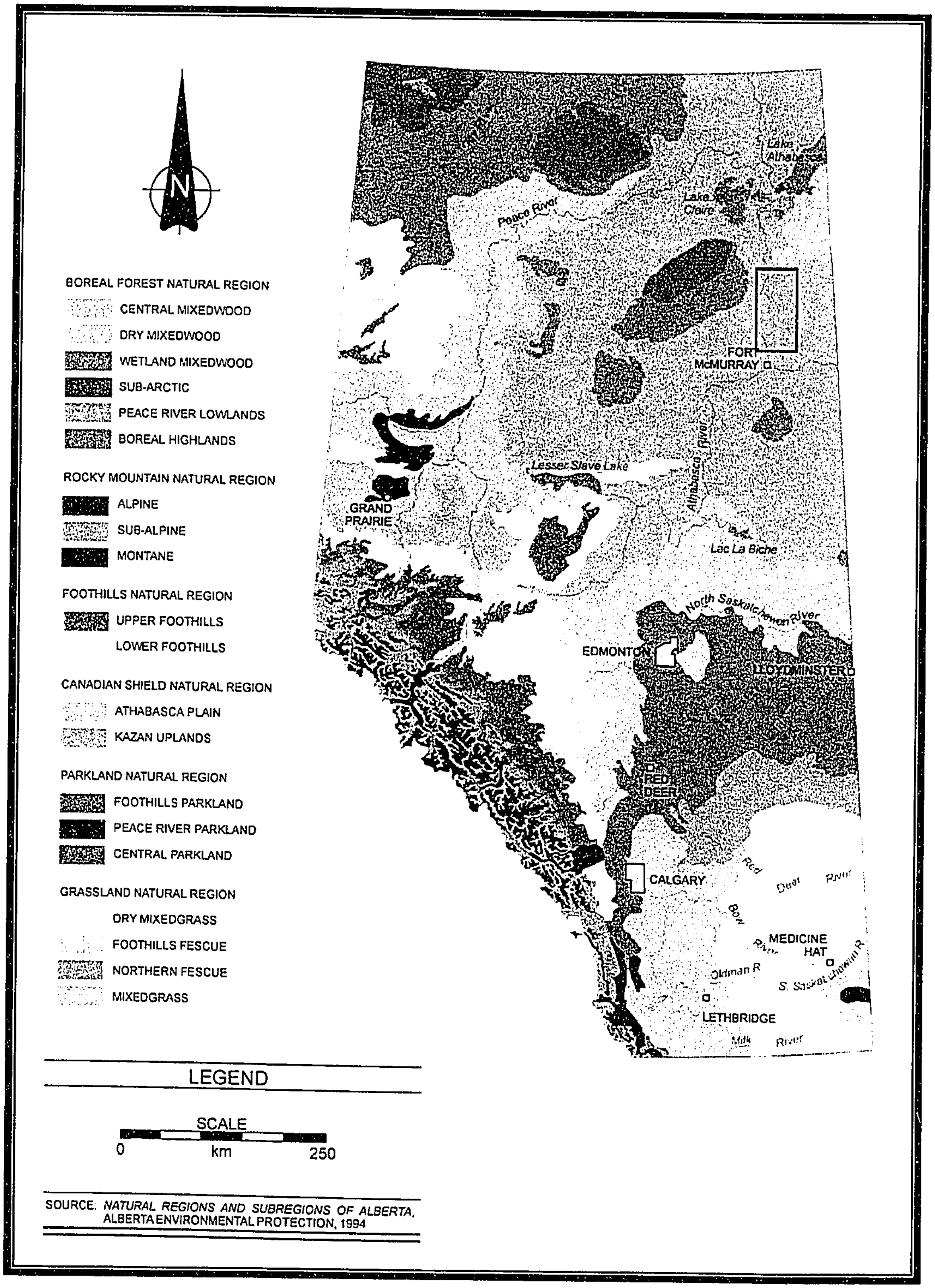


Figure 2: Map of the Oilsands lease areas (adapted from Clarke 2000).

