Archaeological Overview of Northeastern British Columbia: Year Two Report

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The Blueberry River First Nations
The West Moberly First Nations
The Doig River First Nation
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Management Summary

In year two of a five year study of archaeological predictive modelling in NE BC, a number of major tasks were accomplished. An analysis was completed of data gaps in the study area, which allowed for targeted field survey. The principal data gaps identified were a lack of survey near large and medium sized lakes and near double line rivers, and a general lack of sites and survey in the northern part of the study area.

Field survey took place on a series of mapsheets identified using data gap analysis. As well as archaeological observation, field survey also gathered specific information about higher potential landforms, through observation and recording of terrain, slope, vegetation cover, and field-assessed archaeological potential. This data was used in a variety of analyses later. Some 53,000 metres of survey were conducted in the Fort Nelson Lowlands and Etsho Plateau, with the assistance of Fort Nelson and Prophet River First Nations. Almost 700 shovel tests were conducted. Only three sites were found in this large area.

The number of non-site negative data "survey" points was virtually doubled compared to the first year, through mapping archaeologically surveyed pipelines, wellsite and ancilliary developments reported by consultants in the last year, and through new targeted field survey. Some 210 consultants reports were reviewed for survey coverage information.

TRIM II Orthophotos with a resolution of 1m were obtained for many of the mapsheets that contain archaeological sites. Orthophotos were used as a backdrop to examine the accuracy of various archaeological site GIS data sets, including the sites mapped during the first year of this project, updated Archaeology and Forestry Branch, and Archaeological Site Awareness Program sites. Substantial errors were found in all data sets, with the orthophotos often allowing extremely precise site location corrections. Over 120 new sites were recorded in the provincial inventory in this last year. More than 400 sites have been "orthocorrected" to date. These precisely corrected site locations will provide data for various model building tasks and increase the precision of the model.

Modelling proceeded through several preliminary models to the one presented in this report. This model is quite successful at identifying high potential areas: almost 40% of known sites are modelled in less than 8% of the area. About half the area is in low potential, with about 13% of the known sites also in this zone. A large segment of moderate potential comprises the remainder. The present model has no terrain variables, and these provide the greatest potential for improving the model.

Five different methods were explored to identify the minor topographic features that are strongly associated with archaeological sites. These methods included: review of archaeological site inventory form descriptions of landform; use of the VIP ArcInfo command to identify hilltops, ridges, and terrace edges; digitizing by hand areas of higher potential using orthophotos; use of image analysis software to identify these areas from orthophotos; and using a new method to identify landforms from the TRIM digital elevation model. We anticipate implementing the last two methods in the next round of model building.

Acknowledgements

Numerous individuals have assisted with the development and refinement of the Year Two deliverables for the NE BC Archaeological Overview. These include:

Bob Powell, Senior Policy Advisor, Aboriginal Relations Branch, Ministry of Energy and Mines, who took over project co-ordination early in its second year;

Tom Ouellette, Director of Aboriginal Relations and Land Use, and Vera Brandzin, Heritage Conservation Program Manager, at the Oil and Gas Commission (OGC) offices in Fort St. John. Grant Fox, GIS Coordinator, provided digital wellsite and pipeline data used in our previous survey mapping;

Ken Barth of the Fort Nelson First Nation and Orest Curniski of the Prophet River First Nation arranged for field assistants. Orest Curniski and Council Members of the Prophet River First Nation met with fieldcrew members prior to fieldwork to discuss general project issues and field approach;

James Pike, Planning and Assessment, Archaeology & Forests Branch of the Ministry of Sustainable Resource Management is our Project Officer; Chris Spicer, Senior Business Analyst, Business Application Services, who assisted with our acquisition of ortho-photos used for site corrections, and Ian Whitbread, and John McMurch, Inventory and Mapping, who provided site information from the Provincial Heritage Registry Database, the main archaeology site database for the province;

Doug Glaum, director of the Archaeology Site Awareness Project, provided site location data for portions of the study area. Thanks to Margaret Rogers for organising the transfer of data.

Romi Casper at the Heritage Resource Centre of the Ministry of Community, Aboriginal and Women's Services provided access to catalogued and uncatalogued reports.

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Introduction

This report presents the second year results for the NE BC Archaeological Overview Assessment. Millennia Research was awarded the five-year contract by the Ministry of Energy and Mines (MEM) to complete an AOA in northeastern BC for the MEM and the BC Oil and Gas Commission (OGC). Millennia Research has partnered with Timberline Forest Inventory Consultants, who provide Geographic Information System (GIS) support, and with Big Pine Heritage Consulting and Research Ltd, as our study area specialists.

The Year One report for the AOA outlined the general project scope and objectives as provided in the BC Archaeological Impact Assessment Guidelines and the project Request for Proposals. In general terms, the project is intended to produce an archaeological potential model which will assist MEM and OGC managers in identifying archaeological resources during operational planning and minimising adverse impacts.

The NE BC AOA covers a continuous area defined by the following map sheets in the National Topographic Survey 1:250,000 grid: 94O, 94P, 94J, 94I, 94H, the eastern half of 94G, and the northern half of 94A (see Figure 1). This area is bounded to the north by British Columbia's border with the District of Mackenzie, Northwest Territories, and to the east by the border with Alberta. It is approximately 380 km from north to south, and between 120 and 230 km east to west, close to 78,000 square kilometres in area. It encompasses 372 Borden blocks, and includes parts of the Fort Nelson and Fort St. John Forest Districts.

This report spans the period of April 1, 2001 to March 31, 2002. The report outlines the Year 2 objectives, presents a general overview of predictive model development, summarizes data gaps identified in the previous year's data, meetings with First Nations and other consultants, survey coverage mapping, site checks, trail and palaeo site research, and our approach to the identification of topographic features, it includes a discussion of initial model development, and presents fieldwork results. The final section of the report outlines areas of further research and model refinement to be undertaken in the third year of the project.

Project Review Committee

Overall project direction is the responsibility of the Project Review Committee. The current Committee consists of Bob Powell (MEM), Tom Ouellette (OGC), James Pike (Archaeology and Forests Branch), Mary Viszlai-Beale (Ft. Nelson Forest District), and Dr. Quentin Mackie (University of Victoria).

General Approach

The general approach to the development of the NE AOA potential model is to combine existing archaeological site and survey data, social, environment, and landform data in GIS format, analysis of data gaps, field survey to address data gaps, and iterative model building. We are trying to obtain a representative body of previous survey coverage, rather than trying to be exhaustive, and generally directing time and funds towards activities that will result in the "biggest bang for the buck". This said, some of the data sets are critical to the production of an accurate model. Computerised modelling will always produce a product, which might seem very good superficially, but we want to avoid the "garbage in, garbage out" syndrome. For this reason, we have been meticulous in correcting known site locations, since this is so important to the final product.

Year Two Objectives

The Terms of Reference (TOR) identified specific tasks for each of the five years of the project.

Year Two tasks include:

- Fieldwork
- Mapping of newly recorded archaeological sites
- Inventory of new archaeological survey data
- Testing and refinement of model
- Reporting

Glossary

An AOA report can be laden with terminology not familiar to those outside the discipline. Inclusion of technical language relating to complex computer-generated predictive models can further distance readers. It is hoped that the glossary of terms included as Appendix 1 will provide a quick reference to aid in interpreting and understanding this report and the processes and research upon which it is based.

Consultation with Other Consultants

On July 3, 2001, Pete Dady (representing Millennia Research) met with Remi Farvaque, Bruce Dahlstrom, Chris Bezant and Sean Moffett of Big Pine about the upcoming fieldwork. Additionally, he made several attempts to meet with Keary Walde of Heritage North Consulting Ltd., to no avail. Copies of the first year's report were hand-delivered to both Big Pine and Heritage North.

D'Ann Owens met with Tara Mather of Heritage North on October 15, 2001 to provide an update on the progress of the AOA and discuss upcoming fieldwork.

Discussions with First Nations

Attempts were made to meet with the representatives of several First Nations. A meeting was held with Orest Curniski (Prophet River First Nation) on July 3, 2001. Several phone calls and faxes were exchanged with Howard Southwell (Blueberry River First Nation), but due to logistical problems there was not a meeting. Dolly Apsassin, of the Doig River First Nation, declined a meeting.

A pre-field meeting was held with Orest Curniski and some members of the Prophet River First Nation on October 15, 2001. The overall project budget and its office-to-field dollar and time ratios were discussed. Concern was expressed by Council members that the project was run from Victoria, with little local involvement, and that the product might resemble recently completed, large scale overviews with little to no fieldwork, very limited reporting, and little opportunity for First Nation involvement. The involvement of Big Pine Heritage as the area specialists, field participation of members of Prophet River and Ft. Nelson First Nations, and the estimate ratio of field days and costs to office time were discussed.

Predictive Model Development

Certain factors such as the availability of food and drinking water are assumed to be important to the choices people make about where to establish camps, hunting sites, villages, and most other site types. An archaeological predictive model works by analysing the location of known sites compared to areas known to not have sites. Features of the landscape are used for this comparison. Most predictive models use mapped information available through geographic information systems (GIS) to analyse this information.

Introduction

Predictive modelling has developed as a sub-discipline of archaeology over the last two decades. Modelling now is used primarily as a management device (e.g., Altschul 1990, Bergerud 1996, Brandt, et al. 1992, Dalla Bona 2000, Ebert 2000, Kohler 1985, Kohler 1986, Warren 1990, Wescott and Brandon 2000), but also as a research tool (e.g., Fedje and Christensen 1999, Sydoriak Allen 2000). Predictive models are very useful tools for heritage resource management. For instance, choices between alternative pipeline routes can be made to minimize the lengths of routes in high potential zones. This can save large amounts of money by reducing the amount of field inventory and impact assessment work, and reducing the chance of disturbing highly significant archaeological remains which are expensive to mitigate.

The largest and most sophisticated archaeological modelling project to date has been the MN/Model project in Minnesota (Hudak, et al. 2001b). An area several times the size of the NE study area was modelled over a six year period, with a budget of US$4.5 million. The model has already saved more money in reduced archaeological survey and mitigation costs than it cost to develop, saving about US$3 million per year to the state's Department of Transport (http://www.mnmodel.dot.state.mn.us/pages/history.html). Mn/Model, following the example of previous modelling efforts, is based on the assumption that the most important factors controlling precontact hunter-gatherer settlement and activity location decisions were physical and biotic attributes of the landscape. The Mn/Model project's goal was to develop models with a minimum Kvamme's gain statistic of 0.61. Kvamme's Gain is a simple formula, 1 – (% area/%sites) (Hobbs, et al. 2001, Wescott and Kuiper 2000). This means no more than 33 percent of the landscape is classified as high and medium potential, and at least 85 percent of the known sites are correctly predicted (Gibbon and Hobbs 2001). This goal was exceeded by the final Mn/Model.

In Canada, large-area modelling has been conducted in Northern Ontario (Dalla Bona 2000) and for many forest districts in BC (e.g., Arcas Consulting Archeologists Ltd 1998, Eldridge 1999, Golder Associates Ltd., et al. 1998, Lindberg and Moyer 1999). In BC, much modelling has been deductive (e.g. Klassen 1998), using ethnographic information and intuitive/experienced-based site location patterning to determine the most likely combination variables that would fit a particular precontact activity. Millennia's methods have stressed inductive modelling using univariate and multivariate analysis to determine differences in the distribution of sites to non-sites, with empirical testing of the results. Outside BC, most modelling has used a variety of multivariate statistical analyses, particularly multiple logistic regression, though multiple discriminant analysis, maximum distance classifiers, quadratic classification procedures, and maximum likelihood distance classification techniques also are used (Gibbon 2001).

NE Model building used techniques and approaches developed by Millennia Research Limited over the last ten years (Eldridge and Mackie 1993). There are many similarities between the Millennia approach and the Mn/Model and Northern Ontario projects. These include an equal emphasis on negative data (non-sites) derived from high-quality field survey methods, error-checking site location accuracy, and the use of Kvamme's Gain statistic to empirically measure the performance of models. However, several differences exist between the Millennia model development system and that of projects such as Mn/Model. The NE project has included site boundary polygon digitising, which was desired by the Mn/Model developers, but remains to be done there (Gibbon and Hobbs 2001). We also have the use of 1m resolution digital orthophotos for both site location corrections and remote sensing, a tremendously valuable data source not used in other modelling projects. The Mn/Model project did extensive geological mapping to identify areas where archaeological sites might occur that were deeply buried by Holocene geological processes (Hudak, et al. 2001a); this is not expected to be a major factor in the generally shallow soils of the NE study area.

The biggest single difference between most other sophisticated modelling projects and the current NE project is Millennia's use of simple desktop database applications to build the model. The data is obtained using GIS, but it is the associated generated database that is used for further analysis and modelling. Using logistic regression, either in ArcInfo Grid or in a statistical program such as S-Plus (Hobbs, et al. 2001), building a new model is computationally complex and relatively slow. Because the Millennia method uses a very large random sample of the entire study area ("Grid" points) rather than the entire map area, models can be run in minutes, rather than hours or days of GIS processing time. The model can be 'tweaked' in a new iteration with new variable weightings, filter conditions, or archaeological potential 'cutpoints' and the results evaluated almost immediately. This results in rapid model development. The speed also allows for intuition to play a role in model development. When a model has reached a stage where iterative model improvement is negligible, the database code is translated into ArcInfo AML code, and the model run on the GIS program. Plot images or hard-copy plots are then examined and critiqued.

In other areas of BC, this modelling approach has resulted in some powerful and precise models: for instance, in Ditidaht territory, 91.6 % of CMT sites were modelled in 16.6% of the land with older forests, a excellent Kvamme gain of 0.818.

The following sections provide a summary of the limitations and assumptions of predictive models, the nature of information used in developing a predictive model, the goals of a predictive model and how models should be used once they have been applied.

Assumptions and Limitations of Predictive Modelling

- The basic assumption underlying predictive modelling in archaeology is that human behaviour in the past shows regularities; that people did not wander randomly about the land but that they moved in an organised and planned fashion.

- Certain environmental factors such as availability of drinking water, food, and fuel influenced where people decided to live, camp, etc.

- Given the above, archaeological remains will be distributed in a predictable pattern; most sites will be located within or near economic resources.

- If a model is developed using GIS software (as this one is) the model must use information which is or can be mapped. Most predictive models give preference to environmental data because the location of streams, lakes, plant resources, etc. can be mapped.

- People who used small sites only once or very infrequently would not need as many resources as they would if living in larger settlements. Because of the large scale of the mapped data used in GIS modelling, small pockets of important resources, small bodies of drinkable water, and small areas of dry, level ground, that people could have camped on or used may not be mapped. As a result, sites may be situated in areas mapped as low potential.

- Almost all of the digital map products available to archaeologists are descriptions of current land patterns, but the landscape and climate have changed considerably in the past. Model development should consider changes in the environment through time.

Nature of the Data used for Modelling

For a model to be effective in identifying areas that probably contain archaeological remains, it must also identify areas with a low likelihood of archaeological deposits. To meet both these aims, three types of points are required:

- sites (positive data),

- survey or non-sites (areas that have been surveyed by archaeologists and are known not to have sites - negative or nil data), and

- randomly but evenly spaced points across the entire region (grid data).

Relationships between these datasets and mapped variables are investigated using "Near-to" and "Identity" analyses. "Near-to analysis" measures the distance from a point to features such as a large lake. "Identity analysis" identifies whether the point is located in the lake or on land. In this example, the large lake is what is known as a variable; variables can be environmental, geographical, or cultural. These analyses are repeated for each point in each of the three types of points noted above. If analysis of the resulting data reveals that sites tend to be closer than non-sites, it can be said that the *known* sites are non-randomly distributed in relation to the large lake. For this reason it is important that sites are accurately mapped.

GIS can gather data on many variables useful for model development such as forest cover, biogeoclimatic zone, distance to water, distance to lakes with fish, distance to streams with fish, aspect (the direction the site faces), and wildlife capability. Other important variables are identified through a review of ethnographic information, such as TUS, and oral histories.

These sources can also suggest the importance of individual variables in determining site location. Finally, trail locations can be digitally traced so that they too can be considered in model development.

Model Development

Once the relationships between sites, non-sites (survey points), grid points, and model variables is analysed this understanding is applied the study area. Areas similar to those with known sites are rated as high potential, and areas similar to those with no known sites are rated as low potential. Areas in-between are rated as moderate. The goal of any predictive model should be to maximise the number of known and unrecorded sites in areas of high potential and to minimise the number of sites found in areas of low potential. At the same time, the model should strive to be precise by maximising the total land area in the category of low potential and minimise the total land area in high potential.

Data Used in Analysis

The NE AOA model was based on data collected in Year 1 of the project, since the orthophotos needed to correct site locations were received too late for incorporation of revised data. New near-to and identity analysis will allow for further model development in early Year 3. The data obtained for analysis for the NE AOA model was based on the following mapped sources:

- TRIM (Terrain and Resources Information Mapping), at 1:20,000 scale, provided the base mapping layer. Included were water bodies, wetlands, slope and aspect derived from a DEM, the road system, and features such as rapids, eskers and waterfalls;
- Aboriginal trail data (see Trails Mapping);
- Digital forest cover data and forest development plans from Ft. Nelson Forest District and Ft. St. John Forest District at 1:20,000;
- Known archaeological sites, obtained from the Provincial Heritage Register Database (PHRD) and the Archaeological Site Awareness Program (ASAP), checked for accuracy using original site inventory forms;
- Previously surveyed areas as indicated in AIA and reconnaissance reports.
- Wellsite and pipeline digital data to identify the location of previously surveyed area as indicated in AIA and reconnaissance reports.

Geographical information was gathered by plotting the following in GIS format:

- Archaeological site locations as points or polygons, with polygons translated to a point every 30 m around the perimeter;
- A grid of points spaced 100 meters apart on linear surveys such as roads and pipelines, 100 meters apart on areal survey such as ancillary developments and cutblocks, and covering all surveyed areas which were further than 200 meters from any site; and

- A grid of points spaced 2 km apart covering the entire study area.

The gathering of this data provided, respectively:

- Site or positive data: known locations of archaeological sites coded by type (CMT, lithic scatter, burial site, etc);
- Survey or negative data: surveyed areas where sites or CMTs are known to be absent (non-sites); and
- Grid point or random data: a random sample of points reflecting the general geographic features of the study area.

Variables

Although many of the features used in identity and near-to analysis reflect known archaeological correlates, many simply reflect available GIS data. In order to discover previously unknown relationships, a large number of variables was considered for the NE AOA (Table 1). Most distance measurements were limited to 2000 meters from the site, non-site, or grid point to limit GIS processing time. It was assumed at the outset that most environmental features would not influence site location at great distances.

Table 1. Variables for Year 2 model.

Field	Field Name	Type	Comment
1	REC_NUM	Character	Borden Number, overall unique indentifier
2	SURV_NUM	Character	Survey Number, unique ID for survey points
3	GRID_NUM	Numeric	Grid Number, unique ID for grid points
4	TYPE	Character	Type, Archaeological site, Survey or Grid
5	EXPECT	Numeric	Potential Value assigned by model
6	EXP_CLASS	Character	Potential Class assigned by model
7	BGC_ZONE	Character	Biogeoclimatic zone
8	SUBZONE	Character	Biogeoclimatic subzone
9	ECO_SEC	Character	Ecosection
10	ECOTONE	Numeric	Distance in metres to a BGC subzone boundary
11	TBRLN	Numeric	Distance in metres to alpine timberline (forest cover mapping)
12	ESKERS	Numeric	Distance in metres to an esker
13	TRAILS	Numeric	Distance in metres to a trail
14	LAKEVS	Numeric	Distance in metres to a very small lake
15	LAKESM	Numeric	Distance in metres to a small lake
16	LAKEMED	Numeric	Distance in metres to a medium lake
17	LAKELG	Numeric	Distance in metres to a large lake
18	RV_DBL	Numeric	Distance in metres to a double line river
19	IN_LKRV	Character	Located in a lake or a double line river
20	RV_INT	Numeric	Distance in metres to an intermittent river
21	RV_SGL	Numeric	Distance in metres to a single line river
22	WETLG	Numeric	Distance in metres to a large wetland
23	WETSM	Numeric	Distance in metres to a small wetland
24	WETSM_ID	Character	Located in a small wetland
25	WETLG_ID	Character	Located in a large wetland
26	IN_WET	Character	Located in a wetland of any size
27	FOR_AGE	Numeric	Forest age class, 1-9 (BC Forest Cover map)
28	FOR_HGHT	Numeric	Forest height class, 1-5 (BC Forest Cover map)
29	ASPEN_ID	Character	Forest stand contains aspen
30	ASPEN_P	Numeric	Percentage of Aspen

31	BIRCH_ID	Character	Forest stand contain birch
32	BIRCH_P	Numeric	Percentage of birch
33	COTTON_ID	Character	Forest stand contains cottonwood
34	COTTON_P	Numeric	Percentage of cottonwood
35	LPINE_ID	Character	Forest stand contains lodgepole pine
36	LPINE_P	Numeric	Percentage lodgepole pine
37	BSPR_ID	Character	Forest stand contains black spruce
38	BSPR_P	Numeric	Percentage black spruce
39	WSPR_ID	Character	Forest stand contains white spruce
40	WSPR_P	Numeric	Percentage of white spruce
41	SITES_NR	Numeric	Distance in metres to nearest archaeological site
42	BORDEN	Character	Borden number (for archaeological sites only)
43	X_COORD	Numeric	UTM metres easting (coordinate)
44	Y_COORD	Numeric	UTM metres northing (coordinate)
45	NTS	Character	NTS 1:50,000 sheet
46	PALAEO	Logical	Palaeoindian site (for archaeological sites only)
47	RISE	Logical	Archaeological site located on a rise
48	KNOLL	Logical	Archaeological site located on a knoll
49	RIDGE	Logical	Archaeological site located on a ridge
50	TERRACE	Logical	Archaeological site located on a terrace
51	HILLTOP	Logical	Archaeological site located on a hilltop
52	HILLSIDE	Logical	Archaeological site located on a hillside
53	FEATURL	Logical	Archaeological site at a featureless location
54	ESKER	Logical	Archaeological site located on an esker (not TRIM)
55	BREAK	Logical	Archaeological site located at a slope break
56	LSTHN100M	Logical	Archaeological site corrected by less than 100 metes
57	REVISED	Logical	Archaeological site location corrected
58	NOT_MAPB	Logical	Archaeological site not correctable
59	NEARWATR	Logical	Archaeological site located near water body
60	NOT_ENUF	Logical	Archaeological site not correctable
61	FLAG	Logical	Archaeological site needed to be reexamined
62	PRECONT	Logical	Precontact period archaeological site
63	HISTORIC	Logical	Historic period archaeological site
64	LITHIC	Logical	Lithic scatter archaeological site
65	TRAIL	Logical	Trail (recorded as archaeological site)
66	CMT	Logical	Culturally modified tree archaeological site
67	SUBSIST	Logical	Subsistence feature at archaeological site
68	HABITAT	Logical	Habitation archaeological site
69	CULTMAT	Logical	Other cultural material, archaeological site
70	BURIAL	Logical	Human remains at archaeological site
71	EARTHWORK	Logical	Earthworks at archaeological site

For each variable, a field was created in a database. Data types included distance measurements (numeric continuous variables), identity fields (nominal or logical variables) and ranked data (numeric ordinal variables). The variables can be thought of as comprising six broad classes of data.

The first class of data used for analysis describes the general ecological context in which any point is located. Features such as ecosections, biogeoclimatic zone and sub-zone describe the climate, animal and plant species located in a particular region. These zones are based upon Meidinger (1991).

The second class of data describes surficial features and includes variables such as distance to eskers, derived from TRIM identities.

The third class of data describes nearness to water features. Streams and rivers were classified according to the general size of the stream or river by TRIM mapping with a single or double line. Lakes were classified by size.

The fourth class of variable describes the forest cover in which a point falls. The species present, the relative percentage for each tree species, the average age class of the tree stand, the average height of tree stand was listed for each point. This data was obtained from Ministry of Forests.

The fifth data class recorded for each point was for trails. These were digitized from a variety of archival and library sources. Historic trails obviously connected settlements with each other and settlements with areas of intensive resource use. Many types of sites can be expected to occur along and at the ends of trails. Other types of social features from a traditional use study would add tremendously to the model, such as ethnographically identified named places. These data have not be obtained to date.

A sixth class of data was specific to archaeological site locations. These included site types such as historic, lithic, or Palaeoindian and topographic features such as knolls. This information was derived from site inventory forms.

The data was stored in ArcInfo coverages by Timberline, who conducted near-to and identity analysis for sites, non-sites, and random grid points. The resulting data was provided in dbf format to Millennia for further analysis and modelling. All of the data was stored in a single database in Dbase format using FoxPro. The file has over 28 000 data points.

Summary of Data Gap Analysis for the Northeast

A data gap is a missing or underrepresented variable that is desirable for modelling. Variable data can be missing completely, mapped at an inappropriate scale, or available only for part of the study area. Variables can also be highly skewed in their distribution. This section of the report does not discuss data gaps that are entirely missing variables; rather, it describes the results of analysis for the distribution of data gathered in Year One of the project and reported in Dady (2001). This analysis was specifically geared towards finding data gaps that could be addressed through targeted Year Two field survey.

In order to identify areas needing additional survey, the distribution of survey points was examined and compared to the distribution of grid points, representing the entire study area. The first analysis was of the distribution of survey points across the area as a whole. This was followed by analyses of the distribution of survey to each variable relative to the area as a whole. Finally, analysis was done comparing survey to the intensity of Oil and Gas development, in order to find areas that were underrepresented by archaeological survey.

Environmental Zone Analysis

The analysis of the overall distribution of survey could be accomplished by subdividing the area a number of ways. The area could be examined by topographic mapsheet grid, by another grid such as Borden blocks, or by a natural unit such as biogeoclimatic zones (BGC). The study area is dominated by the Boreal White and Black Spruce (BWBS) biogeoclimatic zone, with very small areas of Alpine Tundra (AT) and Spruce Willow Birch (SWB) zones (Figure 1). With almost 99% of the area in BWBS, dividing the area by BGC zone and subzone is not useful (Table 2). Since grid points are spaced every 2 km, the Grid frequencies in Table 2 can be multiplied by 4 to arrive at the number of square kilometres of land in the study area: thus, the 10 grid points in Alpine Tundra represent about 40 sq km of land.

Table 2. BGC Zone and Subzone areas in the study area.

Zone	Frequency Grid Points	Percent	Cumulative Percent
AT unp	10	.1	.1
BWBS mw	18096	95.8	95.9
BWBS wk	564	3.0	98.9
SWB mk	215	1.1	100.0
Total	18885	100.0	

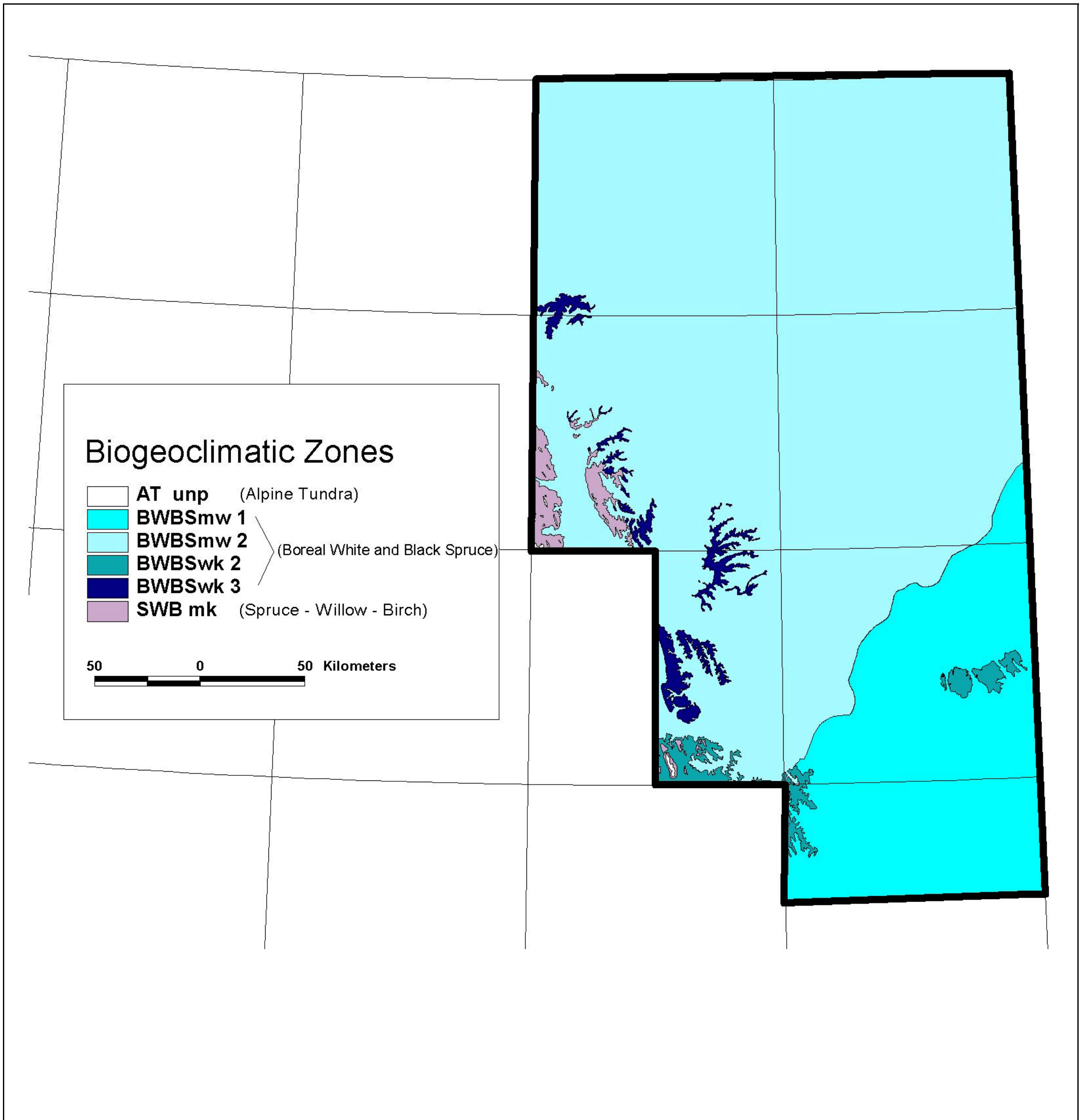


Figure 1. Biogeoclimatic zones. Base grid is 1:250,000 NTS.

The frequency of Survey points (Table 3) shows a complete lack of survey in Alpine, with percentages close to those of Grid for the other zones. Except for the apparent lack of survey in Alpine, the survey is relatively representative of the various BGC zones.

Table 3. BGC Zone and Subzone areas by Survey.

		Frequency Survey Points	Percent	Cumulative Percent
	AT	0	0	0
	BWBS mw	8058	94.0	94.0
	BWBS wk	474	5.5	99.5
	SWB mk	41	.5	100.0
	Total	8573	100.0	

The lack of survey in Alpine represents a lack of systematic survey that can be mapped. Some 17 archaeological sites are found in Alpine (Table 4), the result of casual or opportunistic surveys, and Alpine is actually over-represented in sites compared to the amount of area it represents. Thus, the apparent data gap is trivial.

Table 4. BGC Zone and Subzone areas by Site.

		Frequency Site Points	Percent	Cumulative Percent
	AT unp	17	1.4	1.4
	BWBS mw	1097	89.1	90.5
	BWBS wk	75	6.1	96.6
	SWB mk	42	3.4	100.0
	Total	1231	100.0	

By contrast, ecosections divide the study area into more manageable units than do biogeoclimatic zones (Figure 2, Table 5). They also likely better reflect particular cultural patterns of land use. Ecosections are ecological units based on climate and physiography, and tend to correspond to named physiographic units in common use, such as the "Muskwa Foothills" (of the Rockies) or the "Etsho Plateau". Of the eight ecosections in the study area, one is so small as to be insignificant for modelling purposes (PEL) while the Muskwa Foothills are small compared to the other areas. The remaining areas are all between one-half million and two-and-a-half million hectares, and will be the basis of analysis and modelling in future work.

Table 6 shows the intensity of archaeological survey in each ecosection. The number of survey points is compared to the expected number for that ecosection. The expected number of survey points for each ecosection is derived from the percentage of the overall area in that ecosection multiplied by the overall total number of survey points. Thus, if the Muskwa Foothills were 25% of the study area and there were 1000 survey points, 250 would be the expected number of survey points in Muskwa Foothills. The expected number is subtracted from the observed. If the result is a large negative number, then there is a data gap. If the number is close to 0, then the amount of survey would be about what was expected. If the number is a large positive, then the ecosection is overrepresented. Very large deviations from expected numbers are present in the "Observed-Expected" column. A chi-square analysis, with 7 degrees of freedom, results in a chi-square value of 61,130, which is highly significant.

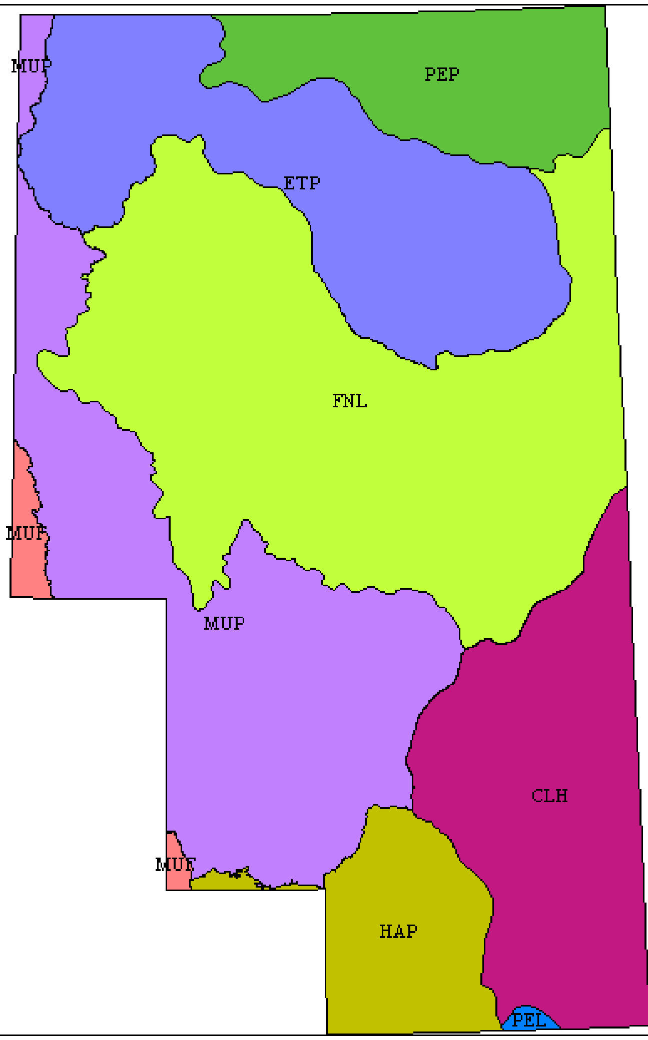


Figure 2. Ecosections in the study area.

Table 5. Ecosection Three-letter Codes and area.

Code	Ecosection	Area Square Km	Area by N Grid Points
CLH	Clear Hills, Central Alberta Upland	11,622	2,787
ETP	Etsho Plateau, Northern Alberta Upland	13,144	3,263
FNL	Fort Nelson Lowlands, Hay River Lowland	24,443	6,039
HAP	Halfway Plateau, Central Alberta Upland	4,851	1,129
MUF	Muskwa Foothills, Northern Canadian Rocky Mountains	797	153
MUP	Muskwa Plateau, Muskwa Plateau	16,391	3,931
PEL	Peace Lowland, Peace River Basin	142	23
PEP	Petitot Plain, Northern Alberta Upland	6,621	1,560

Table 6. Ecosection Survey Intensity.

Ecosection	Frequency Grid	Grid %	Observed N Survey	Survey %	Expected N Survey	Observed-Expected	Data Gap?
CLH	2787	15%	1123	13%	1265	-142.2	MINOR
ETP	3263	17%	462	5%	1481	-1019.3	YES
FNL	6039	32%	1534	18%	2741	-1207.5	YES
HAP	1129	6%	3176	37%	513	2663.5	NO (extreme)
MUF	153	1%	4	0%	69	-65.5	YES
MUP	3931	21%	2192	26%	1785	407.5	NO
PEL	23	0%	0	0%	10	-10.4	MINOR
PEP	1560	8%	82	1%	708	-626.2	YES
Total	18885	100%	8573	100%	8573		

The HAP ecosection is extremely over-represented in survey, with 37% of the survey occurring in this one ecosection, which represents only 6% of the land area. Interestingly, the large number of surveys in HAP has not resulted in a huge skew in the number of recorded sites there: Table 7 shows the relative frequency of sites (compared to expected from proportion of area) and, while HAP is over-represented, it comes nowhere close to 40% of the total that it does with survey. Rather, it is Muskwa Plateau (MUP) that has the lion's share of recorded site points. A chi-square test of these values, with 7 degrees of freedom, results in a chi-square of 1555, which is statistically extremely significant. These large differences between area, survey, and site frequency indicate that site density is extremely different in the various ecosections, and suggests that different predictive models will be required for each ecosection.

Table 7. Ecosection Site Frequency.

