Archaeological Overview of Northeastern British Columbia: Year Four and Five Report and Project Summary

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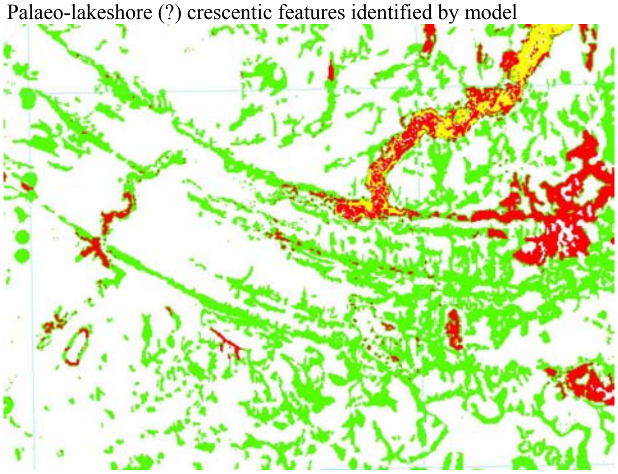
Submitted to the following First Nations
The Fort Nelson First Nation
The Halfway River First Nations
The Dene Tha'
The Blueberry River First Nation
The West Moberly First Nations
The Doig River First Nation
The Acho Dene Koe
The Saulteau First Nation
The Treaty Eight Tribal Association

Palaeo-lakeshore (?) crescentic features identified by model



Millennia Research Limited
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Robert Needlay, Fort Nelson First Nation
Charlie McCarthy, Fort Nelson First Nation
James Wolfe, Prophet River First Nation
Joe Davies, Blueberry River First Nation
Perry Shular, Blueberry River First Nation

Management Summary

A five year project to predict the archaeological potential in Northeastern BC was conducted for the Oil & Gas Commission of BC. The area is extremely large, covering 650 1:20,000 mapsheets. The goal of this project was to improve an earlier model of archaeological potential which had been created when little was known of site distribution in the area, and to improve the new models iteratively. The work was undertaken under the direction of a steering committee drawn from regulators, academics, and First Nations. The general approach was to use existing data, analyse data gaps, address data gaps, and build models iteratively. Field work was scheduled in three of the years to address data gaps and ground truth models. New models were to be produced each year incorporating new data and methods, including new site locations found by consultants in the course of their work (principally related to oil and gas exploration). The model testing was to include known low potential areas where archaeologists had conducted work but found nothing. The mapped locations of known sites were also to be checked and corrected where necessary.

Another project goal was to examine the potential of new technology, especially remote sensing, to add accuracy and precision to potential models.

The five-year time span provided the opportunity to properly test and continuously improve the model. This provided an incredibly valuable opportunity for detailed research on this extremely complex subject.

The project also evolved as project and contract management, as well as chair of the Steering Committee, were transferred from the Ministry of Energy and Mines to the Oil and Gas Commission in 2002.

Year One involved only a few months of work following contract negotiation and a major change to the study area following the first Steering Committee meeting. The work in Year One consisted of creating a detailed plan for the five years, gathering data for modeling from a wide variety of sources, and assessing data gaps (Dady, et al. 2001).

Year Two completed an extensive data gap analysis by comparing surveyed locations to random locations, using a much larger sample of data than was available in Year One. Work commenced on correcting mapped site locations using 1 m resolution orthophotos. Initial fieldwork concentrated on the far north of the study area, where site density was very low and where data gap analysis had shown a lack of survey near large and medium sized lakes and larger creeks and rivers. A large amount of univariate analysis was also undertaken that compared the location of sites in relation to random locations and to surveyed areas where nothing was found. An initial model was constructed, and its performance for the overall area and for each biogeoclimatic zone and ecosection was measured. The initial model performed reasonably well, but with large variation in how well it worked in different ecosections. Five different methods of potentially identifying microtopographic landforms were explored. A new method of identifying topographic landforms from a DEM (digital elevation model) was proposed (Eldridge, et al. 2002).

Year Three focused on two main topics: identifying terrain features with the new method, and using smaller geographic subareas (ecosections) as a basis for creating more

specific and robust models. Field testing was undertaken mainly to test the terrain identification methods used. Site location correction using orthophotos continued. A problem with the site inventory form maps submitted to the provincial register by archaeologists working in the region was noted to be continuing. New forest cover data was obtained and used. Terrain Ecosystem Mapping and Predictive Ecosystem mapping were investigated for possible use in modeling. New models were created for each of the ecosections, with the strongest improvements coming where terrain models were completed using the new terrain identification techniques (Benson, et al. 2003).

Years four and five of the NE BC archaeological predictive modeling were focused on the refinement of the terrain modeling based on field observations as a basis for creating more specific and robust models. This task was very successful and the models created this year are major improvements, in both statistical performance and sophistication, over previous versions.

In recognition of the fact that archaeological potential is strongly correlated with terrain features, especially in areas where the usual indicators are less effective (i.e. large tracts of black spruce muskeg) the terrain model was improved with the inclusion of rectangular running windows. The terrain feature identification was improved but, while the technique of identifying landforms works well, it is hampered by the lack of resolution in the original TRIM DEM. Field survey continued mainly collect spatially accurate and detailed data on ground-based archaeological potential. This survey included identifying terrain features on the map and determining whether or not they existed on the ground; and, identifying terrain features on the ground and determining whether or not they existed on the map. Archaeological potential was recorded for all these features. Thirty-two new sites, seven of which are CMT sites were found during survey, and one previously recorded site was revisited and its location updated (IfRj-1).

Sites location checked during the previous year were changed to polygons and were plotted on the model and were essential for its fine tuning. These precisely corrected site locations have provided data for model creation and testing, and greatly increase the precision of the models. As mentioned before, a problem with site inventory form mapping continued, with the lack of mid-scale maps making it impossible to verify the location of many sites.

In the fall of Year Four, O&G staff made us aware that LIDAR (LIght Detection and Ranging) would soon be commercially available for parts of the study area. This type of remote sensing data, which we had hoped from the inception of the project to be able to find, produces a very accurate and detailed digital elevation model. We obtained some test data from Mosaic Mapping, Calgary, one of the suppliers of LIDAR for NE BC. Whereas TRIM data points are about 80 m apart and are accurate to several metres, the LIDAR data we received had data points every square metre, with sub-metre elevation accuracy of the ground surface, even under trees. This makes the raw data, conservatively, over 64,000 times more detailed than TRIM. Coupled with the new methods of identifying landforms from a DEM, we were able to model for microtopographic landforms. This single data source eliminates the need for proxy variables for landforms, such as forest cover variables (e.g., lodgepole pine only grows on well-drained landforms) and makes archaeological modeling not only much more accurate and precise, but much less expensive in terms of data transfer and translation time and model development time. However, the data is not available for the entire study area, currently the price of LIDAR data is too high for inclusion in the current project. Model development using LIDAR has continued separately for clients in the private sector who have obtained LIDAR data.

A strong focus on the creation of ecosection-specific models continued during Years Four and Five. New models that emphasized landform identification were created and tested for each ecosection. In every case, the model's performance increased.

The Steering Committee has had a long-standing concern that the model development not end with the completion of the contract, and that new data and analytical methods be introduced through time. We concur with this position, and can make a few recommendations. The main one is that LIDAR data should be obtained and used to model in lieu of the present data obtained principally from TRIM and Forest Cover Mapping. LIDAR DEM can provide not only the normal measures of elevation, slope, and aspect insolation, but also landform (including microtopographic features), and tree height. The last can produce maps on a measured tree-by-tree basis, unlike the generalized and often inaccurate Forest Cover mapping. This might be highly productive for modeling environmental boundaries and size of tree stands to fine-tune archaeological potential rating. Landform mapping using LIDAR would be quite sufficient on its own, however, for the next generation of archaeological potential maps. LIDAR modelling greatly reduces the proportion of land area modelled as having potential, yet includes high potential landforms and archaeological site locations that the TRIM based model misses. LIDAR modeling can be expected to increase the accuracy of the models by several orders of magnitude.

One of the areas which remains a data gap in the present model is aboriginal trails. Although many trails were obtained or digitized from historical sources, many more are not incorporated in the model. This variable produced the strongest association with archaeological sites of all in the analysis conducted in Year Two. A number of attempts to obtain additional data from First Nations in the area met with mixed results – several were willing to share their data with us, but for logistical reasons the data transfer never occurred. Filling this data gap would improve the current models.

Acknowledgements

Numerous individuals have assisted with the development and refinement of the deliverables for the NE BC Archaeological Overview throughout the five years of the project. These include:

Year One

Brian Braidwood, Ministry of Energy and Mines, has facilitated contract administration and is the main contact for the project steering committee.

Steve Lipscomb, Leah McMillin, and Joanne White, at Timberline Forest Inventory Consultants, our GIS sub-contractors for the project. In particular we recognise the effort of Lean McMillin, whom we have barraged with data requests and who has responded admirably.

Tom Ouellette, director of Aboriginal Relations and Land Use, Bruce Dahlstrom, Lindsay Oliver, and Mike Wood at the Oil and Gas Commission (OGC) offices in Fort St. John for supplying archaeological and well-site locational data not available through other sources and sharing office space with us during our research time in Fort St. John.

While in Fort St. John we also relied on the study area knowledge and technical GIS support of Rémi Farvacque, Joel Kinzie, Jeff Anderson, Ken Schwab, Nicole Nicholls, and Sean Moffatt as subcontractors from Big Pine Heritage Consulting and Research Ltd. Special thanks to Nicole and Sean for helping with the previous survey mapping, it was much appreciated.

Several Project Officers at the Archaeology Branch assisted with data acquisition. Ian Whitbread, Inventory and Mapping, provided site information from the Provincial Heritage Registry Database, the main archaeology site database for the province. Al Mackie gave us access to the permit log databases. Dave Suttill provided access to his trail information. Doug Glaum provided general project guidance and supervision and reviewed the permit application for year one fieldwork. Jim Pike, Jane Warner, Steven Acheson, and Dave Hutchcroft gave us access to uncatalogued reports currently being reviewed.

Doug Glaum is also directing the Archaeology Site Awareness Project, which has provided corrected site location data for portions of the study area. Thanks to Mark Stone and Margaret Rogers for organising the transfer of data.

Romi Casper at the Cultural Resource Centre of the Ministry of Small Business, Tourism, and Culture was tirelessly patient and helpful during the process of locating and tracking the many reports accessed during this study.

Data coverages were provided by a number of individuals. Mark Rousseau, Land Information Management Officer, Fort Nelson Forest District and Steve Warrington, Land Information Management Officer, Fort St. John Forest District provided digital forest cover and development plan data.

Keary Walde and Karl Hutchings of Heritage North Consulting Ltd. provided useful comments and feedback in regards to the project. Their time in meeting with us is appreciated.

The Acho Dene Koe, Blueberry River, Dene Tha', Doig River, Fort Nelson, Halfway River, Prophet River, Saulteau, and West Moberly First Nations are all thanked for their participation in this project. Chief Roland Wilson, Warren Desjarlais, Eugene Stanyer (West Moberly); Tasha Lalonde (Saulteau); Ken Barth (Fort Nelson); and Bernice Lily (Halfway River) are all thanked for their time in meeting with us, and providing their input on the project. Dolly Apsassin (Doig River); Orest Curniski (Prophet River); and Brian Southwell (Blueberry River) have been our contacts for this project and have provided feedback, and while we have yet to meet them, we look forward to doing so.

The staff at the BC Archives is thanked for their help in location trails information within the study area.

Year Two

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 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 orthophotos used for site corrections, and Ian Whitbread, and John McMurdo, 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.

Year Three

Vera Brandzin, Heritage Conservation Program Manager and Tom Ouellette, Director of Aboriginal Relations and Land Use, at the Oil and Gas Commission (OGC) offices in Fort St. John. Vera provided extensive help and direction and we particularly thank her.

Dan Klassen of the Fort Nelson First Nation; Bernice Lilly of the Halfway River First Nation; Debbie Apsassin of the Blueberry River First Nation; Dolly Apsassin of the Doig River First Nation; and, Dave Caldwell of Prophet River First Nation all met with our staff to arrange field work or to discuss the model mapping results. Thanks to all for their time and effort.

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 orthophotos used for site corrections.

Julie Smith, Todd Christensen, and Keary Walde at Heritage North are thanked for all the help in the field in 2002; and Keary for his help reviewing the model and palaeo site locations in "spring" 2003.

Remi Farvacque and Ken Schwab of Big Pine Heritage Consulting are thanked for their time examining the Clear Hills model mapsheets in "spring" 2003.

Years Four and Five

Vera Brandzin, Heritage Conservation Program Manager, Tom Ouellette, Director of Aboriginal Relations and Land Use, and Geoff Haines, GIS manager at the Oil and Gas Commission (OGC) offices in Fort St. John all assisted in many ways.

Matthew General, Saulteau First Nation; Steven Desjarlais, West Moberly First Nation; Dave Caldwell, Prophet River First Nation; Bernice Lilly, Halfway River First Nation; Debbie Apsassin, Blueberry River First Nation; Dan Klassen, Fort Nelson First Nation; and Darlene Davis, Doig River First Nation. All met with our staff to arrange field work or to discuss the model mapping results. Thanks again to all for their time and effort.

Marhlen Caverhill from Mosaic Mapping Inc. in Calgary provided test LIDAR data. Bob Powell and Tom Ouellette made us aware that this data was available.

James Pike, Planning and Assessment, Archaeology & Forests Branch of the Ministry of Sustainable Resource Management is our Project Officer. David Suttill, Archaeology & Forests Branch of the Ministry of Sustainable Resource Management

Joanne White and Leah Smith at Timberline Forest Inventory Consultants Ltd. are thanked for their invaluable support and opportune feedback throughout the project. Keary Walde, Brad Tanner, Melissa Knight, and Peter Klisowski at Heritage North are thanked for all their help in the field.

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Introduction

This report presents the fourth and fifth year results of the NE BC Archaeological Overview Assessment and provides an overview of the entire project. 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). Subsequently, in 2002, the project and contract management was transferred to the OGC. In this endeavour, Millennia Research has partnered with Timberline Forest Inventory Consultants Ltd, who provide Geographic Information System (GIS) support. We also partnered with Big Pine Heritage Consultants Ltd. and Heritage North Consulting Ltd. as our study area specialists.

The NE BC AOA covers a large continuous area is bounded to the north by the British Columbia border with 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 includes parts of the Fort Nelson and Fort St. John Forest Districts and falls within NTS map sheets 94O, 94P, 94J, 94I, 94H, the eastern half of 94G, and the northern half of 94A (Figure 1). This is one of the largest areas ever modeled for archaeological potential at a large scale (1:20,000) in the world.

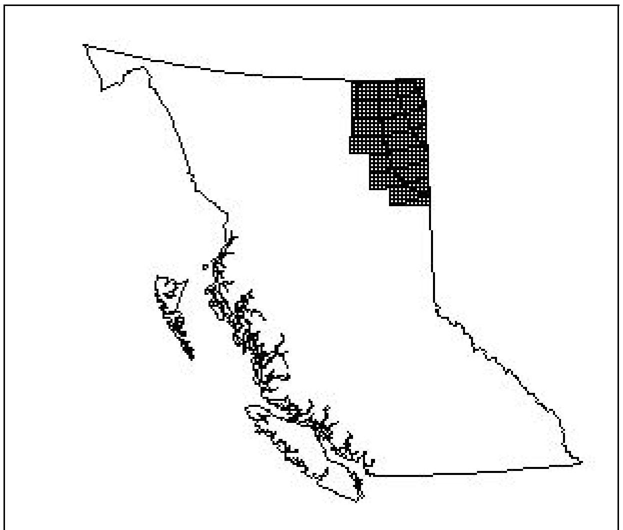


Figure 1. Study Area.

This report reports on the details of work conducted from April 1, 2003 to December 31, 2004, the final two years of the project. Permission was granted by the Steering Committee to combine the results of the last two years (only one of which involved fieldwork) into a single report. The report outlines the Year Four and Five objectives, and describes meetings with First Nations, site checks, trail and palaeo site research, the overall model development, summarizes improvements made in terrain identification, and presents fieldwork results. The final section of the report summarizes the results and suggests ways to continue to improve the model.