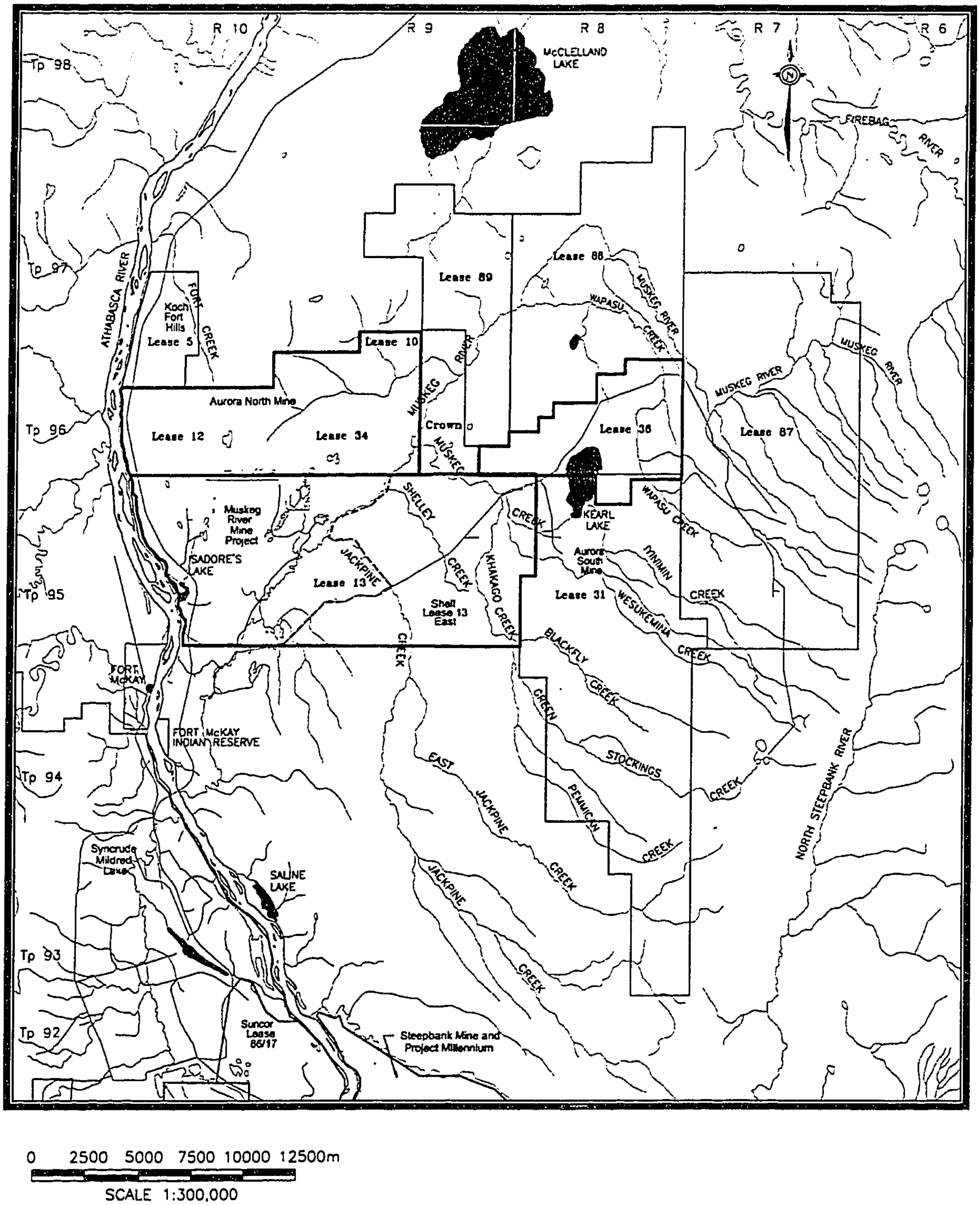
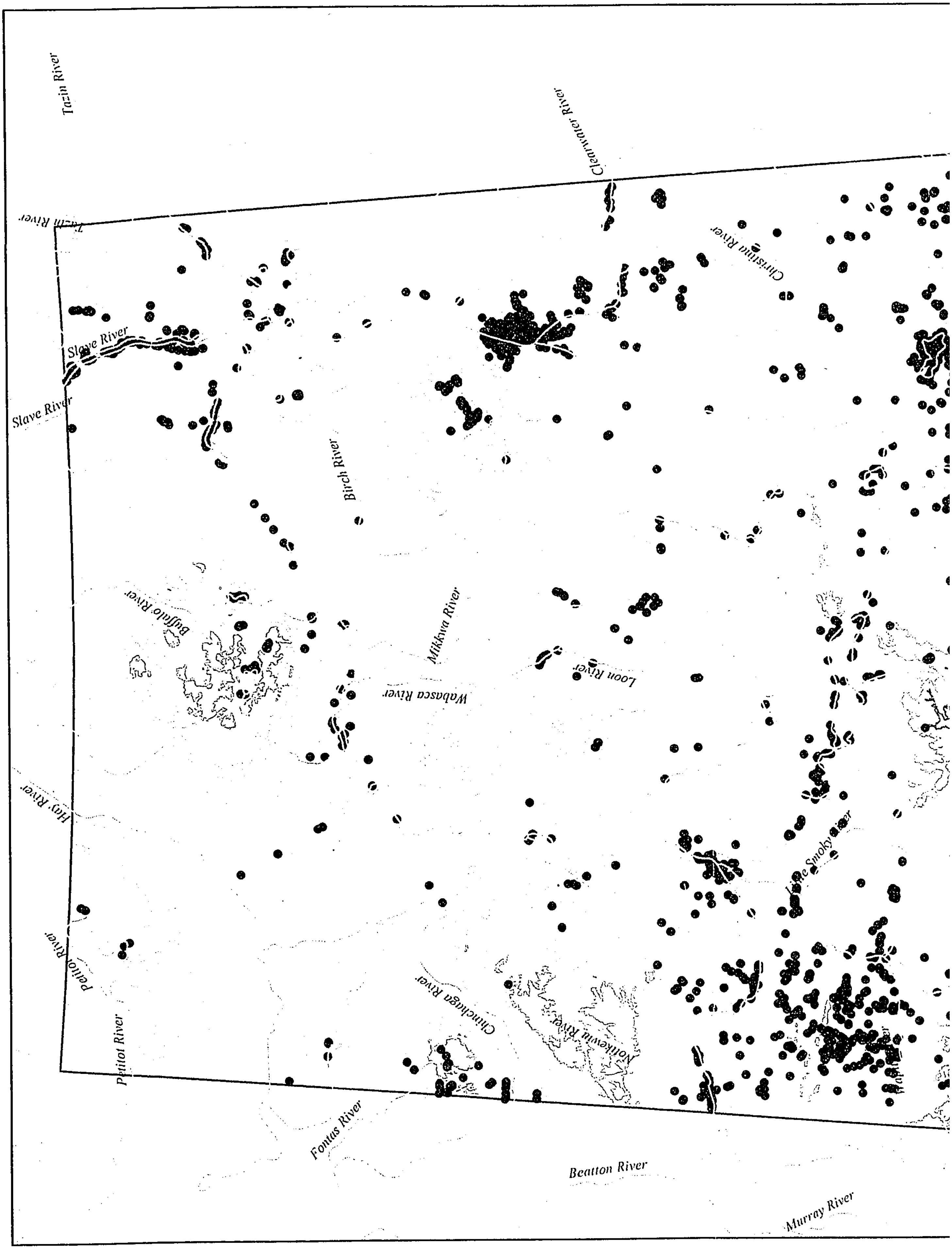