Ecosection	N Grid	Grid %	Observed N Sites	Sites %	Expected N Sites	Observed-Expected	Data Gap?
CLH	2787	15%	147	12%	182	-35	Slightly UNDER
ETP	3263	17%	55	4%	213	-158	Greatly UNDER
FNL	6039	32%	96	8%	394	-298	Greatly UNDER
HAP	1129	6%	135	11%	74	61	OVER
MUF	153	1%	20	2%	10	10	Slightly OVER
MUP	3931	21%	773	63%	256	517	Greatly OVER
PEL	23	0%	4	0%	1	3	Trivial
PEP	1560	8%	1	0%	102	-101	Greatly UNDER
	18885	100%	1231	100%	1231		

Other Variables Analysis

Variables in addition to environmental zones were also examined for internal data gaps. Each variable was examined using both analytical software and graphical representations. The graphs are presented and discussed in Modelling and are not repeated here. The analytical data forms Appendix 2. The following is a summary of the data gap assessment.

<u>No Survey Gaps for:</u>

- Ecotone
- Trails
- Single Line Rivers
- Small Lakes
- Sites
- Birch Stands

<u>Survey Gaps for:</u>

- Eskers (gaps 0-2000 m)
- Timberline (no survey points within 2000 m)
- Large Lakes (no survey points within 2000 m)
- Medium Lakes (gaps 0-2000 m)
- Small Lakes (gaps within 2000 m)
- Very Small Lakes (gaps 0-400 m)
- Double line Rivers (gaps 0-200 m)
- Intermittent Rivers (gaps 0-200 m)
- Large Wetlands (gaps 0-200 and 0-400 m)
- Small Wetlands (gaps 0-1000 m)
- Cottonwood above 34% stand percent

- Aspen above 34% stand percent
- Pine above 34% stand percent
- White Spruce above 67% stand percent
- Black Spruce above 67% stand percent
- Forest age classes 3-6
- Forest height classes 1-2.

Of these data gaps, the most significant appeared to be gaps for the banks of double line rivers, and areas near Large and Medium sized Lakes. Large lakes are often important focii of human activity, and rectifying the lack of survey in the vicinity of larger lakes was thought to be a manageable goal for the first year of survey. Double line rivers are relatively common features, and could be expected to occur in most areas with large lakes selected for survey.

The data for forest cover were found to be difficult to assess mathematically, due to the tendency for percentage data to be rounded into broad categories instead of being true ratio numbers. Data gaps in these were considered to be complex enough to warrant further examination at a later date, using a more sophisticated algorithm.

In order to begin choosing specific areas in which to do data gap archaeological survey, an examination was made of the amount of survey versus the amount of oil and gas development (ignoring the effect of other developments such as highways and forestry). In order to do this, 1:50,000 map sheets were totalled for the number of well sites and the number of survey points (Figure 3, Figure 4). This showed areas that have had heavy development with little archaeological survey (particularly true of mapsheets with fields developed previous to the creation of the Oil and Gas Commission). This also excluded mapsheets that, while technically in the study area, had little or no oilpatch activity.

The 1:50,000 mapsheets with underrepresented survey were converted to the corresponding 1:20,000 mapsheets. Deleting those within ecosections that were already well represented further reduced this selection of mapsheets. The remaining mapsheets were sorted for those that contained large and medium lakes, and those that had road access (Figure 5). Mapsheets in the vicinity of Clarke and Kotcho lakes remained in the selection.

Other Data Gaps

Traditional Use Sites (TUS) information would provide valuable data which could be used in developing the predictive model. At present, no such information was accessible with the exception of publicly available trail maps. Requests for TUS data have been made, but to date we have not been able to resolve issues of confidentially. This is a significant data-gap we will address in Year 3 of the project.

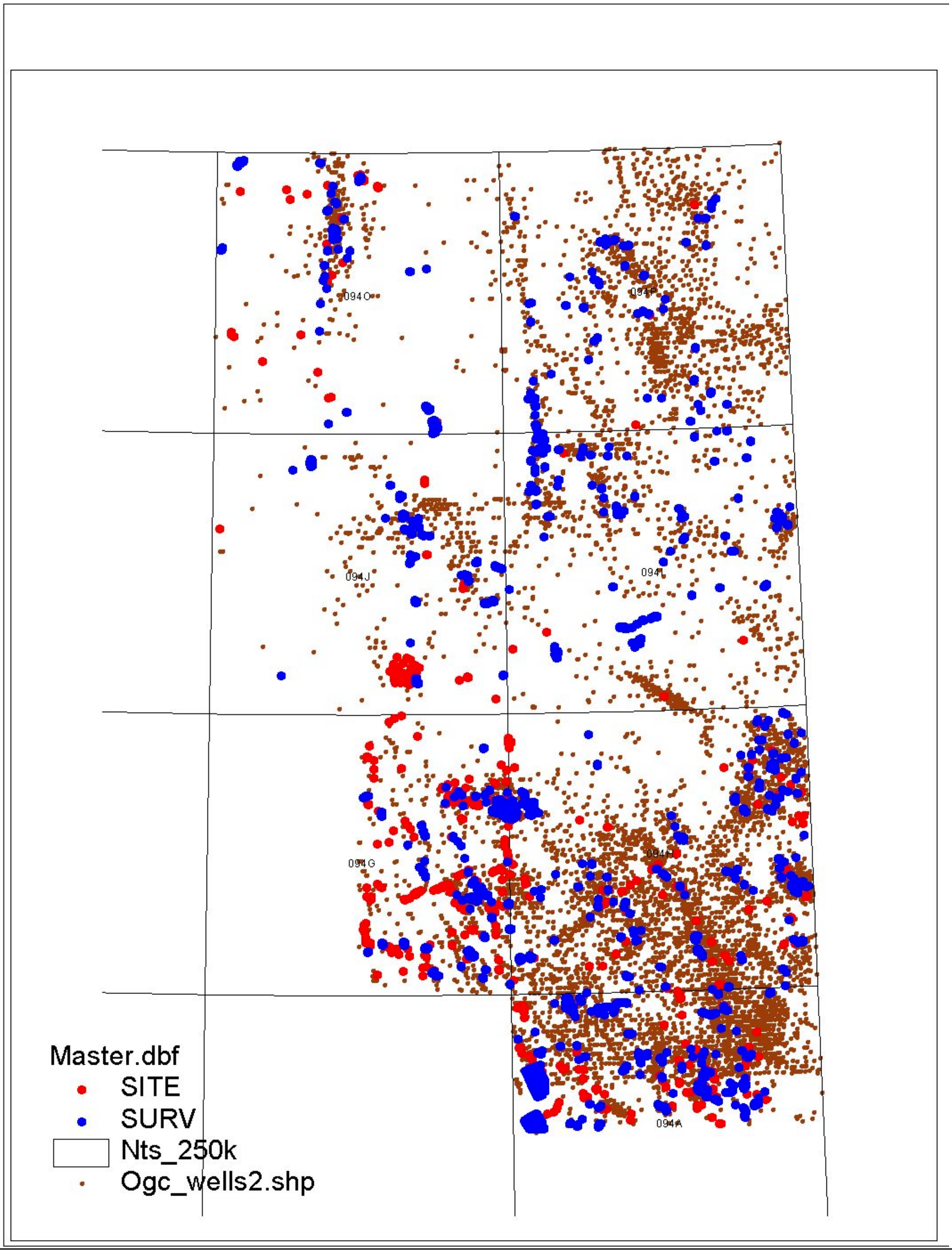


Figure 3. Survey coverage compared to wellsite density and archaeological sites. Base grid 1:250,000 NTS grid.

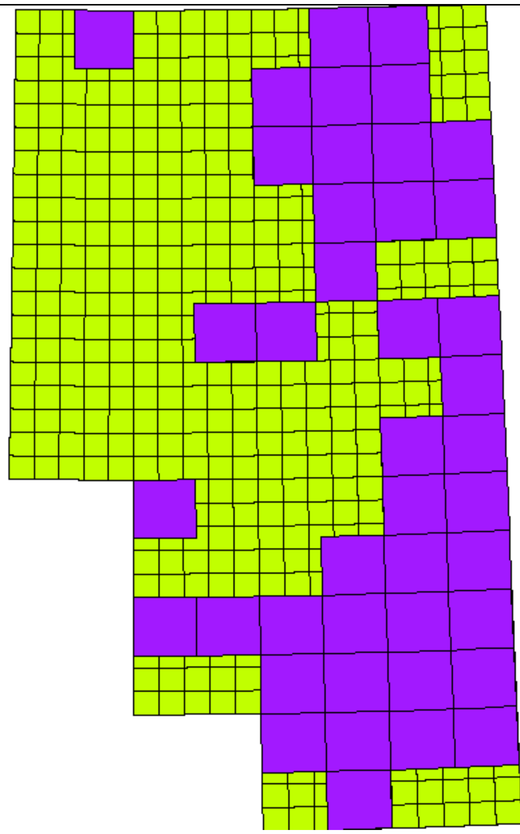


Figure 4. 1:50,000 mapsheets where archaeological survey is underrepresented compared to numbers of wellsites (overlaid on 1:20,000 mapsheet grid of study area).

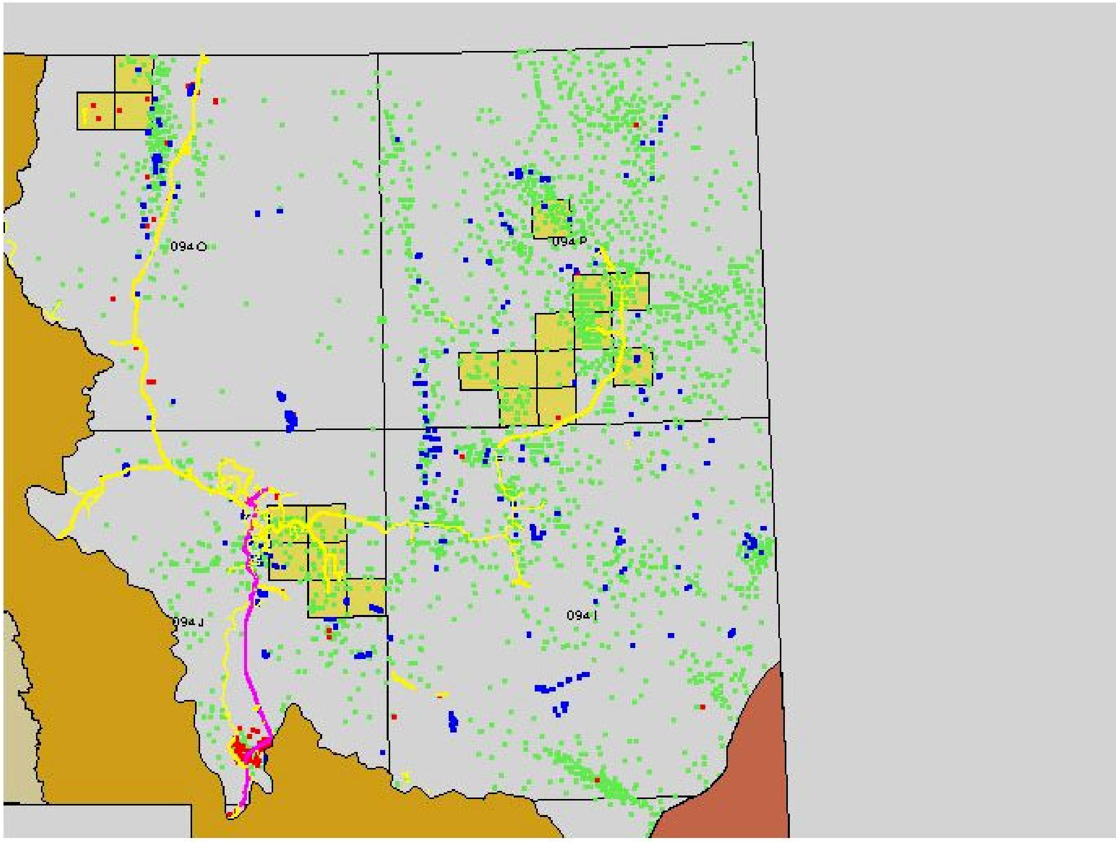


Figure 5. 1:20,000 mapsheets selected for potential survey.

These yellow square mapsheets contain large or medium lakes (not shown), in appropriate ecosections (grey area), under-surveyed (blue dots) compared to oil and gas wells (green dots), and with road access (yellow and purple lines). Red dots are recorded archaeological sites.

The final decision on which mapsheets and areas within the mapsheets to survey was made with the input of the local partner archaeological firm, Big Pine Heritage Consulting.

Archaeological Inventory Study (AIS) – Year 2

According to the BC Archaeological Inventory Guidelines (BC Archaeology Branch 2000), the goal of an AIS is to "identify and record physical evidence of past human activities in a defined study area" by gathering representative data regarding "site distribution and density from varying physical environments". The types of information gathered during an AIS are therefore particularly useful in the development and testing of an archaeological potential model such as the one under development in this AOA.

The Guidelines identify the following characteristics of a successful AIS:

- it must address a specific research or resource management objective;
- it must have a clearly defined scope;
- it must use an appropriate, thorough survey method; the methodology should be directly linked to the program objectives;
- it must be conducted as a field survey;
- it should provide accurate data results; and
- it should provide a summary of previous archaeological investigations.

An initial summary of previous archaeological investigations was presented in the Year 1 report. The following sections outline the results-to-date of the AIS in meeting the remainder of these general goals.

Scope and Objectives

The year two AIS had three main objectives: to address archaeological datagaps; to generate well-documented non-site or negative data; and to gather micro-topographical data for development and testing of a ridge / terrace and high point model for the whole of the study area. This data was to be gathered through target field survey in the general area of Ft. Nelson and subsequent GIS assisted analysis of negative and positive site data and of the success of the preliminary ridge / terrace and high point model.

Survey Sampling Design

In selecting map sheets and areas on the sheets for survey, consideration was given to the following:

- presence of landscape, forest cover, or environmental variables for which gaps were identified in the available survey or site data (refer to Data Gaps section);
- areas of relatively easy access and within relatively close proximity to a settlement (as determined by looking at orthophotos and maps);
- the presence of highpoints, ridges and terrace edges from TRIM DEM VIP command (see Identification of Microtopographic Features section);
- areas of existing or proposed oil and gas developments (as observed from orthophotos);
- a cross-section of the different environmental zones present in the entire study area;
- presence of known sites.

High Point & Ridge and Terrace Model Testing

As noted above, high points and ridge and terrace edges were plotted on the 1:15,000 maps used in the field. Once a general area of survey was selected, nearby highpoints and ridge or terrace edge co-ordinates were entered as waypoints in the GPS units. Photos and notes were taken of the spot when encountered in the field. Characteristics noted included forest cover, slope, elevation, and approximate dimensions, as appropriate.

Archaeological Survey Methods

Survey consisted either of linear transects of varying lengths, which followed roads or seismic lines; or in blocks, 250 x 250 m (6.25ha) in size. Where suitable for logistical reasons, two or more adjacent blocks were sometimes surveyed. The areas surveyed are shown in overview and detailed maps in Appendix 3.

For the linear survey, crews used all-terrain vehicles to follow roads and seismic lines looking for raised microtopographical features on which to test. When such features were encountered, crew members would spread out and shovel test over the expanse of the feature. For the block surveys, crew-members were spaced 20 to 30 m apart, or more where tree stand characteristics provided excellent visibility (such as very open stands with little undergrowth). Crews of two to four persons systematically surveyed the units by making two or more passes within their limits. GPS units with dataloggers were generally used to track the path followed by researchers and to pinpoint site locations, high points, and ridge and terrace edges.

Surface exposures were examined for evidence of archaeological sites, including but not limited to structural remains, lithic scatters, rock art sites, burials, and historical refuse. Where insufficient surface exposures were present, areas judged to possess potential for subsurface deposits were tested. Such areas included rock outcrops, stream banks, natural open areas, potential wet sites, and eskers, ridges or knolls. Shovel tests measuring approximately 35 x 35 cm were used judgementally to test for anthropogenic soils. The matrices were carefully sorted by trowel. Tests were conducted to 'C' horizon deposits.

In forested areas containing pine or aspen, the trees were inspected for cultural modification. No such trees were encountered. Some scarred aspen trees were observed which were thought to be CMTs, but on further examination were determined not to be.

When a site was found, its location was established using a GPS unit, and its boundaries delineated through a series of shovel tests. Artifacts were placed inside a plastic bag and then reburied at the site. One surface find was collected, although we plan to return it to the site during future fieldwork.

Results

The Year 2 fieldwork addressed several survey and site data gaps, generated data for comparison with remote sensing, judgemental mapping, and GIS generated high point and ridge/terrace modelling, located three previously unrecorded lithic sites and relocated one previously recorded site.

The results of the fieldwork in regard to survey and site data gaps are presented in Table 8. More than 52,739 metres of survey was conducted and nearly 700 shovel tests completed on the following 1:20,000 mapsheets: 94J 059, 060, 068, 069, 078, 079, and 088; and 094P 004, 005, and 014. All are within the territories of the Fort Nelson or Prophet River First Nations, or both. All of the areas surveyed fall in the BWBSmw^2 biogeozone which dominates the study area, and within two ecosections: the Fort Nelson Lowlands (FNL) and the Etsho Plateau (ETP). Both of these ecosections are themselves data gaps.

Two areas were surveyed which fell outside the maps originally selected for fieldwork. They included approximately 1556 m of survey on Kotcho Mountain, the only major topographic feature in the vicinity of Kotcho Lake; and, approximatley 1000 m along the Fort Nelson River, in the area of Old Fort Nelson. This was selected to address the double line rivers data-gap.

This year we significantly increased points survey around large and medium lakes. The results of both years' surveys suggest that the highest probability of site occurrence is around lakes, then around double line steams. Sites occurred more frequently in the Etsho Plateau, than they did in the Fort Nelson Lowlands.

The survey on Kotcho Mountain (Appendix 3) can not be used as negative data, despite the absence of recorded sites, as snow cover reduced natural exposures and approaching poor weather did not allow time for testing in this helicopter-accessed area.

Table 8. Fieldwork results.

	Variable*	**Metres of AIS survey**	**AIS Pt Survey**	**Previous Pt Survey**	**Total Pt Survey**	**% increase in Survey**	**Sites recorded AIS**	**Previous sites recorded**	**Total sites recorded**	**% increase in sites**
Data gaps	Large lakes	12,841	12	0	12	infinite	2	4	6	50%
	Medium lakes	1,832	18	34	52	53%	0	26	26	0%
	Double line streams	4,369	43	259	302	17%	1	94	95	1%
	ETP	1,982	19	179	198	11%	2	55	57	4%
	FNL	49,201	492	1363	1855	36%	1	96	97	1%

* only targeted variables are reported.

Data gaps	Variable*	AIS pt Survey: sites Ratio	Previous pt Survey: sites Ratio	Total pt Survey: sites Ratio
	Large lakes	6:1	N/A	2:1
	Medium lakes	0:0	1.4:1	2:1
	Double line streams	43:1	2:1	3:1
	ETP	9:1	3:1	3:1
	FNL	492:1	14:1	19:1

* only those targeted are included in table

As shown in the table above, traverse routes were selected to target specific data gaps. These included large lakes, medium lakes, double line streams, and the ETP and FNL ecosections. At this time analysis hasn't been completed to see how much survey was completed in the other, less significant, datagaps.

Site IgRg-001, which contains a historic cabin and refuse, as well as a single flake, was revisited, and its site location corrected. A site update will be submitted to the Archaeology Branch to reflect this change.

Two of the newly recorded sites and the revisited site (IgRg-001) are located on Kotcho Lake (Appendix 3-2, 94P 005). Site MR0139-1 consists of a single retouched flake found on the surface of a sandy beach on the north side of the lake. MR0139-2 is found off the west bank of the Kotcho River, near the south-east end of Kotcho Lake, and also consists of a single flake. MR0139-3 is approximately 5km north of Clarke Lake (Appendix 3-4, 94J 079), situated on a bench feature overlooking swamp/muskeg. A single flake was found.

Figure 6. Beach on which site MR0139-1 was recorded.

Figure 7. James Wolf , Prophet River F.N., standing on small knoll.

Figure 8. Survey crew shovel testing on a ridge.

Figure 9. Aerial shot of aspen stand on a low ridge.

Previous Survey Mapping

Previous archaeological survey has been mapped (where possible) in order to provide a set of "Negative Data". Negative data are areas where no sites occur, but where archaeologists are known to have looked. These areas can be compared in GIS to where archaeologists have found sites in order to identify patterns of archaeological site density and distribution. These differences can then be built into an archaeological potential model. The survey data can also be compared to the entire area in order to determine if there are "Data Gaps", where not enough survey has taken place. These aspects of the project are dealt with elsewhere in this report.

The survey data mapped during the previous year of the project was improved, and much new survey data was added including additional wellsites and newly acquired digital pipeline data. An updated bibliography of reviewed survey reports is included as Appendix 4. The previous survey data was improved by obtaining new GIS data of oil and gas wellsites from the OGC. To check for accuracy, the point locations of wells in both datasets were visually compared to the locations of the wellpads visible on a sample of 1:20,000 orthophotos. The new GIS database wells almost always map within the square of the wellpad as visible on orthos: those of the database used last year seldom do and are often in error by 100-200m or more. Wells in the new database that had already been identified as receiving archaeological survey were matched using wellnames to wellsite records in last year's database, and the archaeological data transferred to the new database. If the wellname could only be found in the old database, then the wellsite record from the old database was appended to the new database.

Wells receiving survey in the last year were identified through review of the PFR reports submitted in the last year. These wells, 193 in total, were then marked in the wellsite database as having been surveyed. With the availability of many orthophotos by the end of the current year, it was often possible to add areas of ancillary development, such as campsites and borrow pits, as well as the actual wellsite. Such areas were digitized by tracing features visible on orthophotos. In those areas for which we have orthophotos, approximately 30.4ha of ancillary developments have been digitized, as well as 32km of road access. As these areas are often on well-drained lands of higher archaeological potential than their associated wellsites, their addition enhances the data. Mapping of the ancillary developments will continue in the next year of the project as more orthophotos become available. As well, AIA reports from the Archaeology and Forests Branch will be pulled to include information from work conducted under permit.

Other PFR reports were copied for which the wellsite does not appear in the database. Information in reports will be held until the wells are provided in an updated database.

A huge increase in the amount of mapped previous survey was acquired by mapping pipelines. The efficiency of mapping pipeline coverages was evident as it allowed for the addition of larger areas of previous survey, in less time. Pipelines, especially long ones, are particularly useful devices for examining archaeological site patterning because the pipes follow essentially straight lines that crosscut numerous environmental zones and features. In the spring of 2002, the OGC shared with us their newly acquired GIS coverage of pipelines in BC (Figure 10). Although the linework and accompanying database were not directly useable, they provided a map layer that could be quickly and accurately traced on-screen, using the AIA report maps to determine which pipelines had been examined. Over 500 km of pipeline routes were mapped and linked to their AIA report this way. Although this is a large number, it is still a small fraction of the total amount of pipeline in the survey area. The linework was checked against available orthophotos, and adjusted where necessary. Figure 11 shows an example of a mapped pipeline location laid over an orthophoto. Two minor problems are clear: pipeline displacement and simplification of the routing. Where multiple pipelines are adjacent to each other, some lines have been displaced by the OGC (for cartographic clarity) a greater distance than their real-world distance. Usually, only one of several adjacent pipelines has been surveyed. The central mapped line was assumed to be the most accurate and was normally the one traced. This could sometimes be checked against orthophotos. In addition, pipelines as-built often contain small deviations from the proposed routes to deal with local cultural or terrain features. The actual route, as derived from the orthophoto, was digitized where possible.

Finally, the survey conducted in 2001 as part of this study was digitized. This survey took place in identified data gap areas – in this case, primarily near large lakes.

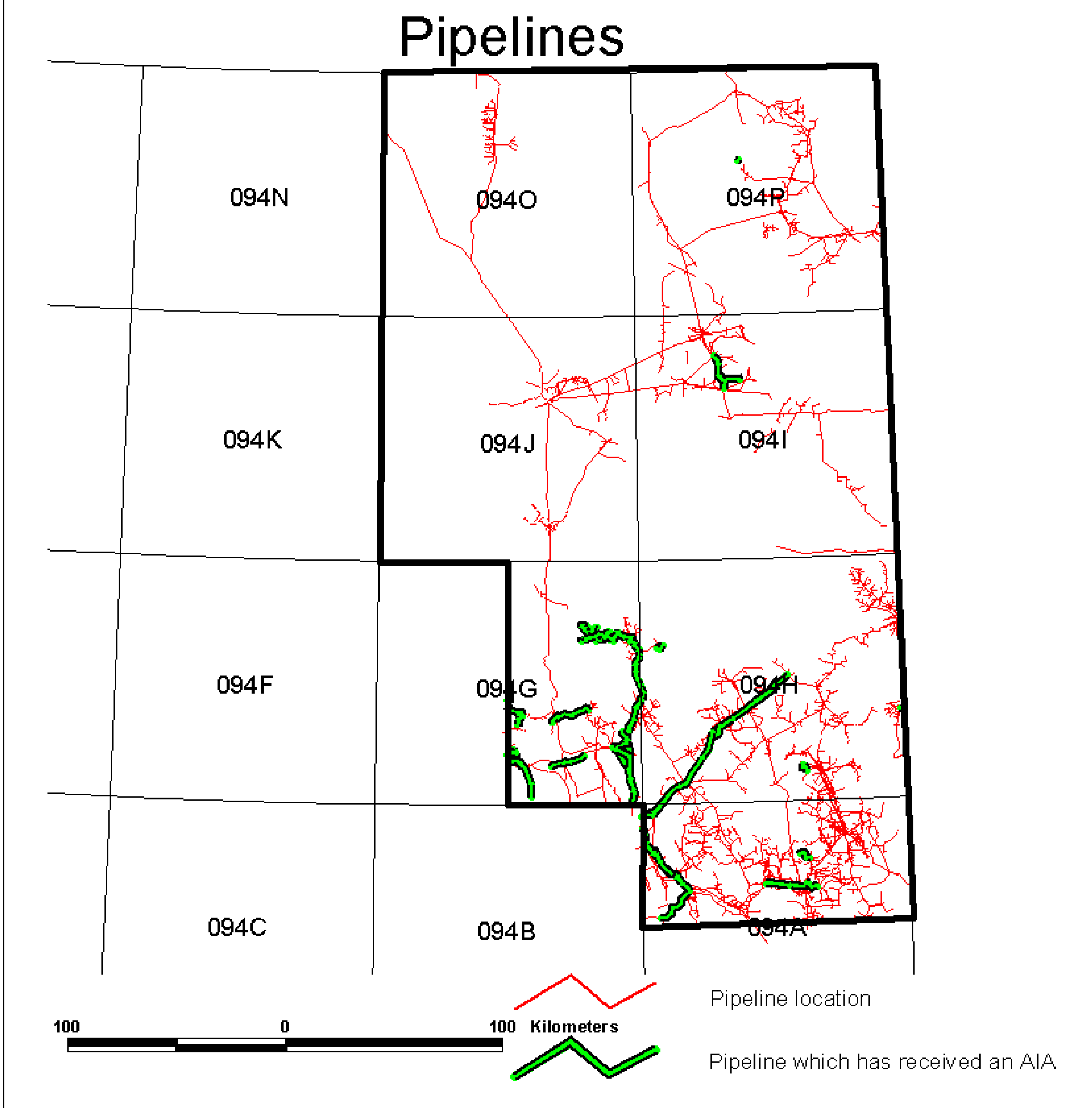


Figure 10. Pipeline locations.

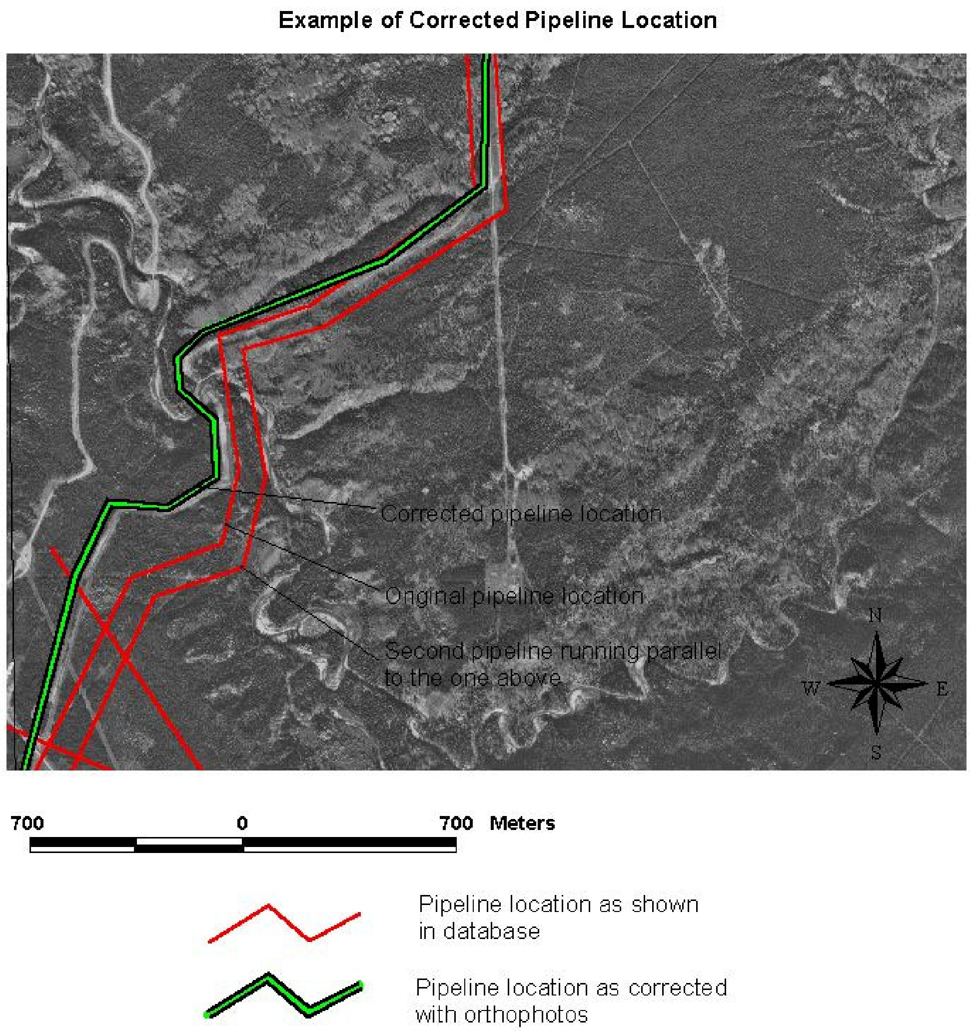


Figure 11. Example of Pipeline Error

Site Corrections – Year 2

Site Data Acquisition

Three sources of data were available to use this year by the NE AOA Project Team. Detailed site information for more than 700 archaeological sites in the study area was obtained in an Access database provided by the Archaeology Branch. The Access database contains written locational data (UTMs, longitude and latitude, a description of location, and access) as well as recorder information and a description of the site itself. The original paper site forms for all sites were reviewed.

Digital site location data was available from three Arc/Info sources: PHRD (Provincial Heritage Registry Database) coverage; corrected site locations from the Archaeology Site Awareness Program; and the Archaeology Branch supplied site locations for those recorded in the last year. The PHRD Ach/Info database was received from the Archaeology Branch last year. Arc/Info coverage was provided in NAD 83 based on locations digitized by the Archaeology Branch staff. As discussed in last years report, errors in site location were often to great for requirements of modelling. In addition, the Archaeology and Forests Branch provided a new shape file, late last year, which included all the sites in the study area not just the new ones recorded. Duplicates in the new file were removed to get the sites in the "New Sites" file. All point sites were changed by the Archaeology and Forests Branch to polygons and single find "point"sites were displayed as 50m circular polygons and sometimes as 1m square polygons, we then had to reduce all those and any site <10m was changed to a point.

The Archaeology Site Awareness Project (ASAP) of the Ministry of Sustainable Resource Management is currently checking and correcting the mapped location of all sites in British Columbia. Although the project is on going, site checks have been completed for Borden blocks containing sites on private property in NE BC. Millennia Research checked and revised the ASAP corrected sites using TRIM II and orthophotos for more accuracy.

Site Location Checking and Site Polygonal Mapping

A model must be effective in distinguishing between areas that probably contain archaeological remains and areas with low likelihood of archaeological deposits. The location and size of archaeological sites must therefore be accurately mapped. For this reason, site location checks were conducted for most of the sites within the project area. Once all site locational datasets were obtained, the PHRD site locations and the ASAP site locations were displayed in ArcView, using different symbols for each.

Site locations, as provided in the PHRD Arc/Info dataset, were checked and corrected against the detail maps accompanying the siteforms. The relative location of the site in PHRD to orthophotos and mapped features such as seismic lines, roads, water bodies, well site, or pipelines was compared to that on the detailed site map. This new approach, using orthophotos, provided greater accuracy than accomplished in Year One, as unique landscape features are not visible in other mapped layers, but are plain on the orthophotos. The orthophotos provided excellent aerial views, showing many features not visible on TRIM data. When ties to landscape features weren't possible the UTMs provided on the siteform were used, if they appeared to have been taken using a GPS. If the PHRD and ASAP ArcInfo data could not be reconciled with the siteform map and /or the orthophoto, it was noted as not mappable: these sites will not be used in the model development process. The methods used during this project are similar to those used by ASAP, providing consistency between projects. The site location checking and polygon mapping was carried out at Millennia Research in the ArcView GIS program, rather than on paper maps. Timberline provided TRIM data as well as the PHRD site locations, which were loaded into ArcView. Conducting site corrections directly in ArcView improved accuracy compared to working on paper maps. With ArcView, it was possible to zoom in on the features used to locate sites and get precise distance measurements. ArcView also allowed one to locate sites through a simple query, rather than having to sort through hundreds of paper maps. Making changes in ArcView also saved the additional steps of having to digitize them later, and then checking new plots.

Whether on the paper plots or in ArcView, sites that were 10 m or greater in at least one dimension were changed from points to polygons. This approach is also similar to that of the ASAP.

Site Location Corrections

Checking and correcting the site locations is, as discussed above, critical to the success of modelling. So far just over half of the sites have been checked using the orthophotos. The remaining sites were not corrected primarily because orthophotos for the area have not yet been obtained, or were obtained too late to be included in this report.

The checking program for the 403 sites that have been ortho checked found that most sites, even those corrected with TRIM data last year or by ASAP, needed additional corrections once the orthophotos were available. The orthophotos allowed for very precise placement of sites. Table 9 shows the scope of corrections. Only 24% of the sites needed no corrections. Sixty-eight percent required corrections, either moving them, changing from points to polygons, adding points or adjusting the size of the polygon.

A small portion of the sites checked, 8%, could not be confidently mapped due to inadequate site forms and site maps. There were no mapped landforms on site forms, or mapping was accurate to the nearest 100 m or more, or had major obvious errors.

Because of the small size of most archaeological sites in the study area, and the small landforms they are often associated with, it is important to correct even 50 to 100m errors to the TRIM map base on which the model will be based. With the use of orthophotos the accuracy of our corrections has been greatly increased compared to last year.

Only 30 sites were changed from points to polygons, where sites were more than 10m long. In a few cases, two or three isolated finds or small clusters that had been grouped as one site were given individual points for each find, using the same Borden number identifier. This low number of polygons is partly the result of the nature of archaeological sites in the study area, but partly the result of the “splitting” tradition of defining sites by the archaeologists working in the area.

Table 9 . Corrected sites (Note: Some sites will have multiple points or polygons, a separate column, points or polygons in file, has been added to illustrate this).

File type	Points or polys in file	Sites in file	Checked	Accurate	Moved or changed	Not enough info
New Sites 2001	126	126	90	4 (4.5%)	82 (81%)	4 (4.5%)
Point Sites	458	451	183	68 (37%)	92 (50%)	23 (13%)
Poly Sites	173	160	130	23 (18%)	103 (79%)	4 (3%)
Total	757	737	403	95 (24%)	277 (68%)	31 (8%)

Trails Research – Year 2

This year, more trails were mapped by hand on TRIM maps plotted at 1:50 000s and sent to Timberline for digitising. The trails were obtained from first edition NTS maps and pre-emptors maps reviewed at BC Archives. The 1:50,000 scale used to transfer the information is not a concern, since the original map scales are the same or much smaller, and actual trail locations will only be an approximation. At the other extreme, we found that some short segments of trails recorded as archaeological sites showed clearly on orthophotos, and we were able to extend the recorded portion of these trails for up to 15 km in both directions tracing the route on the orthophoto. Other probable trails were often seen in the orthophotos, but we required a ground based identification of the trail, and we ignored these others. We concentrated on trail segments not found near known archaeological sites, because already a high correlation exists between the two, as discussed in the model building section. Next year, trails data from TRIM will be used to check and change trails already mapped in the area, comparing the previously digitized the TRIM trails data, or add new segments from the TRIM.

Palaeoindian Sites

For the purposes of this study, and in the Table below, "Palaeo" ("Palaeoindian" Period) means the period from approximately 12,000 BP to approximately 7000 BP; "Mid" means the Middle Archaic Period, from approximately 7000 BP to 5000 BP.

At a steering committee meeting for the project, a concern was raised that Palaeo sites should be modelled for independently of other site types. To address this concern, siteforms and reports were reviewed to identify and tag such sites. When not explicitly stated in the siteform or report that a site dates to the Paleo-Indian Period, the artifact descriptions were compared to other artifact assemblages known to belong to that period. Due to the initially very small number of Palaeo sites within the study area, data was also drawn from areas immediately adjacent to the study area to help build a profile. The number of palaeo sites in the study area has more than doubled in the last year (though the number is still small). The data used includes all newly recorded sites in the provincial inventory to spring 2002.