Project Review Committee

Overall project direction is the responsibility of the Project Review Committee. The current Committee consists of Tom Ouellette (OGC), James Pike (Archaeology and Forests Branch), Mary Viszlai-Beale (Ft. Nelson Forest District), Dr. Quentin Mackie (University of Victoria), Bob Powell, Senior Policy Advisor, Aboriginal Relations Branch, Ministry of Energy and Mines and Vera Brandzin (OGC).

Year Four and Five Objectives

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

Years 4 and 5 tasks include:

- Fieldwork (Year Four only);
- Testing and refinement of model;
- Versioning and Distribution of final models,
- Model implementation, and training for users; and,
- Reporting.

Discussions with First Nations

Discussions with First Nations were geared to introduce Millennia Research and outline the general objectives and developments of the project. Likewise the opportunities for First Nations involvement in various aspects of the project were discussed during these meetings. The timeline of these is outlined below:

Year 1 to March 31, 2001

August 23, 2000. Letters to Chris Bezant, Halfway River FN asking to review permit application and letter outlining project. Also sent copy of project 5 year plan.

September 1 & 5, 2000. Letters outlining project and copy of permit application go to Chief and Councils of Halfway River First Nations, Prophet River First Nation, Fort Nelson First Nation, Dene Tha', Lower Post First Nation and Acho Dene Koe. The letters indicated that we were committed to First Nation participation in the project. Indicated that funds had been proposed or allocated for First Nations for review time to examine and critically comment on ethnographic and predictive modelling report sections; research time to map aboriginal trails (or to obtain mapping from existing sources); field research assistants; meeting time to discuss review comments, examine draft potential maps, presentations; and travel costs for attending meetings or working at research facilities.

Study area is revised to Prophet River, Blueberry and Halfway River areas.

October 13, 2000. Fax to Chris Bezant, Halfway River FN advising of study area change and field work. Chris Bezant was to approach respective Chief and Councils from other Bands to obtain letters of support for the permit application.

Letter and revised permit application and map sent to Orest Curniski -Prophet River First Nation.

Letters were drafted outlining project and revised permit application and map to Howard Southwell - Blueberry River First Nations.

October 25, 2000. Permit application sent out by Archaeology Branch to Blueberry River First Nation, Prophet River First Nation, and Halfway River First Nations.

February 2001. Letters outlining opportunities for First Nations participation in the project and requesting meetings were sent to Blueberry River, Doig River, Fort Nelson, Halfway River, Prophet River, Saulteau, and West Moberly First Nations.

February 20, 2001. Morley Eldridge met with Chief Roland Wilson, Warren Desjarlais, Eugene Stanyer and other council members of the West Moberly First Nations and with Tasha Lalonde and other members of the Saulteau.

February 21, 2001. Morley Eldridge met with Ken Barth of the Fort Nelson First Nation and Bernice Lilly of the Halfway River First Nation.

Telephone and written correspondence with Dolly Apsassin (Doig River), Orest Curniski (Prophet River), Baptiste Metchooyeah (Dene Tha') and Brian Southwell (Blueberry River) who provided feedback throughout year one.

March 2001. Follow up letters sent to all First Nations. Letters included a written request for trail and TUS information, an assurance of confidentiality, and an outline of funds available for compilation of data. Letters were followed up with phone calls.

Year 2 April 2001 – March 2002

May 28, 2001. Year 1 Report sent to Ken Barth, Fort Nelson First Nation; Howard Southwell, Blueberry River First Nation; Chris Bezant, Halfway River First Nations; Orest Curniski, Prophet River Band; Chief and Council, Dene Tha'; Warren Desjarlais, West Moberly First Nations; Dolly Apsassin, Doig River First Nation; Chief and Council, Acho Dene Koe; Tasha Lalonde, Saulteau First Nation and Treaty 8 Tribal Association.

June 2001. Permit Application for Years 2 – 5. Copies sent to First Nations.

July 3, 2001. Meeting with Orest Curniski, Prophet River First Nation.

Phone calls and faxes exchanged with Howard Southwell, Blueberry River First Nation, but he was not able to meet.

Dolly Apsassin, Doig River First Nation declined a meeting.

October 9, 2001. Letter regarding fieldwork study area sent to Chief Liz Logan and Ken Barth, Fort Nelson First Nation; Chief Lisa Wolf and Orest Curniski, Prophet River First Nation.

Liaise with Ken Barth, Fort Nelson First Nation and Orest Curniski, Prophet River First Nation to arrange field assistants.

October 15, 2001. Met with Orest Curniski and Council Members of Prophet River First Nation prior to fieldwork to discuss general project issues and field approach.

Field crew: Genny Kotchea, Allan Kotchea, Mark Whitehead, Fort Nelson First Nation; James Wolf, Fred Jumbie, Prophet River First Nation.

November 26, 2001. Letter summarizing results of fieldwork sent to Ken Barth, Fort Nelson First Nation; Orest Curniski, Prophet River First Nation; Howard Southwell, Blueberry River First Nation; Dolly Apsassin, Doig River First Nation; Tasha Lalonde, Saulteau First Nation; Warren Desjarlais, West Moberly First Nations; Bernice Lilly, Halfway River First Nations.

February 26, 2002. Email correspondence from and to Vanessa Laverdure, Lower Post First Nation. The correspondence informed that the new study area had no overlap with Lower Post, as well as instructions on how to download Year 1 report, and other report of interest.

Year Three April 2002 – March 2003

September 18, 2002. Letters sent to Halfway River, Prophet River, Blueberry River, Doig River and Fort Nelson First Nations, updating project and asking for meetings. Wanted their ideas about where archaeological sites occur across the landscape and any other information that they feel is important to the creation of a model of archaeological potential. Follow-up phone calls were made to arrange meetings and field assistants.

Meeting with Dan Klassen, Fort Nelson First Nation; Bernice Lilly, Halfway River First Nations; Debbie Apsassin, Blueberry River First Nation; Dolly Apsassin, Doig River First Nation; and Dave Caldwell, Prophet River First Nation to arrange field work or to discuss the model mapping results.

September – October 2002 fieldwork.

Meeting held with Dan Klassen, Fort Nelson First Nation regarding the project and future directions.

Field crew: Robert Needlay, Richard Resener, Fort Nelson First Nation; Edward Achla, Halfway River First Nations; Richard Apsassin, Blueberry River First Nation, Laurie Lineham, Doig River First Nation.

Following model completion for the Clear Hills Ecosection, meetings were held with representatives from the Doig, Blueberry, Prophet River and Fort Nelson First Nations. At each meeting the model was discussed and the maps examined. It was reiterated that funds were available for independent review of models and reports. All meetings were positive. Preliminary talks regarding the next round of field testing were discussed at some meetings.

Year Four April 2003 – March 2004

July 10, 2003. Telephone conversations were held with Steven Desjarlais, West Moberly First Nations, regarding the project. Steven also wanted to know who we had previously corresponded with from West Moberly. Sent follow up email with a link to the Year 2 Report for him to download, and advised that we have previously corresponded with Tasha Lalonde and Warren Desjarlais.

July 11, 2003. Letters sent to Matthew General, Saulteau First Nation; Steven Desjarlais, West Moberly First Nations; Dave Caldwell, Prophet River First Nation; Bernice Lilly, Halfway River First Nations; Debbie Apsassin, Blueberry River First Nation; Dan Klassen, Fort Nelson First Nation; and Darlene Davis, Doig River First Nation. The letters advised of upcoming fieldwork, and that Millennia Research would contact them again closer to the time of fieldwork.

July 31, 2003. Fax sent to Dave Caldwell, Prophet River First Nation and Rita Michel and Dan Klassen, Fort Nelson First Nation, to advise of field schedule and details and to request field crew.

August 27, 2003. Telephone conversation with Lynn, Blueberry River First Nation regarding field schedule and dates, as well as requesting field crew. Follow up fax to Lynn, outlining project schedule and details.

August 29, 2003. Faxes sent to Bernice Lilly, Halfway River First Nations and Darlene Davis, Doig River First Nation, outlining field schedule and details.

September 3, 2003. Telephone conversation held with Debbie Apsassin, Blueberry River First Nation. She didn't receive fax sent on August 27, 2003. The Fax was re-sent addressed to Debbie. Debbie was called to confirm receipt.

September 8, 2003. Telephone conversation held with Lynn, Blueberry River First Nation giving details of field assistants that she had scheduled.

September 21, 2003. Fax sent to Bernice Lilly, Halfway River First Nations to follow up on previous faxes and phone calls requesting a field assistant.

Field Crew: Robert Needlay, Charlie McCarthy, Fort Nelson First Nation; Joe Davis, Perry Shular, Blueberry River First Nation; James Wolfe, Prophet River First Nation; Halfway River First Nations and Doig River First Nation.

March 23, 2004. Report for Year 3 sent out to Acho Dene Koe, Blueberry River First Nation, Dene Tha', Doig River First Nation, Fort Nelson First Nation, Halfway River First Nations, Saulteau First Nation, Treaty 8 Tribal Association, and West Moberly First Nations.

March 2004. Morley Eldridge had meetings with Chief and Council, Doig River First Nation and Dave Caldwell and council members from Prophet River First Nation, to discuss the model.

Predictive Model Development History

Archaeological Modeling Advances

Archaeological sites tend to be rare events over the landscape. They are not randomly distributed, however, and archaeologists use a basic assumption that archaeological site location can be correlated with environmental and cultural attributes. Models can be created that indicate the relative probability of encountering an archaeological site, and maps can be generated from these models. Archaeological potential modeling has gained attention throughout the developed world as archaeological site protection legislation has led to regulation of natural resource industries and other developers. The costs of conducting archaeological impact assessment survey can be relatively high, so companies want to concentrate their work in locations where the risks of encountering a site are higher. Good models provide clear guidance for determining where survey takes place and reduces the number of surveys in areas where the risk of encountering a site is very low, thus saving money while effectively managing heritage resources.

Modeling developed rapidly in the 1990s with improved computing power and adoption of GIS. Examples from around the world were available to evaluate what works and what doesn't (e.g., Allen, et al. 1990; Westcott and Brandon 2000). Millennia Research had previously created models for a number of areas in BC (Commonwealth Historic Resource Management Ltd., et al. 1996; Eldridge, et al. 1998; Ferguson, et al. 1996; Lindberg and Moyer 1999; McLaren, et al. 1998; Millennia Research Ltd. 1997; Owens, et al. 1999). Other consultants in BC were also active producing models (e.g., Brolly, et al. 1995; Golder Associates Ltd., et al. 1998; Muir, et al. 1994).

Perhaps the best example of a comprehensive and successful modeling project anywhere was completed in Minnesota in the late 1990s and early 2000s (Hudak, et al. 2001). This project, with a US$4.5 million budget, was developed in response to rapidly rising survey and mitigation costs, and dependence on non-reproducible expert judgements as to where archaeological work was required. The model was developed using the location of known sites and 'negative survey' to assess a wide range of variables with regard to survey bias. Archaeological survey carried out to fill data gaps, and surficial geology mapping was undertaken to take into account the likelihood of deeply buried archaeological sites. The project used logistic regression to create the model. The reports on this work became available in 2001. A review of these reports showed that virtually all of the key components of this landmark study were already being addressed by the Northeast BC modeling project. Significant differences included the treatment of isolated finds and small lithic scatters from the Minnesota model:

> A constraint of building predictive models of archaeological site location is the apparent random distribution of lithic scatters. Since precontact Native Americans in Minnesota traveled across all dry land areas of the state millions of small clusters of artifacts are distributed across the landscape. These most likely represent incidental and very short-term use of the land. Usually called lithic scatters, artifact scatters, or simply find spots, this category of site is usually defined as having very low densities of debitage and tools (e.g., less than 1 artifact per sq meter) and no culturally diagnostic artifacts. In this genre of study, they are called lithic scatters, because they consist for the most part of lithic (stone) artifacts, although fire-cracked rock, bone, and other culturally non-diagnostic material may be present.
>
> (Hobbs and Nawrocki 2001).

The Minnesota model excluded all isolated finds and ran models both with and without lithic scatters. The Minnesota model has several statements regarding the significance of small lithic scatters and their effect on modelling:

> …the exclusion of lithic scatters from predictive model databases will increase the predictive power of models and remove a site type that is insignificant and, therefore, does not require mitigation …Since small lithic scatters as defined in the literature tend to be widely scattered across the landscape, it makes sense to exclude them from the modeled sites; including them usually masks site locational patterns of value for cultural resource management. …It is possible that the large, perhaps overwhelming, nmber of small lithic scatters and special activity sites may be masking the effects of some important variables for predicting more significant sites… It is the larger campsites that archaeologists may use to form their intuitive models of site location, simply because of their visibility and more restricted set of environmental characteristics. In many respects, these campsites also contain the highest information content of any sites. Some may argue that models built with lithic scatters in the database may be emphasizing the location of the smaller, perhaps less significant, sites at the expense of the larger ones. This problem will be addressed in future model evaluation and interpretation.
>
> (Hobbs and Nawrocki 2001).

To avoid the "random location" effect of degrading a model, in Ontario a model simply excluded all sites less than 5 m² (Young, et al. 1995). Isolated finds or small scatters are removed from most models (e.g. Bereziuk and Gibson 2003; Warren and Asch 2000).

These lithic scatters, as described in the quotes above, sounds very much like the archaeology of Northeast BC. If we had excluded all isolated finds and lithic scatters, there would have been very little left to model for! All such sites are automatically protected and must be managed for under BC legislation, unlike Minnesota and some other jurisdictions. In Minnesota, it was acknowledged that many small lithic scatters may actually have considerable significance, but the problems of managing for them were simply avoided.

A model using current techniques has been created for the South Peace area of Alberta (Bereziuk and Gibson 2003). This model has problems derived from a relatively small, biased sample of sites, a large number of which were recorded during academic research along one shore of a major lake and river. The small sample size was further reduced by the necessity to divide it into a 'training sample' and a testing sample. Only four variables were used, one of which was satellite imagery classified into wet or dry sites, which was only available for part of the study area. The resulting model is a heavily dependant on modern hydrography.

The previous archaeological potential model in NE BC was a preliminary model based largely on forest cover and hydrology (Mackie 1997, 1998). This model occasionally became overly simplistic (Figure 1) but was often moderately complex (Figure 3).

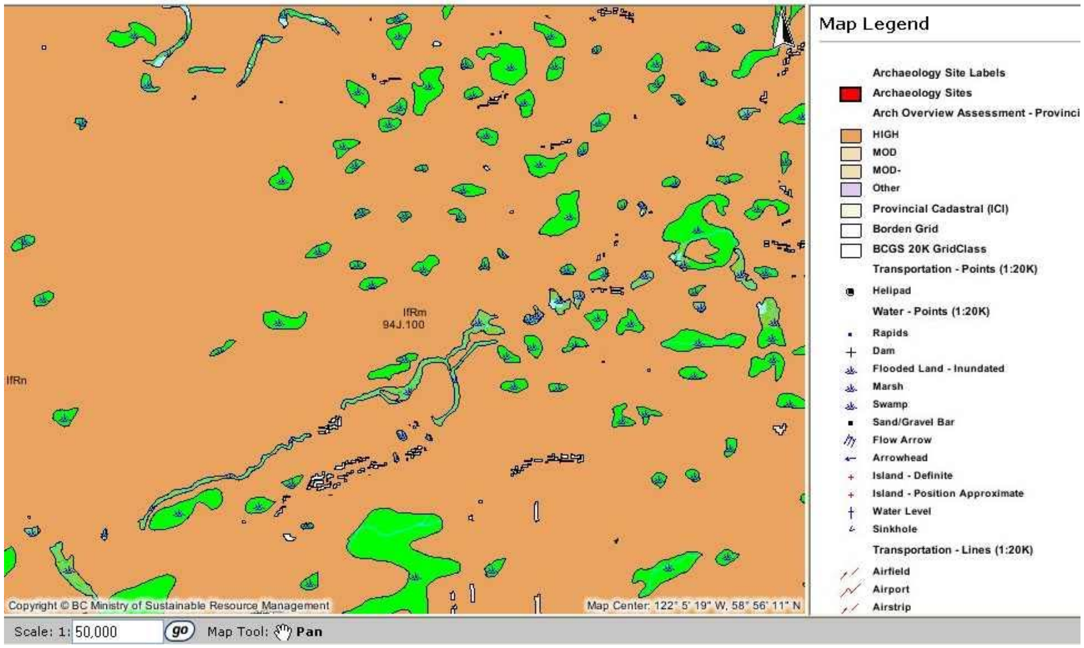


Figure 2. Part of Mackie model displayed in RAAD.