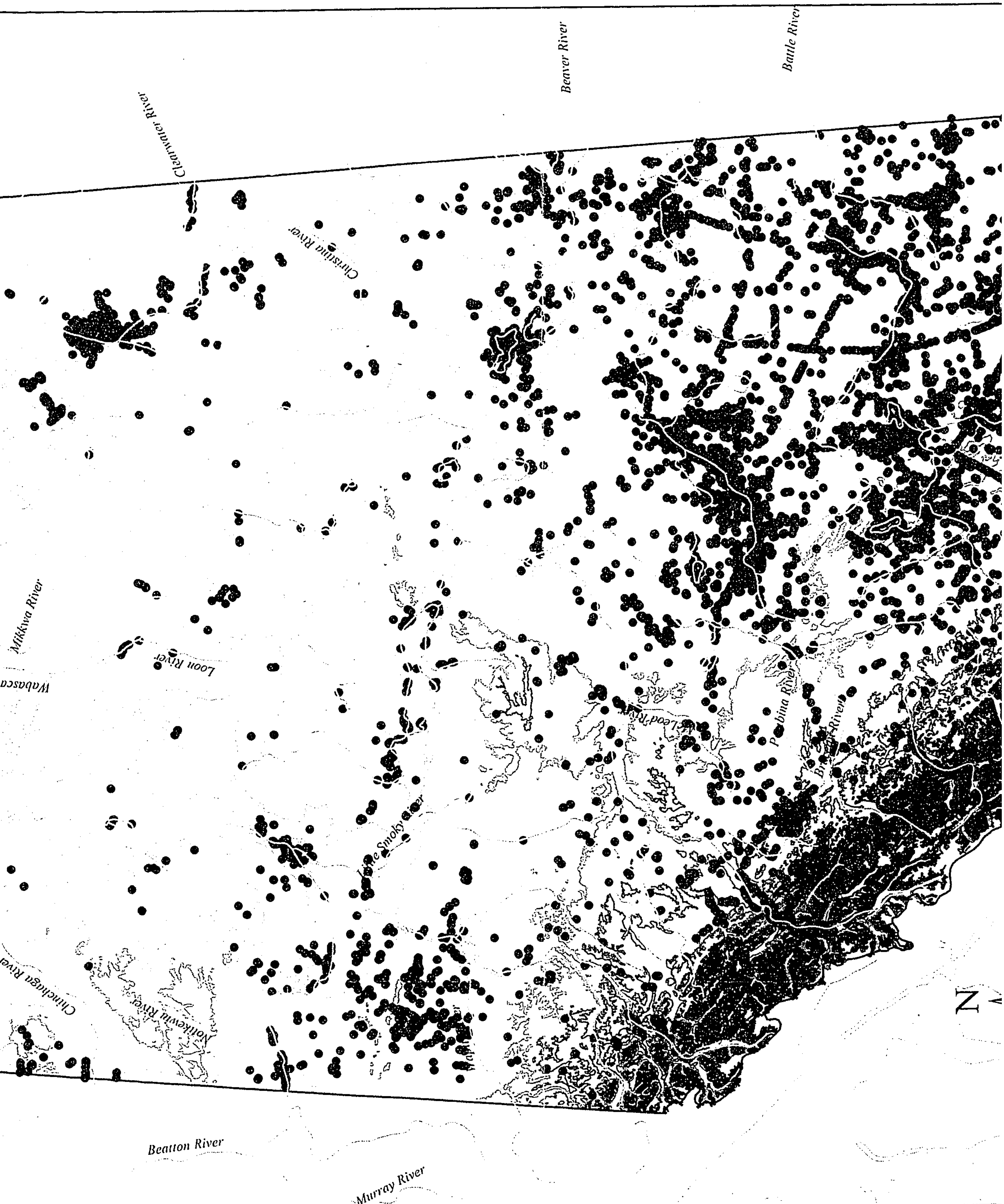