Eight definite palaeo sites and one middle period site have been recorded within the study area (Figure 12). The number of palaeo sites in the study area has increased markedly in the last year. Three more sites have possible palaeo components; one where an undated chert macroblade was found, and two sites not considered positively palaeo because the points found were described only as "lanceolate", and were not ascribed to a time period. Many palaeo points are lanceolate in shape, but so are those of the Milnesand Phase, which date from only 2-5000 BP.

At least 17 (plus one uncertain) more palaeo sites and two (or three) middle period sites are found within two or three Borden blocks of the southern third of the study area, resulting in a total sample size of over 30 sites.

Table 10 summarises the location of palaeo sites in relation to topographic features. Additional detail is available in Appendix 5: Palaeo Sites. The associated topographic features were gleaned from site inventory forms (see 5. Topographic Features Associated with Archaeological Sites). The results suggest that the strongest co-relation is between Paleo-Indian sites and water sources and the next is between the sites and topographic features such as, rises, knolls, ridges, terraces and breaks in slope. This is different from the general pattern of all sites deduced from the site forms. In all sites, water features play a minor part compared with low rises and knolls. The palaeo sites in the study area itself appear to be less strongly associated with water than those outside. This may indicate that the palaeo sites form a pattern more similar to the overall site population of the study area than to palaeo sites outside the study area. Once near-to and ID analysis on the expanded number of palaeo sites in available, a metric analysis of variable characteristics of palaeo sites will be made and compared to the overall site pattern. Additional checks will be made against the location of glacial lake margins, as identified from elevations. A separate PalaeoIndian model will be created if an improvement can be made to the overall model's performance regarding these sites.

Table 10. Summary of Palaeo site locations (note one site may have more than one associated topographic feature).

Features	Sites in Study Area	Sites Outside of Study Area	Total
rise	3	2	5
knoll	5	1	6
ridge	3	3	6
terrace	1	4	5
hilltop	0	0	0
hillside	0	1	1
featureless	0	0	0
esker	0	0	0
break in slope	5	2	7
near water	5	14	19
not mappable	1	0	1
not enough info	0	1	1
Total	23	28	51

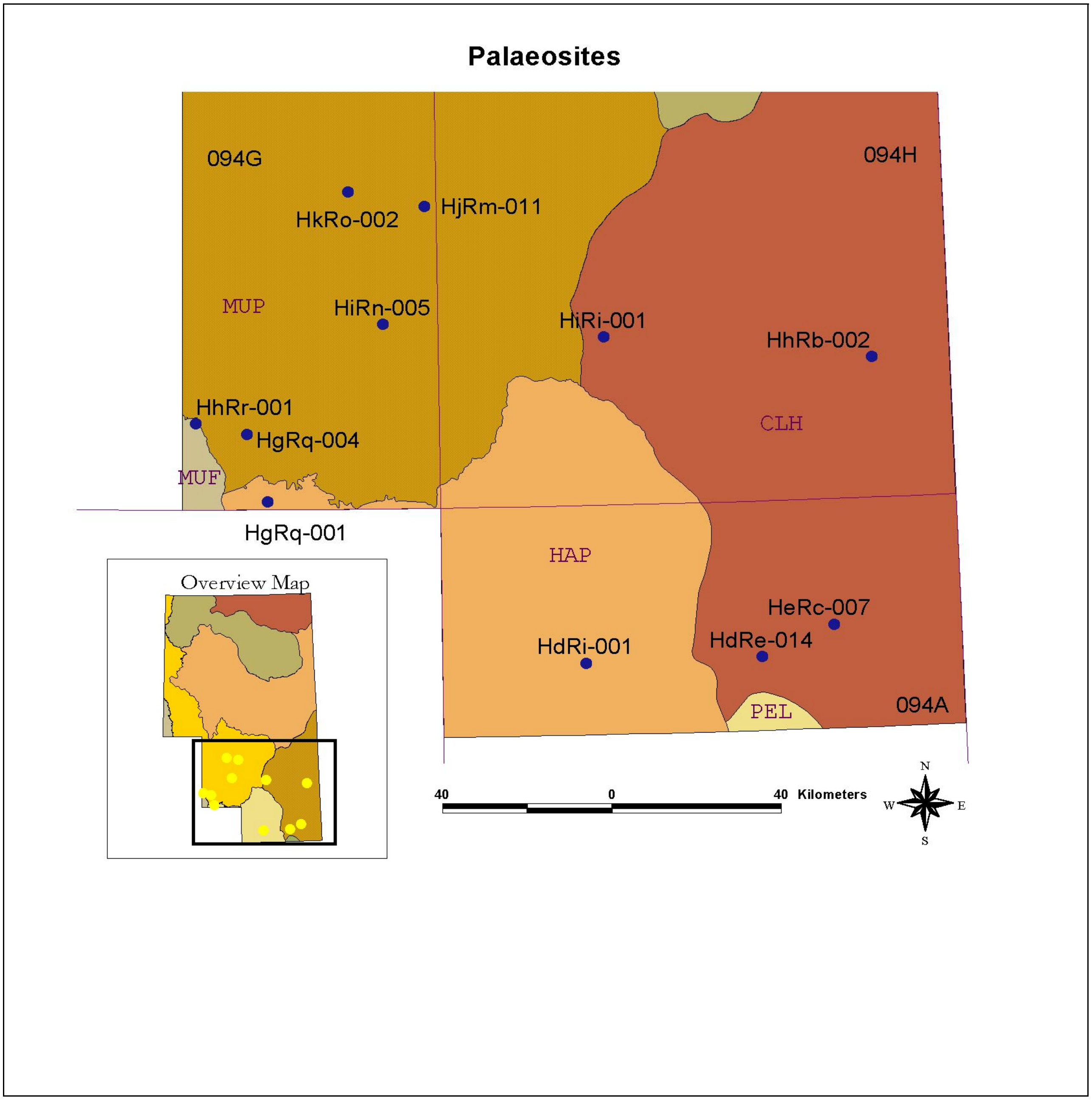


Figure 12. Overview of PalaeoIndian sites.

Identification of Topographic Features

Discussions with archaeological consulting companies in the north-east, and a review of previously recorded sites indicated that most sites within the study area tended to be found on topographical features such as small rises, terraces, ridges, knolls, and other dry, high points of land. Five different approaches were used in attempts to spatially identify these areas from GIS data sources.

1. Ridge/Terrace & High Point (RT/HP) Model

To identify high and moderate potential areas such as rises, terraces, ridges, and knolls, a "Ridge Terrace / High Points" model derived from the ESRI VIP command was developed from TRIM DEM. The resulting product consisted of polygonal shapes representing ridges and terraces, and points for the high points of land; all of which were then placed on orthophotos. The VIP combined with slope data, has been used with some success in other areas of the province. Initial test plots suggested the model was not suitable for large parts of the study area. During fieldwork, survey routes were selected to hit the ridges/terraces and high points identified in the model to test its accuracy.

While in the field, the feeling was that model was not working was confirmed: areas it was indicating as ridges/terraces or high points were often flat and wet, while observed ridges/terraces/high points were not often picked up by the model. The resolution of the DEM is such that there is a limit to the amount of detail that can be extracted, regardless of how it is manipulated. This problem is complicated by limitations of the software.

To evaluate the effectiveness of the model, observations made in the field for 27 survey points in nine areas (see Figure 13) were compared to the model results; particularly areas predicted by the model to contain "no features", "ridges/terraces", or "high points". The results are presented in Table 11.

While ideally a larger number of sample points should be looked at to assess the model, it is apparent without further work that the model is ineffective. In areas it predicted as having no features (20), it was correct only 35% of the time; in areas where a ridge or terrace was predicted (2) it was correct 100% of the time; and, in areas where a high point was predicted (5), it was correct 40% of the time. Although no formal analysis was done, it is unlikely that this result is much higher than chance.

When the RT/HP Model was placed over DEM points (see Figure 17), a similar trend was observed, however, it was noted that its accuracy appeared to improve in areas with greater topographic variation (ie. greater changes in elevation). However, due to a low level of accuracy upon ground-truthing the results of the model in mildly undulating areas, it has been abandoned for other methods of capturing and recording topographical features considered to be congruent with increased potential.

Table 11. RT/HP Accuracy.

Point #	Area	R/T and High Point Model Predicted Terrain Features	VEGETATION - as observed in field	TERRAIN - as observed in field	Field Description	POTENTIAL - as assessed in field	RT/HP Accurate?
1	2	No features	trembling aspen, white spruce	rise	5% slope	M	No
2	2	No features	white spruce, occasional aspen	rise	10% slope, 50x15m area	M	No
3	2	No features	trembling aspen	rise	10% slope	M	No
4	2	No features	alder	ridge	8m wide, 20m from bottom to top, 25% slope	H	No
5	2	No features	trembling aspen	rise	1-1.5m from to to bottom, 14% slope	M	No
6	9	No features	black spruce	rise	20% over 7m	M	No
7	9	Ridge or terrace	trembling aspen, willow, alder, rose, immature white spruce	rise	10% slope over 16m	M	Yes
8	9	Ridge or terrace	trembling aspen, willow, alder, rose, immature white spruce	rise	10% slope over 16m	M	Yes
9	9	No features	trembling aspen, willow, alder, rose, immature white spruce	rise	1m from top to bottom	M	No
10	8	High point	willow, paper birch	rise		M	Yes

11	1	High point	willow, trembling aspen, paper birch, immature black spruce	flat, muskeg		L	No
12	1	High point	grass	flat, muskeg		L	No
13	1	High point	grass	flat, muskeg		L	No
14	1	High point	none - area cleared resulting from road construction	rise	swamp to the north	M	Yes
15	1	No features	white spruce and trembling aspen	ridge	~8m wide, ~60-70 long, 5-7m rise	H	No
16	7	No features	trembling aspen, wild rose	ridge	~12m wide, ~70-75m long, .75-1m rise	H	No
17	7	No features	white spruce, trembling aspen, paper birch	knoll	~50cm rise, 20x20m in area	H	No
18	7	No features	lodgepole pine, paper birch, trembling aspen	rise	very gentle	M	No
19	3	No features	black spruce, white spruce, occasional paper birch	flat		L	Yes
20	4	No features	trembling aspen	ridge	10% over 5m	H	No
21	4	No features	trembling aspen	ridge		H	No
22	5	No features	grass	flat, muskeg		L	Yes
23	5	No features	trembling aspen	flat		M	Yes
24	5	No features	black spruce, labrador tea, scrubby	flat, muskeg		L	Yes
25	6	No features	black spruce, labrador tea, scrubby	flat, muskeg		L	Yes

26	6	No features	black spruce, labrador tea, scrubby	flat, muskeg		L	Yes
27	5	No features	trembling aspen	flat		M	Yes

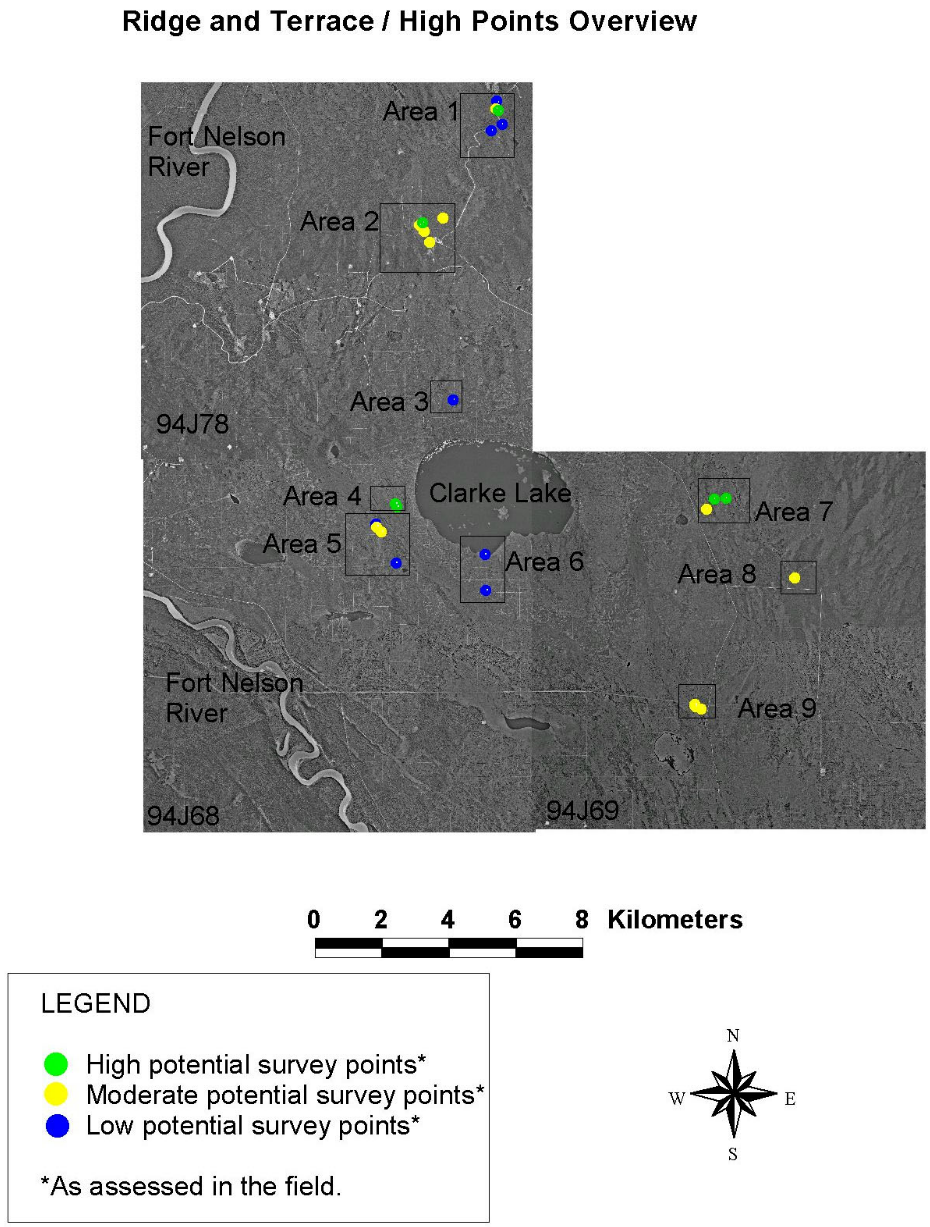


Figure 13. Ridge and Terrace / High Points Overview

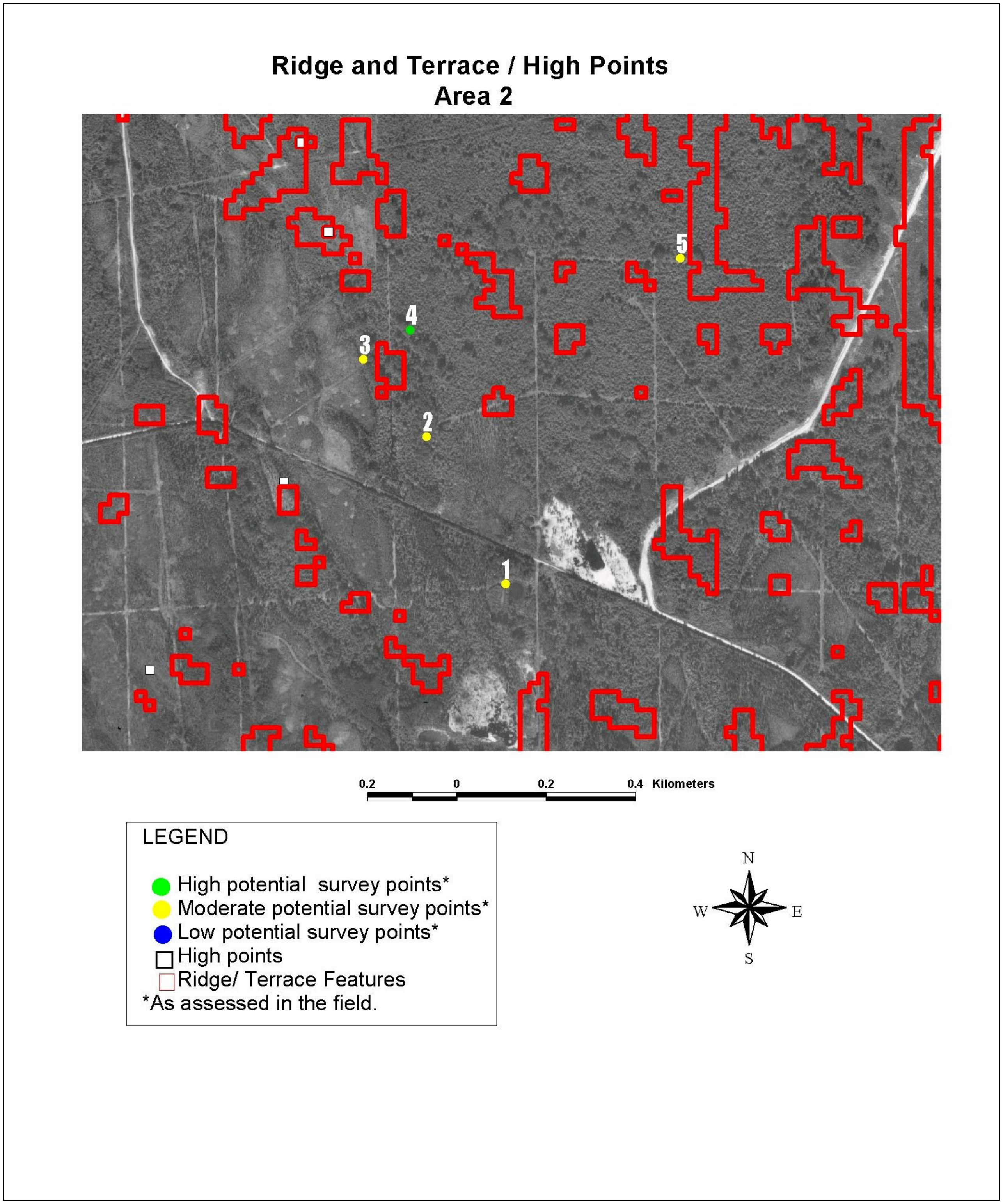


Figure 14. Ridge and Terrace / High Points Area 2

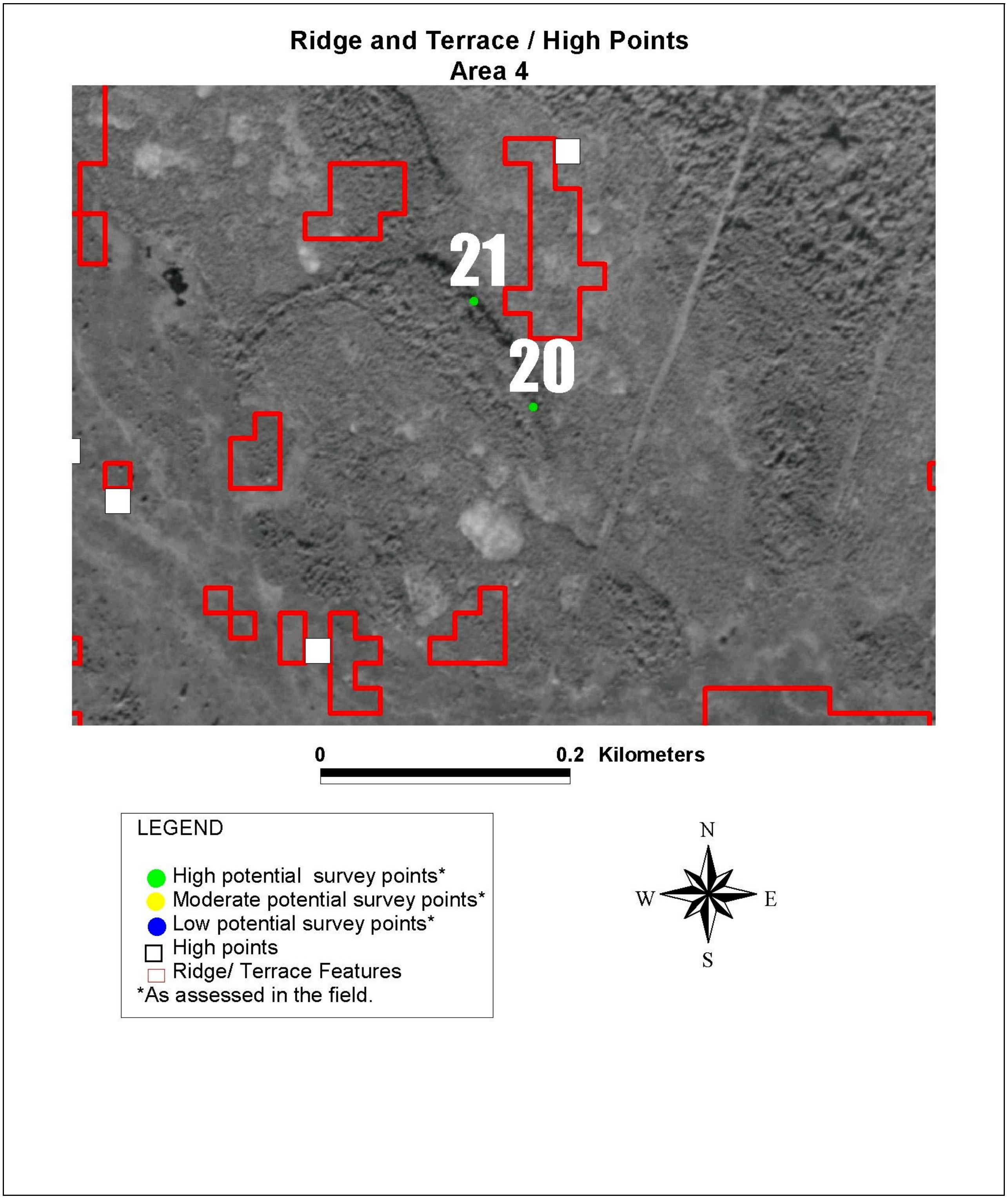


Figure 15. Ridge and Terrace / High Points Area 4

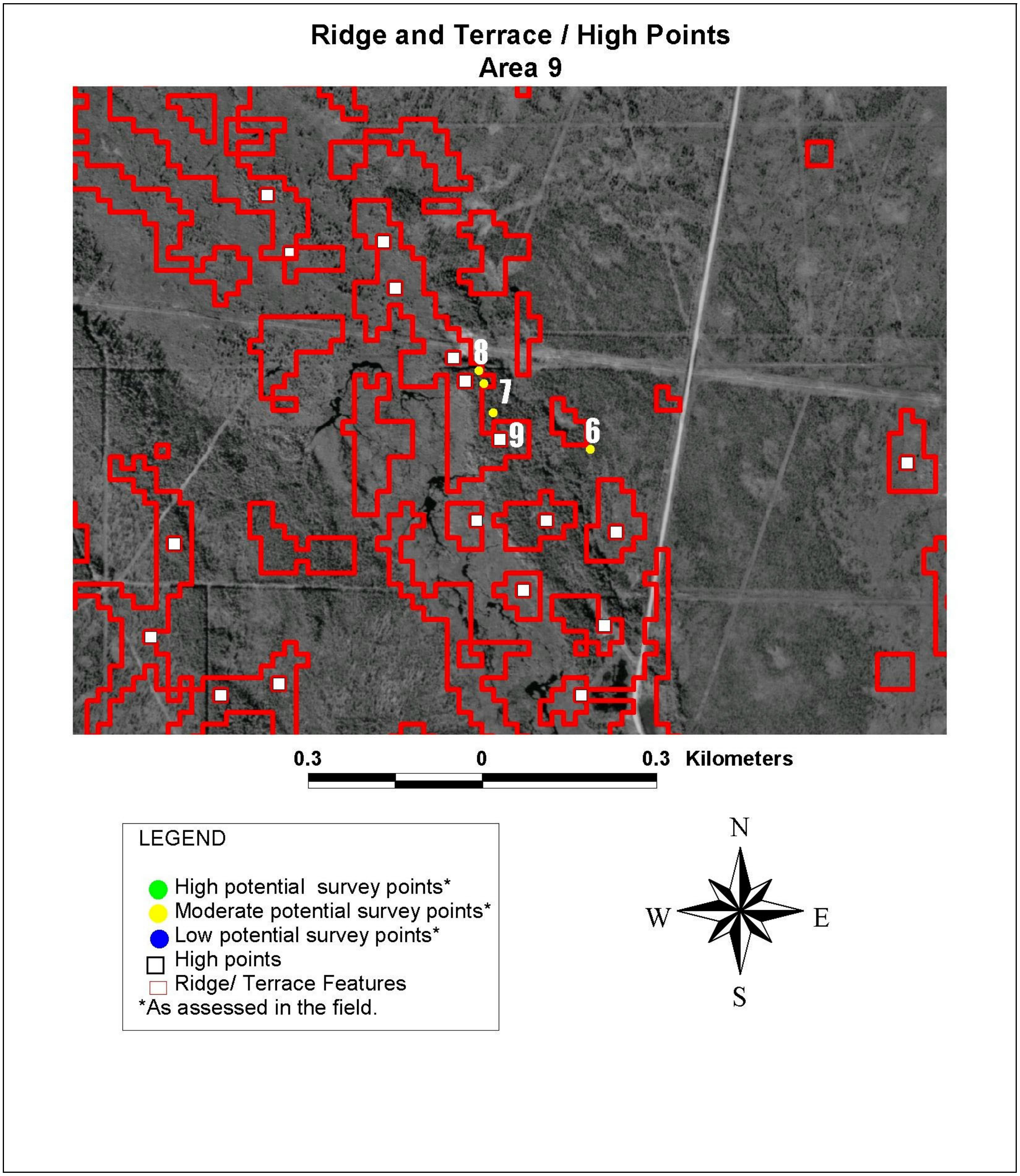


Figure 16. Ridge and Terrace / High Points Area 9

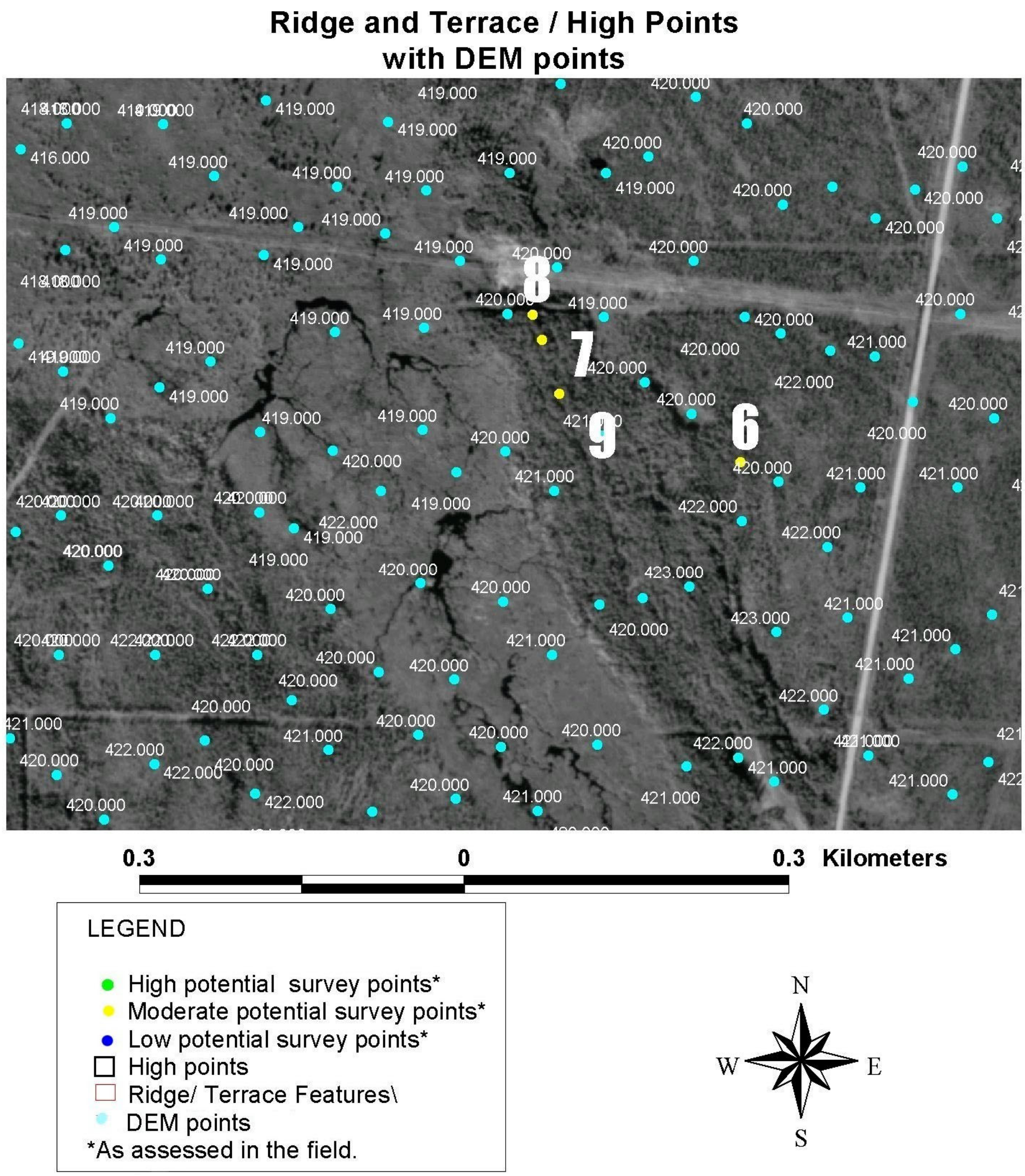


Figure 17. Ridge and Terrace / High Points with DEM Points

2. Microtopographic Feature Digitizing

Microtopographic feature digitizing (MTFD) was conducted on-screen Arc/View using orthophotos and TRIM layers, interpreted at Big Pine Heritage. The effectiveness of MTFD was tested using 26 points whose potential were assessed in the field during the AIS (Table 12). An example is shown in Figure 19.

Table 12. Comparison of Field Assessed Potential and MFD Output

		MFD Output		
		Inside Polygon	Outside Polygon	**Total**
Field Assessed Potential	Low	6	5	11
	Moderate	5	6	11
	Moderate-High	-	-	-
	High	3	1	4
	Total	14	12	26

Six points assessed as low potential in the field fall within an area ascribed as having higher potential by the MTFD, while another five low potential points fall outside the potential polygons. All six of the ground-truthed low potential points falling within an MTFD polygon are on the same microtopographic feature and were in the same polygon, i.e. the six points represent 1 feature. Five points assessed as having moderate potential in the field were captured by MTFD as having potential, however, another six were not. Finally, MTFD caught three of the points assessed as high potential in the field, while missing one.

Conclusions drawn from this comparison can only be considered preliminary due to the small sample size. However, they do suggest that while the MFD is capable of picking up high and low potential areas, it is less successful in identifying moderate potential areas. It performs much better than the RT/HP VIP command.

3. Image Classification for Potential Modelling

With contributions by Joanne White.

Using classification of black and white orthophotos to determine micro-topographical features indicative of high potential is considered to be a promising venture. In some parts of the study area, the topography varies only slightly, and the TRIM DEM is too coarse to reflect these small but critical differences in elevation. However, low knolls, ridges and other topographic features indicate increased potential for finding archaeological remains even in these mildly undulating areas. Such areas can be identified on orthophotos by vegetation changes, in particular the presence of aspen and lodgepole pine. As such, orthophoto classification is potentially much more useful than the DEM for these areas.

Why use image classification?

Essentially, portions of the study area where the digital elevation model is insufficient to capture microtopographic variations can be ‘classified’ using PCI Geomatica classification software. Image classification involves ‘training’ the software to recognize patterns of brightness and texture or directing it to use a clustering approach. To train the software, a portion of the image is selected to be the template or site, i.e. what the software should identify. The software can be instructed to use a variety of algorithms to identify these patterns in other locations on the image (orthophoto). A clustering approach directs the software to seek patterns itself, i.e. ‘unsupervised.’ Testing these algorithms against known areas of high potential will determine whether or not a particular iteration was successful or not. This classification technique was used to try to capture certain topographic features from orthophotos and was successful, the unsupervised technique being the more successful.

After classification, the software can create polygons indicating microtopographical features by a process known as polygonization. These polygons could be integrated spatially into the potential model.

Determining usefulness

A brief experiment with image classification was carried out to determine its usefulness. The polygons digitized by Big Pine as bounding areas of high potential and areas ground-truthed during the AIS were used to determine if any of the spectral values (in this case, shades of grey) of the orthophoto indicated microtopographical features. A visual comparison of the orthophotos with these polygons and points, suggests a very strong correlation between several spectral values of the orthophoto and the areas of microtopographical features indicative of high and moderate archaeological potential. The greys of the orthophoto were separated into different spectral values or shades of grey and randomly assigned colour. Each pixel of the image was therefore assigned a false, bright colour as demonstrated in Figure 19. Each different brightly coloured area was selectively turned off if it was judged to not capture polygons of high potential (See Figure 19). Several colours were determined to best capture the areas by visual inspection; the software could be trained or directed to complete a much more sophisticated classification.

These colours and patterns of pixels closely matched, in many cases, the polygons digitized by Big Pine to indicate microtopographical features. Also, the patterns indicated that the polygon lines were sometimes inaccurate. A visual inspection of the orthophoto verifies that the pixels, when shaded with these bright colours, often more closely represent the actual differences in the vegetation than do the subjectively digitized polygons. Therefore, preliminary results indicate that image classification using different bands of the orthophoto is a promising direction in the identification of microtopography.

To futher test the robustness of these preliminary visual results, the three field-surveyed points of high and moderate potential that occur on this map were examined. These points were displayed over the appropriate orthophoto (see Figure 18). The polygons digitized by Big Pine captured one of the high potential points and one moderate potential point, missing one of the high potential points identified by survey crews. A visual inspection of the colours and patterns associated with the points indicates that the software could potentially be trained or directed to identify all three of the points (see Figure 19).

Future directions

Orthophotos in areas where the DEM is less useful could be classified to determine areas of increased archaeological potential associated with vegetative and topographic changes. This could be tested in areas such as those in Figure 18 and possibly expanded to other areas such as cultivated fields. This could prove to be an efficient and effective way to deal with the expense and subjectivity of digitizing polygons.

Multispectral images could add greatly to the ability for image classification to correctly identify areas of high archaeological potential. However, it is clear that even the one-band orthophotos might provide an affordable alternative to hand digitizing the many mapsheets required to the study area.

After a model was produced and used to create polygons, they should be compared to orthophotos and the polygons digitized by Big Pine to assess their accuracy. Also, a program of ground truthing the polygons would be required to gather additional field points.

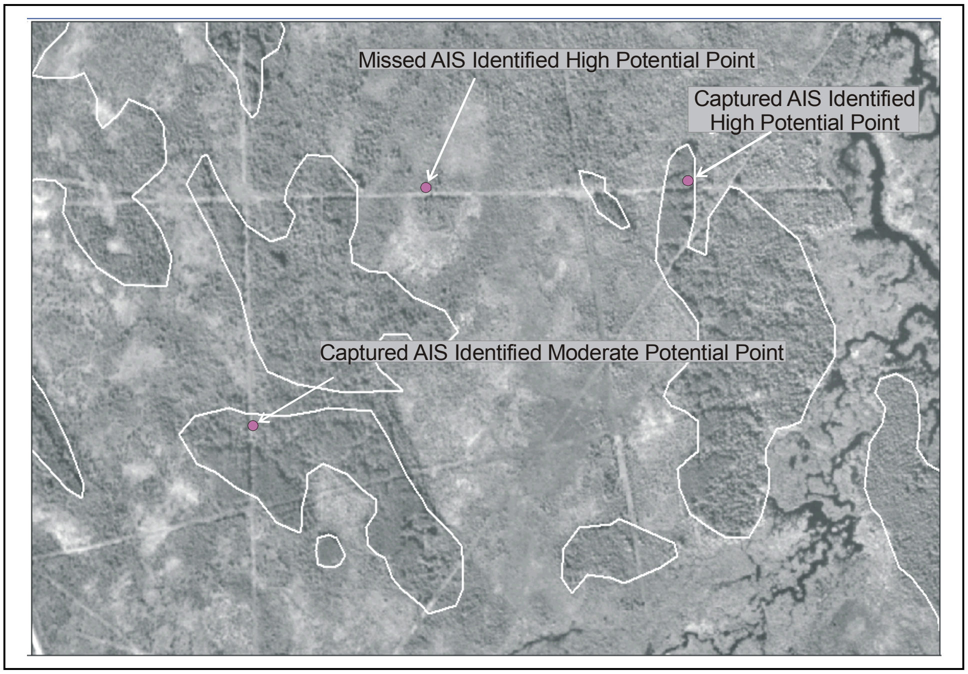


Figure 18. Microtopographical features of high archaeological potential digitized by Big Pine viewed against field data and projected on orthophotos. (portion of 94J.069). White lines indicate polygons of increased potential.