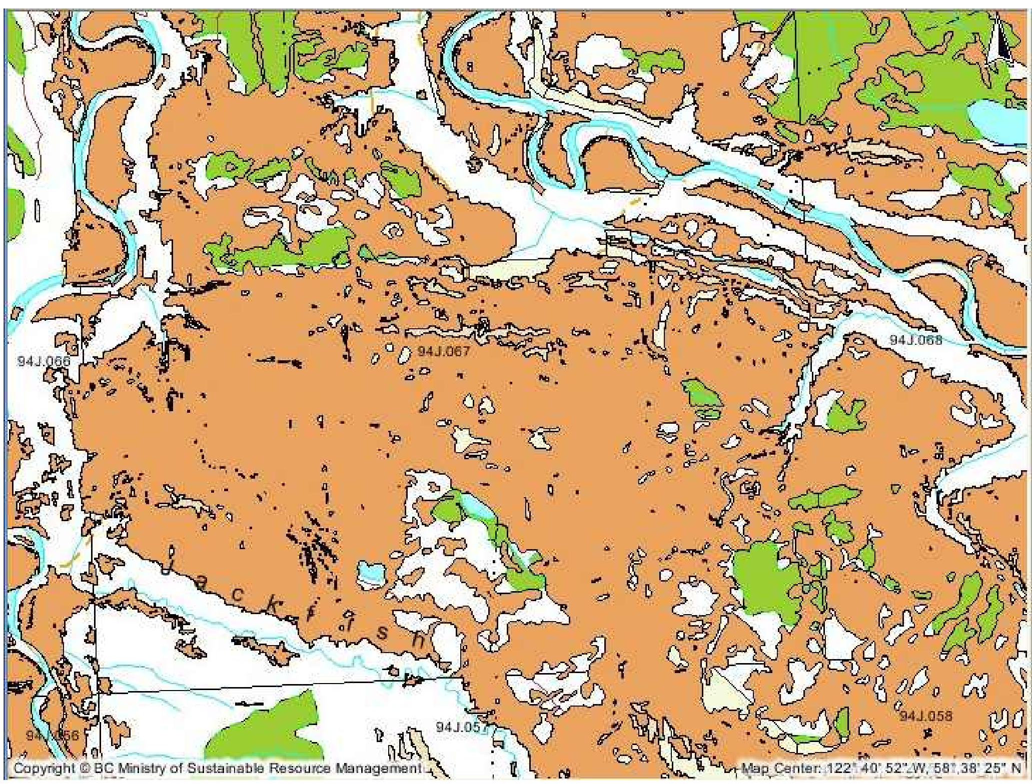


Figure 3. Another part of Mackie model displayed in RAAD.

Model Building Approach

One major option in model building is to choose between a deductive and inductive approach (Kohler and Parker 1986). Deductive models consider how humans make choices concerning location of sites, specify variables that affect these decisions, and then try and operationalize the mapped variables into a prediction of site locations. Deductive models often heavily rely on the ethnographic record of the area. Inductive modeling examines patterns of distribution that distinguish sites from 'non-sites', or places where sites are known or presumed to be absent. These patterns are used to build a probability model of how likely any particular location is to contain a site. Purely inductive modeling has been roundly condemned as theoretically sterile:

> The insistence that "inductive" predictive modeling can be separated or distinguished from "deductive" or explanatory predictive modeling is a clear indication not only of the fact that predictive modeling has not yet reached the point where it can make a contribution to the science of archaeology, but (in my opinion) of the level of sheer indolence among those who think we can "stop" at "inductive predictive modeling." … predictive modeling is … grounded upon that most basic and unthinking assumption … that site… locations are what we want to predict.
>
> (Ebert 2000)

However, Ebert perhaps does not understand that, outside the academic world, site locations are exactly what we do want to predict, for financial, planning, and regulatory reasons. The explanation of the cultural and environmental systems behind the site patterning are of import to academic theory, but of little concern to the oil and gas company landsman wondering if an archaeological assessment will be needed for a proposed pipeline connection to a newly producing well. However, both inductive and deductive approaches were used in the current model, and correlations between site locations and variables were never taken at face value, but rather the explanation for the correlation was always considered.

Modeling starts with evaluating the usefulness of various data sources. Generally, these are in GIS format already, although conversion to digital format is considered for some data (such as trail locations). The data should all be at a scale that is appropriate for the model, and it should be available for the entire study area – although exceptions can be made for this. It is normal to start with a wide variety of variables, drawn from topography (e.g., elevation, distance to large lake), forest cover (e.g., lodgepole pine presence or % of lodgepole pine) and other disciplines such as soils mapping, surficial geomorphology, or ecological unit mapping. Cultural values can include trails, other Traditional Use sites, highways, and previously recorded archaeological sites. Archaeological survey where nothing was found (non-sites) is a variable highly desirable from several aspects. Some apparently useful data sets will be found not to be useful when evaluated, due to inaccuracy, unsuitable scale, incomplete coverage, or redundancy.

Several modeling approaches have been used with success. Luke Dalla Bona created a Weighted Values method during work on the Plains and Ontario (Dalla Bona 2000). This deductive model assigns different variables relative importance to each other, and importance within the variable. For example, a series of distance buffers from waterways might be created – 0-100 scored 3, 100-200 scored 2, and 200-300 scored 1. Then, if lakes are considered more important than streams, the lakes might be given a value of 5 and streams at 4. The score for a location will then be calculated by multiplying the distance score to a lake times 5 and adding the distance score to a stream times 4. An overall score is obtained that is classified into potential ratings.

Logistic regression has gained popularity, even dominance, in modeling due to its robust nature (e.g., Allen, et al. 1990; Brandt, et al. 1992; Hobbs 2001; Petrie, et al. 1995; Warren 1990; Westcott and Brandon 2000). Logistic regression can use data from a wide variety of types (presence/absence through ration level measurements like distance in metres measures). It works using cells, or raster data. Its use is generally combined with univariate analysis of the data. It is usually used step-wise, with all variables added to begin with, then dropping single variables one at a time that appear to be essentially redundant. Often four to a dozen or so variables remain at the end, with a single formula expressing a probability of site presence. There are a number of problems with logistic regression, notably the 'black box' nature of the process and the difficulty in interpreting the final formula's component parts. It also tends to be very inefficient with data, since a large portion of the data is split to be used in 'training' and the remainder are used in 'testing'. Although this is a useful approach since it avoids the problem of modeling results appearing better than they are due to circularity, it is still difficult to achieve representative sample sizes for both modeling and testing phases.

The model creation method used by Millennia is more similar to the Weighted Value methods of Dala Bonna, but includes extensive analysis to determine optimal buffer sizes. The initial data can be represented as points, lines, polygons, or raster grids. As an example, archaeological sites can be considered single points (one for each site regardless of size), or polygons, or as a series of points representing a polygon (either evenly or randomly placed throughout the polygon, or evenly spaced points around the perimeter). The initial analysis and modeling for the current project was conducted using a series of points representing samples of sites, non-sites, and the overall land. Comparison of the non sites to the random sample of land will identify survey bias; comparison of sites to non-sites or to the random sample of land will identify patterns of archaeological site distribution. A few very large site polygons amongst many other very small sites could easily bias the sample of site points, so it is important to make these choices carefully.

The sample sizes used for database-based analysis and modeling were very large: by Year Three, there were some 2000 archaeological site points, 20,000 random land sample points, and 15,000 surveyed non-site points. Although this was an ample sized sample for evaluating the area as a whole, splitting the area into eight ecosections, with separate analysis and modeling for each, considerably reduced the effective sample size.

Data for variable analysis were derived from GIS near-to and identity analysis. Near-to analysis simply returns the distance to nearest lake, for example, in metres for a variable "distance to nearest lake". Identity analysis will return the dominant tree species or age, or the biogeoclimatic zone the point occurs in. This is suitable for classified or ranked data.

Univariate analysis then examined the variables one at a time. Near-to analyses results are graphed and the distributions of the sites and non-sites were compared using the Buffer program developed by Millennia Research (see the Year Two and 3 reports for details). This analysis is done on outside the GIS platform, and is very rapid and powerful. Using this program, frequency distributions can be created using any desired increment (e.g., distance to lake could be assessed in 200 m steps, or 20 m steps), with the results tabulated, graphed, and analysed to find statistically valid differences. Data results can always be examined in a map format as well, further increasing analytical power.

Both obvious and less obvious reasons were sought for unusual distributions. For instance, although there was a very large, statistically significant correlation of site locations with distance to ecotone (where two biogeoclimatic units join) at about 700 metres, it was determined that the correlation was spurious. When the data were examined, it was found that the large spike was caused by a large number of sites found on linear summit terrain, at the top of long, narrow, consistently sloped mountain ridges. The result was that the treeline (the bottom of the Alpine biogeoclimatic zone and the ecotone in question) happened to be about 700 m from the ridge tops wherever sites were found. The obvious reason for the site location was the summit terrain, not the fact that the site happened to be about 700 m from an ecotone. This type of phenomena is known as 'autocorrelation' and is a type of redundancy. No other strong associates were found, and ecotone was dropped from further modeling consideration. Other redundancies were found, for instance in the distribution of birch trees, which were found as a small component of almost all aspen stands. Aspen percentage was retained for modelling while birch was deleted.

Redundancy also occurs in other variables, but sometimes they were only partially redundant, they were retained in the model. Several variables all identify low rises, for instance. Several are derived from the Digital Elevation Model (DEM), but a number of other forest variables (such as presence of lodgepole pine) are proxies for identifying raised well-drained landforms. The forest variables sometimes will identify these high-potential landforms where the DEM data is inadequate. All these are useful.

Some variables had strong direct relationships with site location. For instance, trails showed a very strong relationship with the distribution of archaeological sites, with nearly half of all sites (less than 2 km from a trail) less than 100 m from a trail (Figure 4). Only about 1/20 of the land points (less than 2 km from a trail) (Grid on Figure 4) are less than 100 m from a trail. In this case, the obvious explanation that sites tend to be located near aboriginal trails was accepted.

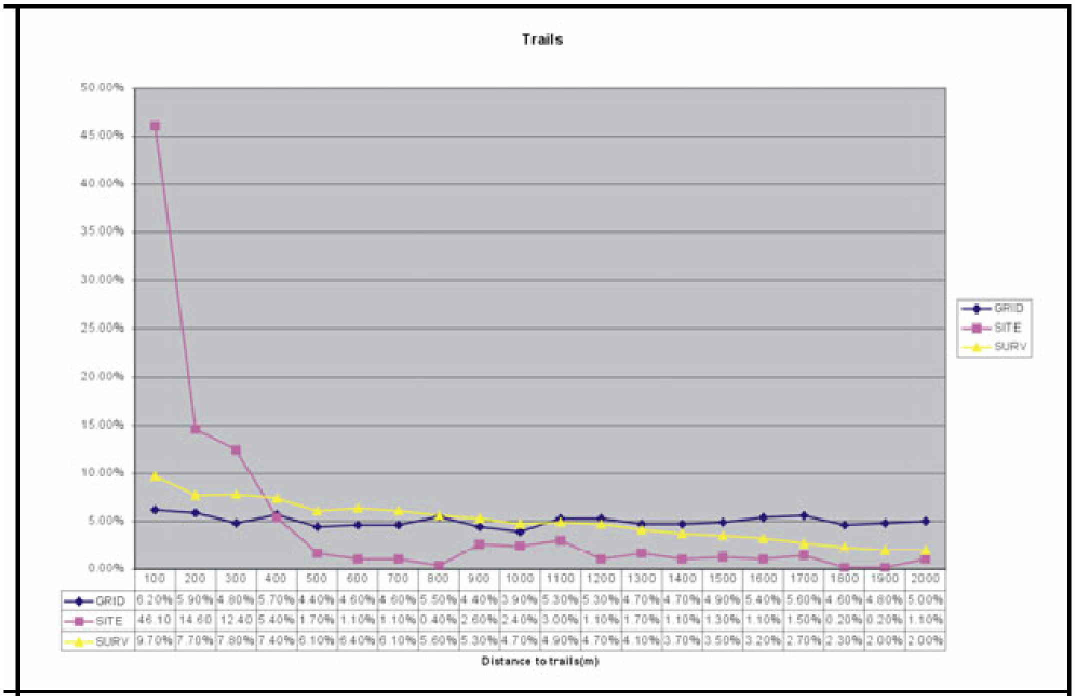


Figure 4. Trails near-to analysis.

The Millennia Research method of model building starts with all locations classed with a value of 0. The model then adds the strongest variable and iteratively adds new variables, assessing model performance at each step. For instance, a model might begin by adding a point for all locations within 50 m of a trail, if that distance was found to be a particularly strongly correlated with site location. Another point is then added for all locations within 300 m of a trail, if 300 m is found to be significantly correlated with site location, but not as strongly as 50 m. The result is that all areas within 50 m now have 2 points, while those 50-300 m have 1. This is broadly similar to Della Bona's Weighted Values Method. Often, variables are added in combination with each other.

As each variable is added in, the results in terms of model capture of sites, surveyed non-sites, and random sites is reported. The Kvamme's Gain statistic– a simple formula, 1-(%area/ % sites), was used to measure model performance at each model iteration. Autocorrelations are sometimes discovered when a variable that was statistically strongly related to site locations is added to the model but the addition has no useful increase in model performance. If an autocorrelation is discovered, it is easy to run the model replacing one variable with the other, and examine the model performance to determine which is best to keep. This essentially duplicates what step-wise logistical regression does; but in a clear, obvious manner, under the direct control of the modeller. It is also computationally much quicker and simpler, particularly when running on large samples.

In the last two years, analysis and modeling was often done by manipulating variables directly in the GIS. Initial work had been done in standard ESRI GIS platforms and using line, point, and polygon data, then using custom analytical programming to model with large samples of sites and non-sites. Later iterations were usually done in ESRI's Spatial Analyst module, working with Map Algebra on GRID layers in raster format, and with complete map data sets for entire ecosections.

Distribution of Sites and Archaeological Survey in NE BC

Known archaeological site distribution is generally much more representative in northeastern BC than elsewhere in Canadian boreal forest. Most other places have very biased samples of archaeological sites, a result of archaeologists doing initial inventories along rivers and lakes (Dalla Bona 2000:86). Survey of high visibility zones along easily accessible shorelines "makes good sense in the context of pioneer reconnaissance, small research budgets, and short field seasons, but it does not generate a representative sample of heritage resources throughout the region" (Hamilton 2000:52). The emphasis on modern drainage leads to a circularity of reasoning on models built on such data. Hamilton (2000), in an article highly critical of continued emphasis in boreal forest predictive and operational models on modern drainage, suggests that "In my experience, boreal forest archaeologists (including myself) seldom intensively inspect more than a 50 to 100 m wide buffer along shorelines" (Hamilton 2000:56). Hamilton finds that early and middle Holocene period sites are seldom found in the areas where archaeologists normally look, and even in later periods, only some types of activities from some seasons are well represented.