Figure 3. Map of archaeological sites in Alberta.



Tazin River
Clearwater River
Tazin River
Christina River
Slave River
Slave River
Birch River
Buffalo River
Mikkwa River
Wabasca River
Loon River
Hay River
Petitot River
Petitot River
Chinchaga River
Notikewin River
Fontas River
Beatton River
Murray River


Clearwater River
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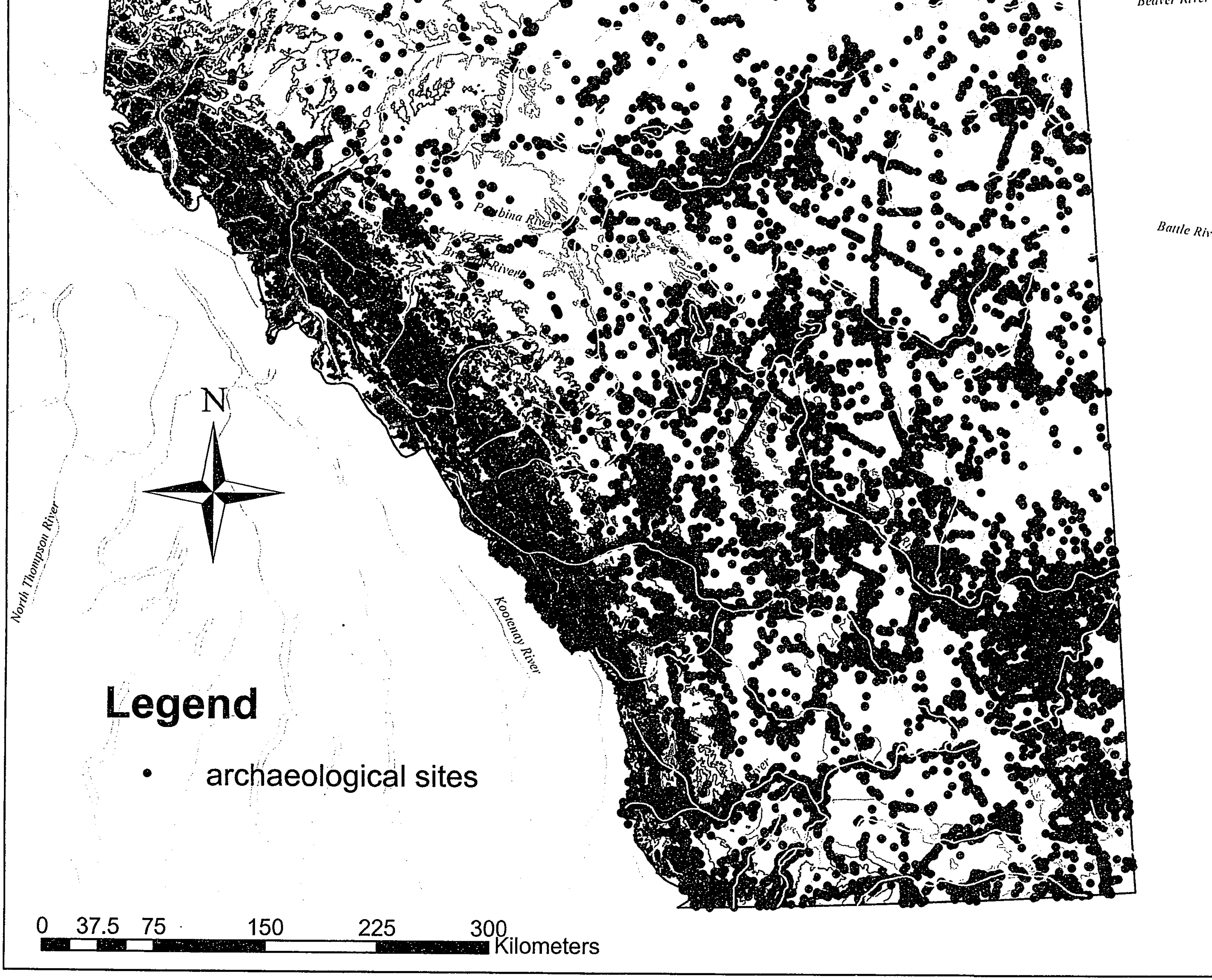
Battle River
Pembina River
Brazeau River
Kootenay River
North Thompson River
N
Legend
archaeological sites
0
37.5
75
150
225
300
Kilometers

Figure 4a. Cultural Distributions, 8,000 – 4,000 BC (adapted from Wright 1995).

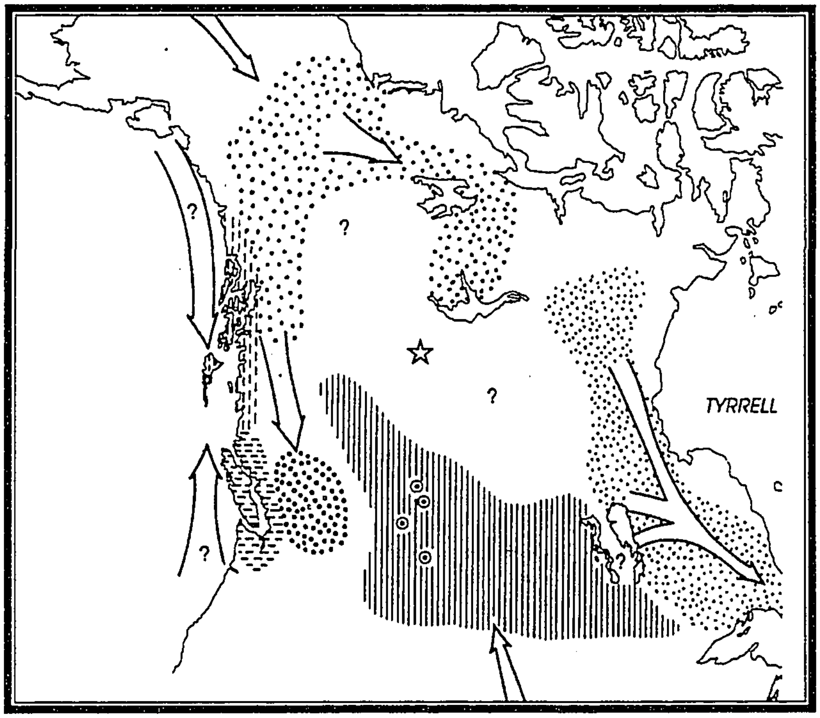

Figure 4b. Cultural Distributions, 4,000 – 1,000 BC (adapted from Wright 1995).