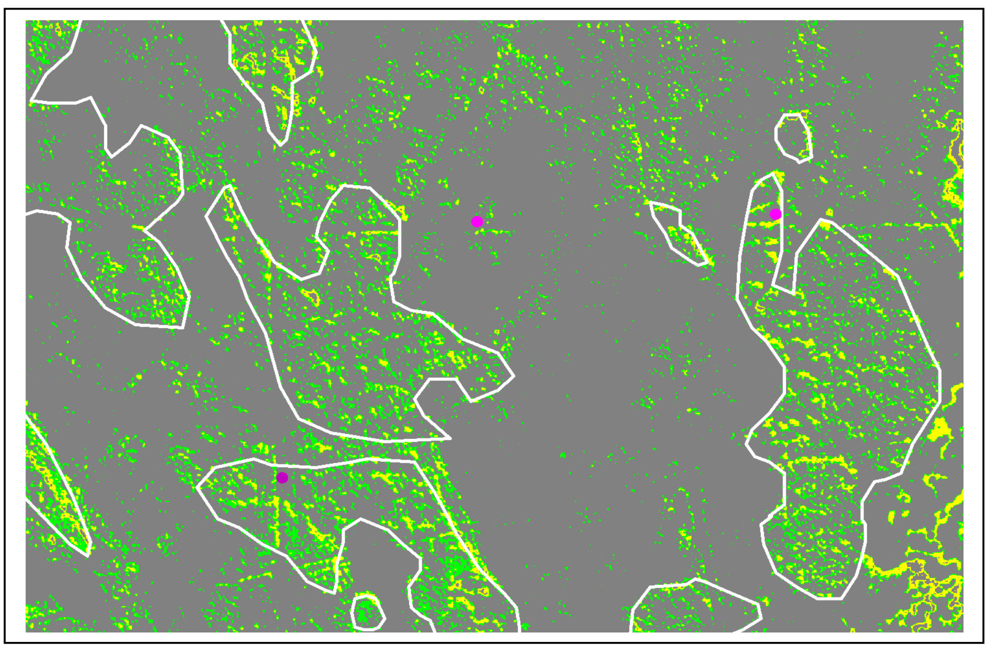


Figure 19. Image classification with digitized polygons, high and moderate potential points from survey.

Note areas of green-yellow closely follow the digitized polygon boundaries and are present at all three surveyed points of increased potential (94J.069), including the one missed by MTFD.

4. Topographic Feature Recognition from DEM

Archaeological predictive models elsewhere have used DEM data to characterise topography. On prairie terrain of Illinois, Warren and Asch (2000) used relief values of above-site relief, below site relief, and total relief within 100 and 500 m catchments. Topographic relief in 500 m catchment was the single most powerful variable in the analysis. Topographic relief was measured by the difference between the elevation of the central cell and the highest or lowest elevation (whichever is largest) of the cells within the catchment interval. This is a fairly crude method of interpreting relief.

The Mn-Model calculated a number of terrain values. The following is a quote from Hobbs (2001).

> *Height above surroundings*: *(*HT90) is measured as the difference in feet between a cell's elevation and that of the lowest cell within 90 meters (a three cell radius). Positive values indicate cells that are higher than their surroundings. Negative values indicate cells that are lower than their surroundings.
>
> ...
>
> *Relative elevation within 90 meters (*REL90A) is the absolute value of the maximum vertical elevation change within a 90 meter radius. This is calculated as the difference between the elevation of the cell and the elevation of the highest or lowest cell within 90 meters, whichever is largest. There are no negative values.
> *Surface roughness* (RGH90), derived from absolute elevation, slope, and relative elevation, using weights and constants derived by Hammer (1993). It is calculated by the formula
>
> RGH90 = ((ABL * 0.3048) + (SLP * 6) + (REL90A * 0.6096)) / 2 (Hobbs 2001).

The values derived are relatively simplistic, and there is no ability to isolate hilltops, ridges, or terrace edges.

A method was conceived by Millennia Research Limited that appears to be different from any others found in the literature or in discussions with GIS technicians. The method is mathematically simple, but produces a large amount of information from the DEM (note that DEM in this context actually refers to a spot height). First, because the DEM points are irregularly spaced, a standard 50 x 50 m grid of raster cells is created and superimposed on top of them (Figure 20). Then, an elevation is interpolated or assigned to each raster cell by averaging all the DEM data points within 100 m (weighing the closest point the most heavily), thereby creating an evenly spaced set of elevation data. This is achieved by using the "Create Grid" command in Arc/View Spatial Analyst (with command options set to the "IDW method", with a 100 m fixed radius for neighbouring points, and a power of 2. No barriers were set in the test sheets, although the results bordering water bodies would improve.) The resulting values quite closely match the DEM point values found in or immediately close to the cells. Deviations and interpolations appear acceptable.

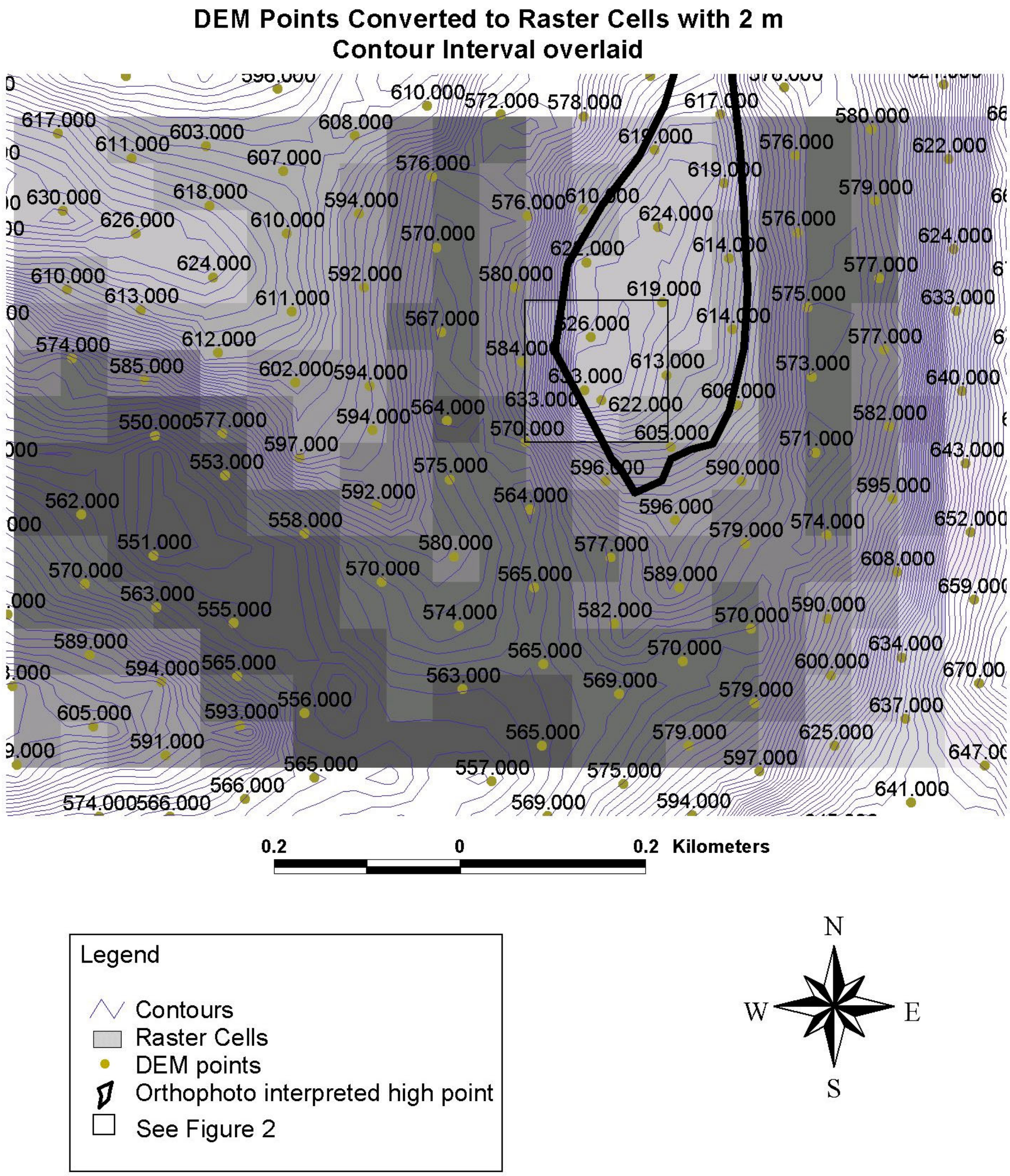


Figure 20. Portion of 94A.067 with DEM points, elevation raster cells, 2 m contour, and orthophoto interpreted isolated high point.

In this figure, the raster cells have been shaded dark to light to reflect elevation bands, light being the highest elevation.

In our example, the area shown in Figure 20 has been enlarged, and is presented in Figure 21. Note how the DEM points, marked by green dots with elevations beside it, are not evenly spaced. A 50 x 50 m grid of raster cells has been placed overtop the map, and an elevation interpolated for each cell, (indicated by the bold number in the centre). The result is an evenly spaced set of elevation data.

Then, for each cell, which is called the "central cell", the values for the eight surrounding cells are collected (Figure 21). The difference between the central (C) cell and each of eight surrounding (S) cells (C minus S) is stored.

In our example, the raster cell with an interpolated elevation of 626.3 is the central cell. Its surrounding cells are (clockwise from the cell above), 624.2, 620.2, 617.4, 613.7, 619, 594.9, 602.5 and 605.5. Figure 21 shows the difference between the central cell and its surrounding cells (C-S).

If the core cell is higher in elevation than the neighbouring cell, the resulting value is positive value, while it is negative if the central cell is lower. Four values are then calculated and stored for each cell:

1. The sum of the positive difference values;

2. The sum of the negative difference values;

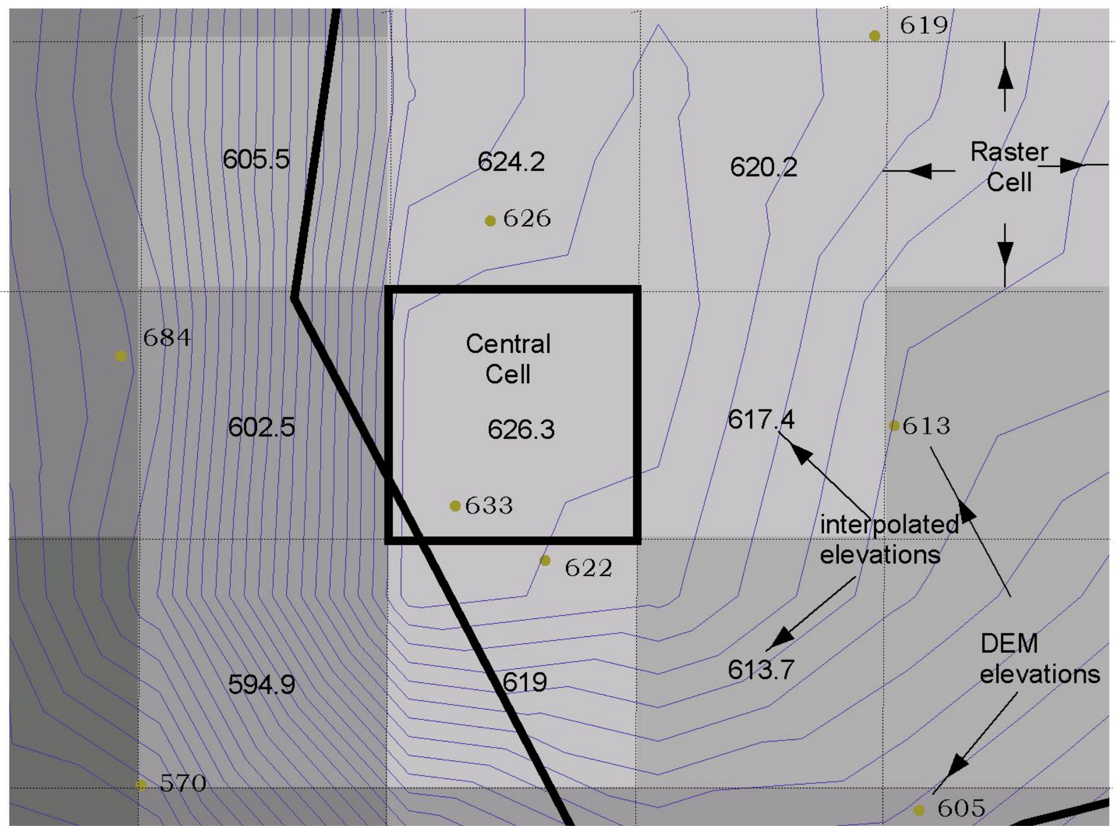
3. The count of positive values;

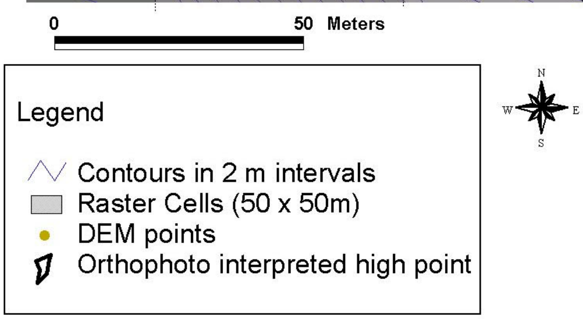
4. The sum of absolute values.

In our example, the central point is higher than all of the neighbouring cells, and as such, the (C-S) values are all positive. The sum of the positive difference values (sum pos) equals 113; the sum of the negative difference values (sum neg) equals 0, since no locations are higher; the count of positive values (count pos) equals 8; and, the sum of absolute values (sum abs) equals 113. These are shown in Figure 21.

These four values allow the landform of the immediate vicinity to be characterized. The sum of absolute values provides an index of ruggedness: areas with steep slopes will have much larger absolute value sums than flatter areas. The count of positive values provides hilltops, flat ridges, and depressions. A hilltop would have a positive value count of 8, since it will be higher than every surrounding cell. This is true of our example. The crest of a sloping ridge will have a count of 6 or 7, since one or two cells along the crest of the ridge will be higher, but the remainder will be lower. The ArcInfo "VIP" command may also show these areas. However, using our technique, we can also show whether the high point is meaningful or not. The sum of absolute values or sum of positive values shows the relative height of the hill above surrounding terrain. Those resulting from spurious small changes in DEM entry will have small positive difference sums (see Table 13 "flat with 1 m local change", although this particular point scores a pos count of 6 rather than 8). A terrace edge will have a positive count of about 4-6, but will be differentiated from a hillside or a steeply sloping ridge by having a very small sum of negative values and a large sum of positive values. Again, the size of the absolute sum difference will provide a scale of the feature. This will be of extreme importance for making the model precise. Depressions would have positive counts of 0 or 1 (and would probably not be of archaeological interest). Table 13 shows the values for selected grid points. The various values combine to characterise the topography of each cell.

DEM Grid Elevations





DEM Grid Elevations

Central Cell	Surrounding Cell	Difference c-s
626.3	624.2	2.1
633	620.2	6.1
	617.4	8.9
	613.7	12.6
	619	7.3
	594.9	31.4
	602.5	23.8
	605.5	20.8
	sum pos	113
	sum neg	0
	count pos	8
	sum abs	113

Figure 21. Detail of previous figure with labelled elevation raster cells, DEM points 2 m contour, and table showing topographic values for central cell.

Table 13. DEM grid elevations and indecies.

Interpolated elevation for the central cell, the elevation of the associated DEM point provided in brackets.	surrounding cell value	Difference c-s	Landform (assessed from 2 m interval contour map)
626.3	624.2	2.1	
(633)	620.2	6.1	
	617.4	8.9	
	613.7	12.6	
	619	7.3	
	594.9	31.4	
	602.5	23.8	
	605.5	20.8	
	sum pos	113	
	sum neg	0	
	count pos	8	hilltop
	sum abs	113	
614.0	604.2	9.8	
(618)	607.4	6.6	
	608	6	
	610.5	3.5	
	617.4	-3.4	
	619.8	-5.8	
	614.2	-0.2	
	606.6	7.4	
	sum pos	33.3	
	sum neg	-9.4	
	count pos	5	hillside below ridge
	sum abs	42.7	
603.2	599.2	4	
(605)	595.7	7.5	
	597	6.2	
	580	23.2	
	590	13.2	
	592	11.2	
	600.1	3.1	
	598	5.2	
	sum pos	73.6	
	sum neg	0	
	count pos	8	knife-edge level ridge
	sum abs	73.6	
623.2	617.4	5.8	

(624)	610.5	12.7	
	613.5	9.7	
	611.1	12.1	
	613.6	9.6	
	610.1	13.1	
	620	3.2	
	619.8	3.4	
	sum pos	69.6	
	sum neg	0	
	count pos	8	hilltop/ridge end
	sum abs	69.6	
611.2	613.5	-2.3	
	603.7	7.5	
	605.8	5.4	
	601.1	10.1	
	602.3	8.9	
	605.8	5.4	
	613.6	-2.4	
	623.2	-12	
	sum pos	37.3	
	sum neg	-16.7	
	count pos	5	sloping ridge
	sum abs	54	
685	685	0	
	685	0	
	684	1	
	684	1	
	684	1	
	684	1	
	685	0	
	685	0	
	sum pos	4	
	sum neg	0	
	count pos	4	flat
	sum abs	4	
685	684	1	
(686)	685	0	
	685	0	
	684	1	
	684	1	
	683	2	
	683	2	
	683	2	
	sum pos	9	
	sum neg	0	
	count pos	6	flat with 1 m local change

	sum abs	9	
680	676	4	
(682)	679	1	
	681	-1	
	681	-1	
	679	1	
	673	7	
	674	6	
	673	7	
	sum pos	26	
	sum neg	-2	
	count pos	6	terrace edge
	sum abs	28	
681	679	2	
	681	0	
	682	-1	
	682	-1	
	681	0	
	679	2	
	680	1	
	676	5	
	sum pos	10	
	sum neg	-2	
	count pos	4	1 cell back from terrace edge
	sum abs	12	
682	681	1	
	682	0	
	682	0	
	682	0	
	682	0	
	681	1	
	681	1	
	679	3	
	sum pos	6	
	sum neg	0	
	count pos	4	2 cells back from terrace edge
	sum abs	6	

These tests show that the concept will work. Fully implementing analysis in a GIS is the next step. Study of test results will allow for assessing variable states and combinations to correctly identify features over the large area. This will greatly enhance the ability of the model to predict archaeological sites, since so many are located on knolls, terrace edges, and slope breaks (see Topographic Features Associated with Archaeological Sites). Analysis can also be done to identify which values and combinations of values are most commonly associated with site locations. ArcInfo can then create polygons from adjoining rasters with appropriate ranges of values of interest, reducing file sizes.

In evaluating this method, it is apparent that it performs at least as well as the hand drawn microtopographic feature digitizing described above. The benefit is that it can be done in an automated computer process rather than by hand. Further, the area assessed can be increased, going out two more raster cells for example, to characterise a larger area. This would provide "catchment area" statistics more refined than those already powerful variables used by other archaeological modelling projects, as discussed above.

5. Topographic Features Associated with Archaeological Sites

The archaeological literature for the study area often comments on the tendency for archaeological sites to occur on the top of ridges, hillocks, and slope breaks such as terrace edges. This association was noted, but had not been assessed. In order to determine the degree of association between sites and various topographic features, site data collected in Years 1 and 2 of the project were reviewed and classified. Location, landform, and other fields of each siteform, together with the sitemap were examined. Keywords were entered as data fields in the database, and summed. These keywords are as follows (Table 14):

Table 14. Topographic features associated with archaeological sites.

Feature	Frequency
Knoll	157
Break in Slope	142
Near Water	109
Ridge	97
Rise	97
Terrace	90
Featureless	40
Hilltop	21
Hillside	11
Esker	9
Not Mappable	47
Not Enough Info	27
Sum (716 sites)	847

No attempt was made to differentiate the recording archaeologist's descriptions (such as the difference between a rise, a knoll, or a hilltop). In some cases, the categories overlapped: of the 109 near water, 32 were also classified as another feature (not including "not mappable or not enough info). Of those classified as break, 14 were also classified as ridges, rises, etc, while one was classified as a hillside. The majority are stand-alone feature descriptions. There are 716 records, representing individual recorded sites in the study, rather than the larger number of points (1200+) derived from large polygons found in the modelling database. Where large polygons were present, multiple keyword features were often entered for the same site, including "featureless" combined with other keywords where appropriate.

Unlike many other modelled areas where associations with major waterbodies dominate, the Northeast sites show a very different pattern, with small knolls and breaks in slope being the prevailing features. This corroborates the observations of other researchers (e.g., Walde 1997)

These features were identified in the field rather than from contour maps, DEM, or orthophoto interpretation. These sites will form a key source for assessing and testing DEM and orthophoto remote sensing attempts to locate significant topographic features. These will, in turn, help the accuracy and precision of the predictive model.

Model Building

Variable Analysis

Univariate analysis is presented in a series of graphs. On each graph, three lines appear: Grid, Site, and Survey. The Grid line represents the entire study area (and is derived from the 18,885 random points spaced 2km apart). Of course, for many variables, only a fraction of these points are represented in 'Grid'. The Site line represents the known archaeological sites. There were about 1,200 total of these points, larger than the total number of sites because large polygons were represented by multiple data points. The Survey line represents non-sites – places known to have had systematic survey where nothing was found. There are 8,482 survey points.

These graphs can be interpreted as follows. The X (horizontal) axis generally shows the distance to the feature in question. The Y (vertical) axis represents the percentage of points for each Grid, Site, and Survey. Any great differences between the grid and survey lines may represent data gaps or survey bias. Any differences between the site and grid lines represent a relationship with the environmental or cultural value; a Buffer program (see description below) determines whether or not the relationship is statistically significant using the Chi-square statistic. The difference can be compared to the survey line as well: for instance, if the site line is far above the grid line at short distances (left side of graph), then the sites may be strongly associated with the variable in question. If the survey line is also very high, then the apparent association may be the result of survey bias. Together, the three lines can be used to examine the strength of associations and suggest an appropriate buffer distance for the variable. This distance would be at, or to the left of, the X value where the lines cross, the point where the sites line drops from above the grid line to below. The value was also determined with the use of the Buffer program written by Millennia Research Limited.

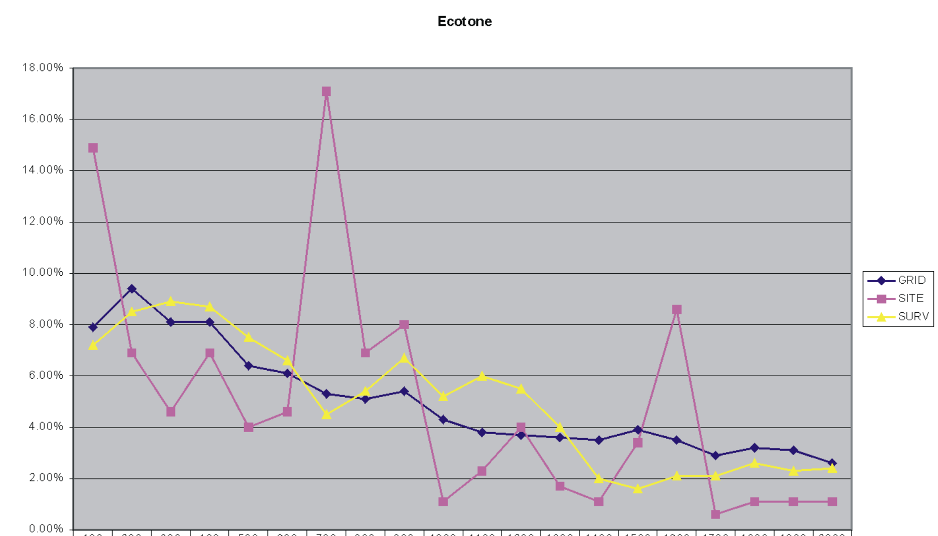
Millennia Research's "Buffer" program statistically assesses the difference in distribution between sites and grids, or between sites and surveys. It uses the Chi-square statistic to see if the difference between the Observed number of site points is different than the Expected number of site points. The expected is derived from the ratio of the grid points: for instance, if 1/10th of the grid points are within 200 m of ethnopoints, we would expect about 1/10th of the sites also to be found within 200 m, randomly by chance, if there was no relationship. About 9/10th would be expected outside. The Chi-square statistic assesses the difference between expected and observed and states the probability that the difference could be expected by chance, as a fraction. The chi-square is calculated as:

$$\text{Chi-square} = \sum \frac{(\text{Observed} - \text{Expected})^2}{\text{Expected}}$$

which totals the numbers expected for observations inside the buffer distance with those outside the buffer. To determine the optimal buffer size, the chi-square statistic was calculated for set intervals from the feature. If a 100 m interval is chosen, starting at 0m, then the number of sites between 0 and 100 m was compared to the number of random grid points between 0 m and 100 m and the number of sites NOT in this interval was compared to the number of grid points not in the interval. The next interval compared sites to grid points from 100 m to 200 m and so on. Once all intervals have been calculated, a new chi-square is calculated for the overall interval from 0 m to the last significant interval.

Because in many cases the surveyed area is not representative of the entire area, a separate set of analyses was completed for SURV instead of GRID. The chi-square was calculated differently for this analysis, since there was a lack of complete independence between SURV and sites (all survey points were deleted if less than 200m from an archaeological site). For this reason, the 'expected' values were obtained by blending the SITE and SURV values for each increment, as is recommended for using the test in this situation (e.g., Steger 1971).

The probability of the observations by chance provides a good measure of how strong a predictor of archaeological sites the variable is. For instance, the statistical probability of the large number of sites observed in the first 100 m from trails is virtually 0: it is such a small number that it could never happen by chance.



	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000
GRID	7.90%	9.40%	8.10%	8.10%	6.40%	6.10%	5.30%	5.10%	5.40%	4.30%	3.80%	3.70%	3.60%	3.50%	3.90%	3.50%	2.90%	3.20%	3.10%	2.60%
SITE	14.90	6.90%	4.60%	6.90%	4.00%	4.60%	17.10	6.90%	8.00%	1.10%	2.30%	4.00%	1.70%	1.10%	3.40%	8.60%	0.60%	1.10%	1.10%	1.10%
SURV	7.20%	8.50%	8.90%	8.70%	7.50%	6.60%	4.50%	5.40%	6.70%	5.20%	6.00%	5.50%	4.00%	2.00%	1.60%	2.10%	2.10%	2.60%	2.30%	2.40%

Distance to Ecotone(m)

Figure 22. Ecotone near-to analysis.

Figure 22 shows the graph for ecotone (the boundary between two biogeoclimatic subzones, considered often to represent a relatively diverse environmental location). In this case, Grid shows a relatively constant decline in percentage from left to right. This is expected for relatively common features (Bonner, et al. 2001). The yellow Survey line is a little more "jumpy" due to a smaller sample size than grid points, but the trend closely follows the Grid line: there is no bias in the location of survey. Sites locations jump above and below the line, suggesting that sample sizes may be too small to form a simple pattern. Whether the approximately double the expected number (from GRIDor SURV) of sites within 100 m of an ecotone is significant or not is unclear: this is where the "Buffer" program is useful. The Buffer program showed the following for Ecotone:

```
Variable:  ECOTONE

Average for sites:  (distance in m)
        ecotone
        697.914
Average for survs:
        ecotone
        745.637

Is ecotone(sites) < ecotone(surv): YES

sites and survs < 2001
sites:          175
survs:         1767


* indicates that expected value is too low [note: o-e means observed-expected]
D.F. = 1

Buffer  100 (o-e):   12.21 |    26 sites |   127 survs |  chi^2=   11.74
Buffer  200 (o-e):   -2.60 |    12 sites |   150 survs |  chi^2=    0.50
Buffer  300 (o-e):   -6.87 |     8 sites |   157 survs |  chi^2=    3.47
Buffer  400 (o-e):   -2.96 |    12 sites |   154 survs |  chi^2=    0.64
Buffer  500 (o-e):   -5.62 |     7 sites |   133 survs |  chi^2=    2.69
Buffer  600 (o-e):   -3.26 |     8 sites |   117 survs |  chi^2=    1.01
Buffer  700 (o-e):   20.09 |    30 sites |    80 survs |  chi^2=   43.15
Buffer  800 (o-e):    2.36 |    12 sites |    95 survs |  chi^2=    0.61
Buffer  900 (o-e):    2.01 |    14 sites |   119 survs |  chi^2=    0.36
Buffer 1000 (o-e):   -6.47 |     2 sites |    92 survs |  chi^2=    5.19
Buffer 1100 (o-e):   -5.91 |     4 sites |   106 survs |  chi^2=    3.74
Buffer 1200 (o-e):   -2.46 |     7 sites |    98 survs |  chi^2=    0.68
Buffer 1300 (o-e):   -3.67 |     3 sites |    71 survs |  chi^2=    2.10
Buffer 1400 (o-e):   -1.42 |     2 sites |    36 survs |  chi^2=    0.60 *
Buffer 1500 (o-e):    2.85 |     6 sites |    29 survs |  chi^2=    2.62 *
Buffer 1600 (o-e):   10.31 |    15 sites |    37 survs |  chi^2=   23.33 *
Buffer 1700 (o-e):   -2.42 |     1 sites |    37 survs |  chi^2=    1.75 *
Buffer 1800 (o-e):   -2.33 |     2 sites |    46 survs |  chi^2=    1.28 *
Buffer 1900 (o-e):   -1.87 |     2 sites |    41 survs |  chi^2=    0.93 *
Buffer 2000 (o-e):   -1.96 |     2 sites |    42 survs |  chi^2=    1.00 *

       100 is the suggested buffer size.

Buffer  100 (o-e):   12.21 |    26 sites |   127 survs |  chi^2=   11.74
```

The Buffer program shows that the difference at 100 m is large enough to be statistically significant with a high Chi-square statistic of 11.74, although the overall pattern of the graph suggests that the variable is of questionable utility. The very large ‘spike’ at 700m, where 10 sites were expected but 30 sites were found, is an autocorrelation with an other variable, which happens to be about 700 m from a ecotone. In this case, the reason for the spike is a large number of archaeological sites located along linear ridges in the southwest of the study area. The ridges are long with evenly sloping sides; the ecotone follows a contour lower down the ridge that happens to be very close to 700 m from the ridge for a long way.

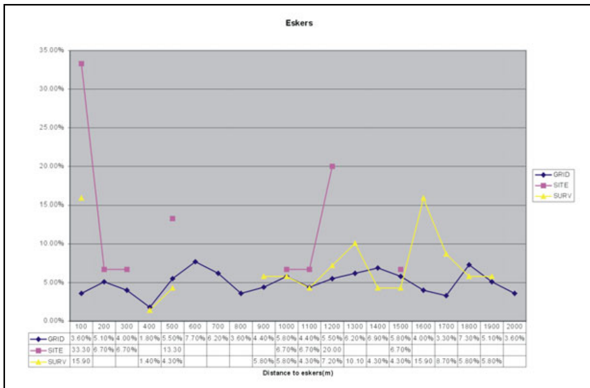


Figure 23. Eskers near-to analysis.

Figure 24. Very Small Lakes near-to analysis.

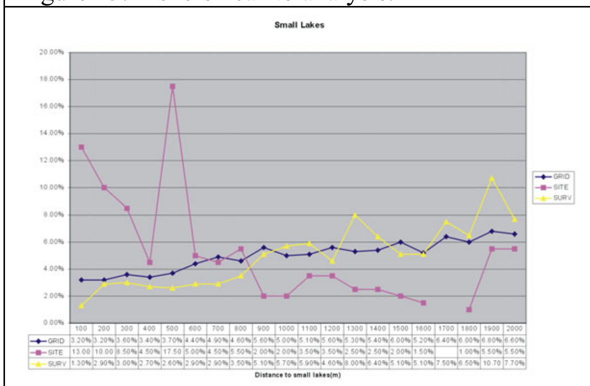


Figure 25. Small Lakes near-to analysis.

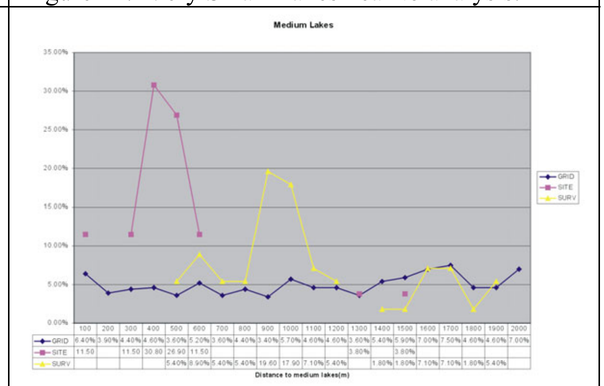


Figure 26. Medium Lakes near-to analysis.

Eskers show a strong association with sites in the immediate area (100 m) of the esker (Figure 23). Unfortunately, this analysis is based on TRIM eskers, which misses many eskers. Small, medium, and large lakes all have strong associations with known sites, even though survey is underrepresented (Figure 25, Figure 26, Figure 27). Very small lakes do not follow this pattern strongly (Figure 24). Large wetlands are negatively associated: sites and survey are closely related, but both are much less common than grid points less than 400 m from these wetland shores (Figure 28). Small wetlands, on the other hand, are quite strongly associated with sites, with sites much more common than either grids or surveys less than 300 m from their shores (Figure 29).

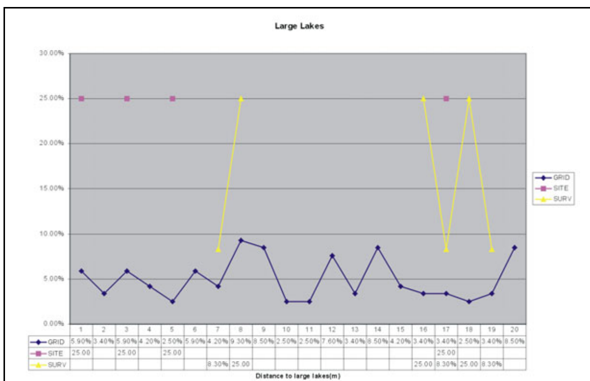


Figure 27. Large Lakes near-to analysis.

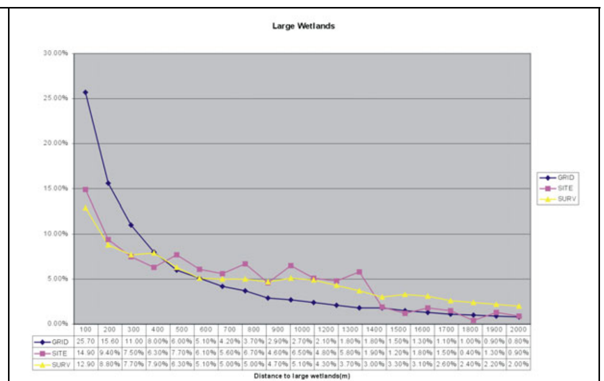


Figure 28. Large Wetlands near-to analysis.

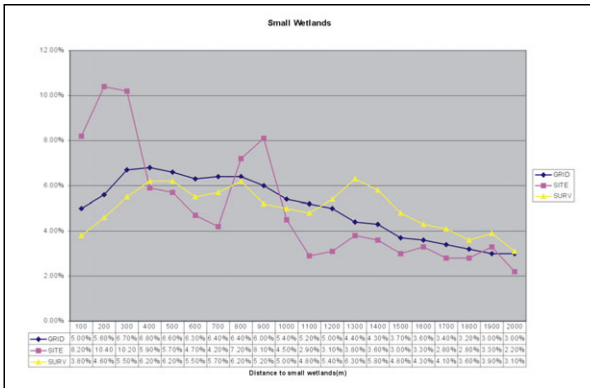


Figure 29. Small Wetlands near-to analysis.

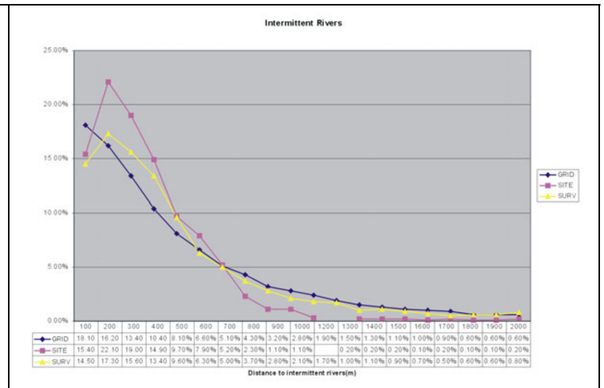


Figure 30. Intermittent Rivers near-to analysis.

Intermittent Rivers (Figure 30) have a negative relationship with sites less than 50m from shore, perhaps because intermittent rivers in this area often flow through swampland. They are associated with these features at a little greater distance. Double line and single line rivers are strongly associated, even though survey is underrepresented near these features (Figure 31, Figure 32). The association with single line rivers is immediate, within 100 m or so. In contrast, double line rivers have disproportionate sites for several hundred metres.

The last two figures are for cultural variables. The distance from archaeological sites is interesting, for it shows clustering of sites themselves (Figure 33). Sites tend to be found close to each other (although some of this is due to a tendency to “split” archaeological remains when defining sites in this region). However, the continuing association of sites several hundred metres apart shows that sites do, indeed, tend to be found in proximity to each other. The grid line for archaeological site near-to has a negative slope, typical for very rare features: few random points will fall close to such features, and the number of random points that are somewhere in the vicinity increases with increasing distance. Survey points abruptly climb from nothing after 200 m. This is because survey points were deleted if they fell within 200 m of a site, since these ‘negative data’ points would otherwise have a good chance of sharing the characteristics of a known site. Trails shows a very strong relationship with sites (Figure 34). The association is extremely strong less than 100 m from a trail, but continues to 400 m. Of all sites that occur within 2 km of a trail, nearly half are found within 100 m. The grid line is nearly flat, typical of relatively rare but long, linear features (Bonner, et al. 2001).

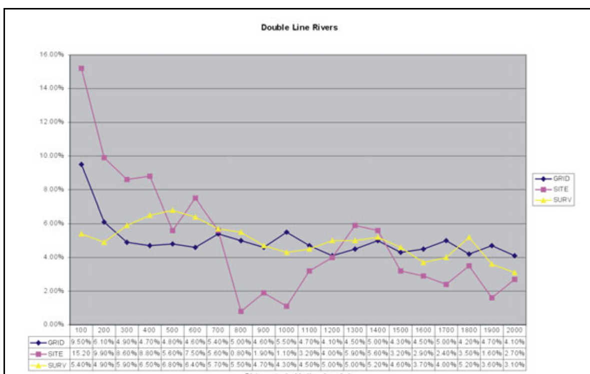


Figure 31. Double Line Rivers near-to analysis.