In northeastern BC, unlike the situation in most of the Canadian boreal forest, an emphasis from the 1970s onwards has been on surveying for landforms not necessarily associated with modern drainage, and many archaeologists have been aware of Pleistocene and early Holocene geological features. This may reflect the early influence of Knut Fladmark, who directed several major studies in the area, (Driver, et al. 1996; Fladmark 1974, 1996; Fladmark, et al. 1988; Fladmark 1980). Fladmark had strengths in Quaternary geology and geomorphology, and he incorporated this into his work and passed on this knowledge to many of his students and colleagues. Field work was conducted in uplands locations from the earliest O&G industry archaeological assessments. Another strong influence in the region has been Keary Walde of Heritage North, who established a working model where archaeological potential was not dependant on modern drainage features. Many sites are located on small raised landforms. A very large sample of surveyed areas at wellsites and along pipeline, access roads was available for analysis. These surveys were guided by the location of seismic lines, wellsites, pipelines, etc., the location of which is mainly a reflection of deeply buried geological structures, and would appear to have little correlation with the factors which influenced precontact land use patterns throughout the Holocene period. Thus the sample of survey is essentially unbiased, although this was tested through analysis of patterning of survey location points vs. random landscape points, and many areas were not included due to poor field methods or reporting.

This survey information made it highly suitable for modeling, without the usual problems of circularity (where all known sites are located close to modern waterways, then a model is created based on close proximity to waterways, model performance will appear to be excellent even though it is actually poor at predicting unknown site locations). The large body of data meant that any biases in survey could be measured. This was accomplished by mapping surveyed locations, and comparing the attributes of these locations to a random sample of the overall land, and will be explained in more detail below.

Identification of Topographic Features

As identified in the Year Two and Three reports, and by several authors referenced therein, the major contributor to archaeological potential in the northeast is terrain (Eldridge, et al. 2002). Knolls, rises, low ridges, terrace edges, and similar features are the usual locations for sites. A tendency for many sites to be located on small knolls and ridges has also been found in similar areas in northeastern Alberta (e.g., Saxburg, et al. 1998; Shortt, et al. 1998).

Hence identifying and modelling for terrain continued to be considered as key to the success of this model. Much of the area is swamp and marsh, so an appropriate location to camp or extract resources in the northeast is often based on raised terrain. In very flat areas, any 'bump out of the muskeg' might contain an archaeological site. In areas with more variable terrain, it is terrace edges, rises, and high, aspen and pine-covered features that seem to have archaeological potential, based on previously recorded site locations and consultation with other contracting archaeologists. Millennia developed a novel technique for the automated identification of terrain features based on relative elevation in a GIS system, as initiated in the Year Two report (Eldridge, et al. 2002). Continued development of this terrain identification technique was a focus of the final year's work on the northeast potential model.

We have described to a great extent in the Year Two and Three reports the advantages and limitations of using digital elevation models (DEM), as a means of identifying areas of topographic interest. However, previous attempts to use DEM in the northeast had not been successful due to the ephemeral nature of some of the landforms and ground resolution of the sample forms taken to build the DEM. A problem that was anticipated with using the northeast DEM was accuracy. As with any computer-created model, the accuracy of the northeast DEM would depend on the quality of the elevation data and the 'fit' of the algorithm used to process the data as well as the anticipated use of the model.

In the second year of the project, a DEM created from TRIM was used by Timberline to attempt to extract terraces, ridges, and other terrain features. These features were extracted using the ArcINFO VIP command. The VIP algorithm attempts to identify major terrain features by examining the surface locally using a 'window.' For these purposes, a 'window' is a small program which in essence 'moves' across a digital surface. The VIP program assumes that each point has 8 'neighbours', which form 4 diametrically opposite pairs, i.e. up and down, right and left, upper left and lower right, and upper right and lower left. The software examines each of these pairs of neighbours for each point, connecting them with a straight line. It then computes the perpendicular distance of the central point from this line diagram from the other points. VIP then averages the four distances to obtain a measure of "significance" for the point and deletes DEM points in order of significance, eliminating the 'least significant' points first. One major problem was found to be that all 'high points' were considered significant no matter what their size. Unfortunately, the VIP algorithm was designed principally to be able to *reduce* the complexity of the terrain models. In the northeast, we were looking to use the full range of complexity and detail available in the data available (see the Year Two report for a critique and explanation of the VIP command). Field ground-truthing of VIP defined topographic features showed the technique to be virtually useless.

Several techniques in addition to the VIP process were examined for dealing with topographic features. First, all recorded archaeological sites were analysed for topographic features. In some cases, features such as 'low ridge' were recorded in a landforms field, but mostly this information was contained in site location descriptions or remarks. This study confirmed that almost all sites were indeed associated with features such as low rises, ridges, knolls, hilltops, breaks in slope, and terrace edges. Secondly, Big Pine Heritage digitized several mapsheets for microtopographic feature using orthophotos, including areas where fieldwork had collected point-specific potential ratings. This was much more successful than the VIP command, but was only moderately successful at predicting on-ground potential. It was also far too expensive to consider for the entire study area. Thirdly, image classification of single-band (TRIM) orthophotos was conducted by Timberline Forest Consultants Ltd using PCI Geomatica classification software. This showed promise but would have required considerable efforts to become operational.

As the DEM by itself or the VIP command was not extracting the detailed topography hoped for, the idea of a moving window, with the ability to access localized terrain differences, was exciting to Millennia archaeologists. Based on this concept, a new 'moving window' technique was conceived. The moving window technique used a grid of elevation data to identify both small and large terrain features. Timberline wrote an AML (Arc Marco Language) script to automate the moving window process, run in ArcINFO's GRID extension, so it could easily be applied to the entire study area in an efficient manner. The Year Two and Three reports discuss the moving window concept in detail so we will only recap here on the most relevant aspects in relation to the further development of the model.

The moving window technique returns a new grid for each variable calculated. The variables are based on the relative differences between the central cell and surrounding cells. As the window 'moves' from cell to cell, it assigns the desired value as the value of the cell in the new, output grid. That is, the number calculated by the software is stored as a non-spatial variable in a table associated with the spatial file. A series of rectangular (7x1 and 25x1) horizontal (east-west) and vertical (north-south) moving window grids with a 20m cell resolution, along with a 9x9 square moving window with a 60m cell size, were requested to Timberline for each of the study area ecosections.

Three variables were calculated. They were:

(1) **positive** (the sum of the differences in meters elevation between the central cell and all cells **lower** than the central cell);

(2) **negative** (the sum of the differences in meters elevation between the central cell and all cells **higher** than the central cell);

(3) **count** (a count of the number of cells **lower** than the central cell).

In essence, as the window moves from cell to cell, it calculates the difference in elevation between each of the cell's nearest neighbours. For the 'positive' grid, the moving window method added up all the differences in elevation that are positive (i.e., the central cell is higher). For example, in a 9x9 window a cell that was 1 m above each of the eight surrounding cells would have a positive value of +8. The same process is used to obtain the 'negative' variable, except that the negative elevation differences (total difference in meters of the cells that are above the central cell) are assigned as an attribute to the cell. For the 'count' variables, a count of the number of neighbours the cell is above is recorded.

Although each variable was calculated into a separate grid, it became obvious after working with the output grids that the power of the moving window method is its ability to combine these variables through Map Algebra and thereby very precisely control the type of feature identified. Details of the Map Algebra will be presented below.

The values assigned to the 'positive' and 'negative' cells vary drastically. For example, the 9x9 moving window positive and negative values add the elevation differences for 80 of the cells' nearest neighbours. Therefore the 'positive' value can be in the thousands, although the count variable can only be a maximum of 80. A count of 80 would indicate that this cell was above every single cell for 540 m out north-south and east-west. A high count combined can be combined with the positive number to identify hilltops of varying sizes.

The grids can be displayed in ArcView or ArcMap and queried using the Spatial Analyst extension. The results of map queries are also grids, and can be saved for later viewing or analysis. When viewed using GIS, the results of the queries were impressive. The basic query used the positive and negative values. The assumption is twofold:

1. sites occur in places slightly elevated above nearby ground (i.e. there is a high positive value);
2. sites tend not to occur in places where there is even higher elevation nearby (i.e. there is not a large negative value - it is not below surrounding terrain, midway down a slope, at the base of a ravine, etc). They also occur on the slope breaks above major coulees and river valleys, or near the edges of terraces – all of which tend not to have higher elevation.

Buffer Programs

Big Pine Heritage mentioned during a meeting that in the Fort Nelson Lowlands about half of the sites located on a generally low swampy area had been missed by the interim models. This prompted us to look closely at the values obtained for the positive/negative grids where archaeological sites and Grid points had been recorded. Consequently the Buffer Programs were run on the FNL positive and negative grid tables.

The buffer programs were run on the FNL and ETP grids to contrast the cut-points selected for the landform filters and their Chi^2 value. The near-to-identity analysis tables for the two eco-sections were obtained from Timberline. The buffers were run on the positive h and v, and negative h and v 25x1 grids, filtering out the big polygon sites, consisting of several points, to prevent the buffer results from being skewed by these. The results of the Buffer Program for the positive values indicated that positive values >=100 and >=60 were appropriate for the majority of sites. The reported presence of sites at the low relief swampy areas reported by Big Pine Heritage indicated that we had to concentrate our analysis in those sites that presented low negative and low positive values. After running the Buffer Program with the negative values it became apparent that in fact there seemed to be various sites that occurred in areas with low negatives and low positives, so the Map Algebra expressions were geared to the identification of these areas.

Map Algebra

Positive and negative grids were combined through Map Algebra to answer to both of the assumptions outlined above. Figure 5 displays an early attempt at using the grid obtained with the 7x1 window in the Fort Nelson Lowlands to identify terrace edges and the more subtle landforms surrounded by muskeg.

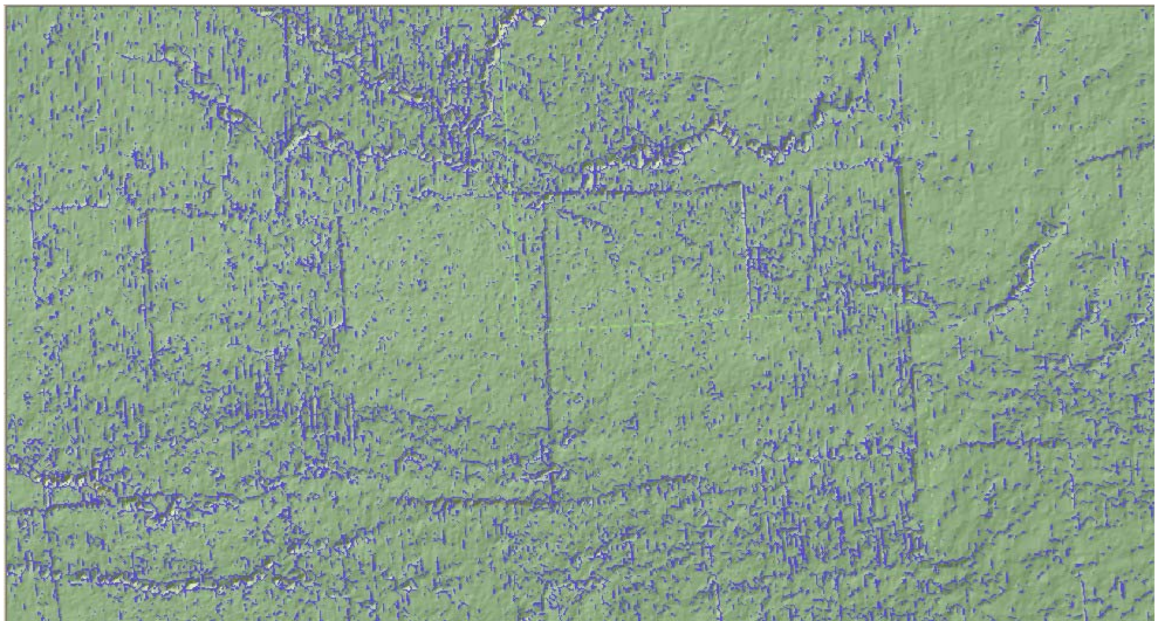


Figure 5. Landform modelling results using a 7x1 rectangular window. Note how DEM seams and calibration lines are also captured.

The above results were obtained using *Raster Calculator*, a module of Spatial Analyst in ArcMap; the following Map Algebra expression was calculated:

(([pos7h] >= 3 & [neg7h] >= -2) | ([pos7v] >= 3 & [neg7v] >= -2)) & [slope] <= 5

This expression selected all cells that contain a combination of positive values equal or greater than 3, with negative values equal or greater than -2 for both horizontal and vertical grids and that are located within a slope value of equal or less than 5 degrees. The expression captured the top of ridges, and terraces especially those running along waterways as well as some micro-landforms located along the flatter areas. However, it also captured a considerable amount of DEM noise such as seams and calibration lines. Increasing the positive and negative values did not get rid of all of this noise, thus it became apparent that the 7x1 grids would not be suitable for this type of landscape.

In this sense only the grids obtained with the 25x1 and 9x9 windows were used for the landform modelling. A series of Map Algebra expressions were calculated in *Raster Calculator* and compared for results. Only the selected expressions are presented here.

(([pos25h] >=100 & [neg25h] >= -50) | ([pos25v] >=100 & [neg25v] >= -50)) & [slope] <=5

The above expression selects all cells where a positive value equal or greater than 100, a negative value equal or greater than -50, and a slope equal or less than 5 degrees co-occur. The result is that this expression effectively captures the top of ridges, and terraces especially those running along waterways as well as some micro-landforms located along the flatter areas.

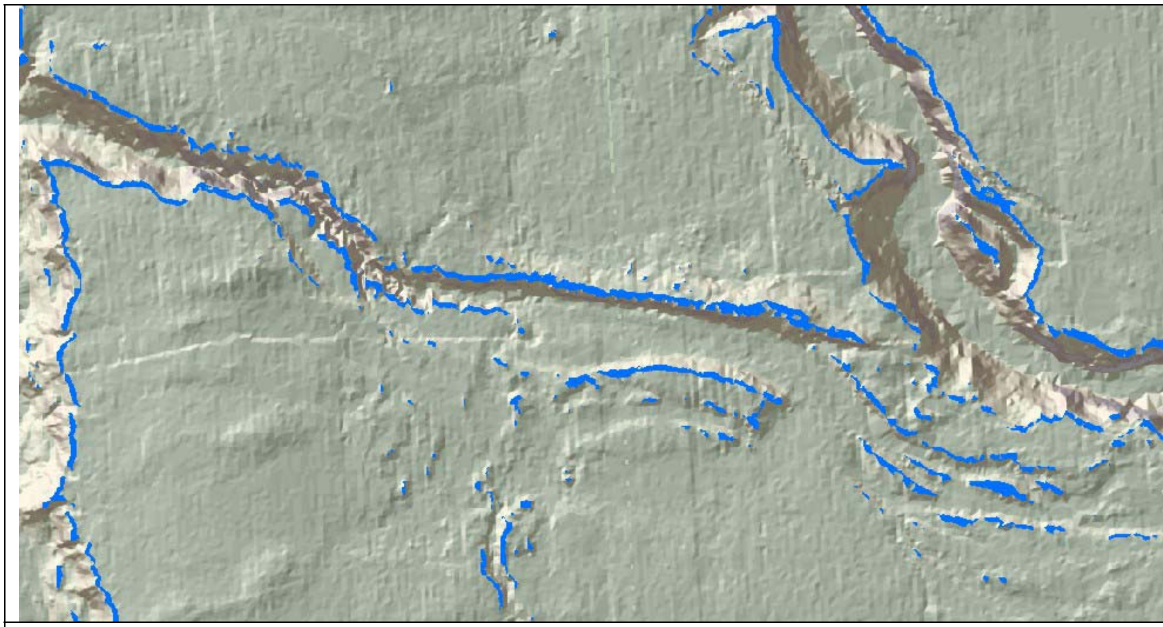


Figure 6. Identification of terraces and ridge tops with 25x1 grids.

(([pos25h] >= 60 & [neg25h] >= -20)| ([pos25v]>= 60 & [neg25v]>= - 20)) & slope <=5

This expression complemented the previous one, since aside from capturing many of the same landforms, it also captures the slope-breaks, toe of the slopes, and many more of the ephemeral landforms located in the flatter muskeg surrounded areas.