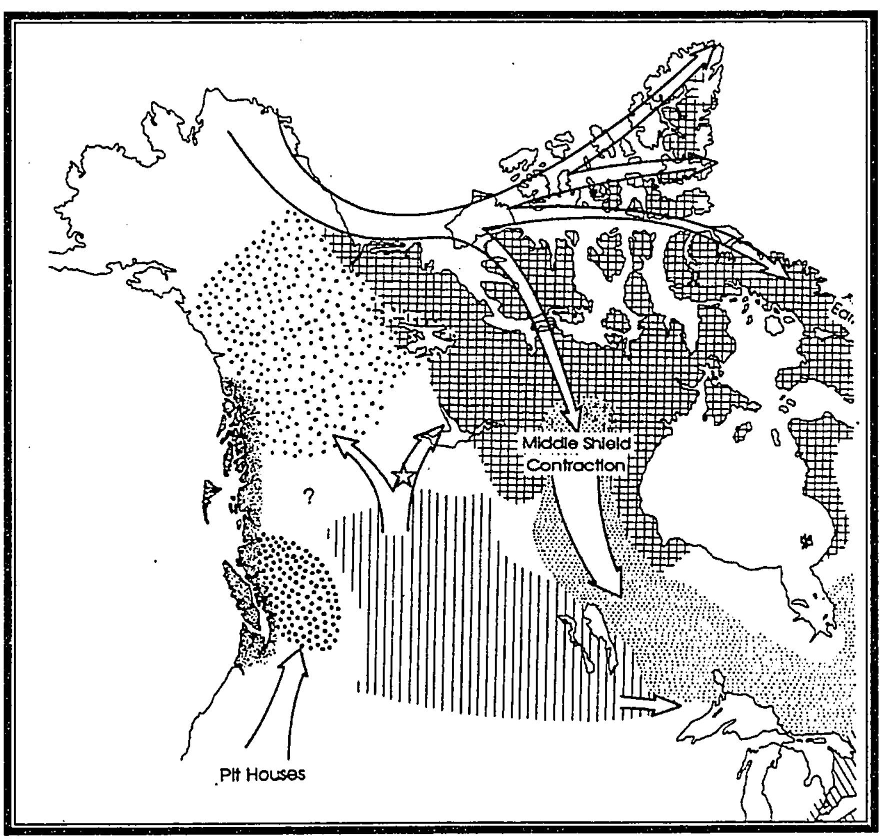

Figure 5. A flow chart illustrating the process involved to obtain clearance for a new development. At any stage of the process a development may obtain clearance, at which point the process is complete.