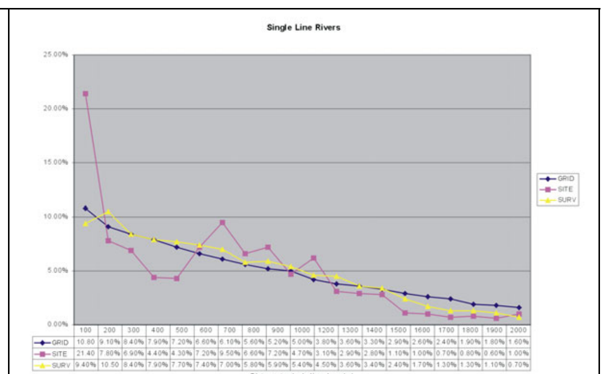


Figure 32. Single Line Rivers near-to analysis.

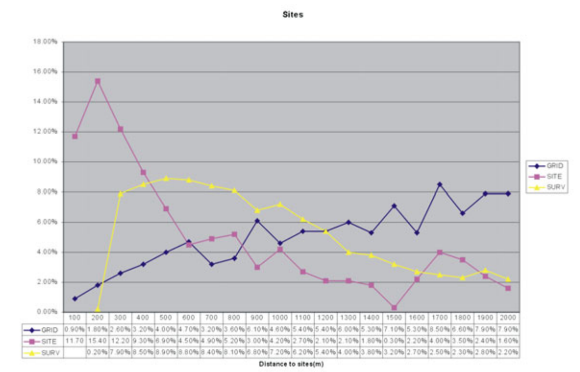


Figure 33. Archaeological sites near-to analysis.

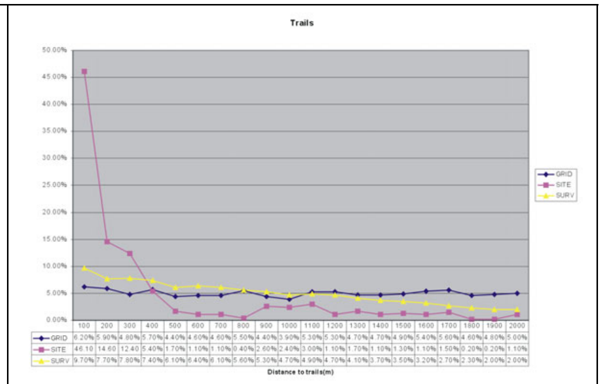


Figure 34. Trails near-to analysis.

Identity variables were not graphed in this manner. The Buffer program was run for those with ranked data classes (such as forest age and forest height). Forest age classes 3,4, and 5 were found to have above-average numbers of sites: surprisingly, age class 8 was underrepresented by sites. Areas with no forest data (such as cultivated fields) showed high numbers of sites, which is expected due to the increased amount of exposures associated with the disturbance of agricultural activities. The forest age and height data shows no clear pattern, however, with large fluctuations of the data between classes.

When analyzing the percentage of various species present at locations and how species present was related to archaeological potential, locations with low tree heights (stunted, older trees as well as young stands), low age class, lakes, rivers and wetlands were filtered out. This analysis shows that areas where older aspen form over 70% of the stand is significantly higher for archaeological sites (Table 15). The first pair of lines show the difference between observed and expected numbers of archaeological sites compared to the number of survey points in these forest classes. The second pair of lines shows the observed and expected compared to the number of grids. The chi-square value shows the strength of the difference between observed and expected. The buffers used in Model 2 are highlighted. In the case of aspen, there is a much stronger pattern related to survey points than to grids. There are only about 1/3 as many survey points in the high percentage aspen than in the low percentage, but the number of sites is almost the same. The ratio of grids is much closer to those of sites, although still significantly different. Stands with over 30% mature, non-stunted black spruce have a much stronger relationship with sites than seen in the aspen. There are about three times as many surveys in the higher percentage class, but there are ten times as many sites. The same holds true for grid points. There are about the same number of grid points in both the large aspen and large black spruce categories, but rather than 124 sites in aspen, there are over 300 in black spruce. This strong pattern with black spruce is surprising considering that black spruce is generally considered to be associated with low archaeological potential, whereas aspen is considered to grow on generally higher potential landforms. The difference is probably due to the filtering of smaller spruce: black spruce which grows to large size is probably on a good growing site, with well drained soil, and these sites will also tend to have higher archaeological potential.

Table 15. Buffer program results for aspen and black spruce percentage

```
Aspen 0-70% and 71-100%
Buffer   71 (o-e):  -44.03 |   145 sites |  2006 survs |  chi^2=   34.50
Buffer  141 (o-e):   44.03 |   124 sites |   786 survs |  chi^2=   34.50
```

```
Buffer   71 (o-e):  -14.74 |   145 sites |  2130 grids |  chi^2=    3.35
Buffer  141 (o-e):   14.74 |   124 sites |  1457 grids |  chi^2=    3.35


Black Spruce 0-30% and 31-100%
Buffer   31 (o-e):  -29.97 |    39 sites |   205 survs |  chi^2=   16.29
Buffer  101 (o-e):   29.97 |   305 sites |   668 survs |  chi^2=   16.29

Buffer   31 (o-e):  -56.07 |    39 sites |   629 grids |  chi^2=   45.70
Buffer  101 (o-e):   56.07 |   305 sites |  1647 grids |  chi^2=   45.70
```

Mature, large cottonwood trees were also strongly associated with archaeological sites, with almost as many sites as survey and grid points (Table 16), although the numbers are small. Mature lodgepole pine stands also are strongly linked with archaeological sites.

Table 16. Buffer program results for cottonwood and lodgepole pine percentage (of species)

```
Cottonwood 1-50% and 51-100%
Buffer   51 (o-e):  -24.62 |    25 sites |   432 survs |  chi^2=   94.30
Buffer  101 (o-e):   24.62 |    32 sites |    36 survs |  chi^2=   94.30

Buffer   51 (o-e):  -24.21 |    25 sites |   480 grids |  chi^2=   87.13
Buffer  101 (o-e):   24.21 |    32 sites |    76 grids |  chi^2=   87.13


Lodgepole pine 1-50% and 51-100%
Buffer   51 (o-e):  -70.90 |   147 sites |  1285 survs |  chi^2=   50.08
Buffer  101 (o-e):   70.90 |   257 sites |   966 survs |  chi^2=   50.08

Buffer   51 (o-e):  -73.66 |   147 sites |  1005 grids |  chi^2=   54.19
Buffer  101 (o-e):   73.66 |   257 sites |   835 grids |  chi^2=   54.19
```

Birch and white spruce are also correlated with archaeological sites, but both are strongly autocorrelated with aspen, with Pearson coefficients > 0.5. Birch often forms a minor component of a predominantly aspen stand. Thus, using aspen in the model will catch most of the sites associated with birch.

Model Building

The model uses individual variables and combinations of variables to add or reduce potential for areas of land. Each command builds on earlier commands, with a cumulative effect. If the command adds a point to a place that already has 1 point, the score for the place is changed to 2. Points can be added or subtracted. Final scores are grouped into Low, Medium, Medium High and High potential classes. Each command is briefly described and discussed below.

Forest Cover Variables

A filter is set to forest age class 3 or older and forest height class 2 or greater, and excluding wetlands, lakes, and rivers. Wetlands and other bodies of water were also excluded, assumed to contain archaeological sites. Then a point is added to the model score for locations with more than 70% aspen, and another for areas with more than 30% black spruce, and another for more than 50% cottonwood. Another point is added for places with more than 50% lodgepole pine. Another point was added for places with white spruce over 60%. This variable was not significant for sites overall, but almost $1/5^{th}$ of the CMT sites were found in stands that were classified as high in white spruce. Finally, a point was added for all areas with a forest age class greater than 5 in the SWB biogeoclimatic zone, since forest cover data indicated a value of '0' for our date species but many CMTs occurred in older stands of some other species.

Lake, River, and Wetland Variables

With a filter set to exclude points within lakes or rivers, a point was added to all places less than 200 m from a very small lake, or less than 500m from a small lake or a medium lake, or 300 m from a large lake. An 'OR' statement is used to avoid getting slivers of high potential mid-way between lakes of different sizes.

A point was added for all areas within 400 m of a double-line river, and another point is added for areas less than 100 m from a single line river. No 'or' statement was used, since it was desirable to make confluences of rivers with each other or with lakes higher potential. Then a point was added for areas 300 m from an intermittent river. A point is then deducted for areas less than 50 m from these intermittent rivers, since sites were negatively associated at this distance.

A point was added for areas less than 100 m from a large wetland or 300 m from a small wetland. An "OR" statement was used for the same reason given for lakes.

Other Environmental Features

A point was added for all areas less than 100 m from an ecotone. A point was added for all areas less than 300 m from an esker. Another point was added for Alpine Tundra areas that already had a point, indicating proximity to an esker or ecotone. This affected only a small area.

Cultural Features

Trails were buffered twice, since they had such a strong correlation with archaeological sites. One point was added to areas less than 300 m from trails, and another added for areas less than 100 m from trails.

As a final step in the model, all areas of swamps, lakes, and rivers were set to a score of 0, to ensure that any potential than had been unwittingly assigned in other commands was removed.

Model Evaluation

The model program written by Millennia Research produces a text file to allow for model evaluation. In this file, the performance of the model is shown by score (the result of the additive modelling), by overall performance, by site type, by biogeoclimatic zone, and by ecosection. There are four columns: one for sites, one for grid, one for survey and one for Kvamme's Gain statistic. The values for sites, grid, and survey are given in percentage. The total number of points involved is given at the end of each subtable. A near-perfect model would have a Kvamme's Gain score of 1, since the % area would be very small, and the % of sites would be very large. Scores will almost always be a decimal. In low potential zones, a high negative number is desired.

The model output is as follows:

```
Model Draft 2 - North East - Score


                sites  grid  surv   Kv Gain
expect  -1:      0.0   0.0   0.0********
expect   0:      4.5  36.8   8.7   -7.25
expect   1:      8.4  12.6  18.4   -0.49
expect   2:     24.0  25.5  38.1   -0.06
expect   3:     24.5  17.2  22.9    0.30
expect   4:     12.9   6.1   8.9    0.53
expect   5:     10.7   1.6   2.8    0.85
expect   6:     13.3   0.3   0.2    0.98
expect   7:      1.5   0.0   0.1    0.99
expect   8:      0.2   0.0   0.0    1.00

OVERALL


               sites  grid  surv   Kv Gain
expect = L:     12.9  49.4  27.1   -2.83
expect = M:     24.0  25.5  38.1   -0.06
expect =MH:     24.5  17.2  22.9    0.30
expect = H:     38.6   7.9  11.9    0.79
Sample n=       1231  18885  8573
***
```

Overall, the model performs well for High potential areas, predicting almost 40% of known sites in less than 8% of the land, for a gain of 0.79. However, the remainder of the distribution is not so good, especially for Moderate, which has a higher percentage of land than sites. Grouping all the higher potential zones and contrasting this with the low potential zone, a gain of 0.41 is achieved. This is acceptable for an early model, especially one that lacks some of the critical variables we hope to include in the forthcoming models – microtopographic features defined from orthophotos, and other topographic features derived from the DEM where the data allows, and traditional use data.

Two site types were singled out for reporting at this modelling stage: CMTs and Palaeo site. CMTs are a suspected data gap in the study area, with only 132 site points (and most of these coming from a few large polygonal sites). The model appears to capture CMTs fairly well, with less than 4% in low potential land. Less than 20% are in high potential, suggesting that there is much room for improvement.

```
CMT


               sites
expect = L:      3.8
expect = M:     38.6
expect =MH:     37.9
```

```
expect = H:    19.7
Sample n=       132
```

Palaeo sites numbered only five in the 'initial' data, of these, two are in low potential, two in moderate, and one in moderate high. Once the large sample of palaeo sites is available, special alteration will be given to modelling for these sites.

The program also shows the model performance by biogeoclimatic zone:

```
AT


               sites  grid  surv   Kv Gain
expect = L:     0.0   0.0**************
expect = M:     0.0  50.0**************
expect =MH:   100.0  50.0******    0.50
expect = H:     0.0   0.0**************
Sample n=        17   10    0

SWB


               sites  grid  surv   Kv Gain
expect = L:     2.4  22.8  12.2   -8.57
expect = M:    45.2  45.1  61.0    0.00
expect =MH:     4.8  23.7  22.0   -3.98
expect = H:    47.6   8.4   4.9    0.82
Sample n=        42  215   41

BWBS


               sites  grid  surv   Kv Gain
expect = L:    13.5  49.7  27.2   -2.69
expect = M:    23.6  25.2  38.0   -0.07
expect =MH:    24.1  17.1  22.9    0.29
expect = H:    38.8   7.9  12.0    0.80
Sample n=      1172  18660  8532
***
```

The model performs fairly poorly in Alpine Tundra, but this is a tiny part of the total. Spruce Willow Birch is also small in area, and the model at first appears to perform rather well here, with only 2.4% of the sites in Low potential. Unfortunately, a small Grid area in low means that the Gain statistic for grouped moderate through high is only 0.20. Black and White Boreal Spruce is the dominant ecozone, and in this zone the model performs essentially identically with the overall model performance.

The model also reports on ecosections, which as discussed in another section, are a much better way to divide the study area then biogeoclimatic zones. The model results for each ecosection are presented then discussed.

```
CLH
```

	sites	grid	surv	Kv Gain
expect = L:	27.2	48.4	38.6	-0.78
expect = M:	27.2	27.9	29.3	-0.02
expect =MH:	24.5	16.0	17.8	0.35
expect = H:	21.1	7.7	14.3	0.63
Sample n=	147	2787	1123	

The Clear Hills are a relatively large area of grid points, but are underrepresented by archaeological sites. The model performance is not good, with an overall Kvamme's gain of 0.29.

ETP

	sites	grid	surv	Kv Gain
expect = L:	30.9	69.7	64.1	-1.26
expect = M:	14.5	14.7	14.1	-0.01
expect =MH:	3.6	11.1	14.1	-2.06
expect = H:	50.9	4.5	7.8	0.91
Sample n=	55	3263	462	

The Etsho Plateau is another large land area with over 3200 grid points but only 55 sites. Over half these sites occur in High potential, with only 4.5% of the land, giving an excellent gain of 0.91. Combined with Moderate, the gain is 0.56, still a good result.

FNL

	sites	grid	surv	Kv Gain
expect = L:	14.6	52.7	21.6	-2.61
expect = M:	20.8	22.7	29.8	-0.09
expect =MH:	32.3	16.2	28.6	0.50
expect = H:	32.3	8.4	19.9	0.74
Sample n=	96	6039	1534	

The Fort Nelson Lowland is the by far the largest ecosection in the study area. It is reasonably well surveyed, but only has 96 recorded sites. This suggests that site density, and archaeological potential, is lower in this zone than in some others. The overall moderate-high gain is 0.44, a fair result.

HAP

	sites	grid	surv	Kv Gain
expect = L:	20.7	27.0	24.1	-0.30
expect = M:	34.8	37.9	43.5	-0.09
expect =MH:	27.4	25.0	22.0	0.09
expect = H:	17.0	10.1	10.4	0.41
Sample n=	135	1129	3176	

The Halfway Plateau has had the most intensive survey of the study area. The site density is moderate to high compared to other ecosections. The model is performing poorly in this ecosection, with an overall moderate-high gain of 0.08.

MUF

```
                sites  grid  surv   Kv Gain
expect = L:      0.0  17.6  25.0********
expect = M:     10.0  45.1   0.0   -3.51
expect =MH:     85.0  26.1  75.0    0.69
expect = H:      5.0  11.1   0.0   -1.22
Sample n=         20  153  4
```

The Muskwa Foothills are a relatively small part of the study area. The model performs relatively poorly here, with an overall moderate-high gain of 0.18. The moderate high is quite good, with 85% of sites in 26% of the land. The high potential zone is poor, however with a lower percentage of sites and grid.

MUP

```
                sites  grid  surv   Kv Gain
expect = L:      7.4  24.6  19.9   -2.34
expect = M:     23.0  38.9  46.6   -0.69
expect =MH:     22.9  26.0  24.9   -0.13
expect = H:     46.7  10.5   8.6    0.78
Sample n=        773  3931  2192
```

The Muskwa Plateau is another large part of the study area, well represented by survey and very well represented by sites – some 773. The model performs well in the high potential zone, which has almost half the sites in 10% of the land. The overall moderate-high gain is 0.19.

PEL

```
                sites  grid  surv   Kv Gain
expect = L:     50.0  47.8******    0.04
expect = M:     25.0  17.4******    0.30
expect =MH:     25.0  21.7******    0.13
expect = H:      0.0  13.0**************
Sample n=          4  23  0
```

The Peace Lowlands are a tiny part of the study area. The model is not performing well here, with an overall gain of –0.04, but the sample here is too small to assess performance accurately.

PEP

```
                sites  grid  surv   Kv Gain
expect = L:    100.0  77.9  70.7    0.22
expect = M:      0.0   9.6  13.4********
expect =MH:      0.0   7.1  13.4********
expect = H:      0.0   5.3   2.4********
Sample n=          1  1560  82
```

The Petitot Plain is a relatively large area, with little survey, and only a single known site. A gain statistic is meaningless in this situation, but the overall low potential of nearly 80% is probably appropriate (See Table 6).

Future Directions

During the course of analyses, modelling, fieldwork, and mapping, a variety of promising and important future directions were identified. These include continued GIS mapping and analysis, obtaining specific or new data sources, model and analysis refinement and testing, and fieldwork to ground-truth results.

During site location corrections, one main item was identified as significant for next year's continued efforts to properly place sites. This is obtaining the remaining orthophotos that are associated with archaeological sites. With a near-complete set of orthophotos from mapsheets with sites, the remainder of sites can be moved and updated as required. Once the large majority of sites are corrected, a database of new near-to and ID analyses values using the corrected site locations as well as new survey data should be conducted. We anticipate that when the new "Remote Access to Archaeology" project is functioning early in the new fiscal year, we will be able to update our sites database/GIS on a frequent as-needed basis. Depending on the level of access to the Provincial data warehouse allowed, we may also be able to view relevant orthophoto data remotely using Web-based tools. This will allow a much more rapid updating of the sites database than has been the case.

The existing model should be re-run with new data identity and near-to data derived from orthocorrected sites and incorporating newly surveyed wellsites and pipelines. The new survey locations will nearly double the SURV points and will address some of the reported datagaps. These trials will indicate if this present model performs better with the improved data.

Models should be constructed that are specific to each ecosection to allow for regional variation. The grid point density for small ecosections will need to be increased to provide a large enough stand-alone sample. A test model should be constructed using logistic regression in one ecosection. This will require near-to analysis with no limits to distance as we normally place on distance variables, but the smaller sub-area should allow this with little impact to processing time. The result should be compared to the model produced using our standard modelling and the modelling time involved in each method. A decision can then be made whether to replace the standard modelling with logistic regression modelling in the final years of the project.

A major new source of data will be the landform identification technique using DEM described above. New GIS coverages should be created after this technique is automated. This work will include analysis of values associated with orthocorrected sites to determine appropriate values that will identify the desired features.

A second major new data source may be remote sensing microtopographic definition for ecosections with low topographic variation. Image classification technique looks promising for identifications of low topographic features in areas where the DEM does not adequately capture areas that indicate increased potential. The DEM landform analysis will allow for identification of those ecosections where this is most critical.

These DEM topographic analysis and remote sensing microtopographic definition will become a part of the Year 3 model refinement, and should provide a major increase in model accuracy and precision compared to the Year 2 model.

Several future directions were identified in the trails research program. Trails are an extremely strong predictor of archaeological site location and we have only a small fraction of known trails in our database. More trail coverage, as well as other TUS features, will be sought from First Nations, and additional liaison time will be budgeted to allow for this. Trail data found in new siteforms and reports should be checked and mapped. As discussed, these trails are often visible on orthophotos, and frequently can be extended beyond the limits of the recorded site. More trails should be mapped from the Surveyor General's records. Trails from TRIM data can be checked and used to correct trails already mapped from small scale historical map sources.

Palaeo site research might include checking artifact repositories for lanceolate projectile points to determine whether questionable sites that list these lanceolate points in their descriptions are in fact palaeo sites. There are only five of these cases both inside and outside the study area. We have also had anecdotal information about a number of additional palaeo sites in the study area that are not included in the present list. We will continue to ask for clarification about these sites through e-mail contacts with the archaeological consultants who recorded these sites.

To date, we have made minimal use of information from northwest Alberta regarding both palaeo and more general site location patterning. In year 3, we will expand the literature survey to include this area.

Finally, a number of aspects should be ground-truthed to obtain new field data. This will include investigating the model performance in a variety of ecosections, assessing performance of the DEM topographic feature identification in a variety of landform types, and obtaining image analysis of microtopographic features. The PEP is a large ecosection that presently has only one recorded archaeological site. This is a concern to address, perhaps at least confirming that this area has, indeed, very few landforms where sites might be expected.

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Appendix 1: Glossary

AIS- Archaeological Inventory Study

Biogeoclimatic zone- This term is used to describe the climate, soil, and vegetation in a region and how they relate to one another in a predictable pattern. The boundaries between one zone and the next are sometimes subtle.

Borden number – A code used to identify archaeological sites in Canada consisting of four letters and a number such as FtUg-004.

Buffer – Land within a set distance from a feature, such as all land within 150m of the shores of a small lake.

Buffer program – This program, used by Millennia Research, statistically assesses the distribution between sites and grids, or between sites and surveys. It uses the Chi-square statistic to see if the difference between the observed number of site points is significantly different than the Expected number of site points.

Chi-squared analysis – Assesses the difference between expected and observed values in a data table and states the statistical probability that the difference could be expected by chance, as a fraction.

Data Gap - A missing or underrepresented variable that is desirable for modelling.

Deductive modelling – using ethnographic information and intuitive/experience-based site location patterning to determine the most likely combination variables that would fit a particular precontact activity.

DEM – Digital elevation model- the GIS stored matrix of elevation points either directly measured from air photos or created from contour maps.

Ecosections – Ecological units based on climate and physiography.

Expected number – When referring to survey points it refers to the number of points theoretically expected. This information is used in the Chi-squared analysis.

GIS- Geographic Information Systems – Computer mapping that stores information about the mapped area.

GPS- Global Positioning System – real world position co-ordinates established from orbiting satellites.

Grid Points – Points evenly spaced 2 km apart covering the entire study area, represents a random sample.

Heritage Resource Management – The management of items of heritage value, such as archaeological sites, artifact collections, heritage landscapes, etc.

Identity analysis – describes the characteristics at an individual point that cannot be measured with a number, such as the characteristic of a point being located in a swamp.

Inductive modelling – this type of modelling uses univariate and multivariate analysis to determine differences in the distribution of sites to non-sites, with empirical testing of the results.

Iteration- repetition or repetitive

Kvamme's gain statistic – a simple formula, 1-(%area/ % sites), used to measure model performance.

Maximum likelihood distance classification techniques- A type of multivariate statistical analyses.

Micro-topographical data- Small-scale terrain features often too small to be mapped.

Modelling – Reducing the complexity and scale of the real world to manageable proportions.

Multiple logistic regression –Multivariate statistical analysis that can combine data of many different types into one formula, that provides a probability that an archaeological site will be located in any particular raster cell.

Multiple discriminate analysis – A type of multivariate statistical analyses.

Maximum distance classifiers – A type of multivariate statistical analyses.

NAD 27, NAD 83 – North American Datum (1927 and 1983).

Near-to analysis- measures the distance from a point to a feature such as a large lake

Observed number –Refers to the number of points actually observed. This information is used in the Chi-squared analysis.

Orthophotos - Aerial photos that have been adjusted and corrected to a co-ordinate system, and can be used as a map.

Polygons - Any closed shape that maps an area. A polygon is the entire area, not just the perimeter lines.

Raster- spatial data stored in regular sized square cells. They can only store one single type of information.

Survey points – Points derived from mapped lines or polygons of archaeological survey (where no archaeological sites are found).

TRIM data – Terrain Resource Information Management data contains digital mapsheets covering the province at a scale of 1:20 000.

Quadratic classification procedures – A type of multivariate statistical analyses.

UTMs – Universal Transverse Mercator co-ordinate system, uses metres North and metres East of datum lines to describe position.

Variable – a characteristic which changes and can be measured.

Appendix 2: Datagaps analysis of individual variables.

The following is the combined results of the datagap analysis program, which was used in conjunction with the graphs presented in "Model Building" to assess data gaps.

The printouts are mostly self-explanatory. A few notes clarify some aspects.

- Any filters on the data are reported near the top of each run. For example, "in_lkrv=' ' and in_wet=' '" means that all points falling in lakes, rivers, and wetlands were excluded from the analysis. When comparing the distribution of grid to survey points near the shores of a large lake, river, or wetland, including the grid points that were close to the shore, but were actually in the lake (or river or wetland), would skew the results of comparing numbers of survey points near the shore. This is because it is assumed that no survey would occur in a body of water. For example, if a small area was being considered for datagap analysis and consisted of a large lake that occupied 50% of its territory, about 50% of the grid points would occur within the lake. This doesn't mean, however, that there is a datagap if there is twice as many grid points to survey points.

- Iterations can be limited to part of the sequence, with statistical reporting considering all values: thus there are separate lines for "Average for grids up to end of iterations" and "Average for grids up to end of sample".

- The sample size is reported for grids and surveys. In this case, there are 1778 grid points in the database that are less than 2000 m from the feature being analysed.

```
grids and survs <   2000
grids:            1778
survs:            1763
```

- The following line is from the results of the main analysis.

```
Buffer  200 (o-e):  -38.32 |   318 grids |   277 survs |  chi^2=    5.67
```

In this case, the program reports a buffer (starting at 0) and ending at 200 m, an observed-expected count of survey points of –38.32 (indicating survey points occur about 38.32/277 or about 14% less often than expected in this buffer size), the number of grids and survs in the buffer iteration, and a chi-square value of 5.67. Each buffer is treated as a 2x2 table of points within the buffer and all those outside the buffer.

GRID	SURV	
		NUMBER OF POINTS WITHIN BUFFER
		NUMBER OF POINTS OUTSIDE BUFFER

The chi-square value, together with the d.f. (degrees of freedom) value of 1, allows an assessment of whether the difference of 38 survey points is expected random variation or not. A chi-square value in excess of 2.71 indicates a that there is a probibility of less than 5% that the variation is random; i.e. it is statistically significant and there is a data gap. Expected cell values less than 5 points can invalidate the chi-square test: any such cells are indicated with an asterix* preceding the chi-square.

- The program reports that "there are no statistically significant differences" or reports that there are "statistically significant more survey points than grid points", or "more grid points that survey points" in an overall buffer. **If there are more grid points than survey points, a data gap is indicated. If there are more survey points than grid points, then there is no data gap.**

- It groups all buffers that are statistically significant into an overall buffer, giving an overall observed-expected a chi-square value for the grouped buffer.

- Occasionally, the program will report no statistically significant data gaps when there is no survey points at all. These must be interpreted as a real data gap.

- Near-to data in metres are only significant at the lower end of the distance values. A data gap at a large distance is not considered significant.

- Near-to data in meters was examined in 100 m increments (or iterations) and 200 m increments (those reproduced here). Occasionally, special runs were made to examine other values such as 50 m increments, iterations starting above 0, etc.

- Near-to data was also examined at a larger scale. Near-to data was restricted to 2000 m, with all values above this entered as 9999. In order to test large-scale patterning, an increment of 5000 m was chosen, so that all values less than 2000 m were selected in the first iteration, and all those greater than 2000 m (i.e., 9999 m) were selected in the second iteration. So, the program reports this as a 0-5000 m and 5001-10000 m, whereas it is really 0-2000 and >2000.

- Identity data in ordinal scale, such as forest age and forest height, are treated as if they were metric data. The program reports "There are significantly more survey points than grid points within 34 meters of A.aspen_p" when it really means there are statistically more survey points in the 1-33% aspen stand. In these cases, the data gaps can occur anywhere in the printout (e.g., it is just as important if the data gap is for 67-100% aspen as it is for 1-33%), and the printout should be interpreted with this in mind.