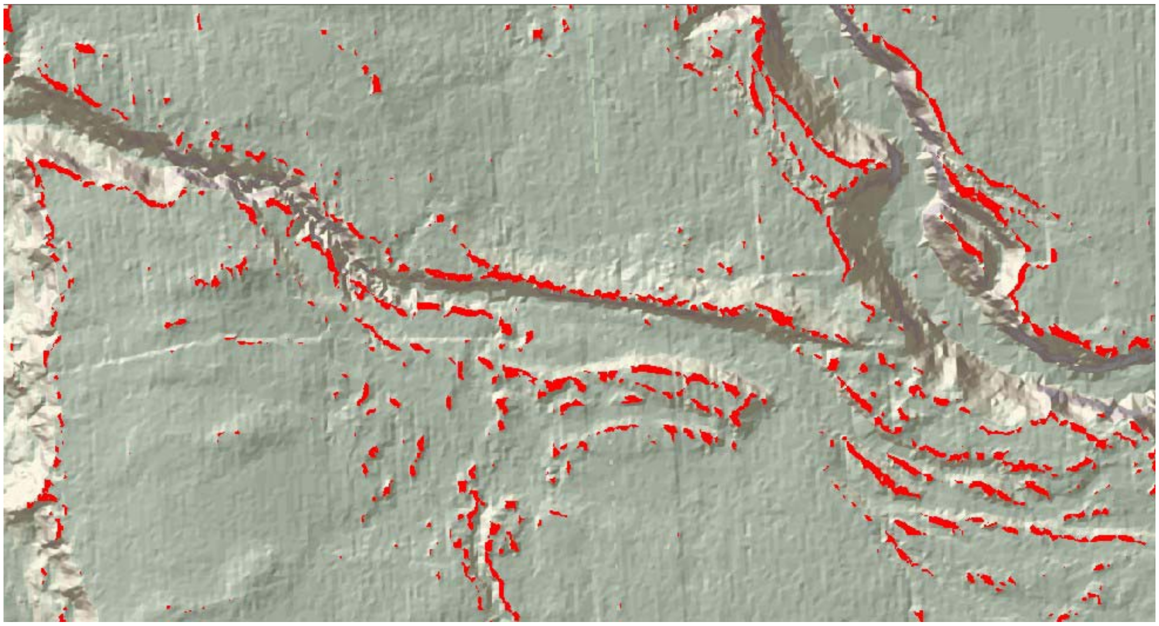


Figure 7. Terraces and ridge tops along with other ephemeral landforms captured with 25x1 grids.

[pos9] > 500 & [cnt9] > 75

In this case only the positive and count values from the 9x9 grid were used in this expression. By selecting the cells with positive value greater than 500 and count greater 75 the most significant landforms such as hilltops, hillocks, or terraces, are captured.

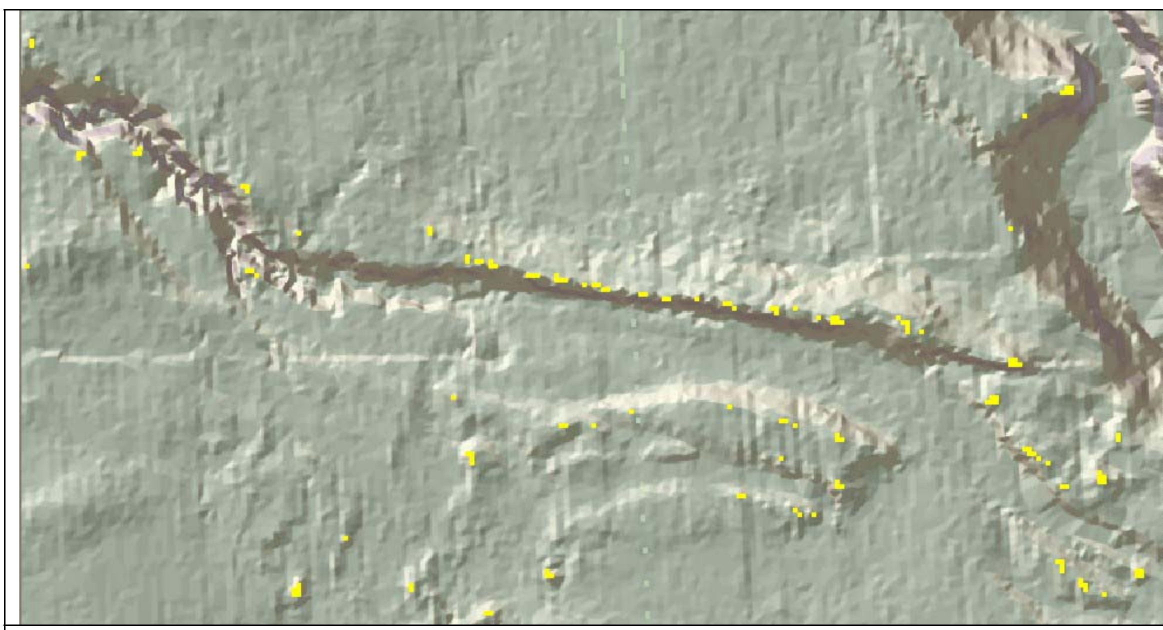


Figure 8. Identification of significant landforms using 9x9 grids.

As each ecosection differs in topography different values were tested for each of the rectangular grids. The 7x1 grids were eliminated altogether since they captured too much DEM noise, and the 25x1 grids captured the same landforms with much less noise. The 9x9 60 meter cell grids performed well in all the ecosections and were included in all the calculations. Each refinement of the equation used to join the positive and negative grids moved towards the goal of selecting ridges, low rises, scarps, and breaks-in-slope. Most of the features greater than approximately 4 m in vertical size were caught by the Map Algebra equations described above. Microtopographic features still exist that are simply missing from the TRIM DEM, however. Millennia archaeologists feel that although there are problems inherent in the TRIM data, it is acceptable for selecting many topographic features. Other techniques, such as orthophotos interpretation or detailed vegetation mapping, can be used to identify microtopographic features outside the model. Running the landform identification technique again with LIDAR data (ca 1800 times more detailed spot elevations) would identify smaller features, and nearly eliminate 'false positives' where TRIM identifies landforms where there are none.

Compilation of 25x1 and 9x9 grid results

It was obvious that the different Map Algebra expressions used complemented each other in targeting specific types of landforms, so it was deemed necessary to combine them through a simple additive calculation performed in Raster Calculator. However, this combination had to undergo a process of DEM "noise" clean up, and the reclassification of the Pos 9 60m grid to a 20m. These steps are described below and displayed graphically in Figure 9:

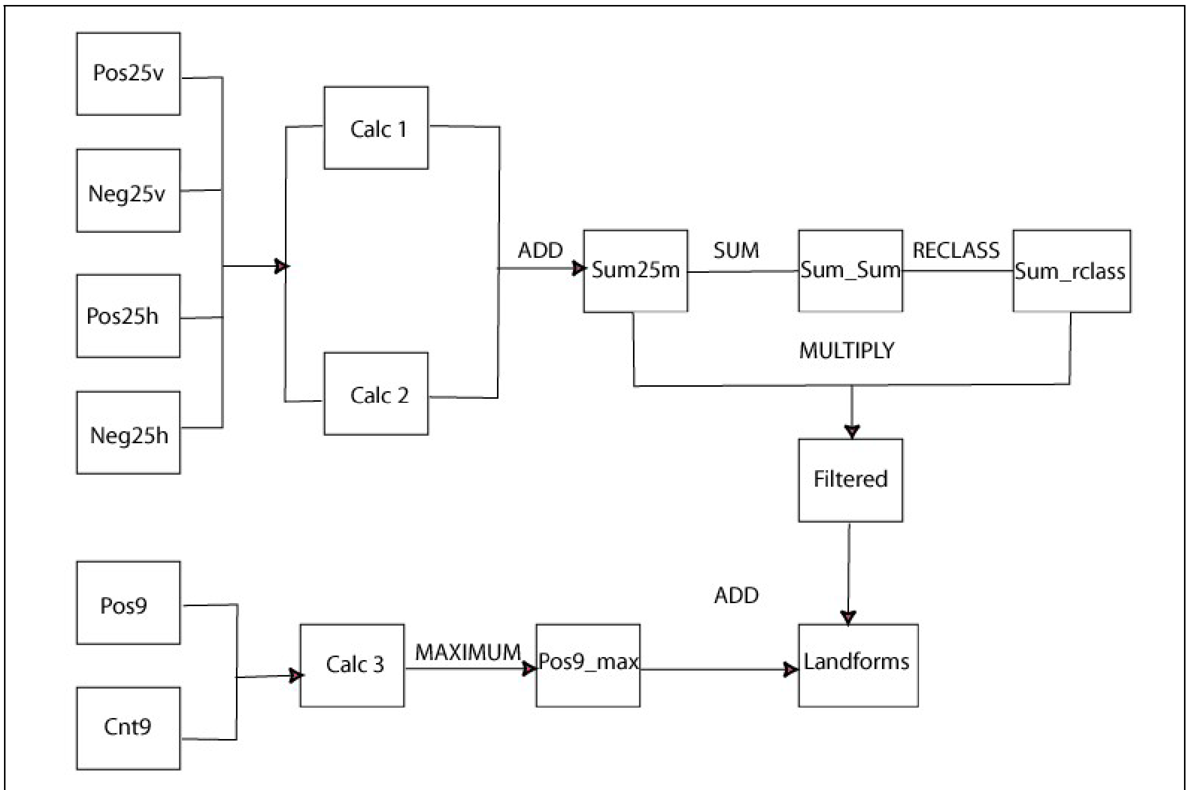


Figure 9. Cartographic model for landforms.

[Calc1] + [Calc2] combined the different landforms described above resulting in the grid "*Sum25m*". Examining this grid over spot elevations, orthophotos and suggested most single isolated cells were probably produced by DEM noise. Therefore, single cells were removed through a filtering process. A neighbourhood statistics routine was used to obtain the sum of the combined calculations grid. Single isolated cells in the original data would produce a neighbourhood value of 1 in a layer called ("*Sum_Sum*"). In turn "*Sum_Sum*" was reclassified assigning a value of 0 to all values from 0 to 1, and a value of 1 to those greater than 2. The resulting grid ("*Sum_rclass*") was multiplied by the original "*Sum25m*", thus reducing the value of isolated cells to 0 while retaining the other values ("*Filtered*"). Now Calc 4 was added to "*Filtered*" after reclassified to a 20m-cell size. A neighbourhood statistics was run on Calc 4 obtaining the maximum value with a 1x1 window and a cell resolution of 20m. This preserved the original values of Calc 4 while at the same time changing the cell size.

Finally, the resulting grid was added to "*Filtered*" resulting in the final grid named "*Landforms* ". This technique worked beyond expectation. The ability to mathematically manipulate and combine the grids obtained through the square and rectangular running window technique, the model worked at picking out not only the macro-topographic features but also mid sized topographic features in relatively featureless areas such as those found in the Fort Nelson Lowlands (Figure 10).

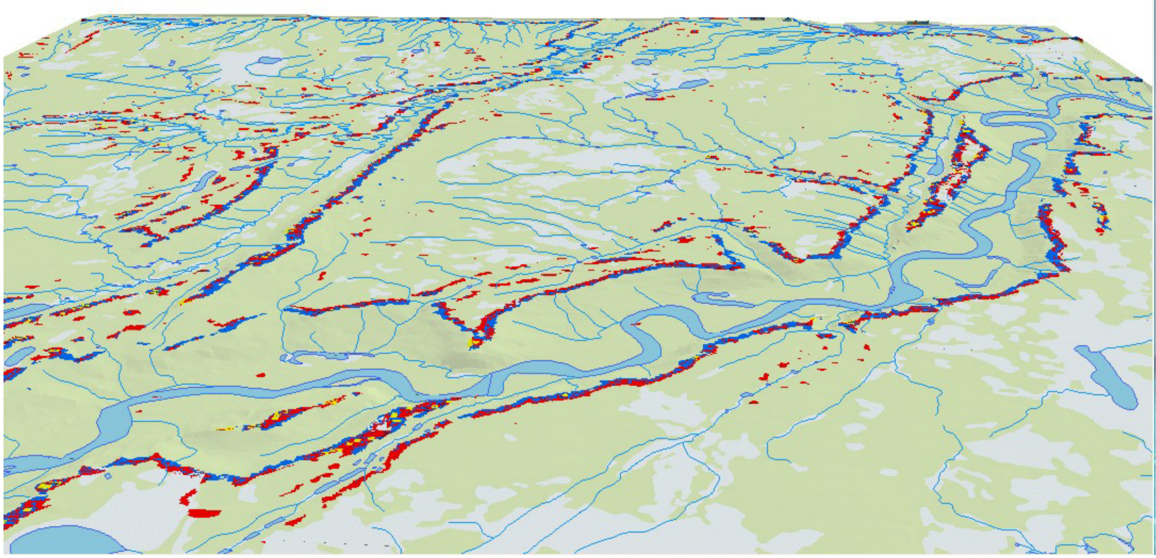


Figure 10. Final results of landform modelling through Map Algebra showing part of the Fort Nelson Lowlands.

Intensive ground-truthing of the preliminary terrain-identification algorithms found them to be generally very effective. A discussion of the field season and the results of the initial terrain modelling is provided in the AIS section.

Additional discussion of landforms that are identified through the modelling process and appear on the potential maps is provided in the section regarding map interpretation.

Identification of factors that limit current model performance

Although the landform identification significantly enhanced the overall model some issues related to data quality are still apparent. First, the TRIM II data from which the DEMs are generated still have significant gaps and/or tiling and calibration lines. These gaps create "noise" on the resulting DEMs especially for those eco-sections that have low relief such as FNL. Consequently, the map algebra expressions aimed towards the identification of small landforms will also pick up spurious landforms. These spurious landforms, although relatively simple to visually identify, have proven impossible to filter out without getting rid of actual landforms. Secondly, the distance between sample elevation points from which the DEMs were generated can range from 60 to 90 meters apart. This means microtopographic landforms will normally be missed altogether.

Until better data (LIDAR) can be obtained for modelling, this limitation will represent something to bear in mind when interpreting the model. More field observations will certainly be of great value to help fine tune the model in those areas where it is possible, but the quality of the TRIM data will continue to represent an issue. Recently landform identification with the use of LIDAR data has been carried out for the Fort Nelson Lowlands and the Etsho Plateau. LIDAR is at least 1800 times more detailed than TRIM. The results of modeling with LIDAR have been astounding with the capability to identify small landforms (including some on which archaeological sites are recorded) of only a few meters in extent and less than a meter in height (Figures 11-13).

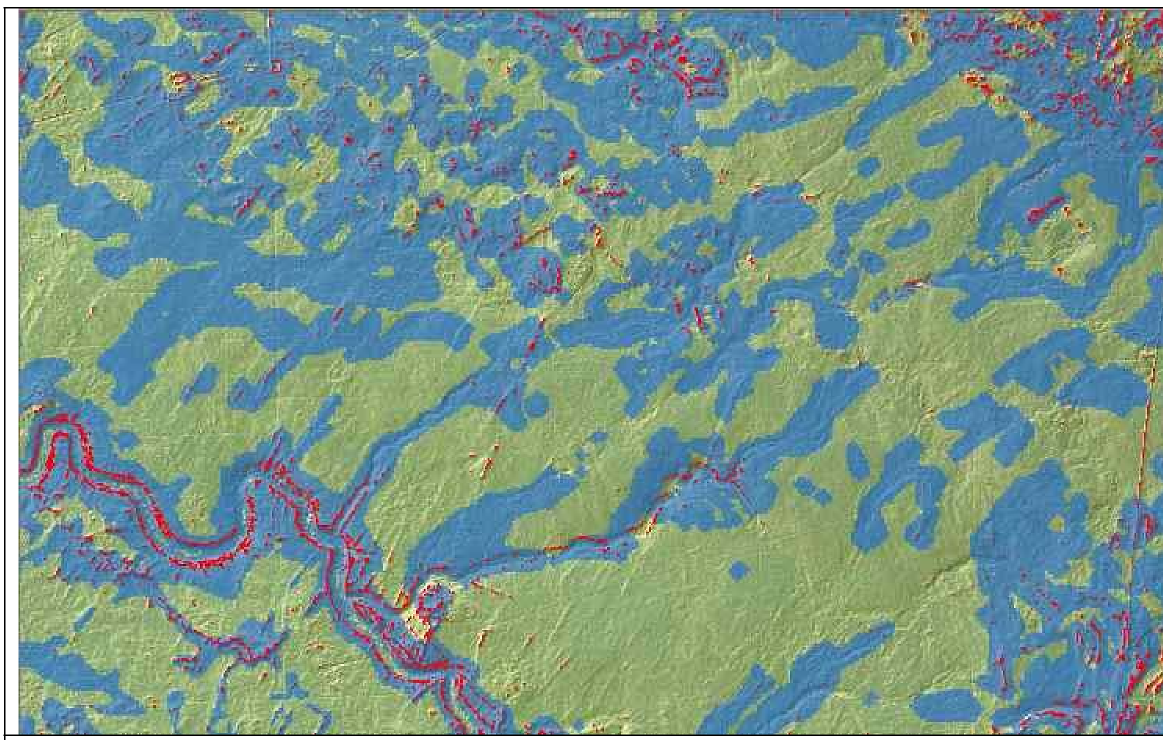


Figure 11. Landforms with potential captured with TRIM (blue) and LIDAR (red) data.