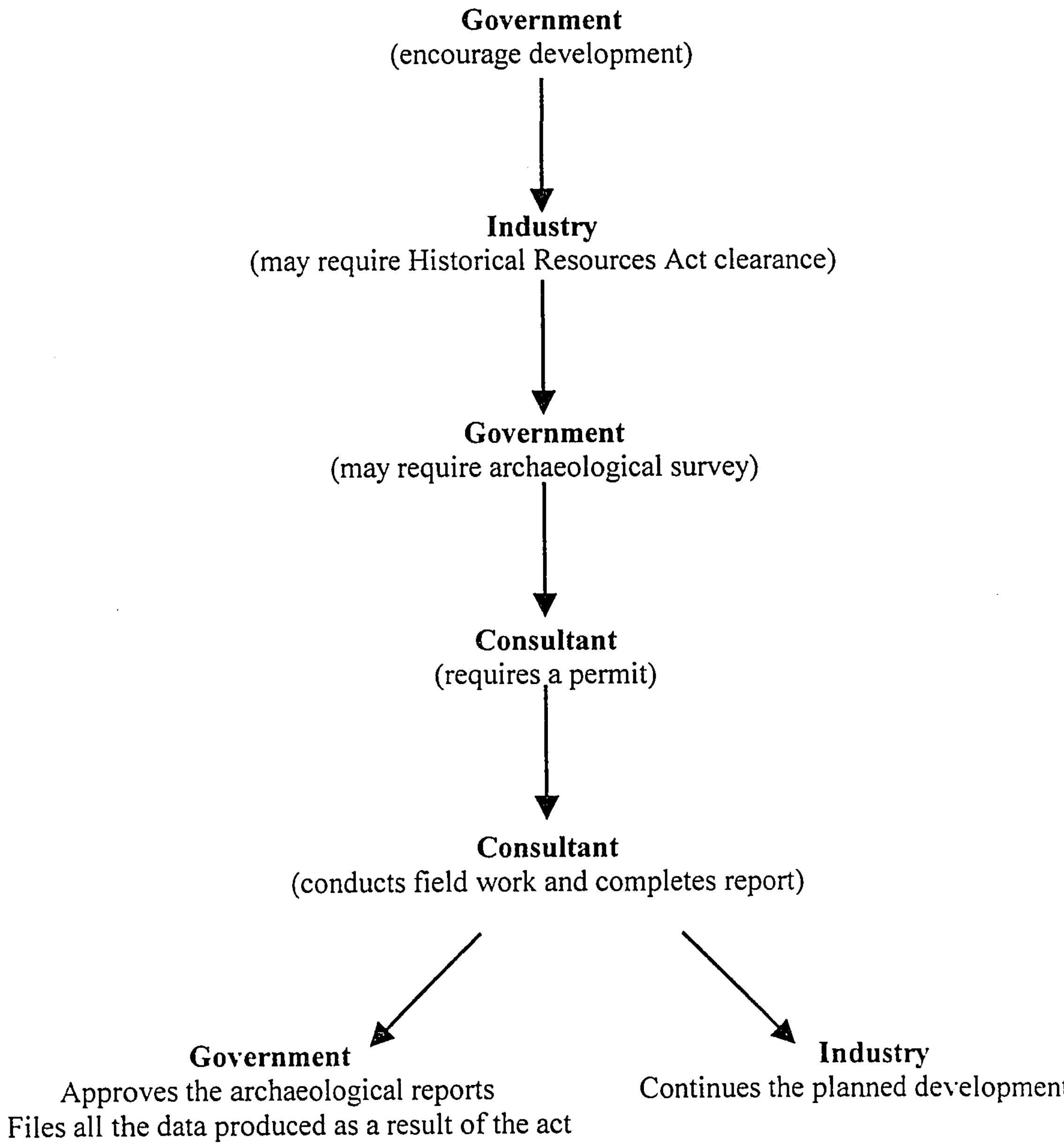

Figure 6. Map from Ronaghan (1981). Dashed lines indicate site boundaries.

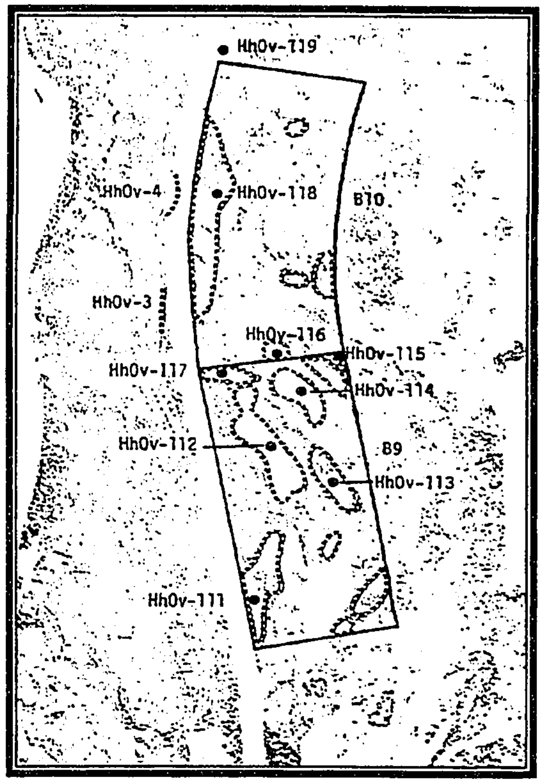

Figure 7. Map from Unfreed 2000. Yellow areas represent sites found by Ronaghan (1981) and revisited by Unfreed (2000).

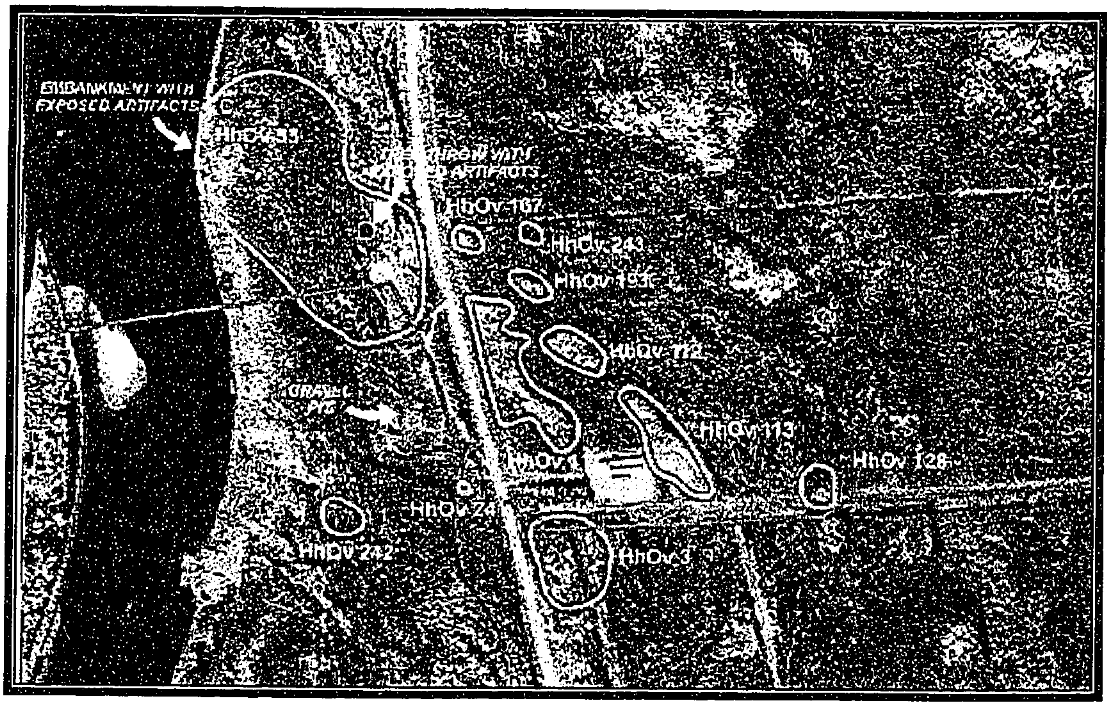

Figure 8. Photograph showing the intermittent area between topographically raised features where sites were identified by Ronaghan (1981) and Unfreed (2000). The red pin-flags represent lithic scatters (courtesy of Kowal 2001, pers. comm.