- A simple histogram is generated from the data for survey points and grid points.

```
DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y □

in_lkrv='  ' and in_wet='  '
Enter iteration size: 200 □

Enter start point for iterations: 200 □

Enter end point for iterations: 2000 □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y □

Variable:  A.SITES_NR

Average for grids up to end of iterations:
     A.sites_nr
       1221.417
Average for survs up to end of iterations:
     A.sites_nr
        872.311
Average for grids up to end of sample:
     A.sites_nr
       1221.417
Average for survs up to end of sample:
     A.sites_nr
        872.311

Is A.sites_nr(surv) < A.sites_nr(grids) - using sample: YES

grids and survs <   2000
grids:             808
survs:            4480


* indicates that expected value is low
D.F. = 1

Buffer  400 (o-e):  509.13 |    42 grids |   742 survs |  chi^2= 1174.15
Buffer  600 (o-e):  426.51 |    67 grids |   798 survs |  chi^2=  533.97
Buffer  800 (o-e):  459.32 |    49 grids |   731 survs |  chi^2=  826.67
Buffer 1000 (o-e):  118.90 |    92 grids |   629 survs |  chi^2=   31.28
Buffer 1200 (o-e):   32.08 |    88 grids |   520 survs |  chi^2=    2.37
Buffer 1400 (o-e): -195.37 |    98 grids |   348 survs |  chi^2=   79.94
Buffer 1600 (o-e): -295.54 |   102 grids |   270 survs |  chi^2=  176.76
Buffer 1800 (o-e): -450.35 |   120 grids |   215 survs |  chi^2=  357.99
Buffer 2000 (o-e): -486.16 |   127 grids |   218 survs |  chi^2=  398.24

There are significantly more survey points than grid points within 1000
meters of A.sites_nr

Buff % 1000 (o-e): 1395.34 |  33.8%grids |  64.9%survs |  chi^2= 1942.61

A.SITES_NR Histograms !

     GRID
```

```
  400| *****
  600| ********
  800| ******
 1000| ***********
 1200| **********
 1400| ************
 1600| ************
 1800| **************
 2000| ***************

     SURV

  400| ****************
  600| *****************
  800| ****************
 1000| **************
 1200| ***********
 1400| *******
 1600| ******
 1800| ****
 2000| ****
```

```
DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

in_lkrv='  ' and in_wet='  '
Enter iteration size: 200

Enter start point for iterations: 0

Enter end point for iterations: 2000

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y

Variable:  A.ECOTONE

Average for grids up to end of iterations:
      A.ecotone
        773.966
Average for survs up to end of iterations:
      A.ecotone
        745.083
Average for grids up to end of sample:
      A.ecotone
        773.966
Average for survs up to end of sample:
      A.ecotone
        745.083

Is A.ecotone(surv) < A.ecotone(grids) - using sample: YES

grids and survs <   2000
grids:          1778
```

```
survs:          1763


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):  -38.32 |   318 grids |   277 survs |  chi^2=    5.67
Buffer  400 (o-e):   25.43 |   288 grids |   311 survs |  chi^2=    2.70
Buffer  600 (o-e):   23.92 |   228 grids |   250 survs |  chi^2=    2.90
Buffer  800 (o-e):  -11.43 |   186 grids |   173 survs |  chi^2=    0.79
Buffer 1000 (o-e):   41.44 |   171 grids |   211 survs |  chi^2=   11.21
Buffer 1200 (o-e):   72.11 |   132 grids |   203 survs |  chi^2=   42.92
Buffer 1400 (o-e):  -17.94 |   126 grids |   107 survs |  chi^2=    2.77
Buffer 1600 (o-e):  -58.95 |   125 grids |    65 survs |  chi^2=   30.15
Buffer 1800 (o-e):  -21.11 |   105 grids |    83 survs |  chi^2=    4.55
Buffer 2000 (o-e):  -15.16 |    99 grids |    83 survs |  chi^2=    2.48

There are significantly more grid points than survey points within  200
meters of A.ecotone

Buff %  200 (o-e):  -38.32 |  17.9%grids |  15.7%survs |  chi^2=    5.67


A.ECOTONE Histograms !

     GRID

  200| *****************
  400| ****************
  600| ************
  800| **********
 1000| *********
 1200| *******
 1400| *******
 1600| *******
 1800| *****
 2000| *****

     SURV

  200| ***************
  400| *****************
  600| **************
  800| *********
 1000| ***********
 1200| ***********
 1400| ******
 1600| ***
 1800| ****
 2000| ****


Variable:  A.TBRLN

Average for grids up to end of iterations:
        A.tbrln
       1028.671
Average for survs up to end of iterations:
```

```
        A.tbrln
          0.000
Average for grids up to end of sample:
        A.tbrln
       1028.671
Average for survs up to end of sample:
        A.tbrln
          0.000

Is A.tbrln(surv) < A.tbrln(grids) - using sample: YES

grids and survs <   2000
grids:           106
survs:             0


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):    0.00 |     8 grids |     0 survs |  chi^2= ******* *
Buffer  400 (o-e):    0.00 |    12 grids |     0 survs |  chi^2= ******* *
Buffer  600 (o-e):    0.00 |    11 grids |     0 survs |  chi^2= ******* *
Buffer  800 (o-e):    0.00 |    12 grids |     0 survs |  chi^2= ******* *
Buffer 1000 (o-e):    0.00 |     3 grids |     0 survs |  chi^2= ******* *
Buffer 1200 (o-e):    0.00 |    13 grids |     0 survs |  chi^2= ******* *
Buffer 1400 (o-e):    0.00 |    17 grids |     0 survs |  chi^2= ******* *
Buffer 1600 (o-e):    0.00 |    12 grids |     0 survs |  chi^2= ******* *
Buffer 1800 (o-e):    0.00 |    11 grids |     0 survs |  chi^2= ******* *
Buffer 2000 (o-e):    0.00 |     7 grids |     0 survs |  chi^2= ******* *

There are no surveys within this distance and there are   106 grid points!


A.TBRLN Histograms !

*** ERROR:

Either GRID or SURV = 0 and thus histograms cannot be produced!


Variable:  A.ESKERS

Average for grids up to end of iterations:
       A.eskers
       1122.004
Average for survs up to end of iterations:
       A.eskers
       1099.791
Average for grids up to end of sample:
       A.eskers
       1122.004
Average for survs up to end of sample:
       A.eskers
       1099.791

Is A.eskers(surv) < A.eskers(grids) - using sample: YES

grids and survs <   2000
```

```
grids:            91
survs:            27


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):    3.22 |     6 grids |     5 survs |  chi^2=    6.23 *
Buffer  400 (o-e):   -0.89 |     3 grids |     0 survs |  chi^2=    0.92 *
Buffer  600 (o-e):   -3.26 |    11 grids |     0 survs |  chi^2=    3.71 *
Buffer  800 (o-e):   -2.37 |     8 grids |     0 survs |  chi^2=    2.60 *
Buffer 1000 (o-e):    1.33 |     9 grids |     4 survs |  chi^2=    0.73 *
Buffer 1200 (o-e):    0.03 |    10 grids |     3 survs |  chi^2=    0.00 *
Buffer 1400 (o-e):   -0.26 |    11 grids |     3 survs |  chi^2=    0.02 *
Buffer 1600 (o-e):    3.85 |    14 grids |     8 survs |  chi^2=    4.21 *
Buffer 1800 (o-e):    1.33 |     9 grids |     4 survs |  chi^2=    0.73 *
Buffer 2000 (o-e):   -2.97 |    10 grids |     0 survs |  chi^2=    3.33 *

There are significantly more survey points than grid points within  200
meters of A.eskers

Buff %  200 (o-e):    3.22 |   6.6%grids |  18.5%survs |  chi^2=    6.23 *


A.ESKERS Histograms !

     GRID

  200| ******
  400| ***
  600| ************
  800| ********
 1000| *********
 1200| **********
 1400| ************
 1600| ***************
 1800| *********
 2000| **********

     SURV

  200| ******************
  400|
  600|
  800|
 1000| **************
 1200| ***********
 1400| ***********
 1600| *****************************
 1800| **************
 2000|


Variable:  A.TRAILS

Average for grids up to end of iterations:
       A.trails
        974.726
```

```
Average for survs up to end of iterations:
       A.trails
        764.046
Average for grids up to end of sample:
       A.trails
        974.726
Average for survs up to end of sample:
       A.trails
        764.046

Is A.trails(surv) < A.trails(grids) - using sample: YES

grids and survs <   2000
grids:          1087
survs:          3546


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):  163.03 |   141 grids |   623 survs |  chi^2=   66.40
Buffer  400 (o-e):  168.11 |   114 grids |   540 survs |  chi^2=   84.90
Buffer  600 (o-e):  129.09 |    95 grids |   439 survs |  chi^2=   58.92
Buffer  800 (o-e):   65.47 |   105 grids |   408 survs |  chi^2=   13.85
Buffer 1000 (o-e):   46.09 |    95 grids |   356 survs |  chi^2=    7.51
Buffer 1200 (o-e):   -9.32 |   108 grids |   343 survs |  chi^2=    0.27
Buffer 1400 (o-e):  -53.48 |   101 grids |   276 survs |  chi^2=    9.57
Buffer 1600 (o-e): -136.15 |   115 grids |   239 survs |  chi^2=   55.26
Buffer 1800 (o-e): -163.53 |   105 grids |   179 survs |  chi^2=   86.42
Buffer 2000 (o-e): -209.32 |   108 grids |   143 survs |  chi^2=  138.08

There are significantly more survey points than grid points within 1000
meters of A.trails

Buff % 1000 (o-e):  571.80 |  50.6%grids |  66.7%survs |  chi^2=  368.86


A.TRAILS Histograms !

     GRID

  200| ************
  400| **********
  600| ********
  800| *********
 1000| ********
 1200| *********
 1400| *********
 1600| **********
 1800| *********
 2000| *********

     SURV

  200| *****************
  400| ***************
  600| ************
  800| ***********
```

```
 1000| **********
 1200| *********
 1400| *******
 1600| ******
 1800| *****
 2000| ****□

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y □

in_wet='  ' and in_lkrv='  '
Enter iteration size: 5000 □

Enter start point for iterations: 0 □

Enter end point for iterations: 10000 □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :t □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y □

Variable:  A.ECOTONE

Average for grids up to end of iterations:
      A.ecotone
       8623.676
Average for survs up to end of iterations:
      A.ecotone
       7915.657
Average for grids up to end of sample:
      A.ecotone
       8623.676
Average for survs up to end of sample:
      A.ecotone
       7915.657

Is A.ecotone(surv) < A.ecotone(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  595.51 |  1778 grids |  1763 survs |  chi^2=  356.97
Buffer10000 (o-e): -595.51 | 10148 grids |  6068 survs |  chi^2=  356.97

There are significantly more survey points than grid points within 5000
meters of A.ecotone

Buff % 5000 (o-e):  595.51 |  14.9%grids |  22.5%survs |  chi^2=  356.97
```

```
A.ECOTONE Histograms !

     GRID

 5000| **************
10000|
*****************************************************************************
********

     SURV

 5000| **********************
10000|
*****************************************************************************


Variable:  A.TBRLN

Average for grids up to end of iterations:
        A.tbrln
       9919.270
Average for survs up to end of iterations:
        A.tbrln
       9999.000
Average for grids up to end of sample:
        A.tbrln
       9919.270
Average for survs up to end of sample:
        A.tbrln
       9999.000

Is A.tbrln(surv) < A.tbrln(grids) - using sample: NO

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  -69.60 |   106 grids |     0 survs |  chi^2=   70.23
Buffer10000 (o-e):   69.60 | 11820 grids |  7831 survs |  chi^2=   70.23

There are significantly more grid points than survey points within 5000
meters of A.tbrln

Buff % 5000 (o-e):  -69.60 |   0.9%grids |   0.0%survs |  chi^2=   70.23


A.TBRLN Histograms !

     GRID

 5000|
```

```
10000|
*****************************************************************************
**********************

     SURV

 5000|
10000|
*****************************************************************************
***********************


Variable:  A.ESKERS

Average for grids up to end of iterations:
       A.eskers
       9931.265
Average for survs up to end of iterations:
       A.eskers
       9968.317
Average for grids up to end of sample:
       A.eskers
       9931.265
Average for survs up to end of sample:
       A.eskers
       9968.317

Is A.eskers(surv) < A.eskers(grids) - using sample: NO

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  -32.75 |    91 grids |    27 survs |  chi^2=   18.09
Buffer10000 (o-e):   32.75 | 11835 grids |  7804 survs |  chi^2=   18.09

There are significantly more grid points than survey points within 5000
meters of A.eskers

Buff % 5000 (o-e):  -32.75 |   0.8%grids |   0.3%survs |  chi^2=   18.09


A.ESKERS Histograms !

     GRID

 5000|
10000|
*****************************************************************************
**********************

     SURV

 5000|
```

```
10000|
******************************************************************************
**********************


Variable:  A.TRAILS

Average for grids up to end of iterations:
       A.trails
       9176.479
Average for survs up to end of iterations:
       A.trails
       5817.268
Average for grids up to end of sample:
       A.trails
       9176.479
Average for survs up to end of sample:
       A.trails
       5817.268

Is A.trails(surv) < A.trails(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e): 2832.24 |  1087 grids |  3546 survs |  chi^2= 12365.6
Buffer10000 (o-e): -2832.2 | 10839 grids |  4285 survs |  chi^2= 12365.6

There are significantly more survey points than grid points within 5000
meters of A.trails

Buff % 5000 (o-e): 2832.24 |   9.1%grids |  45.3%survs |  chi^2= 12365.6


A.TRAILS Histograms !

     GRID

 5000| *********
10000|
******************************************************************************
*************

     SURV

 5000| *********************************************
10000| *******************************************************


Variable:  A.LAKEVS

Average for grids up to end of iterations:
       A.lakevs
```

```
       3420.249
Average for survs up to end of iterations:
       A.lakevs
       2999.669
Average for grids up to end of sample:
       A.lakevs
       3420.249
Average for survs up to end of sample:
       A.lakevs
       2999.669

Is A.lakevs(surv) < A.lakevs(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  414.50 |  8654 grids |  6097 survs |  chi^2=  110.20
Buffer10000 (o-e): -414.50 |  3272 grids |  1734 survs |  chi^2=  110.20

There are significantly more survey points than grid points within 5000
meters of A.lakevs

Buff % 5000 (o-e):  414.50 |  72.6%grids |  77.9%survs |  chi^2=  110.20


A.LAKEVS Histograms !

     GRID

 5000|
************************************************************************
10000| ***************************

     SURV

 5000|
*****************************************************************************
10000| **********************


DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

in_wet='  ' and in_lkrv='  '
Enter iteration size: 200

Enter start point for iterations: 0

Enter end point for iterations: 2000

For the chi-square analysis, do you want to limit the
```

```
sample to the end point of the iterations (Y/N)? :y 

Variable:  A.LAKEVS

Average for grids up to end of iterations:
       A.lakevs
        932.882
Average for survs up to end of iterations:
       A.lakevs
       1009.044
Average for grids up to end of sample:
       A.lakevs
        932.882
Average for survs up to end of sample:
       A.lakevs
       1009.044

Is A.lakevs(surv) < A.lakevs(grids) - using sample: NO

grids and survs <   2000
grids:          8654
survs:          6097


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e): -127.35 |   608 grids |   301 survs |  chi^2=   40.72
Buffer  400 (o-e): -188.39 |  1014 grids |   526 survs |  chi^2=   56.28
Buffer  600 (o-e):  -64.10 |  1103 grids |   713 survs |  chi^2=    6.06
Buffer  800 (o-e):  -64.05 |  1137 grids |   737 survs |  chi^2=    5.90
Buffer 1000 (o-e):   39.61 |  1058 grids |   785 survs |  chi^2=    2.40
Buffer 1200 (o-e):  158.49 |   929 grids |   813 survs |  chi^2=   42.99
Buffer 1400 (o-e):   58.06 |   870 grids |   671 survs |  chi^2=    6.11
Buffer 1600 (o-e):   59.40 |   729 grids |   573 survs |  chi^2=    7.50
Buffer 1800 (o-e):   69.94 |   653 grids |   530 survs |  chi^2=   11.50
Buffer 2000 (o-e):   58.40 |   553 grids |   448 survs |  chi^2=    9.35

There are significantly more grid points than survey points within  800
meters of A.lakevs

Buff %  800 (o-e): -443.89 |  44.6%grids |  37.3%survs |  chi^2=  130.78


A.LAKEVS Histograms !

     GRID

  200| *******
  400| ***********
  600| ************
  800| *************
 1000| ************
 1200| **********
 1400| **********
 1600| ********
 1800| *******
 2000| ******
```

```
     SURV

  200| ****
  400| ********
  600| ***********
  800| ************
 1000| ************
 1200| *************
 1400| ***********
 1600| *********
 1800| ********
 2000| *******


Variable:  A.LAKESM

Average for grids up to end of iterations:
       A.lakesm
       1174.792
Average for survs up to end of iterations:
       A.lakesm
       1231.245
Average for grids up to end of sample:
       A.lakesm
       1174.792
Average for survs up to end of sample:
       A.lakesm
       1231.245

Is A.lakesm(surv) < A.lakesm(grids) - using sample: NO

grids and survs <   2000
grids:          1622
survs:           507


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):    1.93 |    61 grids |    21 survs |  chi^2=    0.20
Buffer  400 (o-e):   -2.95 |   115 grids |    33 survs |  chi^2=    0.26
Buffer  600 (o-e):  -12.32 |   129 grids |    28 survs |  chi^2=    4.09
Buffer  800 (o-e):  -14.14 |   138 grids |    29 survs |  chi^2=    5.06
Buffer 1000 (o-e):   -4.01 |   176 grids |    51 survs |  chi^2=    0.33
Buffer 1200 (o-e):    4.74 |   164 grids |    56 survs |  chi^2=    0.49
Buffer 1400 (o-e):   19.42 |   181 grids |    76 survs |  chi^2=    7.51
Buffer 1600 (o-e):  -14.76 |   188 grids |    44 survs |  chi^2=    4.20
Buffer 1800 (o-e):   -2.33 |   225 grids |    68 survs |  chi^2=    0.09
Buffer 2000 (o-e):   24.42 |   245 grids |   101 survs |  chi^2=    9.17

There are no significant differences!


A.LAKESM Histograms !

     GRID
```

```
  200| ***
  400| *******
  600| *******
  800| ********
 1000| **********
 1200| **********
 1400| ***********
 1600| ***********
 1800| *************
 2000| ***************

     SURV

  200| ****
  400| ******
  600| *****
  800| *****
 1000| **********
 1200| ***********
 1400| **************
 1600| ********
 1800| *************
 2000| *******************


Variable:  A.LAKEMED

Average for grids up to end of iterations:
      A.lakemed
       1169.700
Average for survs up to end of iterations:
      A.lakemed
       1089.975
Average for grids up to end of sample:
      A.lakemed
       1169.700
Average for survs up to end of sample:
      A.lakemed
       1089.975

Is A.lakemed(surv) < A.lakemed(grids) - using sample: YES

grids and survs <   2000
grids:           149
survs:            34


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):   -1.60 |     7 grids |     0 survs |  chi^2=    1.68 *
Buffer  400 (o-e):   -1.83 |     8 grids |     0 survs |  chi^2=    1.93 *
Buffer  600 (o-e):    0.58 |    15 grids |     4 survs |  chi^2=    0.11 *
Buffer  800 (o-e):   -0.28 |    10 grids |     2 survs |  chi^2=    0.04 *
Buffer 1000 (o-e):    9.35 |    16 grids |    13 survs |  chi^2=   26.82 *
Buffer 1200 (o-e):    1.35 |    16 grids |     5 survs |  chi^2=    0.56 *
Buffer 1400 (o-e):   -3.11 |    18 grids |     1 survs |  chi^2=    2.67 *
Buffer 1600 (o-e):   -0.56 |    20 grids |     4 survs |  chi^2=    0.08 *
```

```
Buffer 1800 (o-e):   -2.11 |    18 grids |      2 survs |  chi^2=    1.23 *
Buffer 2000 (o-e):   -1.79 |    21 grids |      3 survs |  chi^2=    0.78 *

There are no significant differences!


A.LAKEMED Histograms !

     GRID

  200| ****
  400| *****
  600| **********
  800| ******
 1000| **********
 1200| **********
 1400| ************
 1600| *************
 1800| ************
 2000| **************

     SURV

  200|
  400|
  600| ***********
  800| *****
 1000| **************************************
 1200| **************
 1400| **
 1600| ***********
 1800| *****
 2000| ********


Variable:  A.LAKELG

Average for grids up to end of iterations:
       A.lakelg
       1228.078
Average for survs up to end of iterations:
       A.lakelg
          0.000
Average for grids up to end of sample:
       A.lakelg
       1228.078
Average for survs up to end of sample:
       A.lakelg
          0.000

Is A.lakelg(surv) < A.lakelg(grids) - using sample: YES

grids and survs <   2000
grids:             15
survs:              0


* indicates that expected value is low
```

```
D.F. = 1

Buffer  200 (o-e):    0.00 |     0 grids |     0 survs |  chi^2= ******* *
Buffer  400 (o-e):    0.00 |     0 grids |     0 survs |  chi^2= ******* *
Buffer  600 (o-e):    0.00 |     1 grids |     0 survs |  chi^2= ******* *
Buffer  800 (o-e):    0.00 |     2 grids |     0 survs |  chi^2= ******* *
Buffer 1000 (o-e):    0.00 |     3 grids |     0 survs |  chi^2= ******* *
Buffer 1200 (o-e):    0.00 |     1 grids |     0 survs |  chi^2= ******* *
Buffer 1400 (o-e):    0.00 |     3 grids |     0 survs |  chi^2= ******* *
Buffer 1600 (o-e):    0.00 |     1 grids |     0 survs |  chi^2= ******* *
Buffer 1800 (o-e):    0.00 |     1 grids |     0 survs |  chi^2= ******* *
Buffer 2000 (o-e):    0.00 |     3 grids |     0 survs |  chi^2= ******* *

There are no surveys within this distance and there are    15 grid points!


A.LAKELG Histograms !

*** ERROR:

Either GRID or SURV = 0 and thus histograms cannot be produced!


Variable:  A.RV_DBL

Average for grids up to end of iterations:
       A.rv_dbl
        887.010
Average for survs up to end of iterations:
       A.rv_dbl
        915.445
Average for grids up to end of sample:
       A.rv_dbl
        887.010
Average for survs up to end of sample:
       A.rv_dbl
        915.445

Is A.rv_dbl(surv) < A.rv_dbl(grids) - using sample: NO

grids and survs <   2000
grids:          3084
survs:          2494


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e): -141.92 |   497 grids |   260 survs |  chi^2=   59.74
Buffer  400 (o-e):   43.90 |   334 grids |   314 survs |  chi^2=    8.00
Buffer  600 (o-e):   81.41 |   321 grids |   341 survs |  chi^2=   28.50
Buffer  800 (o-e):    1.28 |   336 grids |   273 survs |  chi^2=    0.01
Buffer 1000 (o-e):  -40.55 |   316 grids |   215 survs |  chi^2=    7.17
Buffer 1200 (o-e):   23.74 |   260 grids |   234 survs |  chi^2=    2.93
Buffer 1400 (o-e):   27.18 |   278 grids |   252 survs |  chi^2=    3.61
Buffer 1600 (o-e):   16.30 |   242 grids |   212 survs |  chi^2=    1.47
Buffer 1800 (o-e):   16.40 |   253 grids |   221 survs |  chi^2=    1.43
Buffer 2000 (o-e):  -27.75 |   247 grids |   172 survs |  chi^2=    4.19
```

```
There are significantly more grid points than survey points within  200
meters of A.rv_dbl

Buff %  200 (o-e): -141.92 |  16.1%grids |  10.4%survs |  chi^2=   59.74


A.RV_DBL Histograms !

     GRID

  200| ****************
  400| **********
  600| **********
  800| **********
 1000| **********
 1200| ********
 1400| *********
 1600| *******
 1800| ********
 2000| ********

     SURV

  200| **********
  400| ************
  600| *************
  800| **********
 1000| ********
 1200| *********
 1400| **********
 1600| ********
 1800| ********
 2000| ******


Variable:  A.RV_INT

Average for grids up to end of iterations:
       A.rv_int
        388.023
Average for survs up to end of iterations:
       A.rv_int
        416.400
Average for grids up to end of sample:
       A.rv_int
        388.023
Average for survs up to end of sample:
       A.rv_int
        416.400

Is A.rv_int(surv) < A.rv_int(grids) - using sample: NO

grids and survs <   2000
grids:         11612
survs:          7750
```

```
* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e): -515.43 |  4599 grids |  2554 survs |  chi^2=  143.31
Buffer  400 (o-e):  338.82 |  2925 grids |  2291 survs |  chi^2=   78.60
Buffer  600 (o-e):  136.11 |  1642 grids |  1232 survs |  chi^2=   19.69
Buffer  800 (o-e):    5.95 |   962 grids |   648 survs |  chi^2=    0.06
Buffer 1000 (o-e):    1.27 |   527 grids |   353 survs |  chi^2=    0.00
Buffer 1200 (o-e):   -7.96 |   391 grids |   253 survs |  chi^2=    0.25
Buffer 1400 (o-e):  -17.18 |   237 grids |   141 survs |  chi^2=    1.90
Buffer 1600 (o-e):   24.23 |   139 grids |   117 survs |  chi^2=    6.40
Buffer 1800 (o-e):   18.25 |   109 grids |    91 survs |  chi^2=    4.62
Buffer 2000 (o-e):   15.94 |    81 grids |    70 survs |  chi^2=    4.73

There are significantly more grid points than survey points within  200
meters of A.rv_int

Buff %  200 (o-e): -515.43 |  39.6%grids |  33.0%survs |  chi^2=  143.31


A.RV_INT Histograms !

     GRID

  200| ***************************************
  400| *************************
  600| **************
  800| ********
 1000| ****
 1200| ***
 1400| **
 1600| *
 1800|
 2000|

     SURV

  200| ********************************
  400| *****************************
  600| ***************
  800| ********
 1000| ****
 1200| ***
 1400| *
 1600| *
 1800| *
 2000|


Variable:  A.RV_SGL

Average for grids up to end of iterations:
       A.rv_sgl
        688.893
Average for survs up to end of iterations:
       A.rv_sgl
        666.837
Average for grids up to end of sample:
```

```
       A.rv_sgl
        688.893
Average for survs up to end of sample:
       A.rv_sgl
        666.837

Is A.rv_sgl(surv) < A.rv_sgl(grids) - using sample: YES

grids and survs <   2000
grids:         10887
survs:          7571


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e):  -56.68 |  2273 grids |  1524 survs |  chi^2=    2.57
Buffer  400 (o-e):  -36.40 |  1811 grids |  1223 survs |  chi^2=    1.26
Buffer  600 (o-e):   80.44 |  1492 grids |  1118 survs |  chi^2=    7.23
Buffer  800 (o-e):   84.17 |  1281 grids |   975 survs |  chi^2=    9.01
Buffer 1000 (o-e):   81.13 |  1097 grids |   844 survs |  chi^2=    9.59
Buffer 1200 (o-e):   82.86 |   863 grids |   683 survs |  chi^2=   12.42
Buffer 1400 (o-e):   37.96 |   732 grids |   547 survs |  chi^2=    3.03
Buffer 1600 (o-e):  -74.08 |   571 grids |   323 survs |  chi^2=   14.59
Buffer 1800 (o-e): -101.94 |   427 grids |   195 survs |  chi^2=   36.43
Buffer 2000 (o-e):  -97.44 |   340 grids |   139 survs |  chi^2=   41.45

There are no significant differences!


A.RV_SGL Histograms !

     GRID

  200| ********************
  400| ****************
  600| *************
  800| ***********
 1000| **********
 1200| *******
 1400| ******
 1600| *****
 1800| ***
 2000| ***

     SURV

  200| ********************
  400| ****************
  600| **************
  800| ************
 1000| ***********
 1200| *********
 1400| *******
 1600| ****
 1800| **
 2000| *
```

```
Variable:  A.WETLG

Average for grids up to end of iterations:
        A.wetlg
        572.437
Average for survs up to end of iterations:
        A.wetlg
        795.751
Average for grids up to end of sample:
        A.wetlg
        572.437
Average for survs up to end of sample:
        A.wetlg
        795.751

Is A.wetlg(surv) < A.wetlg(grids) - using sample: NO

grids and survs <   2000
grids:          9489
survs:          4611


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e): -783.20 |  3184 grids |   764 survs |  chi^2=  596.68
Buffer  400 (o-e): -104.10 |  1628 grids |   687 survs |  chi^2=   16.53
Buffer  600 (o-e):   44.63 |  1040 grids |   550 survs |  chi^2=    4.43
Buffer  800 (o-e):   52.38 |   880 grids |   480 survs |  chi^2=    7.07
Buffer 1000 (o-e):  164.08 |   681 grids |   495 survs |  chi^2=   87.65
Buffer 1200 (o-e):  185.51 |   569 grids |   462 survs |  chi^2=  132.40
Buffer 1400 (o-e):  100.23 |   514 grids |   350 survs |  chi^2=   42.53
Buffer 1600 (o-e):  133.20 |   405 grids |   330 survs |  chi^2=   94.17
Buffer 1800 (o-e):  109.59 |   326 grids |   268 survs |  chi^2=   78.51
Buffer 2000 (o-e):   97.69 |   262 grids |   225 survs |  chi^2=   77.08

There are significantly more grid points than survey points within  400
meters of A.wetlg

Buff %  400 (o-e): -887.30 |  50.7%grids |  31.5%survs |  chi^2=  683.12


A.WETLG Histograms !

     GRID

  200| ********************************
  400| ****************
  600| **********
  800| *********
 1000| *******
 1200| *****
 1400| *****
 1600| ****
 1800| ***
 2000| **
```

```
     SURV

  200| ****************
  400| **************
  600| ***********
  800| **********
 1000| **********
 1200| **********
 1400| *******
 1600| *******
 1800| *****
 2000| ****


Variable:  A.WETSM

Average for grids up to end of iterations:
        A.wetsm
        810.021
Average for survs up to end of iterations:
        A.wetsm
        952.709
Average for grids up to end of sample:
        A.wetsm
        810.021
Average for survs up to end of sample:
        A.wetsm
        952.709

Is A.wetsm(surv) < A.wetsm(grids) - using sample: NO

grids and survs <   2000
grids:          9265
survs:          6426


* indicates that expected value is low
D.F. = 1

Buffer  200 (o-e): -297.26 |  1174 grids |   517 survs |  chi^2=  124.27
Buffer  400 (o-e): -226.27 |  1422 grids |   760 survs |  chi^2=   61.32
Buffer  600 (o-e): -124.04 |  1240 grids |   736 survs |  chi^2=   20.65
Buffer  800 (o-e):  -71.62 |  1212 grids |   769 survs |  chi^2=    7.02
Buffer 1000 (o-e):  -58.69 |  1029 grids |   655 survs |  chi^2=    5.43
Buffer 1200 (o-e):   64.67 |   867 grids |   666 survs |  chi^2=    7.67
Buffer 1400 (o-e):  252.67 |   743 grids |   768 survs |  chi^2=  134.69
Buffer 1600 (o-e):  187.71 |   593 grids |   599 survs |  chi^2=   91.53
Buffer 1800 (o-e):  137.48 |   527 grids |   503 survs |  chi^2=   54.83
Buffer 2000 (o-e):  135.34 |   458 grids |   453 survs |  chi^2=   60.66

There are significantly more grid points than survey points within 1000
meters of A.wetsm

Buff % 1000 (o-e): -777.87 |  65.6%grids |  53.5%survs |  chi^2=  417.22


A.WETSM Histograms !
```

```
     GRID

  200| ************
  400| ***************
  600| *************
  800| *************
 1000| ***********
 1200| *********
 1400| ********
 1600| ******
 1800| *****
 2000| ****

     SURV

  200| ********
  400| ***********
  600| ***********
  800| ***********
 1000| **********
 1200| **********
 1400| ***********
 1600| *********
 1800| *******
 2000| *******

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

in_wet='  ' and in_lkrv='  '
Enter iteration size: 5000

Enter start point for iterations: 0

Enter end point for iterations: 10000

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y

Variable:  A.LAKESM

Average for grids up to end of iterations:
       A.lakesm
       8798.860
Average for survs up to end of iterations:
       A.lakesm
       9431.352
Average for grids up to end of sample:
       A.lakesm
       8798.860
Average for survs up to end of sample:
       A.lakesm
       9431.352

Is A.lakesm(surv) < A.lakesm(grids) - using sample: NO
```

```
grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e): -558.06 |  1622 grids |   507 survs |  chi^2=  338.43
Buffer10000 (o-e):  558.06 | 10304 grids |  7324 survs |  chi^2=  338.43

There are significantly more grid points than survey points within 5000
meters of A.lakesm

Buff % 5000 (o-e): -558.06 |  13.6%grids |   6.5%survs |  chi^2=  338.43


A.LAKESM Histograms !

     GRID

 5000| *************
10000|
*****************************************************************************
*********

     SURV

 5000| ******
10000|
*****************************************************************************
****************


Variable:  A.LAKEMED

Average for grids up to end of iterations:
      A.lakemed
       9888.689
Average for survs up to end of iterations:
      A.lakemed
       9960.320
Average for grids up to end of sample:
      A.lakemed
       9888.689
Average for survs up to end of sample:
      A.lakemed
       9960.320

Is A.lakemed(surv) < A.lakemed(grids) - using sample: NO

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1
```

```
Buffer 5000 (o-e):  -63.84 |   149 grids |    34 survs |  chi^2=   42.18
Buffer10000 (o-e):   63.84 | 11777 grids |  7797 survs |  chi^2=   42.18

There are significantly more grid points than survey points within 5000
meters of A.lakemed

Buff % 5000 (o-e):  -63.84 |   1.2%grids |   0.4%survs |  chi^2=   42.18


A.LAKEMED Histograms !

     GRID

 5000| *
10000|
*****************************************************************************
*********************

     SURV

 5000|
10000|
*****************************************************************************
**********************


Variable:  A.LAKELG

Average for grids up to end of iterations:
       A.lakelg
       9987.968
Average for survs up to end of iterations:
       A.lakelg
       9999.000
Average for grids up to end of sample:
       A.lakelg
       9987.968
Average for survs up to end of sample:
       A.lakelg
       9999.000

Is A.lakelg(surv) < A.lakelg(grids) - using sample: NO

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):   -9.85 |    15 grids |     0 survs |  chi^2=    9.86
Buffer10000 (o-e):    9.85 | 11911 grids |  7831 survs |  chi^2=    9.86

There are significantly more grid points than survey points within 5000
meters of A.lakelg
```

```
Buff % 5000 (o-e):   -9.85 |   0.1%grids |   0.0%survs |  chi^2=    9.86


A.LAKELG Histograms !

     GRID

 5000|
10000|
*****************************************************************************
**********************

     SURV

 5000|
10000|
*****************************************************************************
***********************


Variable:  A.RV_DBL

Average for grids up to end of iterations:
       A.rv_dbl
       7642.688
Average for survs up to end of iterations:
       A.rv_dbl
       7106.089
Average for grids up to end of sample:
       A.rv_dbl
       7642.688
Average for survs up to end of sample:
       A.rv_dbl
       7106.089

Is A.rv_dbl(surv) < A.rv_dbl(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  468.95 |  3084 grids |  2494 survs |  chi^2=  146.47
Buffer10000 (o-e): -468.95 |  8842 grids |  5337 survs |  chi^2=  146.47

There are significantly more survey points than grid points within 5000
meters of A.rv_dbl

Buff % 5000 (o-e):  468.95 |  25.9%grids |  31.8%survs |  chi^2=  146.47


A.RV_DBL Histograms !

     GRID
```

```
 5000| *************************
10000|
***************************************************************************

     SURV

 5000| *******************************
10000| *********************************************************************


Variable:  A.RV_INT

Average for grids up to end of iterations:
       A.rv_int
        641.071
Average for survs up to end of iterations:
       A.rv_int
        515.517
Average for grids up to end of sample:
       A.rv_int
        641.071
Average for survs up to end of sample:
       A.rv_int
        515.517

Is A.rv_int(surv) < A.rv_int(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  125.18 | 11612 grids |  7750 survs |  chi^2=   78.06
Buffer10000 (o-e): -125.18 |   314 grids |    81 survs |  chi^2=   78.06

There are significantly more survey points than grid points within 5000
meters of A.rv_int

Buff % 5000 (o-e):  125.18 |  97.4%grids |  99.0%survs |  chi^2=   78.06


A.RV_INT Histograms !

     GRID

 5000|
*****************************************************************************
********************
10000| **

     SURV

 5000|
*****************************************************************************
*********************
```

```
10000| *


Variable:  A.RV_SGL

Average for grids up to end of iterations:
       A.rv_sgl
       1499.994
Average for survs up to end of iterations:
       A.rv_sgl
        976.678
Average for grids up to end of sample:
       A.rv_sgl
       1499.994
Average for survs up to end of sample:
       A.rv_sgl
        976.678

Is A.rv_sgl(surv) < A.rv_sgl(grids) - using sample: YES

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  422.24 | 10887 grids |  7571 survs |  chi^2=  286.27
Buffer10000 (o-e): -422.24 |  1039 grids |   260 survs |  chi^2=  286.27

There are significantly more survey points than grid points within 5000
meters of A.rv_sgl

Buff % 5000 (o-e):  422.24 |  91.3%grids |  96.7%survs |  chi^2=  286.27


A.RV_SGL Histograms !

     GRID

 5000|
******************************************************************************
**************
10000| ********

     SURV

 5000|
******************************************************************************
*******************
10000| ***


Variable:  A.WETLG

Average for grids up to end of iterations:
        A.wetlg
```

```
       2498.694
Average for survs up to end of iterations:
        A.wetlg
       4580.001
Average for grids up to end of sample:
        A.wetlg
       2498.694
Average for survs up to end of sample:
        A.wetlg
       4580.001

Is A.wetlg(surv) < A.wetlg(grids) - using sample: NO

grids and survs <  10000
grids:         11926
survs:          7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e): -1619.8 |  9489 grids |  4611 survs |  chi^2= 2060.69
Buffer10000 (o-e): 1619.79 |  2437 grids |  3220 survs |  chi^2= 2060.69

There are significantly more grid points than survey points within 5000
meters of A.wetlg

Buff % 5000 (o-e): -1619.8 |  79.6%grids |  58.9%survs |  chi^2= 2060.69


A.WETLG Histograms !

     GRID

 5000|
******************************************************************************
**
10000| ********************

     SURV

 5000| ***********************************************************
10000| *****************************************


Variable:  A.WETSM

Average for grids up to end of iterations:
        A.wetsm
       2860.321
Average for survs up to end of iterations:
        A.wetsm
       2575.751
Average for grids up to end of sample:
        A.wetsm
       2860.321
Average for survs up to end of sample:
        A.wetsm
```

```
       2575.751

Is A.wetsm(surv) < A.wetsm(grids) - using sample: YES

grids and survs <  10000
grids:          11926
survs:           7831


* indicates that expected value is low
D.F. = 1

Buffer 5000 (o-e):  342.30 |  9265 grids |  6426 survs |  chi^2=   86.32
Buffer10000 (o-e): -342.30 |  2661 grids |  1405 survs |  chi^2=   86.32

There are significantly more survey points than grid points within 5000
meters of A.wetsm

Buff % 5000 (o-e):  342.30 |  77.7%grids |  82.1%survs |  chi^2=   86.32


A.WETSM Histograms !

     GRID

 5000|
****************************************************************************
10000| **********************

     SURV

 5000|
****************************************************************************
*****
10000| *****************

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_age>0 and aspen_p>0
Enter iteration size: 33.5

Enter start point for iterations: 0

Enter end point for iterations: 100

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y


Variable:  A.ASPEN_P

Average for grids up to end of iterations:
             A.aspen_p
             45.992568
Average for survs up to end of iterations:
```

```
             A.aspen_p
             37.784591
Average for grids up to end of sample:
             A.aspen_p
             45.992568
Average for survs up to end of sample:
             A.aspen_p
             37.784591

Is A.aspen_p(surv) < A.aspen_p(grids) - using sample: YES

grids and survs <    100
grids:          3902
survs:          3751


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):  519.11 |  1450 grids |  1913 survs |  chi^2=  307.65
Buffer   67 (o-e): -288.42 |  1488 grids |  1142 survs |  chi^2=   94.00
Buffer  101 (o-e): -668.25 |  2216 grids |  1462 survs |  chi^2=  485.15

There are significantly more survey points than grid points within   34
meters of A.aspen_p

Buff %   34 (o-e):  519.11 |  37.2%grids |  51.0%survs |  chi^2=  307.65

A.ASPEN_P Histograms !

     GRID

   34| *************************************
   67| **************************************
  101| ********************************************************

     SURV

   34| **************************************************
   67| ******************************
  101| **************************************□

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y □

for_age>0 and birch_p>0
Enter iteration size: 33.5 □

Enter start point for iterations: 0 □

Enter end point for iterations: 100 □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y □

Variable:  A.BIRCH_P
```

```
Average for grids up to end of iterations:
             A.birch_p
             32.705366
Average for survs up to end of iterations:
             A.birch_p
             27.791469
Average for grids up to end of sample:
             A.birch_p
             32.705366
Average for survs up to end of sample:
             A.birch_p
             27.791469

Is A.birch_p(surv) < A.birch_p(grids) - using sample: YES

grids and survs <    100
grids:          1025
survs:           211


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):  -10.72 |   635 grids |   120 survs |  chi^2=    2.31
Buffer   67 (o-e):   26.60 |   274 grids |    83 survs |  chi^2=   17.12
Buffer  101 (o-e):    0.00 |   170 grids |    35 survs |  chi^2=    0.00

There are no significant differences!

A.BIRCH_P Histograms !

     GRID

   34| *************************************************************
   67| **************************
  101| ****************

     SURV

   34| ********************************************************
   67| ***************************************
  101| ****************

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_age>0 and cotton_p>0
Enter iteration size: 33.5

Enter start point for iterations: 0

Enter end point for iterations: 100

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y
```

```
Variable:  A.COTTON_P

Average for grids up to end of iterations:
            A.cotton_p
             24.908284
Average for survs up to end of iterations:
            A.cotton_p
             16.929600
Average for grids up to end of sample:
            A.cotton_p
             24.908284
Average for survs up to end of sample:
            A.cotton_p
             16.929600

Is A.cotton_p(surv) < A.cotton_p(grids) - using sample: YES

grids and survs <    100
grids:           676
survs:           625


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):  137.27 |   494 grids |   594 survs |  chi^2=  153.24
Buffer   67 (o-e): -117.53 |   152 grids |    23 survs |  chi^2=  126.81
Buffer  101 (o-e):  -40.64 |    71 grids |    25 survs |  chi^2=   28.12

There are significantly more survey points than grid points within   34
meters of A.cotton_p

Buff %   34 (o-e):  137.27 |  73.1%grids |  95.0%survs |  chi^2=  153.24

A.COTTON_P Histograms !

     GRID

   34|
*************************************************************************
   67| **********************
  101| **********

     SURV

   34|
*****************************************************************************
******************
   67| ***
  101| ****

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_age>0 and bspr_p>0
```

```
Enter iteration size: 33.5 □

Enter start point for iterations: 0 □

Enter end point for iterations: 100 □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y □

Variable:  A.BSPR_P

Average for grids up to end of iterations:
              A.bspr_p
             53.507375
Average for survs up to end of iterations:
              A.bspr_p
             44.068562
Average for grids up to end of sample:
              A.bspr_p
             53.507375
Average for survs up to end of sample:
              A.bspr_p
             44.068562

Is A.bspr_p(surv) < A.bspr_p(grids) - using sample: YES

grids and survs <    100
grids:          3051
survs:          1196


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):   84.74 |   868 grids |   425 survs |  chi^2=   29.50
Buffer   67 (o-e):  111.00 |  1125 grids |   552 survs |  chi^2=   44.26
Buffer  101 (o-e): -1478.7 |  5711 grids |   760 survs |  chi^2= -1120.3 *

There are significantly more survey points than grid points within   67
meters of A.bspr_p

Buff %   67 (o-e):  195.74 |  65.3%grids |  81.7%survs |  chi^2=  141.42

A.BSPR_P Histograms !

     GRID

   34| ****************************
   67| ************************************
  101|
*****************************************************************************
*****************************************************************************
*********************************

     SURV

   34| ***********************************
   67| **********************************************
```

```
  101| *****************************************************************

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_hght>2 and bspr_p>0
Enter iteration size: 33.5

Enter start point for iterations: 0

Enter end point for iterations: 100

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y

Variable:  BSPR_P

Average for grids up to end of iterations:
                bspr_p
             32.615534
Average for survs up to end of iterations:
                bspr_p
             39.093750
Average for grids up to end of sample:
                bspr_p
             32.615534
Average for survs up to end of sample:
                bspr_p
             39.093750

Is bspr_p(surv) < bspr_p(grids) - using sample: NO

grids and survs <    100
grids:             515
survs:             320


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):  -68.62 |   310 grids |   124 survs |  chi^2=   61.41
Buffer   67 (o-e):   97.17 |   151 grids |   191 survs |  chi^2=  142.39
Buffer  101 (o-e):  -46.57 |    83 grids |     5 survs |  chi^2=   50.14

There are significantly more grid points than survey points within   34
meters of bspr_p

Buff %   34 (o-e):  -68.62 |  60.2%grids |  38.8%survs |  chi^2=   61.41

BSPR_P Histograms !

     GRID

   34| **************************************************************
   67| ******************************
  101| *****************
```

```
     SURV

   34| **************************************
   67| ***********************************************************
  101| *

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_age>0 and wspr_p>0
Enter iteration size: 33.5

Enter start point for iterations: 0

Enter end point for iterations: 100

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y

Variable:  A.WSPR_P

Average for grids up to end of iterations:
              A.wspr_p
             40.828235
Average for survs up to end of iterations:
              A.wspr_p
             39.649388
Average for grids up to end of sample:
              A.wspr_p
             40.828235
Average for survs up to end of sample:
              A.wspr_p
             39.649388

Is A.wspr_p(surv) < A.wspr_p(grids) - using sample: YES

grids and survs <    100
grids:           850
survs:          1717


* indicates that expected value is low
D.F. = 1

Buffer   34 (o-e):   -4.74 |   437 grids |   878 survs |  chi^2=    0.05
Buffer   67 (o-e):   60.08 |   196 grids |   456 survs |  chi^2=   11.85
Buffer  101 (o-e):  -55.86 |   343 grids |   637 survs |  chi^2=    7.55

There are no significant differences!

A.WSPR_P Histograms !

     GRID

   34| ***************************************************
```