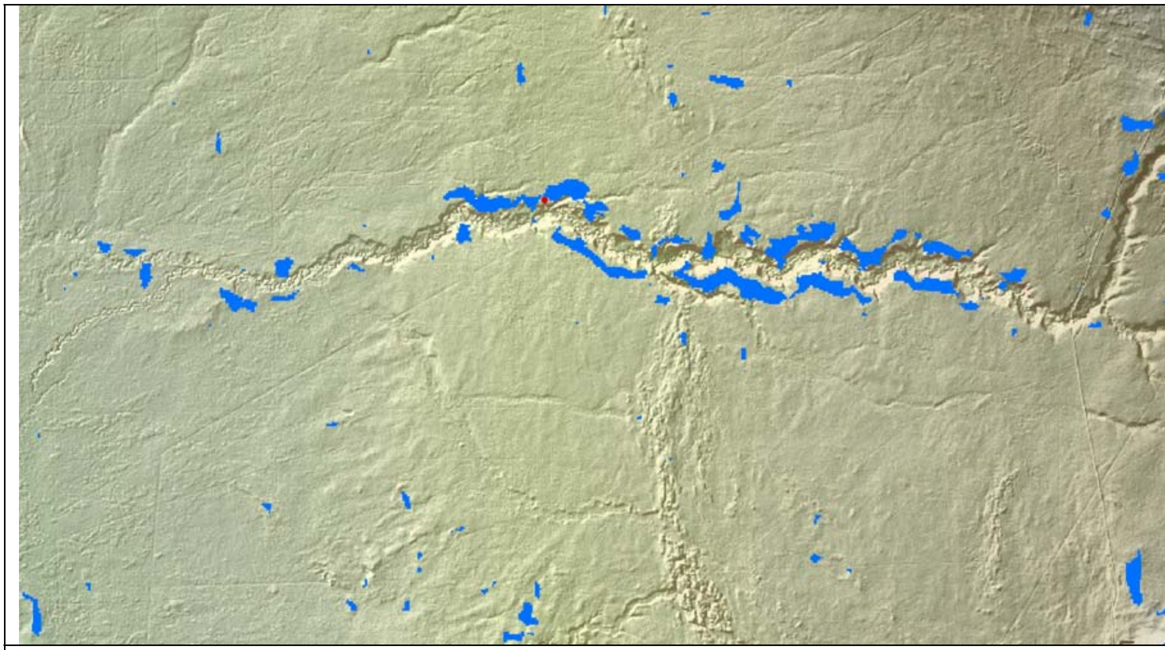


Figure 12. Landforms identified with TRIM DEM data in FNL, note missed archaeological site (red dot, centre) and landforms to the south (LIDAR hillshade base layer).

Figure 13. Same view as above, showing archaeological site captured and identification of landforms as subtle as 30 cm in height due to greater ground resolution of LIDAR.

Archaeological Inventory Study (AIS) – Year Four

As identified in the Year Two Report (Eldridge, et al. 2002), and following the BC Archaeological Inventory Guidelines (BC Archaeology Branch 2000), the goal of Millennia Research's archaeological inventory assessment (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 Year Two and Three reports detail the archaeological investigations undertaken by Millennia Research during the 2001 and 2002 field seasons. The Year Two fieldwork concentrated on filling data gaps. Ecosections were identified using GIS queries where the amount of archaeological survey was underrepresented compared to the number of wellsites. Data gap analysis also identified large and medium sized lakes as underrepresented by archaeological survey. Therefore, archaeological survey was concentrated in these areas. Several ecosections were represented, but all work was in the north. The scope of the project was limited, with only 16 days of fieldwork by a crew of three. As with other years, the emphasis for fieldwork was to record on-ground potential ratings with good georeferencing, rather than to maximise the number of sites found. Three lithic sites were found and recorded, and another site revisited during the fieldwork.

In Year Three, 2002 field season, a slightly larger field effort was made, with 30 days of field time. Seven new sites were recorded, along with 300 survey points that were used to independently test model performance. Six of the sites were lithic scatters and one was a lodgepole pine CMT. Six of the seven new sites were recorded on terrain features identified by the new terrain modelling tool.

The following sections outline the results-to-date of the AIS during the 2003 field season in meeting the remainder of these general goals.

Scope and Objectives

The Year Four AIS main objective remained the same as in the previous years: to ground-truth the terrain tool and archaeological potential model developed by Millennia Research Limited. This involved gathering macro- and micro-topographical data and recording field-assessed archaeological potential for these features. Also, the efficacy of a terrain model in the differing regions of the study area was evaluated. The information thus gathered was the basis of the fine-tuning of the models in year five.

This data was to be gathered through field survey in the general area of Ft. Nelson, Tetsa River, Pink Mountain, Fort St. John, and north of Fort St. John regions (see Figure 14).

Survey Sampling Design

Consideration was given to the following characteristics in selecting survey areas for Year Four:

- access and proximity to a settlement (as determined by looking at orthophotos and maps);
- the presence of highpoints, ridges and terrace edges identified by the terrain model and differing in size, location in relation to other topographic features, shape, and frequency from other mapsheets selected;
- presence of known sites; and,
- a distribution across all ecosections in the study area.

With these considerations in mind, map sheets 94A.051 and 94A.072 were selected in HAP, 94A.067 and 94A.098 were selected in CLH, 94G.087 and 94G.098 were selected in MUP, 94I.093and 94O.065 were selected in ETP, 94J.001 was selected in MUF, 94J007 and 94J.017 were selected for the MUF/FNL ecosections, 94J.049, 94J.050, 94J.088, and 94J.095 were selected in FNL, and 94P.057, and 94P.064 were selected within the PEP environmental zone (Figure 14).

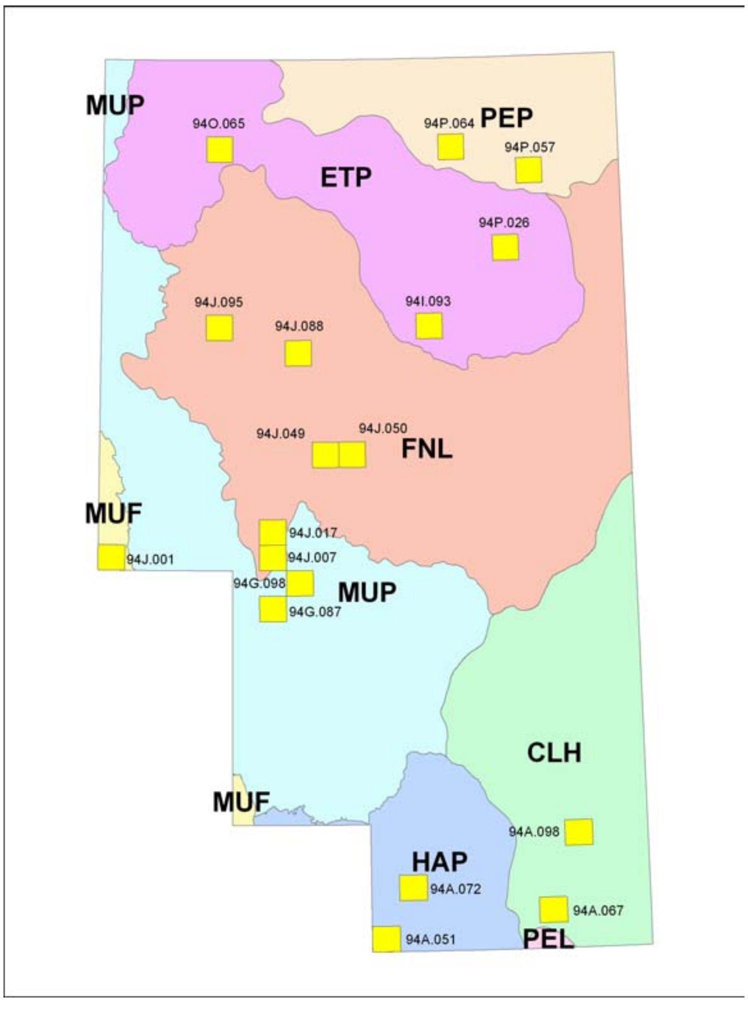


Figure 14. 1:20,000 Map sheets where 2003 AIS survey was conducted.

Terrain Model Testing

The terrain model (both 20 meter grid cell size and 50 meter grid cell size iterations) was plotted on the 1:20,000 maps used in the field. Once a general area of survey was selected, mapped highpoints, ridges, and terrace edge co-ordinates were located in the field via GPS. Terrain features encountered during survey which were not identified on the map were also recorded. Photos and notes were taken of these features.

The following information was recorded as survey points when terrain features (or lack thereof) were encountered:

Mapsheet	UTM	MapRate	Grnd Rate	Notes

where the MapRate was the terrain model potential rating from the map, and the Grnd Rate was the archaeological potential assigned to that location in the field based on all available data such as ground cover, forest cover, slope, visibility factors, water, etc. Notes included reasons why the location was ascribed its potential rating, if testing occurred, if a site was found, ground cover, forest cover, slope, elevation, and approximate dimensions, as appropriate. Since it was sometimes necessary to collect data points from areas outside the hardcopy printed mapsheets, MapRate was often left blank, since this could be autofilled by the GIS from the model once the coordinates were entered.

In addition to seeing if the model was picking up the landforms, it was also tested to see if it was accurately depicting their extent. This was achieved by crew members walking along the edges of the features and seeing if it correlated with the maps.

Survey Methods

Fieldwork was carried out between August 19 to September 4, 2003 and September 8- 25, 2003. Crew members were drawn from Millennia Research, Heritage North Consulting, the Blueberry River First Nation, the Fort Nelson First Nation and the Prophet River First Nation. Work was carried out under Permit 2001-270, issued by the Archaeology Branch, Ministry of Sustainable Resource Management.

Survey consisted of a combination of controlled and judgemental survey to find areas of increased potential. For the controlled survey, the UTMs of terrain features, as determined from the maps, were entered as waypoints into GPS units which guided the crews to those areas. The judgemental survey was usually secondary to the waypoints, and occurred while accessing the pre-determined waypoints. Survey was conducted by foot, helicopter, all-terrain vehicle (ATV), and made use of existing roads, seismic lines, and paths. Generally crews consisted of one archaeologist from Millennia, one archaeologist from Heritage North Consulting, and one First Nation assistant. When two crews were working simultaneously, one crew would use ATVs and one crew would conduct pedestrian survey. The selection of survey waypoints depended on the type of access. It should be stressed that the survey conducted during this project was specialized and not always suitable for resource management (AIA) decisions. In many cases, areas of potential were identified, but not shovel tested, and therefore can not be considered to have been intensively surveyed with no site found.

Several features each day were selected for sub-surface testing due to their high potential for archaeological sites as indicated by the archaeologists from Heritage North Consulting. These features, such as knolls, hilltops, terrace edges, and ridges were tested with up to 45 tests per feature. Generally, very small features (e.g., 5x5 m) were tested with 2 or 3 shovel tests; large features such as a long ridge would be searched for a specific highest-potential area, such as a place combining the ridge with a local high and a good overview of a nearby valley. Such areas could be up to about 20 m x 50 m and would have the highest numbers of shovel tests. Since not finding a site even if one were present would not result in site loss or contravention of the *Heritage Conservation Act* (as this work was not an impact assessment shovel test frequency was not a major concern. Shovel tests were approximately 35 x 35 cm in size and were excavated to sterile deposits, usually associated with the ‘C’ horizon. Matrices were trowel sorted or screened using a ¼ inch mesh. Terrain features exhibiting good 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.

In forested areas containing pine or aspen, the trees were inspected for cultural modification.

When a site was found, its location was established using a GPS unit, and its boundaries delineated through a series of shovel tests. Photos were taken and maps drawn as required. Artifacts were recorded and normally collected if found in shovel tests or if required for additional analysis (e.g., obsidian flakes).

Results

Thirty-two new sites were recorded as a result of fieldwork, the location of one previously recorded site was updated (IfRj-1) and 642 survey points were collected to be used in the analysis of the terrain and potential models.

Newly Recorded Sites

Muskwa Foothills

IaRx-1, IaRx-2, IaRx-3, and IaRx-4

These highly significant sites located in the Muskwa Foothills may prove to be one of the most important archaeological site complexes in the Northern Rockies. The sites occur on a large outwash plain with low rises and small hummocks near a small lake, situated within mountainous terrain. It is part of a very large complex of archaeological remains along the terrace/outwash plain above Gathto Creek and around small lakes. In some places, large blanks and biface preforms are as numerous as to form a continuous layer even stacked several deep, on the surface. Where slight disturbance has occurred from a big-game guide's road, lithics are very dense over large areas. These observations suggest that a major chert quarry is nearby. It was likely used for a very long time, although no diagnostic artifacts were found in the brief visit to this very large site complex. Big game is abundant in the area, and long-term hunting camps are likely as well. It is likely that materials as early as Palaeo-Indian will be found at this site with additional fieldwork.

Ground potential: Very High **Model potential:** Very High to High

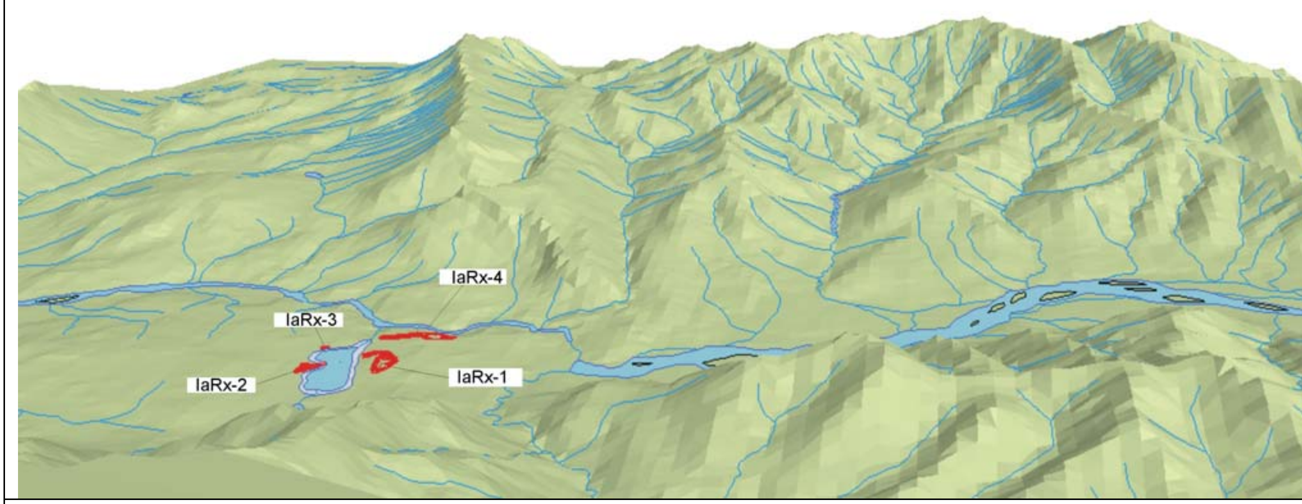


Figure 15. Location in the Muskwa Foothills landscape of IaRx-1 to IaRx-4 sites.