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Appendix I

Permit Number	Permit Holder	Affiliation	Project Type	# of New Sites	# of Revisits	# HSAS	Final Report Tittle	Report Authors
73-004	Losey, T.C.	self employed	oil sands	31	1		Syncrude lease no. 17, an archaeological survey	Losey, Timothy C. and Cort Sims
74-010	Losey, T.C.	self employed	roads	36			see 74-014	see 74-014
74-031	Losey, T.C.	self employed	oil sands	40	0		Archaeological investigations on Athabasca tar sands lease 13	Losey, Timothy C. and Cort Sims
74-032	Losey, T.C.	self employed	oil sands	0			The Beaver Creek site: a prehistoric stone quarry on Syncrude lease #22	Losey, Timothy C.
75-08	Donahue		Research	12	-	-	Athabasca River Survey	Donahue
75-014	Sims, C.	self employed	roads	3	0	0	An archaeological survey of certain boreal forest highway projects in northeastern Alberta, 1975	Sims, Cort
76-05	Sims, C.	self employed	Research	32	-	-	Athabasca River Survey	Sims, Cort
77-043	Reeves, B.O.K.	Lifeways	roads	30	2	14	Archaeological reconnaissance, Alberta Transportation Highway construction program transitional parkland and northeastern boreal forest	Reeves, Brian O.K. and Edward J. McCullough
77-087	Reeves, B.O.K.	Lifeways	oil sands	3		1	Historical resources impact assessment, Syncrude Canada Ltd., western portion of lease no. 17	McCullough, Edward J. and B.O.K. Reeves
78-056	Gryba, E.M.	self employed	roads	19	0		Highway archaeological survey (north), 1978: final report	Gryba, Eugene M.

78-071	McCullough, E.J.	Lifeways	roads				Conservation archaeology, Alberta Transportation highway construction program, project no. 963: final report	Head, Thomas
79-056	Conaty, G.T.	self employed	oil sands	6	0	0	Alsands lease archaeological survey final report	Conaty, Gerald T.
79-066	Gryba, E.M.	self employed	roads	0	8	8	Highway archaeological salvage projects in Alberta	Gryba, Eugene M.
79-118	Wood, W.J.	ARESCO	oil sands	1	0	0	Archaeological mitigation research project proposed Fort Hills townsite and airport : final report	Wood, William J.
79-124	Mallory, O.L.	Paleo Sciences Integrated Limited	roads		7		1979 archaeological investigations on highway project no. 963	Mallory, Oscar L.
80-091	Ronaghan, B.M.	Lifeways	oil sands	59	10		Historical resources impact assessment Fort McMurray energy corridor Fort Hills townsite and airstrip [volume 1] : final report; Historical resources impact assessment of selected portions of the Alsands Lease 13 [volume 2] : final report	Ronaghan, Brian M.
80-133	McCullough, E.J.	McCullough Consulting	oil sands	16			Historical resources inventory & assessment NOVA, Petro Canada oil sands joint venture core-hole drilling program BSL 5	McCullough, Edward J.
80-166	Losey, T.C.	self employed	roads	0	1	0	Reconnaissance and delineation of the Beaver Creek Quarry site (HgOv-29) and an historical resources impact assessment of proposed borrow pit expansion areas on highway project 963: final report	Losey, Timothy C.
81-094	McCullough, E.J.	FMA	oil sands	1	0	0	Historical resources impact assessment Canstar Oil Sands Ltd. Calumet construction camp and Athabasca River access road	McCullough, Edward J.
81-129	McCullough, E.J.	FMA	oil sands	44	0	0	Historical resources studies Canstar Oil Sands Ltd. bitumous sands leases 33, 92 and 95	McCullough, Edward J., Michael C. Wilson and C.M. Fowler

81-153	Ronaghan, B.M.	Lifeways	roads	0	1	0	Controlled surface collection of the Cree Burn Lake site (HhOv-16) Highway 963 : final report	Ronaghan, Brian M.
82-042	McCullough, E.J.	FMA	oil sands	2	0	0	Bituminous sands leases 29, 31, 32, and 78 post-clearance survey: an experimental approach	McCullough, Edward J. and C.M. Fowler
82-075	McCullough, E.J.	FMA	oil sands	1	0	0	Canstar Oil Sands Ltd. post-construction audit bituminous sand leases 38 and 39	McCullough, Edward J. and Gloria J. Fedirchuk
84-053	Van Dyke, S.G.	Lifeways	oil sands	32	1		Historical resources impact assessment Syncrude Canada Ltd. Lease No. 22	Van Dyke, Stanley and B.O.K. Reeves
86-075	Gryba, E.M.	self employed	roads; forestry	4	0		Interim Report: Fort MacKay Ranger Station and Water Pipeline, and Fort MacKay - Fort Chipewyan Winter Road HRIA	Gibson, Terrance H. and Eric Damkjar
93-045	Dau, B.J.	Ethos	roads	7	2	0	Historical resources impact assessments 1993-94 highways developments : final report	Dau, Barry J.
95-083	Balcom, R.J.	Golder	oil sands	2	0	0	Historical resources impact assessment Steepbank mine project	Balcom, Rebecca J.
96-013	Gorham, L.R.	FMA	oil sands	1	16	3	Historical resources impact assessment and monitoring Solve-Ex Corporation oil sands co-production experimental project and highway 63 extension	Gorham, L.R.
96-072	Shortt, M.W.	Lifeways	oil sands	6	3		Aurora mine north 1996 archaeological studies Cree Burn Lake and east pit - tailings	Shortt, Mack W.
96-088	Gorham, L.R.	FMA	oil sands	0	1	0	Historical resources impact mitigation Solve-Ex Corporation oil sands co-production experimental project and Highway 63 extension site HhOv 118	Gorham, L.R.
97-043	Shortt, M.W.	Lifeways	oil sands	22	19		Historical resources impact assessment Aurora Mine north highway and utility and access corridors : final report	Saxberg, Nancy and Mack W. Shortt, Brian O.K. Reeves
97-107	Ronaghan, B.M.	Golder	oil sands	16	9	0	Historical resources impact assessment for the Muskeg River Mine project	Ronaghan, Brian M.
97-116	Shortt, M.W.	Lifeways	oil sands	16	2		Aurora Mine North east pit opening, plant site, tailings, and related workings HRIA and mitigation studies : final report	Shortt, Mack W. and Nacy Saxberg and Brian O.K. Reeves