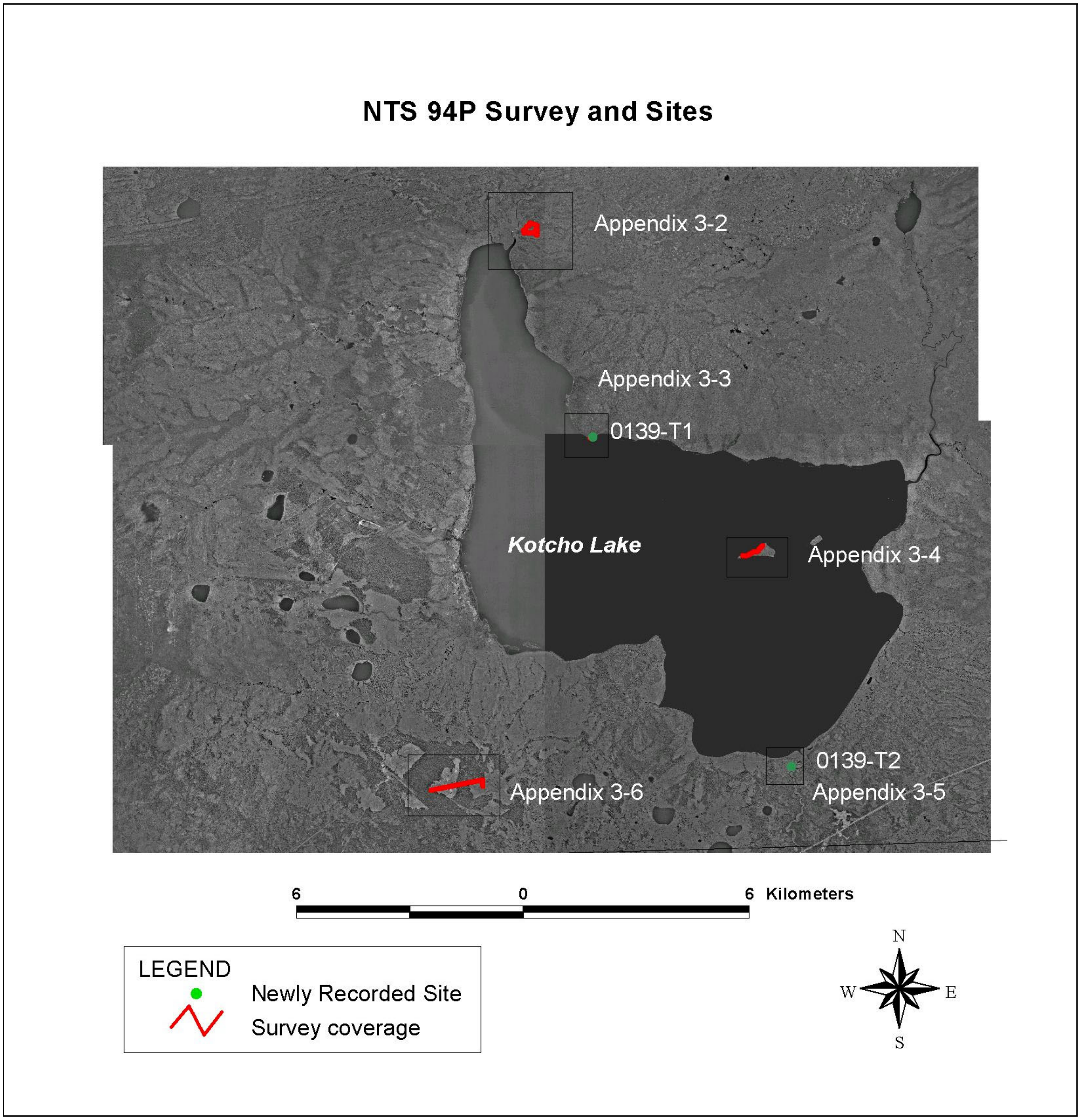
```
   67| **********************
  101| ***************************************

     SURV

   34| **************************************************
   67| *************************
  101| ************************************
```

```
DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y

for_age>0
Enter iteration size: 1

Enter start point for iterations: 1

Enter end point for iterations: 8

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y

Variable:  A.FOR_HGHT

Average for grids up to end of iterations:
    A.for_hght
          1.85
Average for survs up to end of iterations:
    A.for_hght
          2.37
Average for grids up to end of sample:
    A.for_hght
          1.85
Average for survs up to end of sample:
    A.for_hght
          2.37

Is A.for_hght(surv) < A.for_hght(grids) - using sample: NO

grids and survs <      8
grids:         13271
survs:          7211


* indicates that expected value is low
D.F. = 1

Buffer    1 (o-e): -1261.8 |  5552 grids |  1755 survs |  chi^2=  907.31
Buffer    2 (o-e): -470.19 |  4824 grids |  2151 survs |  chi^2=  132.51
Buffer    3 (o-e): 1013.54 |  2259 grids |  2241 survs |  chi^2= 1008.58
Buffer    4 (o-e):  667.46 |   612 grids |  1000 survs |  chi^2= 1404.47
Buffer    5 (o-e):   50.96 |    24 grids |    64 survs |  chi^2=  199.49

There are significantly more grid points than survey points within    2
meters of A.for_hght
```

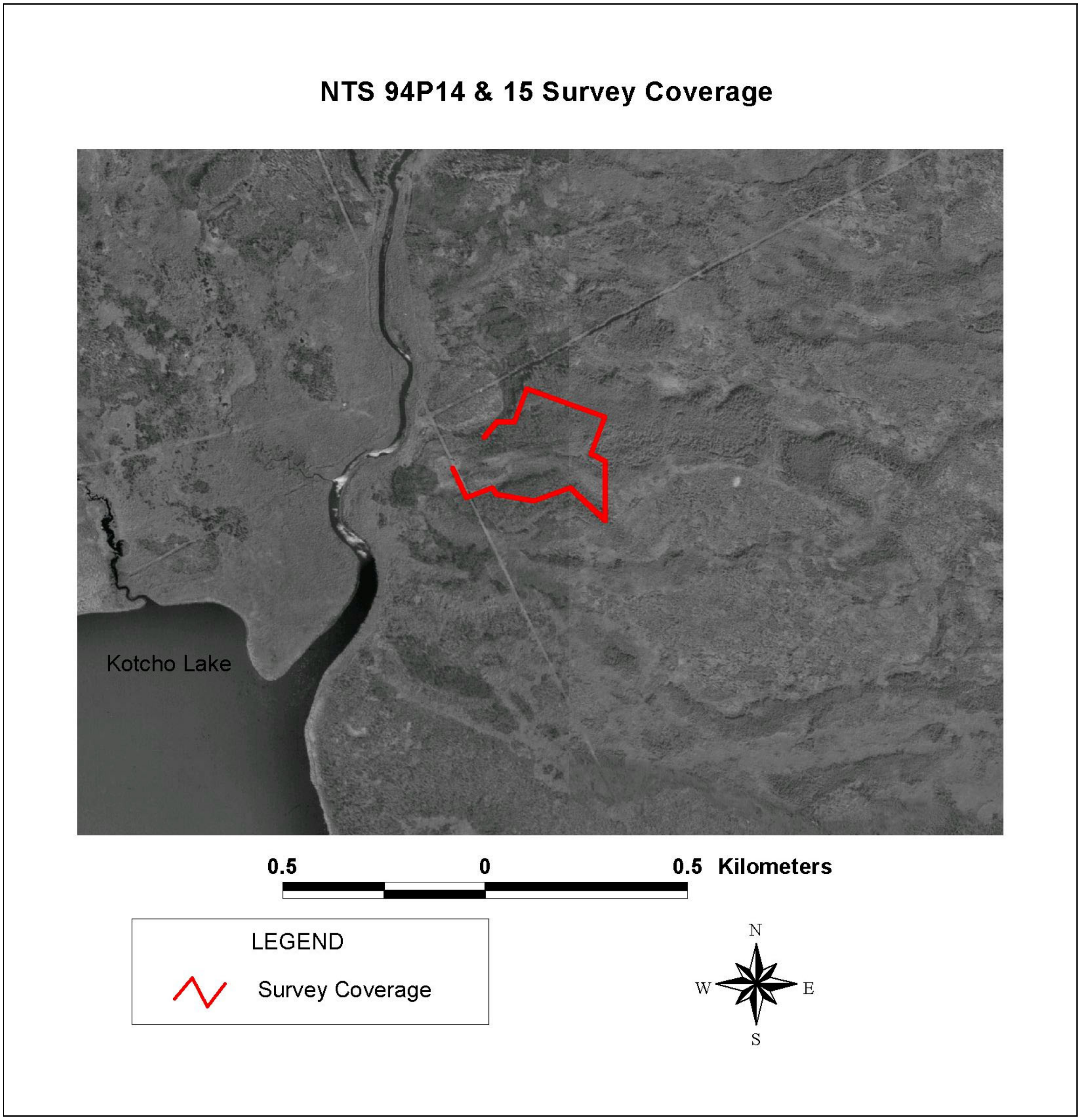
```
Buff %    2 (o-e): -1732.0 |  78.2%grids |  54.2%survs |  chi^2= 2438.98

A.FOR_HGHT Histograms !

     GRID

    2| *****************************************
    3| ************************************
    4| *****************
    5| ****
    6|
    7|
    8|

     SURV

    2| ************************
    3| *****************************
    4| *******************************
    5| *************
    6|
    7|
    8| □

DATAGAPS ANALYSIS (c) 2001 MILLennia RESearch LTD.

Output stored in file named GAPS_ALL.txt in current directory
Do you want a filter on? Y/N: y □

for_age>0
Enter iteration size: 1 □

Enter start point for iterations: 1 □

Enter end point for iterations: 10 □

For the chi-square analysis, do you want to limit the
sample to the end point of the iterations (Y/N)? :y □

Variable:  FOR_AGE

Average for grids up to end of iterations:
       for_age
          4.90
Average for survs up to end of iterations:
       for_age
          4.74
Average for grids up to end of sample:
       for_age
          4.90
Average for survs up to end of sample:
       for_age
          4.74

Is for_age(surv) < for_age(grids) - using sample: YES

grids and survs <     10
```

```
grids:          13271
survs:           7211


* indicates that expected value is low
D.F. = 1

Buffer    1 (o-e):  322.59 |   194 grids |   428 survs |  chi^2= 1001.83
Buffer    2 (o-e):  797.09 |  1001 grids |  1341 survs |  chi^2= 1263.42
Buffer    3 (o-e): -356.00 |  2087 grids |   778 survs |  chi^2=  132.62
Buffer    4 (o-e): -568.03 |  2030 grids |   535 survs |  chi^2=  345.35
Buffer    5 (o-e): -474.41 |  2108 grids |   671 survs |  chi^2=  233.60
Buffer    6 (o-e): -271.67 |  3901 grids |  1848 survs |  chi^2=   49.31
Buffer    7 (o-e):  129.18 |  1045 grids |   697 survs |  chi^2=   31.90
Buffer    8 (o-e):  421.80 |   904 grids |   913 survs |  chi^2=  388.68
Buffer    9 (o-e):   -0.54 |     1 grids |     0 survs |  chi^2=    0.54 *

There are significantly more survey points than grid points within    3
meters of for_age

Buff %    2 (o-e): 1119.68 |   9.0%grids |  24.5%survs |  chi^2= 2121.81

FOR_AGE Histograms !

     GRID

    2| *
    3| *******
    4| ***************
    5| ***************
    6| ***************
    7| *****************************
    8| *******
    9| ******
   10|

     SURV

    2| *****
    3| ******************
    4| **********
    5| *******
    6| *********
    7| *************************
    8| *********
    9| ************
   10| □
```

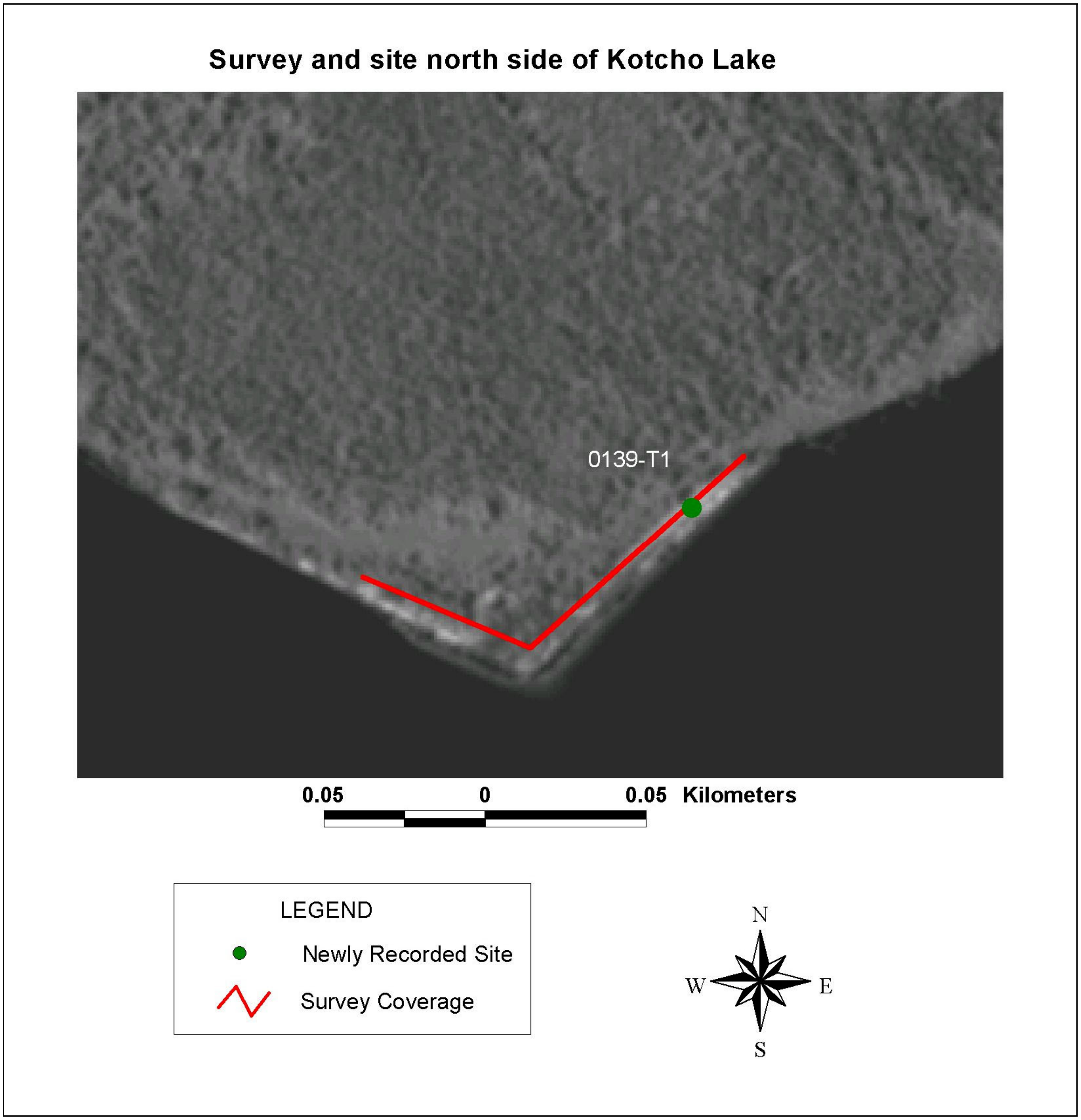
Appendix 3: AIS Survey Coverage



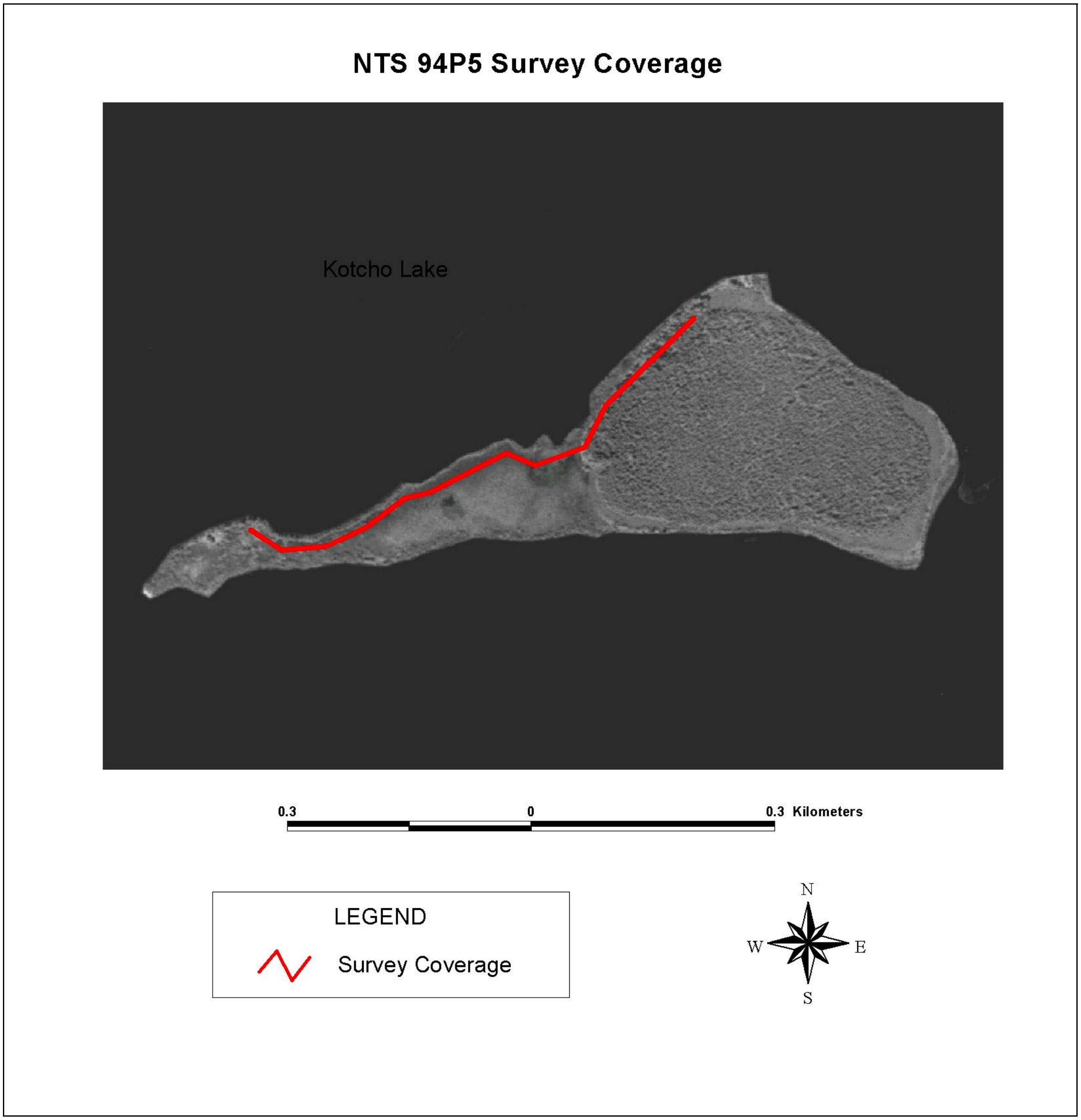
Appendix 3- 1. Overview of NTS 94P sites and survey



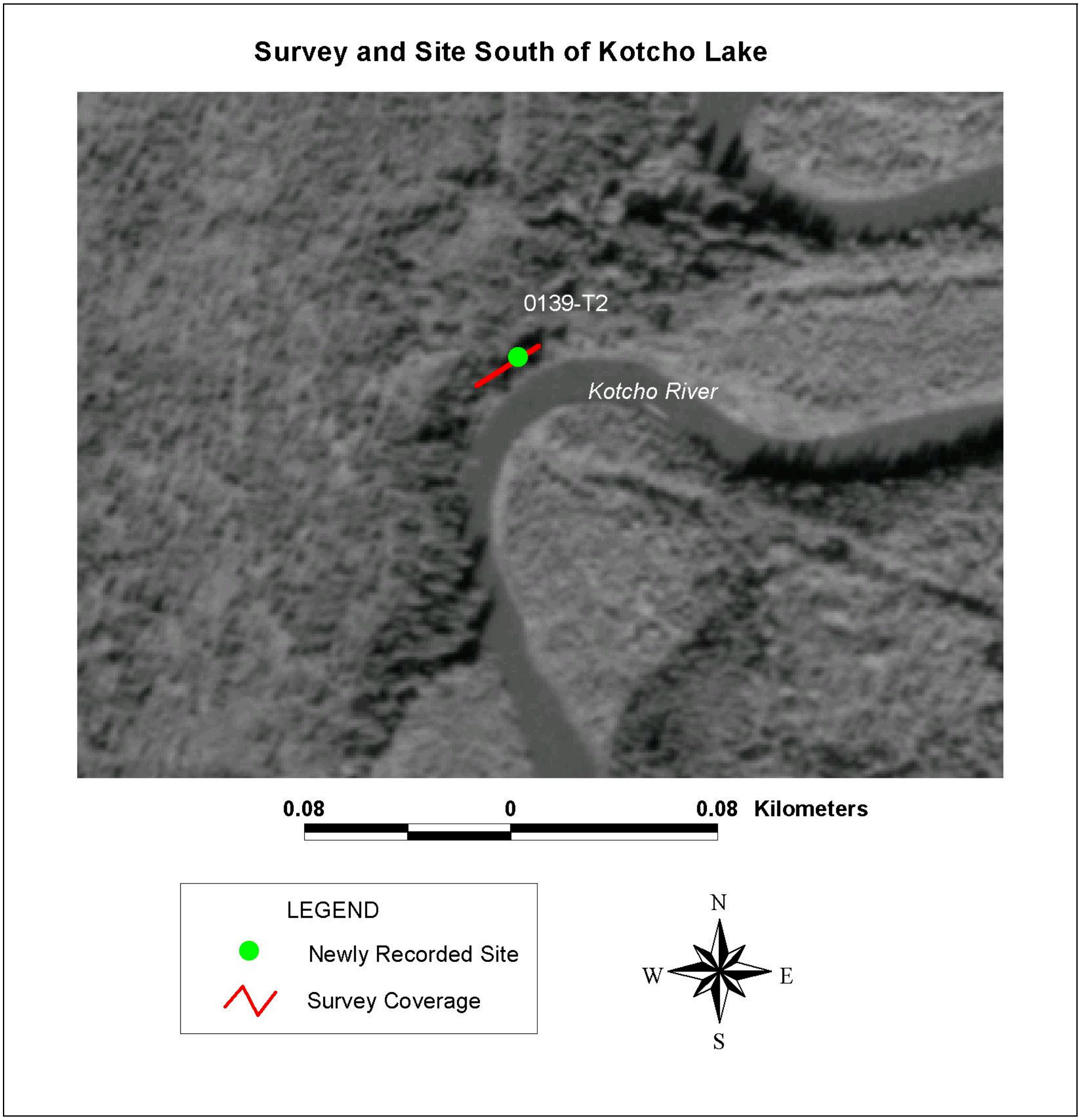
Appendix 3- 2. Survey at north end of Kotcho Lake (94P.014 and 15).



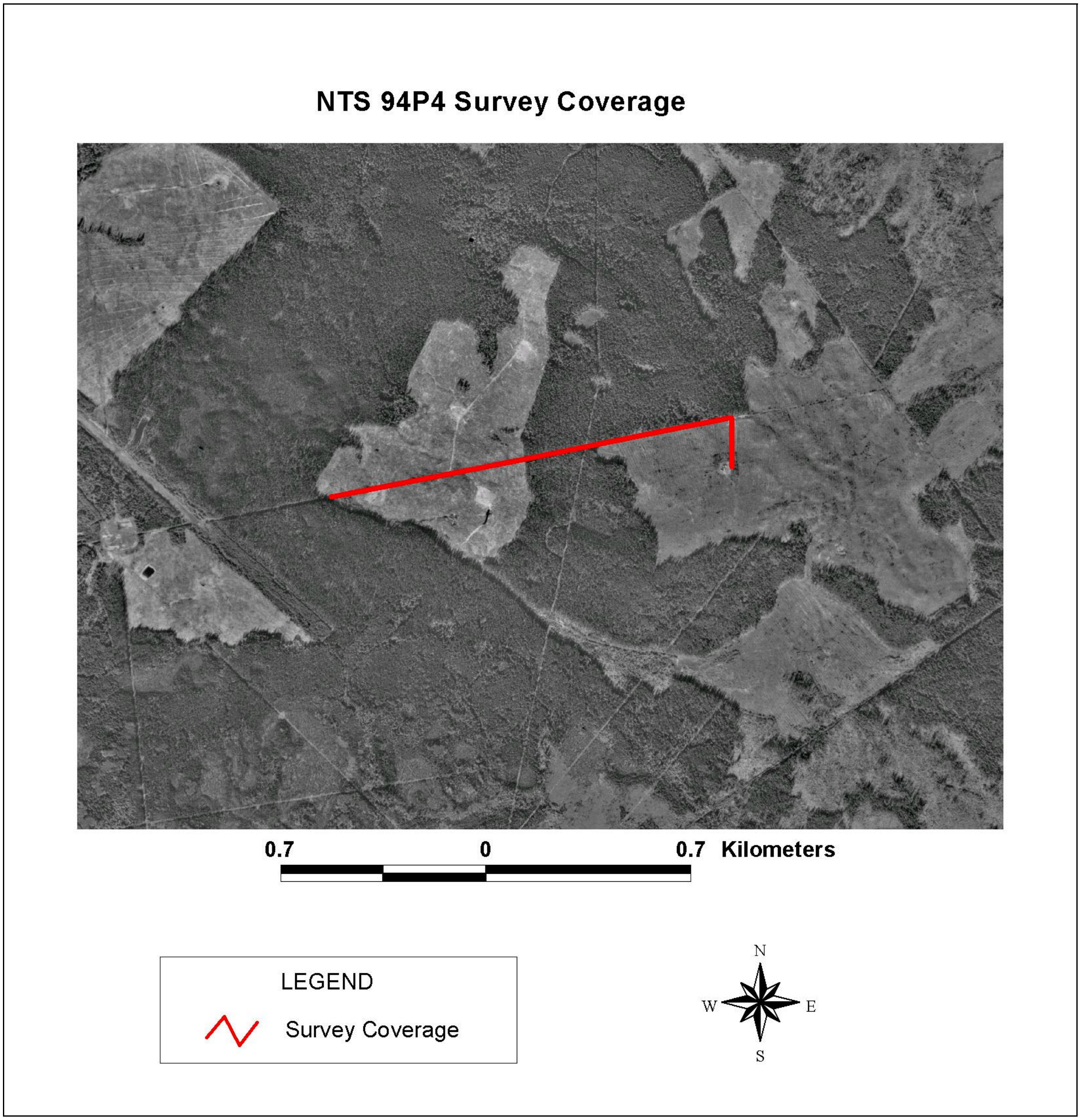
Appendix 3- 3. Survey and site north end of Kotcho Lake (94P.005).



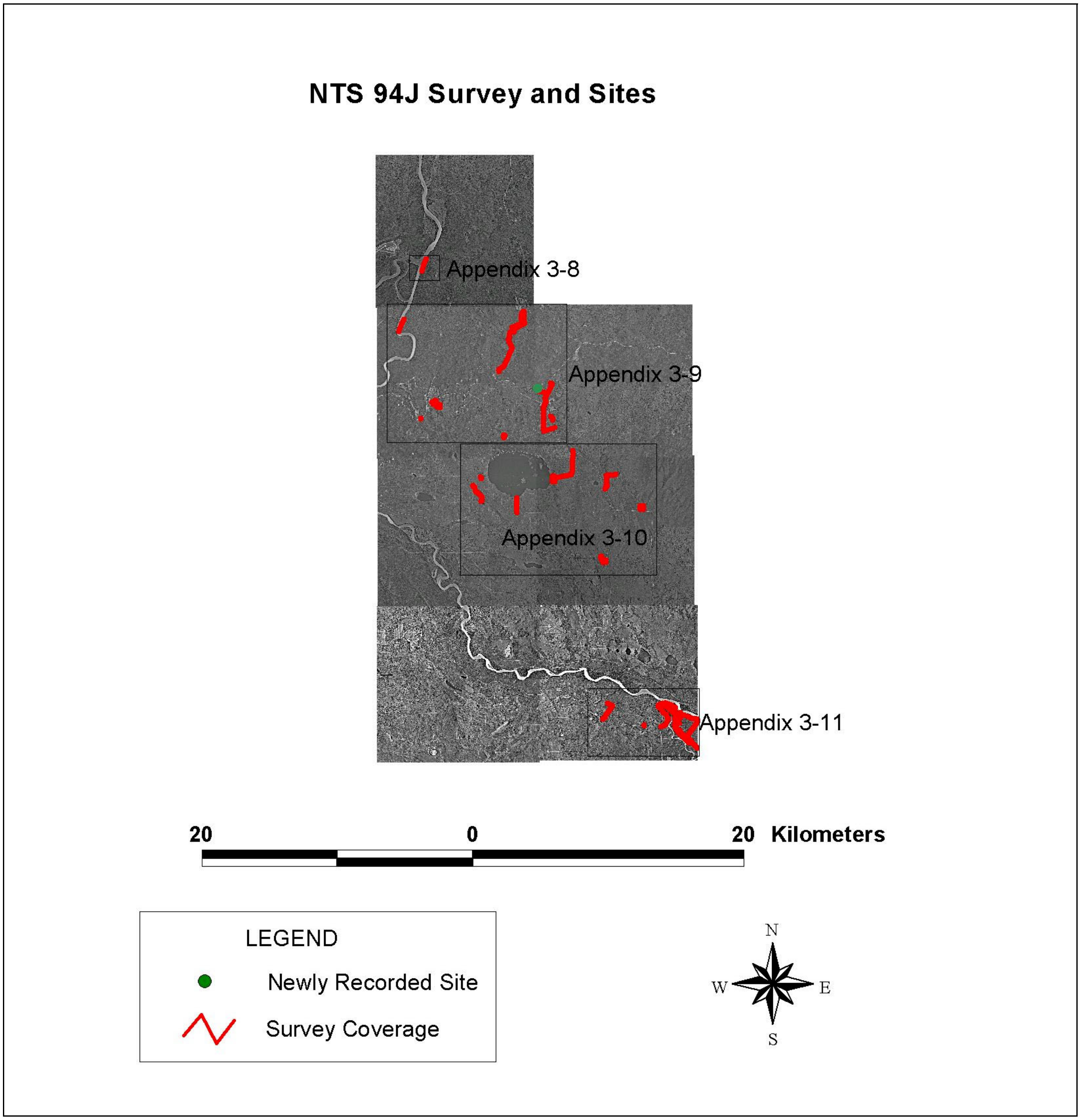
Appendix 3- 4. Survey coverage on Kotcho Island (94P.005).



Appendix 3- 5. Survey and site south of Kotcho Lake (94P.005).

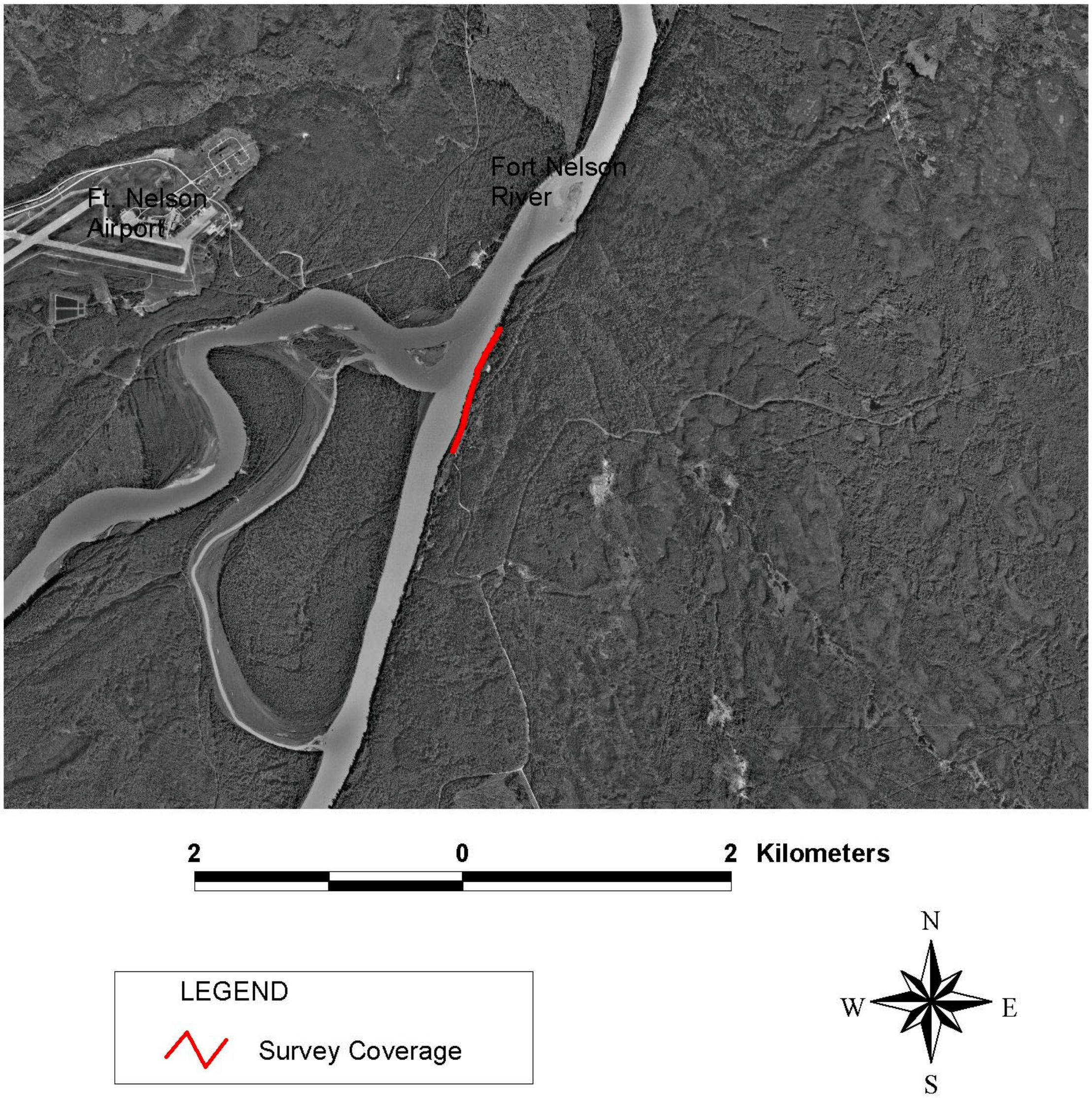


Appendix 3- 6. Survey on Kotcho Mountain (94P.004).

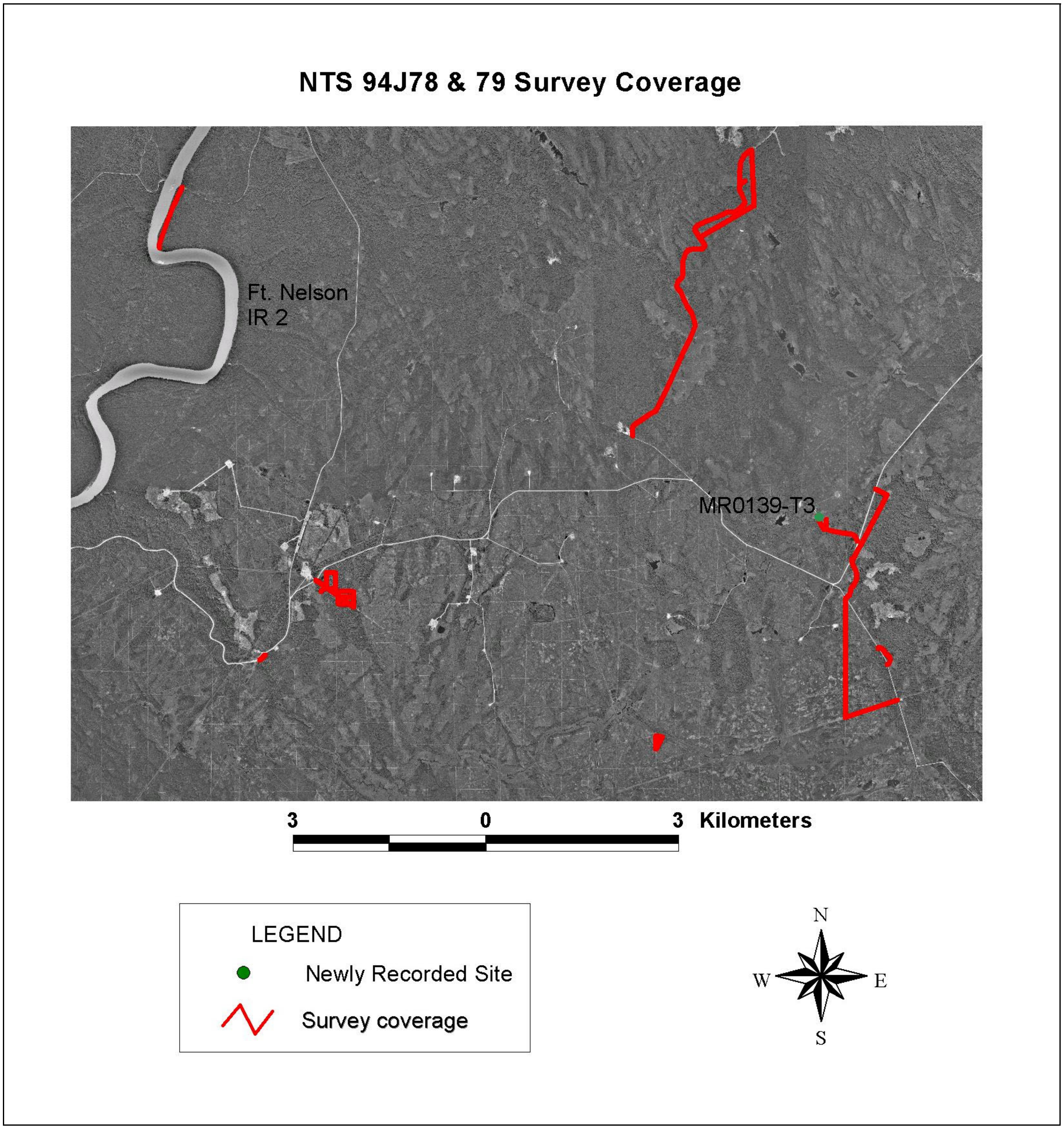


Appendix 3- 7. Overview of survey and sites in 94J.