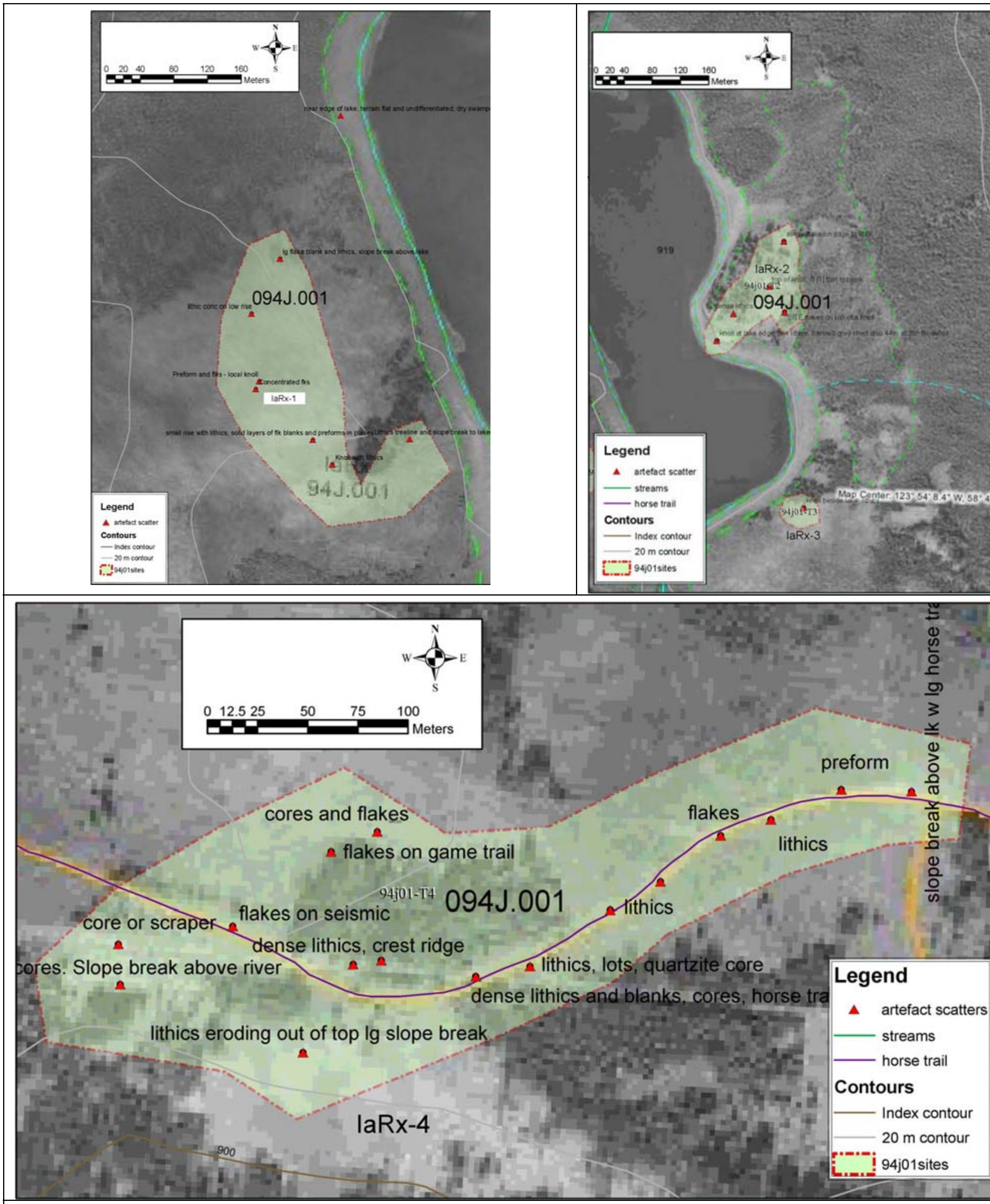


Figure 16. Details of IaRx sites.

Figure 17. Site IaRx-1 looking SE.

Figure 18. Gathto Creek from IaRx-4 at the slope break.

Figure 19. Biface preform, T1.

Figure 20. Biface preform, T1.

Figure 21. Keeled prepared core, T4.

Figure 22. Biface preforms and large blanks carpet a knoll top, T1.

Muskwa Plateau

HkRq-2

The site is located on a small knoll overlooking a small creek that is part of the drainage system of the Prophet River in the Muskwa Plateau. The knoll is covered with lodgepole pine, willow, some spruce and aspen. The ground cover is kinnikinnick, grasses, moss and Labrador tea.

Ground potential: High **Model potential:** Medium

Comment on potential: The site falls only 4 m north of a High potential area.

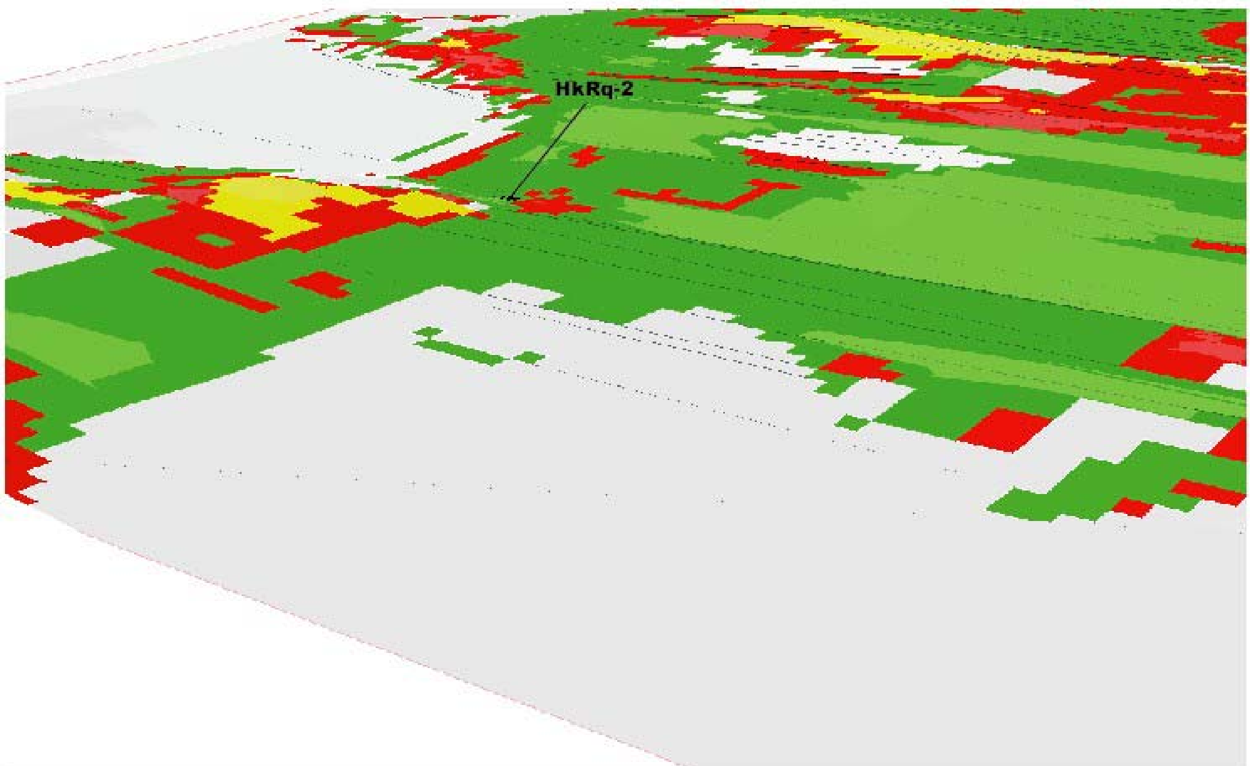


Figure 23. Location of HkRq-2 with respect to High potential areas.

Figure 24. View of HqRq-2 looking south from road.	**Figure 25. Unifacial scraper recovered from site HqRq-2.**

HkRq-3

Also in the Muskwa Plateau, this subsurface lithics site is located on a small knoll overlooking a small marshy pond to the east. The tree cover is consists of lodgepole pine, with open understory. Some immature and mature willow is also present, and the ground cover consists largely of kinnikinnick.

Ground potential: Very High **Model potential:** High

Figure 26. General views of site HkRq-3

FNL J03

This is another CMT site located in the Muskwa Plateau on a very large high plateau to the south east of Prophet River. The top is flat, homogenous and semi-saturated. Due to the size of trees and depth of scars, it is likely that the site post dates 1846.

Ground potential: High **Model potential:** Medium

Comment on potential: Only 7m south of High potential area.

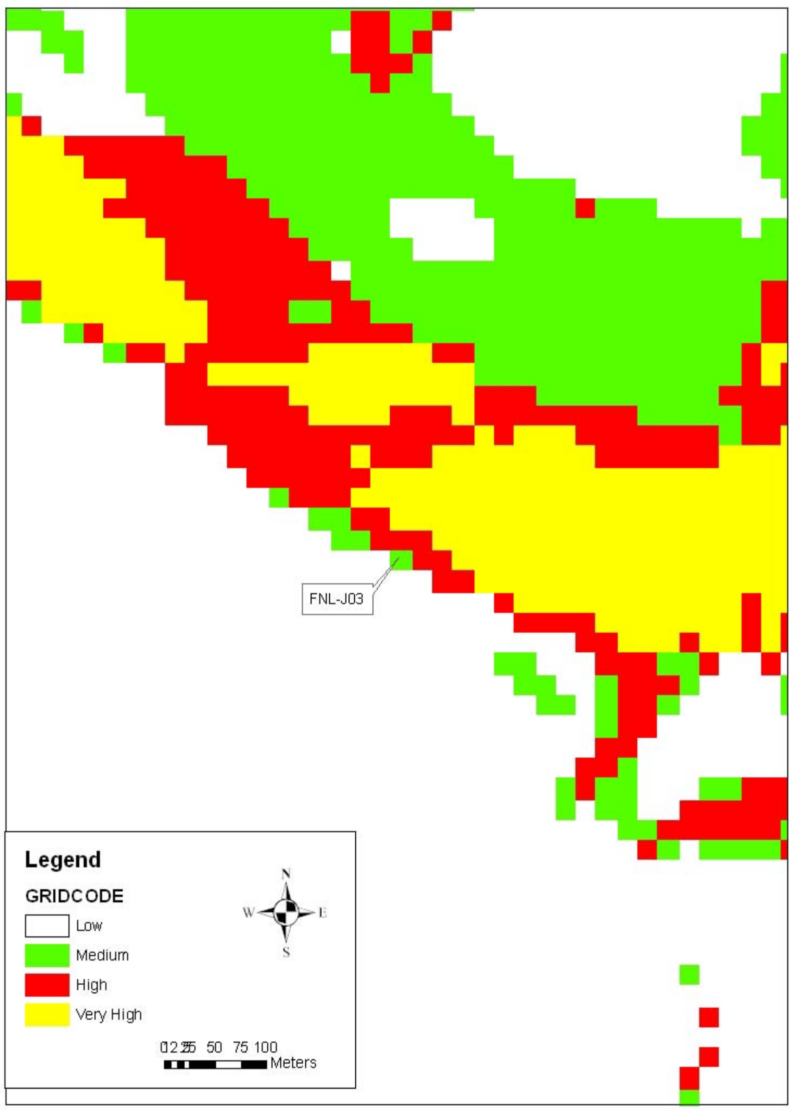


Figure 27. Location of site FNL JO3 with respect to High potential area.

Figure 28. CMT at site FNL JO3.

Etsho Plateau

IJRS-3

The site is situated on the Etsho Plateau and lies on a well-defined small aspen and pine ridge cut through by small creek, with a short steep drop to the creek. A small chert pressure flake was recovered in one of four shovel tests. Rounded pebbles and occasional potlid flakes of chert occur naturally in the area (including within the same shovel test), but the pressure flake has cultural attributes including a prepared platform edge with a lip.

Ground potential: Very High **Model potential:** High

IJRS-2

Also located in the Etsho Plateau, this pre-contact, subsurface lithics site lies on a poorly defined local high spot on large low ridge, covered by aspen and pine. Small chert pressure flakes and shatter were recovered in two of 10 shovel tests.

Ground potential: High **Model potential:** Medium

Comment on potential: The site lies just 14m north of High potential area.

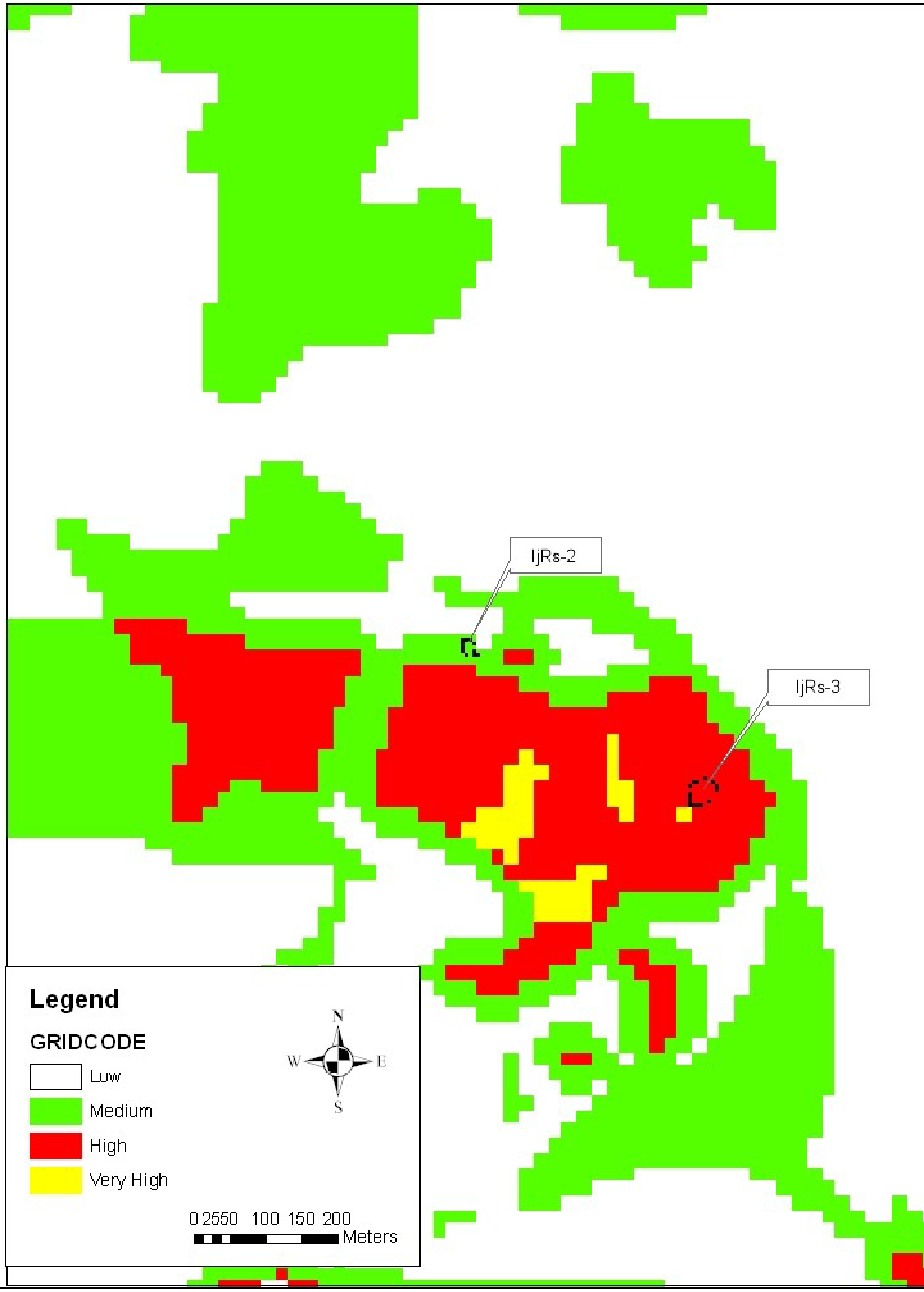


Figure 29. Location of site IJRS-2 with respect to High potential area. The overall potential follows large aspen ridges.