98-040	Saxberg, N.J.	Lifeways	oil sands		7			
98-096	Fedirchuk, G.J.	FMA	oil sands	3	0	0	Historical resources overview Gulf Canada Resources Ltd. Surmont Lease : final report	Fedirchuk, Gloria J.
98-145	Clarke, G.M.	Golder	oil sands	14	0	0	Historical resources impact assessment Mobil Lease 36	Clarke, Grant M.
99-024	Saxberg, N.J.	Lifeways	oil sands	17	4			
99-053	Amundson, L.J.	Stantec	roads		1		Historical resource inventory and assessment of the Cree Burn Lake site (HhOv-16) adjacent to Highway 63	Amundson, Leslie J. and Charles Ramsay
99-073	Clarke, G.M.	Golder	oil sands	17	8			
00-045	Kowal, W.A.	Altamira	roads	2	1	1	Historical resources impact assessment proposed Secondary Highway 628 (79 Avenue) from west of Golden Spike Road to junction of Highway 60	Kowal, Walter A. and Bruce F. Ball
00-087	Clarke, G.M.	Golder	oil sands	5	23			
00-130	Unfreed, W.J.	FMA	oil sands	80	16	15	Historical resources impact assessment TrueNorth Energy L.P. Fort Hills Oil Sands Project: final report	Unfreed, Wendy J., Gloria J. Fedirchuk and Eugene M. Gryba
00-136	Green, D.C.	Golder	oil sands	5	0	3	Historical resources impact assessment OPTI Long Lake project	Green, D'Arcy C.
00-175	Ball, B.F.	Altamira	roads	24	16		Historical resources impact assessment proposed Highway 63:14 upgrade Athabasca River crossing to km 10: final report	Ball, Bruce F. and Walter A. Kowal
01-072	Ball, B.F.	Altamira	roads	1	1			
01-073	Ball, B.F.	Altamira	roads		1			
01-074	Ball, B.F.	Altamira	roads	3	15			
01-094	Ball, B.F.	Altamira	roads		5			
01-110	Ball, B.F.	Altamira	roads		1			
01-146	Ball, B.F.	Altamira	roads		6			
01-202	Green, D.C.	Golder	oil sands	7			Historical resources impact assessment Petro-Canada Meadow Creek project archaeological research permit 2001-202 (ASA 01-202)	Green, D'Arcy C.

01-228	Gryba, E.M.	FMA	oil sands	13	1	0	Supplemental historical resources impact assessment TrueNorth Energy L.P. Fort Hills oil sands project (eastern half of Lease 52, Twp 97, Rges 10-11, W4M): final report	Gryba, Eugene M., Wendy J. Unfreed and A. Kate Peach
01-230	Clarke, G.M.	Golder	oil sands	13	4	0	Historical resources impact assessment for Jackpine Mine - Phase I: final report	Clarke, Grant M.
01-248	Clarke, G.M.	Golder	oil sands	36	20		Historical resources impact assessment Canadian Natural Resources Limited Project Horizon: final report	Clarke, Grant M.
01-315	Gryba, E.M.	FMA	oil sands	0	11	0	Historical resources impact mitigation and interim avoidance measures TrueNorth Energy L.P. Fort Hills Oil Sands Project (selected sites in leases 5 and 52; Twps 96-97, Rge 10, W4M)	Gryba, Eugene M. and Wendy J. Unfreed
02-140	Saxberg, N.J.	Lifeways	oil sands	61	1	1	Syncrude Canada Ltd. Aurora Mine North historical resources impact assessment 2002 field studies: final report	Saxberg, Nancy J., Brad Somer and Brian O.K. Reeves
02-143	Tischer, J.C.	FMA	oil sands	1	18			
02-148	Clarke, G.M.	Golder	oil sands	1				
02-163	Tischer, J.C.	FMA	oil sands	1	0	0	Historical resources impact assessment ConocoPhillips Canada Resources Corp. Surmont in-situ oil sands project phase 1 stage 1: final report	Tischer, Jennifer C.
02-179	Green, D.C.	Golder	oil sands	1	0	0	Historical resources impact assessment for Suncor Energy Ltd. south tailings point project: final report	Green, D'Arcy C.
03-145	Tischer, J.C.	FMA	oil sands	2	0	0	Historical resources impact assessment ConocoPhillips Canada Resources Corp. Surmont in-situ oil sands project: final report	Tischer, Jennifer C.
03-244	Bouchet-Bert, L.	Golder	oil sands	1	1			
03-269	Bryant, L.	Golder	oil sands					
03-279	Saxberg, N.J.	Lifeways	oil sands					

Appendix II

4500 Archaeological Permits Since 1973

(Figure courtesy of Alberta Community Development)