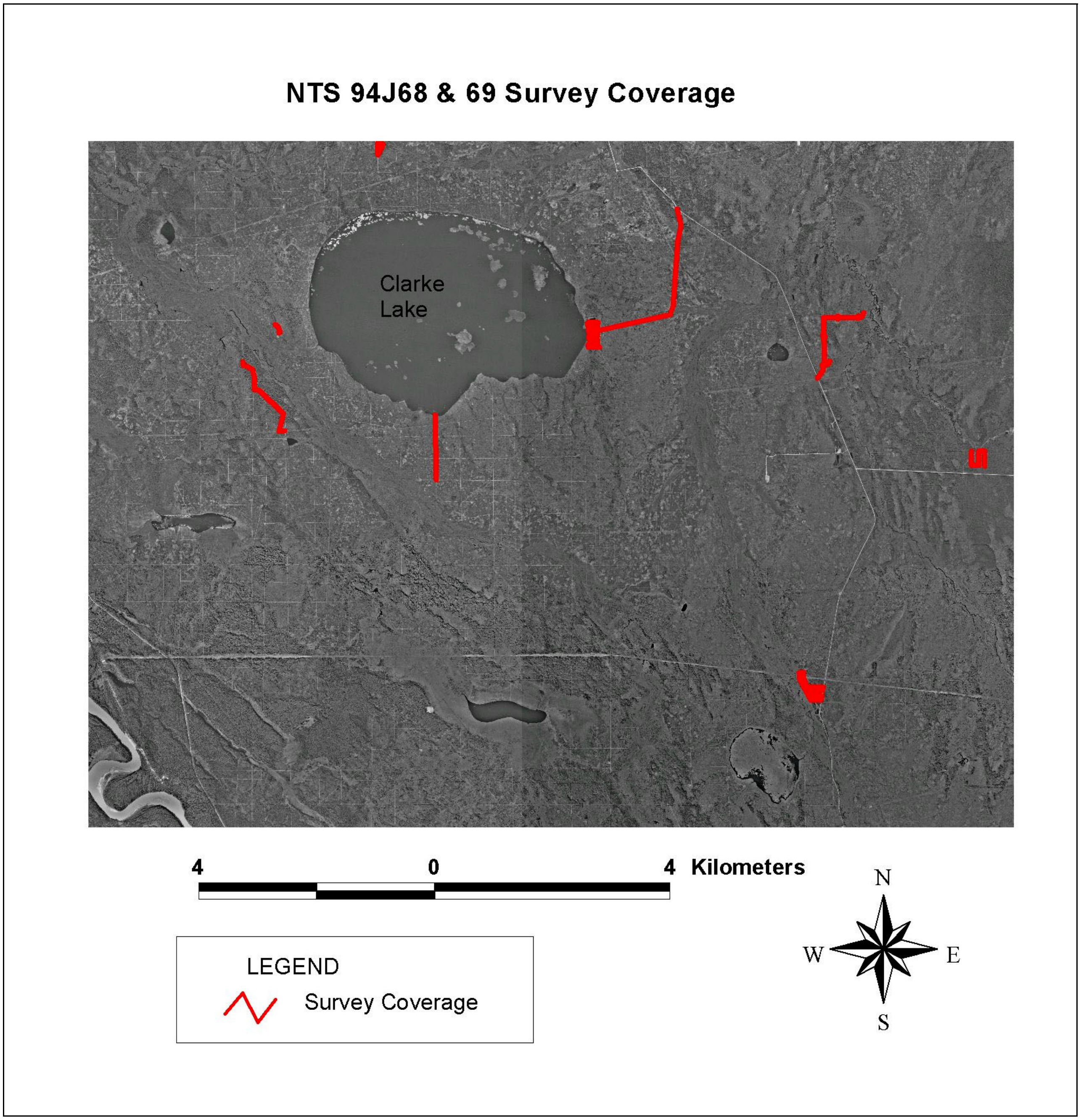
NTS 94J88 Survey Coverage



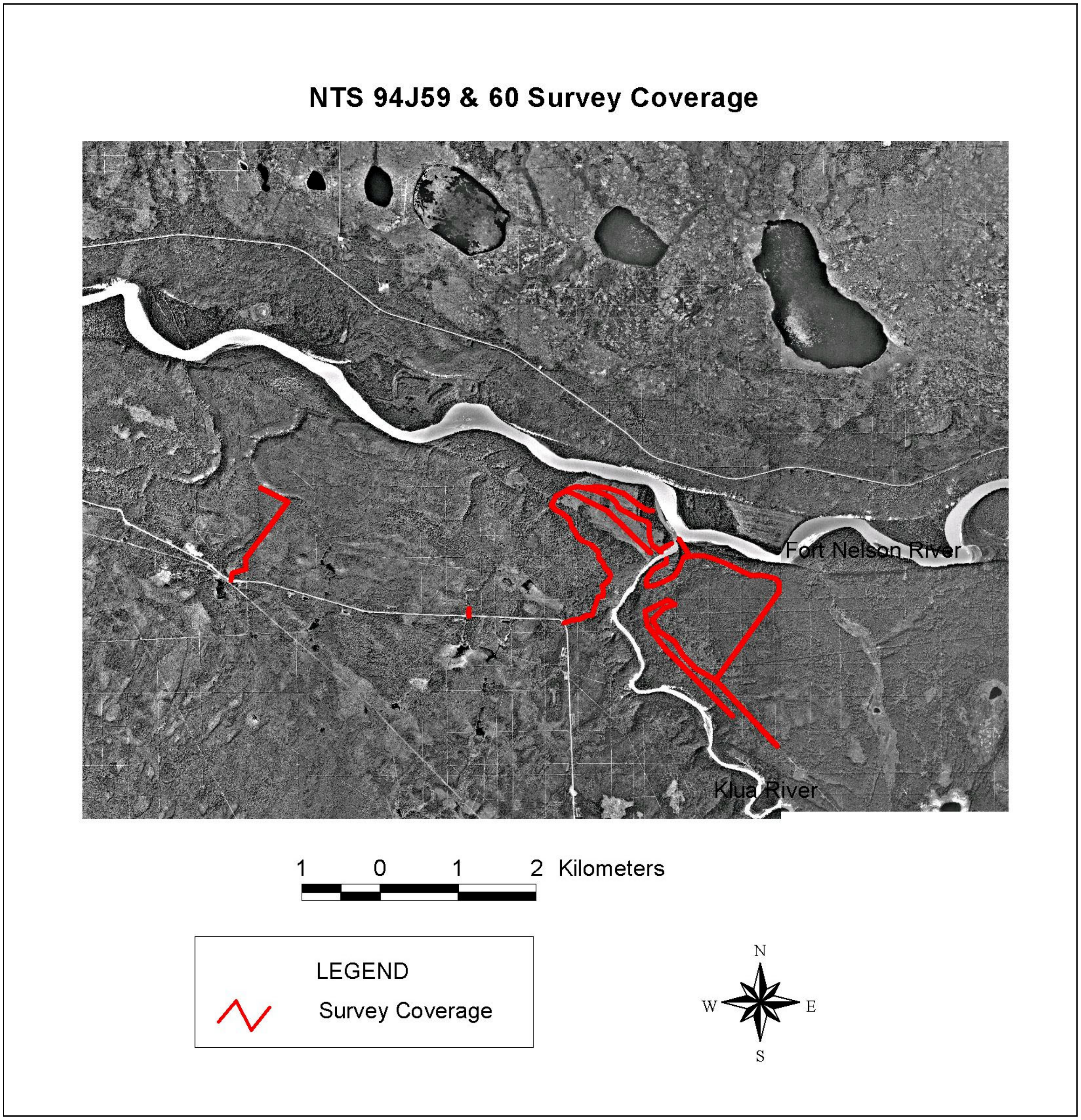
Appendix 3- 8. Survey along Fort Nelson River (94J.088).



Appendix 3- 9. Survey on map sheets 94J78 and 79.



Appendix 3- 10. Survey around Clarke Lake (94J.068-69).



Appendix 3- 11. Survey on Fort Nelson River (94J.059-60).

Appendix 4: Bibliography of Reviewed Survey Reports

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Anderson, J.
2000b *PFR of UPRI Jedney a-57-K, 94-G-08.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001a *PFR of Canadian Natural Resources Ltd. Proposed Wellsite b-72-F, 94-A-15.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001b *PFR of Coastal Oil and Gas Canada Inc. Laprise compressor site extension c-79-A, 94-G-8.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001c *PFR of Penn West HZ Helmet Proposed Wellsite d-42-H, 94-P-11.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001d *PFR of Penn West Wellsite S Thetlaandoa d-47-F, 94-P-06.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001e *PFR of Penn West Wellsite Thetlaandoa b-67-F, 94-P-6.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001f *PFR of Petro-Canada Oil and Gas Ltd. Access Road from b-18-G to d-10-G, 94-G-08.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001g *PFR of Petro-Canada Oil and Gas Ltd. access road to b-12-F, 94-G-08.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J.
2001h *PFR of Petro-Canada Oil and Gas Ltd. Proposed Wellsite b-A84-B, 94-G-08.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001i *PFR Penn West Helmet wellsite b-76-L, 94-P-11.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001j *PFR PennWest Helmet wellsite c-58-A, 94-P-11.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001k *PFR PennWest wellsite HZ Helmet c-58-J, 94-P-11.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001l *PFR Ricks Nova Scotia wellsite c-18-J, 94-H-01.* Non Permit Report at the OGC, Fort St. John, B.C.

Anderson, J. and M. Hill.
2001m *PFR Penn West Helmet wellsite a-38-J, 94-P-11.* Non Permit Report at the OGC, Fort St. John, B.C.

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Carmichael, C.
2001a *PFR Anadarko Canada Corporation Anadarko HZ Green d-A44-A/94-G-10 Lease Extension.* Non Permit Report at the OGC, Fort St. John, B.C.

Carmichael, C.
2001b *PFR of Anadarko Canada Corp. Anadarko HZ Caribou c-22-B/94-G-7.* Non Permit Report at the OGC, Fort St. John, B.C.

Carmichael, C.
2001c *PFR of Pioneer Natural Resources Canada Inc. Pioneer Chinchaga b-76-A/94-H-8 Wellsite and Remote Dump.* Non Permit Report at the OGC, Fort St. John, B.C.

Carmichael, C.
2001d *PFR of Pioneer Natural Resources Canada Inc. Pioneer Conroy a-86-B/94-H-12.* Non Permit Report at the OGC, Fort St. John, B.C.

Carmichael, C.
2001e *PFR of Quarry Oil and Gas Lts Quarry et al Buick d-9-L/94-1-15.* Non Permit Report at the OGC, Fort St. John, B.C.

Clouthier, T.
2001a *PFR of CNRES W Buick c-46-E, 94-A-14.* Permit Report at the OGC, Fort St. John, B.C. (Permit 2001-100).

Clouthier, T.

2001b *PFR of Domcan Boundary Corp. Proposed Summer Access Within Unit 77, Block L, P. & N.G., 94-A-14.* Non Permit Report at the OGC, Fort St. John, B.C.

Dahlstrom, B.
2001a *PFR Enco. et al Buick b-A86-I, 94-A-11.* Non Permit Report at the OGC, Fort St. John, B.C.

Dahlstrom, B.
2001b *PFR of Suncor Bernadet A8-1-88-25, 94-A-12.* Non Permit Report at the OGC, Fort St. John, B.C.

Dahlstrom, B.
2001c *PFR Penn West wellsite Buick 14-18-88-19. W. 6M.* Non Permit Report at the OGC, Fort St. John, B.C.

Dahlstrom, B.
2002 *PFR of AEC Ladyfern D-2-G, 94-H-1.* Non Permit Report at the OGC, Fort St. John, B.C.

Farcvacque, R.
1999 *PFR of Proposed Remington Energy Ltd. Wellsite Remington et al Buick b-A45-B, 94-A-14.* Non Permit Report at the OGC, Fort St. John, B.C.

Farcvacque, R.
2000a *PFR of Coastal N Bubbles b-22-G, 94-G-08.* Non Permit Report at the OGC, Fort St. John, B.C.

Farcvacque, R.
2000b *PFR of Penn West d-61-K, 94-P-06 Temporary Campsite.* Non Permit Report at the OGC, Fort St. John, B.C.

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2000c *PFR of Talisman Arc Buick 8-36-88-20, W.6M.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001a *PFR of Penn West Thetlaandoa c-88-L, 94-P-6.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001b *PFR of Wellsite Anadarko HZ Dogrib c-10-A, 94-G-07.* Non Permit Report at the OGC, Fort St. John, B.C.

Farvacque, R.

2001a *PFR Murphy Northstar Osprey b-71-K, 94-A-15.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001c *PFR Talisman Velma d-22-A, 94-H-07.* Non Permit Report at the OGC, Fort St. John, B.C.

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2001d *PFR Talisoman Ladyfern b-16-J, 94-H-01.* Non Permit Report at the OGC, Fort St. John, B.C.

Haley, S.
2000a *PFR of AECOG HZ Petitot b-77-F/94-P-12.* Non Permit Report at the OGC, Fort St. John, B.C.

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Haley, S.
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Schwab, K.
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Schwab, K.
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Schwab, K.
2001e *PFR Quarry et. al W Currant c-72-L, 94-A-09.* Non Permit Report at the OGC, Fort St. John, B.C.

Schwab, K.

2001f *PFR Quarry et.al. W Currant c-36-L, 94-A-09.* Non Permit Report at the OGC, Fort St. John, B.C.

Smith, J.
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2000c *Canadian Resources Limited Proposed Permanent Access Road to Wellsite a-18-H, 94-A-13.* Non Permit Report at the OGC, Fort St. John, B.C.

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2000d *PFR of Wellsite Numac Encal Zaremba A-78-L, 94-H-7.* Permit Report at the OGC, Fort St. John, B.C. (Permit 2000-296).

Walde, K.
2001a *PFR of Proposed Extensions to Existing Wellsite Suncor et al Blueberry D-A36-D, 94-A-13.* Non Permit Report at the OGC, Fort St. John, B.C.

Walde, K.
2001b *PFR of Proposed Wellsite El Paso Oil and Gas Canada Inc. Bubbles c-36-A, 94-G-8.* Non Permit Report at the OGC, Fort St. John, B.C.

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2000 *PFR of Startech Energy Peejay D-10-H, 94-A-15 Wellsite.* Non Permit Report at the OGC, Fort St. John, B.C.

Appendix 5: Palaeo Sites

In Table below, “Point Types” and “Location” are as described in the report or siteform cited.

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
HdRi-1	Siteform by D. Zibauer (Walde 1994)	**Yes**	**P?**	-chert **macroblade**, “may indicate a Palaeoindian component at this site” (siteform by Zibauer)	Low knolls on SW-facing second terrace of the Blueberry River.
HdRe-14	(Hutchings and Walde 1998)	**Yes**	**P**	**-lanceolate** point, palaeo site	Low topographical rise.
HeRc-7	Siteform by Walde, and presumably (Walde 2000)	**Yes**	**P**	**-lanceolate** point, 5.5 x 2.8 x 0.5 cm “possible Palaeo-Indian provenience”	Raised pine-covered feature with distinct break nearby.
HgRq-1	(Wilson and Carlson 1987) (Walde 1997)	**Yes**	**P**	**-thin, roughly leaf-shaped, parallel flaked biface**	Creek bank (Wilson and Carlson 1987).
HhRb-2	Siteform	**Yes**	**P**	-Scottsbluff style point	Low knoll.
HhRr-1 (Pink Mountain)	(Walde 1992) (Wilson 1996)	**Yes**	**P**	-**“Clovis” “fluted”**, -**Lerma**, -**Scottsbluff** type points, -**microblade core**	On prominent knoll 1 km N/NE from the N end of Pink Mountain.
HiRi-1	(Walde 1995) (Walde and Coates 1997)	**Yes**	**P**	**-lanceolate** point fragment (medial) with parallel flake scars	Break in slope with good view.
HiRp-5	Siteform	**Yes**	**?***	**-lanceolate** point	Ridge.
HjRm-11	Siteform	**Yes**	**P**	-“Based on the presence of a base of a lanceolate point the site could be Late-Paleoindian”	Topographic rise located on the north side of a NE flowing water run, at the base of a high NW-SE trending ridge.

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
HkRo-2	(Walde and Handley 1994) (Walde 1997: p5-41)	**Yes**	**P**	-**Hells** (or **Hell**) **Gap lanceolate** point 9500 BP	Small terrace-like feature on natural saddle that forms a draw between an enclosed basin and Trutch Creek.
IaRn-3	Siteform	**Yes**	**?***	"Artifact…may represent the mid portion of a **lanceolate** point"	Break in slope ca. 300 m from E end of W Klua Lake, 200 m S of creek.
HiRn-5	Siteform	**Yes**	**M**	-**Oxbow** type point	At a break in slope near the base of a hill descending northward into the Sikanni Chief River valley.
HaRc-13	(Fladmark 1974:101)	No	**P**	-basal fragment of a **lanceolate concave-base** projectile point; "suggests a relatively early age" (Fladmark 1974: 101)	The 1450' terrace.
HbRc-1	(Fladmark 1975) siteform by Spurling, 1975	No	**P**	-"**early** appearing artifacts" (Fladmark 1975: 9) - "a large site and important" "several large bifaces found" (siteform by Spurling, 1975)	Plateau above the Beatton River.

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
HbRd-2 "Bedier Site"	(Fladmark 1974:99) (Fladmark 1975) (Fladmark 1980:126,130, 131), (Walde 1997)	No	**P**	**-Fluted lanceolate,** (Clovis or Clovis-like) **-Plainview** (lanceolate, concave base, base and lateral edge grinding) **-spurred end-scrapers made on the end of blades, similar to southern Palaeo-Indian examples** (Fladmark 1980:133)	7.5 km E of Ft. St. John, (1 km from Alberta point site) on low fossil periglacial mound, about 500 m back from rim of Beatton River valley. Fladmark suggests Gerret and Bedier sites found at margin of a shallow lake or wide floodplain which existed before present river valley - (Walde 1997: p5-36) [more in (Fladmark 1980)].
(HbRd-2? HcRe-1? A third site?)	(Walde 1993:17, 18)	No	**P**	**-Dartlike fluted triangular point,** "possibly unique to the Peace River region" (Walde 1993: iii, 17, 18)	"Near Ft. St. John, overlooking the Beatton River" [recently collected by local residents, no site name given, same area as Fladmark site(s) above].
HbRe-21	(Fladmark 1975) siteform by Spurling, 1975	No	**P**	**-Alberta** point	Near break in slope.
HbRe-23	(Fladmark 1980:126,127), (Walde 1997: p5-35)	No	**P**	**-Alberta**	East lip of the Beatton River valley, 7 km NE of Ft. St. John.
HbRf-39 Charlie Lake Cave	(Walde 1997)	No	**P**	**-"fluted" "Clovis"** **-Plainview**	
?	(Walde 1997: p5-36), and in unknown 1995 Walde report	No	**?***	**-Lanceolate** point	Palaeobeach ridge back from east shore of Charlie Lake. No site number given.

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
HcRe-1 "Gerret site"	(Fladmark 1975) (Fladmark 1980:126,129), (Walde 1997)	No	**P**	-elongate **lanceolate point** with slightly concave base, **flute** on one side -broad stubby **lanceolate point** with slightly concave base**,** large **basal thinning flakes** one side	13 km NE of Ft. St. John, 2 km from W lip of Beatton River valley – boggy land in poorly drained area between slight periglacial mounds.
HcRe-2	(Fladmark 1975), siteform by Spurling, 1975	No	**P**	-"basal portion of chert biface, possible **Paleo** point" (siteform by Spurling)	Near break in slope; plateau/terrace above the Beatton River.
HcRg-1	(Fladmark 1980:126,129), (Walde 1997)	No	**P**	**-Scottsbluff** (of Knife River flint from South Dakota)	6 m below surface at Stoddard Creek crossing, 24 km NW of Ft. St. John.
HeRm-1	(Walde 1997: p5-42, 5-51)	No	**P**	**-Lanceolate** point -early post-Holocene	On top of ridge. (Four other sites in area between Townsend and Gundy Creeks too, on tops of ridges. Walde concludes that N-S trending heights of land separating creek drainages, and side valley terrace features in area have high potential for palaeo sites).
HeRp-1	(Wilson and Carlson 1987), (Walde 1997)	No	**P**	**-Alberta** **-Large corner/side notched ["palaeo"** (Wilson and Carlson 1987)]	-Terrace (Wilson and Carlson 1987) -On western side of a high hill overlooking the Halfway Riv about 2km to the east (Walde 1997).

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
HeRp-2	(Wilson and Carlson 1987), (Carlson and Dalla Bona 1996), (Walde 1997)	No	**P**	**-fluted** **-Nakah Phase** [from Fisherman Lake, NWT (Wilson and Carlson 1987)] **-large, thin, well-made side-notched**	-On a small rise, adjacent to intermittent creek, vicinity of confluence of Chowade and Halfway Rivers (Carlson and Dalla Bona 1996).
HeRq-1	(Wilson and Carlson 1987), (Carlson and Dalla Bona 1996), (Walde 1997)	No	**P**	-**Cody Complex** (large, lanceolate, parallel sided and parallel flaked) -Wilson in (Carlson and Dalla Bona 1996:33) calls same point **Agate Basin**	-Terrace (Wilson and Carlson 1987), vicinity of confluence of Chowade and Halfway Rivers.
(HeRp-2? HeRq-1? A third site?)	(Walde 1993:17,18)	No	**P**	**-Dartlike fluted triangular point** "possibly unique to the Peace River region" (Walde 1993: iii, 17, 18)	Vicinity of Chowade/Halfway rivers [collected by local residents, no site name given, same area as Wilson and Carlson site(s) above].
HfRm-3	(Walde 1997: p5-42)	No	**P**	-**Lanceolate** point -early post-Holocene	Small terrace feature to east of creek.
HgRu-7	(Walde 1996:24,25) (Walde 1997)	No	**P**	-**Fluted** point fragment, probably lanceolate	On low topographical rise, upslope from Turnoff Creek.
HfRo-3	(Wilson and Carlson 1987) and (Walde 1997)	No	**M?**	-possible? **Archaic (Middle Prehistoric Period)**	Creek bank (Wilson and Carlson 1987).

Site #	Reference	In study area?	Palaeo Or Mid?	Point Types	Location
IfSh-1 ("Callison Site", "IeSh-1")	(Walde 1997: p5-42, 5-51)	No	**M**	Lanceolate – tentatively related to Taye Lake Complex (microblades prominent – p5-54) of SW Yukon, 5-7000 BP	"Extinct Lake Beach ridge".
"site at Crooked Lake" (IlSo-5?) in 1979 Liard River survey	(Walde 1997: p5-42, 5-51)	No	**M**	Microblade fragments place site between 4 and 6000 BP	

* Text of cited report does not ascribe point to palaeo or middle periods. (Milnesand points are *lanceolate* but date from only 2000-5000 BP – see sites HbRf-53 and HbRf-7.)

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Appendix 6: Updated Trails List

Following is the updated Trails List:

Key:

Trail # - Each trail or trail fragment was given a discrete number. Multiple entries under one number indicate multiple sources.

NTS Sheet – The portion of the study area in which the trail is located, by 1:50,000 NTS map sheet number. If no other source is indicated in the **Notes** field, then the source is the First Edition NTS map sheet(s) listed in this field – see Appendix 2 for a list of sources.

Confidence – Rated "1" through "4".

1. Ground-truthed trails – recorded as a result of fieldwork.
2. Trails mapped on first edition NTS 1:50,000 maps.
3. Trails labelled "position approximate" on first edition NTS 1:50,000 maps.
4. Trails found on sketch maps.

Trail/Cart – Rated "T", "C", or "O".

T. Trail, including those labelled "Pack Trail" on source map.
C. Labelled "Cart Track" on source map.
O. Other. Labelled as various types of rough roads on source maps, but had a possibility or likelihood of following the route of an aboriginal trail.

"**Data Mapped**" column – no entry means not mapped yet; "**20**" means mapped on 1:20k hard copies; "**50**" means mapped on 1:50k hard copies; "**AV**" means mapped in ArcView

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T001	H/13	2	T	SF map for HlRl-002, mapped on 1:50,000.	**50**
T001	G/9 G/10E G/10W G/16, H/13	3	T	N side Trutch Cr. To N. side Sikanni Chief River; trail head just north of Trutch village. Crosses/joins T018 on H/13. ("Position Approximate" on G/9 and 16, not on G/10 or H/13).	**50**
T002	G/10E G/15E	2?	T	From S. side of Horse Range Creek to join T001. On G/15E but doesn't appear on G/16 which adjoins.	**50**
T003	H/13	2	T	Short spur off T001, north.	**50**
T004				**[number deleted - part of T018]**	
T005				**[number deleted - part of T018]**	
T006	G/15E	2	T ?	From headwaters of Boat Cr., runs N to J/2. Should continue on G/16 but doesn't - on G/16 would go north of Boat Creek?	**50**
T007	G/15W	2	T ?	From w side of old Alaska Hwy westward to G/14 (outside study area) N of Minaker River.	**50**

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T008	G/2E G/2W	2	T?	North side of Halfway River.	**50**
T008	G/2	4	T	MR244-C. Peace - Yukon Trail, Fort St. John to Fort Graham. Small part of trail enters study area @ northernmost bend of Halfway River.	**50**
T009	G/2E G/2W	2	T	From T008 to Pink Mountain.	**50**
T010	G/2E	2	T ?	(From B/15) E side of Cameron R - joins dry weather road S of Alaska Hwy and then onto Alaska Hwy S of Pink Mtn.	**50**
T011	G/2E	2	O	Dry weather road from Pink Mountain at Alaska Hwy along ridge to join Alaska Hwy N of mile post 155. Is Alaska Highway in area following route of old trail?	**50**
T012	G/7W G/2W G/7E G/2E	2	T ?	From G/16 joins G/7W N of Sikanni Chief Cr and joins w/ Alaska Hwy near hwy crossing of Sikanni Chief Cr on G/2E.	**50**
T013	G/2W	2	T	From Halfway River trail (T008) along W side of Two Bit Cr, then Quarter Cr N to Moose Lick Cr and then off W side of sheet into G/3.	**50**
T014	G/7E G/7W	2	T	From just N of where Buckinghorse R crosses Alaska Hwy. Runs east on north side of Buckinghorse R. Crosses Middle Fork Cr to end at Daniels Cr .	**50**
T015	P/2, P/3	3	C	Freehand with very few reference points.	**50**
T016	A/10W	2	O	Cont. on A/15W - cont, s. on A/10W but as a straight line; straight line sections not mapped.	**50**
T017				**[number deleted - part of T018]**	
T018	H.014	1	T	Trail fragment through HgRh-001 (SF map). "Old Freight Trail to Ft. Nelson".	**20**
T018	J/7, J/10, J/15, J/1 J/8? G/16, H/3, H/5, H/6, H/13, H/12, H/16,	2	T	Ft Nelson Trail on NTS maps. (On J/15, J/10, J/7 etc, it is mapped on west or south side of Ft. Nelson River – but sources MR 178/MR216 say it followed route of T046 on east or north side.) Siteform for HlRl-3 says that site is "on top of ridge adjacent to Klua Lakes trail (old Sikanni/ Fort Nelson/ Fort St. John Trail)".	**50**
T018	H/13, G/16	2	T	SF map for HlRl-002 (taken from NTS 1:50,000).	**50**
T018		2	T	Ft Nelson Trail from TRIM.	To be done
T018	J/7, J/10, J/1, J/8?	4	T	Ft Nelson Trail Controller of Surveys, 1921. (MR244-A and MR216 – better copy in MR216). pack trail incomplete on this map. According to MR 178/MR216, trail was blazed about 1898 for the Klondike Gold Rush, and not well established until the 1920s, or alternatively, blazed in 1919-1920 (MR178 p18,19; MR216 p19). T018 may be depicted as going from Ft St John to Ft. Nelson, but from confluence of Sikanni Chief and Fontas rivers northward, it follows previously existing T046.	To be done

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T018 (HjRm-1)	G/9	1	T	From siteform for HjRm-001 (and MR244-D) – two trail fragments of the Fort Nelson Trail given a Borden number. "2 segments are located 3 to 4 km N of Donnie Cr., about 6 km upstream of its confluence with Sikanni Chief Riv". This area is rugged upland country.	**[Area roughly mapped on 1:50]**
T018	A, H/12, I, J	4	T	MR178. From Ft. St. John north up west side of Beatton River, north side of Sikanni Chief River, north side of Ft Nelson River (latter segment same as current route of BC Rail – and probably following aboriginal trail there (MR178 p18; MR216 p17).	
T018	A/10W	3	O	A portion mapped; straight line sections not mapped.	**50**
T018	A/10, A/14, A/15	4	T	B.C. Department of Lands, 1922 Pre-Emptor's Map, Peace River Sheet (Map #3E), Surveyor General, Victoria, B.C	**50**
T019	J/1	2	T		**50**
T020	J/1	2	T		**50**
T021	J/1, J/8	2	T		**50**
T022	J/1 J/2	2	T	Joins J/2.	**50**
T023	J/2	2	T	From Prophet River.	**50**
T024	J/2	2	T	Short section between Alaska Highway and T023.	**50**
T026				**[number deleted - part of T018]**	
T027				**[number deleted - part of T018]**	
T028	H/13, G/16	2	T	From T001, S side of Sikanni Chief River, to T018.	**50**
T029				**[number deleted - part of T001]**	
T030	G.008	1	T	MR242. Trail fragment near HgRo-003.	
T031	G.008	1	T	MR242. Trail fragment near HgRo-003.	
T032	G.017	1	T	MR242. Trail fragment near HhRq-002 and 003.	
T033	G/1	1	T	MR242. Trail fragment through HgRo-001.	
T034	G/2	1	T	MR242. Trail fragment near HhRq-002.	
T035	G/2	1	T	MR242. Trail fragment near HhRq-003 - same trail as T034?	
T036				**[number deleted - part of T018]**	
T037	H.014	2	T	Branches off T018, SF map for HgRh-001.	**20**
T038	A/10	1	T	MR124. Passes through or v. near HdRd-3,4,5,6,7,8,9.	**20**
T038	A058, A/10	1	T	MR122. Passes through HdRc-001 and TUS sites.	**20 and 50**
T039	A058	1	T	MR124. Connects to T038. Passes through HdRd-9.	**20**

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T040	A058	1	T	MR124. Connects to T038. Passes through HdRd-9.	**20**
T041	A058	1	T	MR124. Connects to T038. Passes through or near HdRc-4.	**20**
T042	A058	1	T	MR124. Connects to T038. Passes through or near HdRd-3.	**20**
T043	A058	1	T	MR124. Connects to T038. Passes through HdRd-4.	**20**
T044	A/9, A/10	1	T	MR122. From confluence of T038 and T024, NE.	**50**
T045				**[delete number – same as T008]**	
T046		4	T	MR178 Trail from Peace River Crossing (Alberta) to Ft Nelson. Northwest up south side of Fontas River, to confluence of Fontas, Sikanni Chief, and Ft. Nelson rivers, where T018 runs into T046. According to MR 178/MR216, trail was blazed in 1898 for the Klondike Gold Rush, but section "from confluence of the Sikanni Chief and the Fontas rivers the route followed an old Indian trail along the high ground immediately east of the Fort Nelson River towards Fort Nelson" (MR178 p18; MR216 p17). This section mapped as T046A; remainder as T046B. T018 may be depicted as going from Ft St John to Ft. Nelson, but from confluence of Sikanni Chief and Fontas rivers northward, it follows previously existing T046A (the aboriginal trail section).	
T046A	J/15, J10, J/8 J/9, I/5	4	T	From Ft. Nelson south on aboriginal trail (MR178, see note above) on north side of Ft. Nelson River.	**50**
T046B	I/5, I/6, I/7, I/1, I/5, I/6, small fragment on I/8 not mapped yet	4	T	From confluence with Sikanni Chief River, south and east on south side of Fontas River.	**50**
T046		4	T	MR244-A.	
T047	J/15	2	T	Fragments on NTS First Editions. Rest of trail corresponds to Alaska Highway?	**50**
T047	J/14, J/15	4	T	MR178. Trail from Ft Nelson heading west on north side of Muskwa River, continues out of study area. According to MR 178/MR216, T047 is a continuation of T046, goes west to Pelly River.	
T048	J/15, 0/1, 0/8, 0/9, 0/16	2	T	[Fort] "Simpson Trail" from NTS 1st edition. ["trail" on J/15, "winter road" on others – but skirts edge of "Trail Lake" on O/9. All say "To Ft. Simpson"].	**50**
T048	J/15	4	T	MR178. Trail north from Ft Nelson.	**50**
T048		2	T	"Simpson Trail" from TRIM [J/15, 0/1, 0/8, 0/9, 0/16].	To be done
T049	H/6	1	T	MR118.	**20**

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T050	H/6	1	T	MR118.	**20**
T051	H/12, H/13	2	T	From T018 NE to S side of Sikanni Chief River, where it ends…	**50**
T052	O/3	2	T	From NTS.	**50**
T053	0/5	2	T	From NTS.	**50**
T054	0/6, 0/7	2	T	Patry Lk, east. Joins T057.	**50**
T055	0/6	2	T	Patry Lk, north.	**50**
T056	0/6	2	T	Joins T054 to T055.	**50**
T057	0/6, 0/7, 0/11	2	T	From NTS.	**50**
T058	H/5	2	T	From NTS.	**50**
T059				**[delete number – same as T018]** From Muskwa village, NE, to confluence of Ft. Nelson and Muskwa rivers.	
T060	A/12	2	T	From NTS.	**50**
T061	A/12	2	T	From Halfway IR, east, then north.	**50**
T062	A/12	2	T	Joins T061 east of IR.	**50**
T063	A/12	2	T	Cameron River, east.	**50**
T064	A/12	2	T	Joins T061 to T063.	**50**
T065	A/12	2	T	Joins T063.	**50**
T066	A/12	2	T	Deadhorse Creek trail.	**50**
T067	A/12	2	T	East-west, to Monowon/Blueberry.	**50**
T068	A/12	2	T	Joins T061 to Hwy and end of T069.	**50**
T069	A/12	2	T	Joins T066 to Hwy and end of T068.	**50**
T070	A/12	2	T	Joins T066.	**50**
T071	A/12	2	T	Joins T066 to Hwy.	**50**
T072	A/12	2	T	North from Hwy.	**50**

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T073	A/12	2	T	South from Hwy, crosses T063.	**50**
T074				**[number deleted - part of T018]**	
T075	G/15	2	T	From old Alaska Highway north to Prophet River.	**50**
T076	J.017, J.018	1	T	Fragment of Klua Lakes trail near IaRp-016.	
T077	I/2, I/7	2	T	Kahntah River trail to north to Kahntah. Possibly same as T046? South end, and north of Kahntah, trail turns into seismic lines.	**50**
T078	H061	1	T	(old T1 on 1:20 map) From siteform for HjRl-004.	**20**
T079	H061	1	T	(old T2 on 1:20 map) From siteform for HjRl-004.	**20**
T080	H061	1	T	(old T3 on 1:20 map) From siteform for HjRl-004.	**20**
T081	H061	1	T	(old T4 on 1:20 map) From siteform for HjRl-004.	**20**
T082	H061	1	T	(old T5 on 1:20 map) From siteform for HjRl-004.	**20**
T083	H061	1	T	(old T6 on 1:20 map) From siteform for HjRl-004.	**20**
T084	H061	1	T	(old T7 on 1:20 map) From siteform for HjRl-004.	**20**
T085	H061	1	T	(old T8 on 1:20 map) From siteform for HjRl-004.	**20**
T086	A/9, A/10, A/11, A/12	4	T	(B.C. Department of Lands 1922), (Topographical Survey of Canada 1928). Major E/W route.	**50**
T087	A/11	4	T	(B.C. Department of Lands 1922), (Topographical Survey of Canada 1928). From T086 south.	**50**
T088	A/11	4	T	(B.C. Department of Lands 1922). Along Aitken Creek, across the Blueberry R., and along Stoddard Creek.	**50**
T089	A/11	4	T	(B.C. Department of Lands 1922). Along Buick Creek, across the Blueberry R., and along Montney Creek	**50**
T090	A/11, A/10, A/15	4	T	(B.C. Department of Lands 1922). From T018 west along north side of the Blueberry River.	**50**
T091	A/10	4	T	(B.C. Department of Lands 1922). A branch from T018 to the Blueberry River.	**50**
T092	A/10	4	T	(B.C. Department of Lands 1922). From T095, north.	**50**
T093	A/10	4	T	(B.C. Department of Lands 1922). From T086, south.	**50**
T094	A/10	4	T	(B.C. Department of Lands 1922). Branch joining T092 and T086.	**50**
T095	A/9, A/10	4	T	(Topographical Survey of Canada 1928). From T093 east.	**50**

Trail #	NTS Sheet	Confi-dence	Trail/Cart	Notes	Data Mapped
T096	A/9	4	T	(B.C. Department of Lands 1922). From T095 at its crossing of the Doig River, south.	**50**
IlRr-3	0/15	1	T	From siteform - trail fragments previously given a Borden number.	**AV**
IlRr-4	0/15	1	T	From siteform - trail fragment previously given a Borden number.	**AV**