IfRj-1

Located in the Etsho Plateau, the site lies on a low ridge covered by aspen and some pine. It is the same site as the single-flake site recorded by Big Pine several years ago, although it was misplotted 330 m too far to the west in HRIA. A fragment of an edge-ground stemmed point was found, which probably dates to the mid or early period. The point and several obsidian flakes were subject to x-ray florescence technique and all were identified as coming from Mt Edziza in northwestern British Columbia, about 500 km to the west. The site boundary was not determined but it probably extends westwards along slope of ridge crest.

Ground potential: High **Model potential:** Medium

	
Figure 30. Winter road cutting through IfRj-1 site looking east. Note the low relief topography. This site	**Figure 31. Obsidian stemmed point mid-section from IfRj-1. Lateral stem edge-grinding is present. The obsidian source is over 500 km to the southwest.**

IfRj-3

This site consisted of a single subsurface chert flake located on top of slope break above pond in the Etsho Plateau.

Ground potential: High **Model potential:** Very High

IhRe-1

The site is a pre-contact subsurface lithic scatter located in the Etsho Plateau, next to a small creek with vegetation cover consisting of small balsam fir with some pine present.

Ground potential: High **Model potential:** High

Comment on potential: Less than 1.5m to the west a Very High potential area is located.

IhRe-2

The site, also a pre-contact subsurface lithic scatter is situated on a flat at a slope break above a creek south of Kwokullie Lake.

Ground potential: High **Model potential:** Very High

Fort Nelson Lowlands

FNL JO1

This is a CMT site located in the Fort Nelson Lowlands, on a small slightly sloping bench above a small tributary of the Prophet River. One lodgepole pine and one aspen tree were culturally stripped for cambium. In the vicinity, other trees with natural scars were found. Also, in the vicinity are numerous axe/saw cut stumps, possibly associated with the small church to the east of the highway. Due to the size of trees and depth of scars, it is likely that the site post dates 1846.

Ground potential: High **Model potential:** Very High to High

Figure 32. Site NFL JO1 CMT 1 and CMT 2.

IaRp-18

Located in the Fort Nelson Lowlands, the site is situated on a flat-topped terrace aproximately 50 meters north of Adsett Creek and 2 meters above it. The site produced several black chert flakes and reduction flakes in seven shovel tests. The forest cover is predominantly aspen, with some pine present.

Ground potential: Very High **Model potential:** Medium

Comment on potential: Approximately 80 meters to the north of the site the model identifies an extensive High potential area.

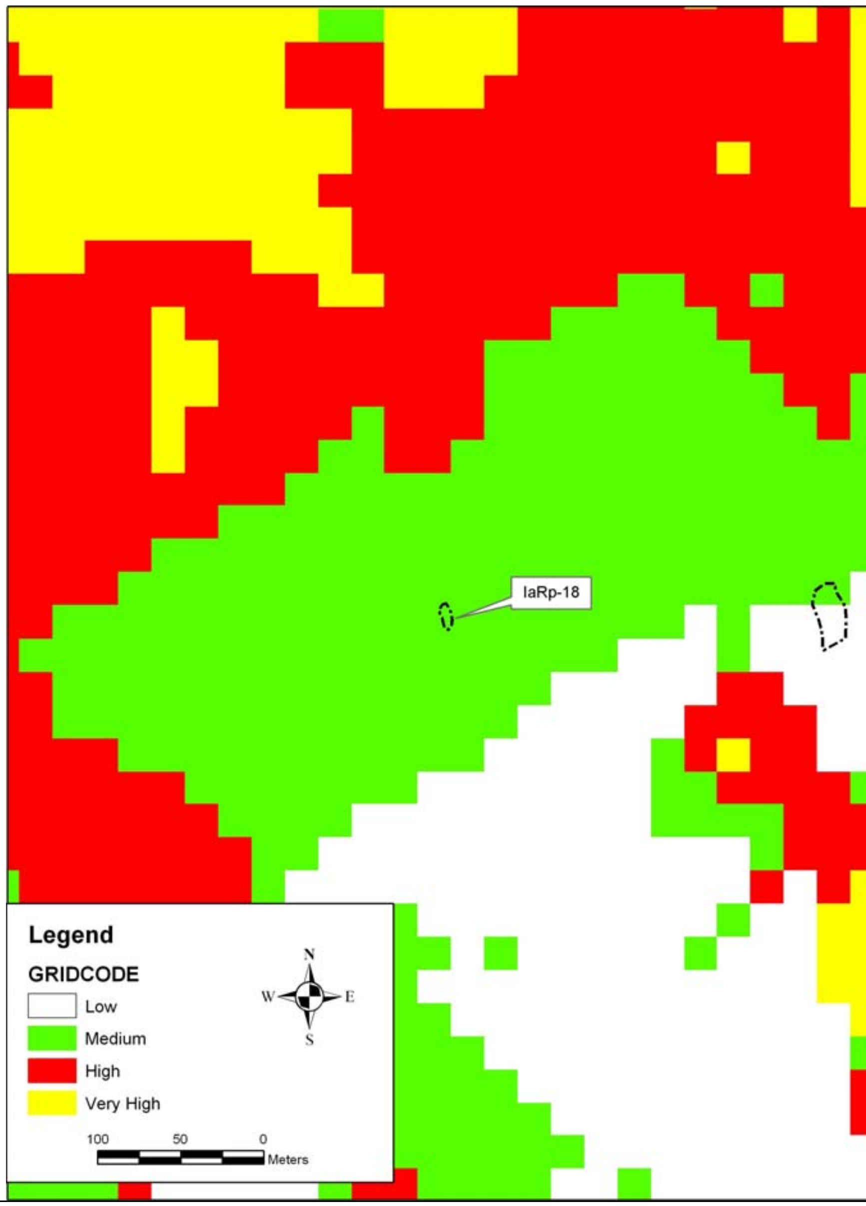


Figure 33. Location of site IaRp-18 with respect to High potential.

Figure 34. General view of site IaRp-18.

IaRp-17

The site consists of subsurface lithics, and is located on a small knoll overlooking Adsett Creek and a Tributary in the Fort Nelson Lowlands. The tree cover consists of some small mature spruce, lodgepole pine, and a few aspen. The understory is formed by immature spruce and aspen. Groundcover is kinnikinnick, Labrador tea and mosses.

Ground potential: High **Model potential:** Low to Medium

Comment on potential: The site falls 28m northeast from a High potential area.

Figure 35. General views of site IaRp-17.

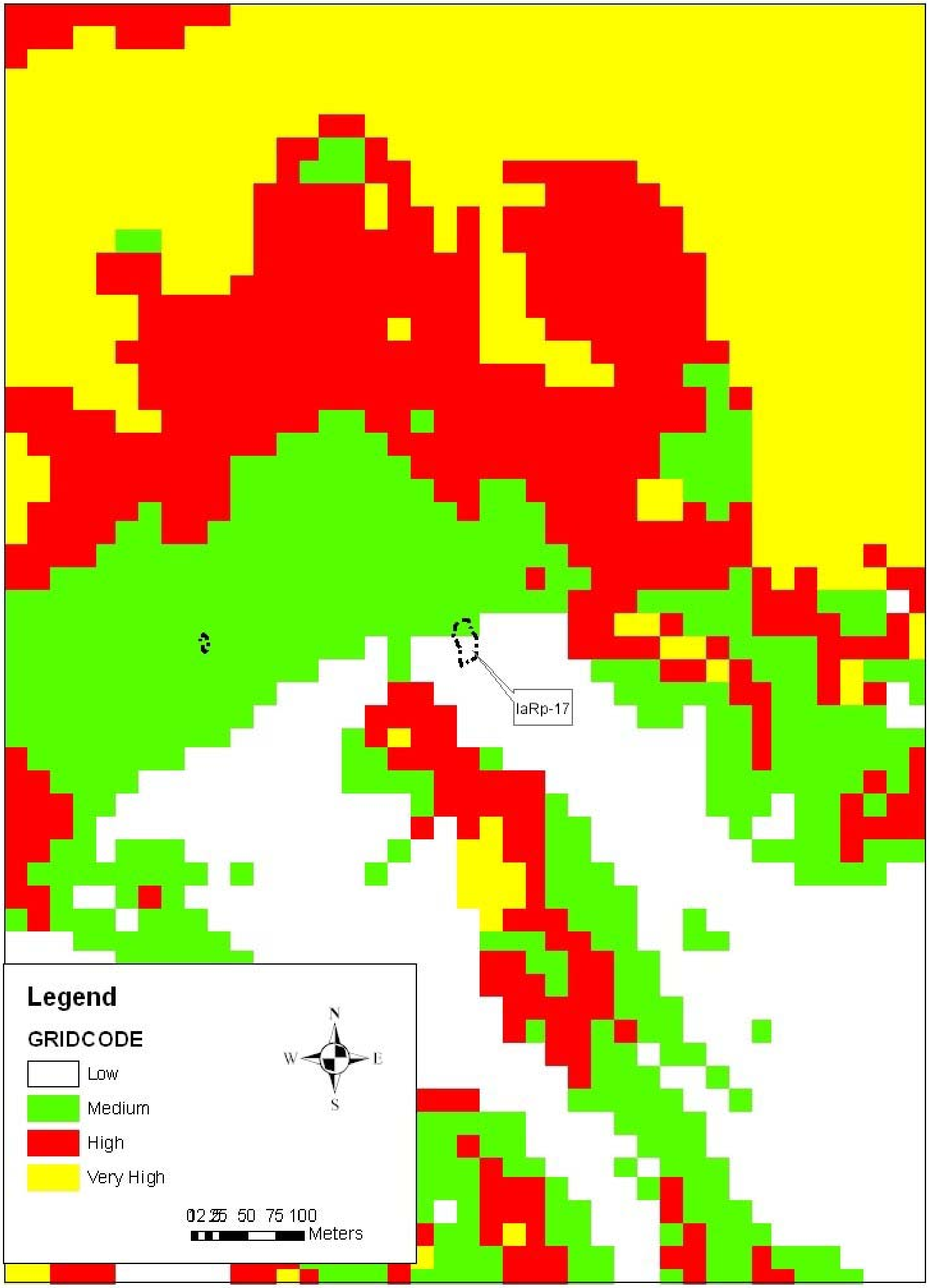


Figure 36. Location of site IaRp-17 with respect to High potential areas.

IcRn-7

Located in the Fort Nelson Lowlands, the site lies atop a large flat plateau covered by spruce, birch poplar, balsam fir. Large game (moose) was observed in the vicinity.

Ground potential: High **Model potential:** Low

Figure 37. General views of site IcRn-7.

IcRn-8

The site is represented by a single subsurface flake recovered on a ridge top crosscut by a gravel road in the Fort Nelson Lowlands.

Ground potential: High **Model potential:** Low

Figure 38. View of site IcRn-8 from road.

IcRn-9

This site also consisted of a single subsurface chert flake, located on a flat knoll surrounded by muskeg in the Fort Nelson Lowlands. The soil on the knoll is well drained with spruce and pine present in the area.

Ground potential: High **Model potential:** High/Medium

Figure 39. General view of site IcRn-9.

IcRn-10

The site consists of several subsurface chert flakes located in the Fort Nelson Lowlands on a small terrace above a swampy drainage. The vegetation cover consists of mixed spruce and aspen. The area has good drainage. The understory is comprised of spruce saplings and mosses cover the ground. A tributary of Klua Creek drains the area. In turn the Klua Creek drains into the Fort Nelson River.

Ground potential: Very High **Model potential:** High

Comment on potential: The site lies less than 1m south of an area of Very High potential.

Figure 40. General views of site IcRn-10.

IeRp-6

The site consists of a single cottonwood CMT located in the Fort Nelson Lowlands.

Ground potential: High **Model potential:** Medium

Comment on potential: The CMT lies about 6.5 m west of High potential area.

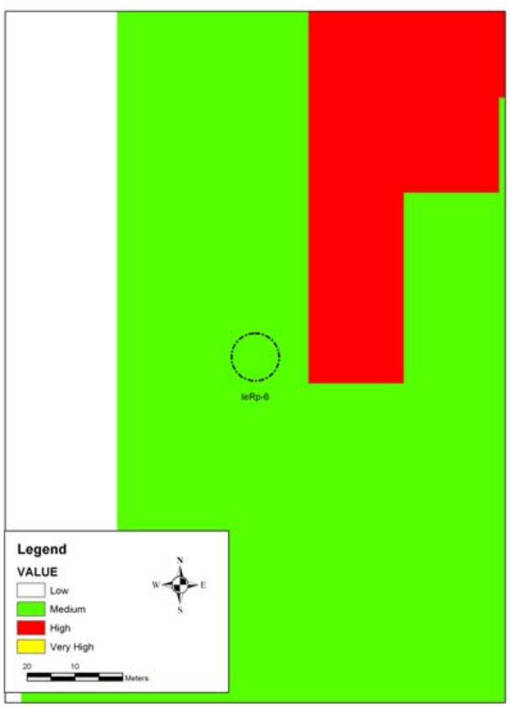


Figure 41. Location of IeRp-6 with respect to High potential area

Figure 42. Cottonwood CMT at IeRp-6.

IeRp-7

Consisting of a single subsurface unifacially retouched chert flake, this site is located in the Fort Nelson Lowlands on top of flat area, break-in-slope along the east bank of the Nelson River, approximately 3.5 km due east-south-east from Fort Nelson airport.

Ground potential: High **Model potential:** Very High

Figure 43. Artifact in-situ at site IeRp-7.

Figure 44. Unifacially retouched flake from IeRp-7.

IfRt-3

The site consists of a single flake located in the Fort Nelson Lowlands on top of break-in-slope overlooking the south end of Beaver Lake. The area was disturbed by the construction of a recreational facility.

Ground potential: High **Model potential:** High

IfRt-4

This site produced several subsurface chert flakes. It is located in the Fort Nelson Lowlands on top of small bench overlooking Beaver Lake at its southern end.

Ground potential: High **Model potential:** Low/High

Halfway Plateau

HAP J04

This is a CMT site located in the Halfway Plateau on the slightly sloping south bank of the Blueberry River. The site most likely post-dates 1846 due to diameter of trunk and healing lobe thickness.

Ground potential: Low **Model potential:** High

Figure 45. Site HAP JO4 CMT 1 & 2

HAP J05

This is another CMT site is in the Halfway Plateau located on the slightly sloping south bank of the Blueberry River. The site most likely post-dates 1846 due to diameter of trunk and healing lobe thickness.

Ground potential: High   **Model potential:** High to Medium

Figure 46. CMT at site HAP JO5

HAP J06

This is a CMT site is located on a flat bank above the Cameron River, in the Halfway Plateau. The surrounding area is flat and grassy with lots of aspen and some immature spruce.

Ground potential: High **Model potential:** High

Figure 47. CMT at site HAP JO6.

KB311

The site consists of seven pine CMTs, located in the Halfway Plateau along a continuous gentle slope. Due to the size of trees and depth of scars, it is likely that the site post dates 1846.

Ground potential: Medium **Model potential:** Low

Comment on potential: KB311 is 10m west of Medium potential area.

Figure 48. Site KB311 CMT 1.

Figure 49. Site KB311 CMT 5.

Clear Hills

HdRe-41

The site consists of a subsurface lithic scatter located in the Clear Hills ecosection on a small flat aspen covered ridge near the Beatton River, which meanders around the north, west, and south of the site. The forest cover consists of mature aspen; the understory is open and is comprised of immature willow, rose, and cranberry. Ground cover is lingonberry and grasses.

Ground potential: High **Model potential:** Low

Comment on potential: Site is located just 30m north of Very High potential. Landform models ridge OK, shows site just over edge of feature.

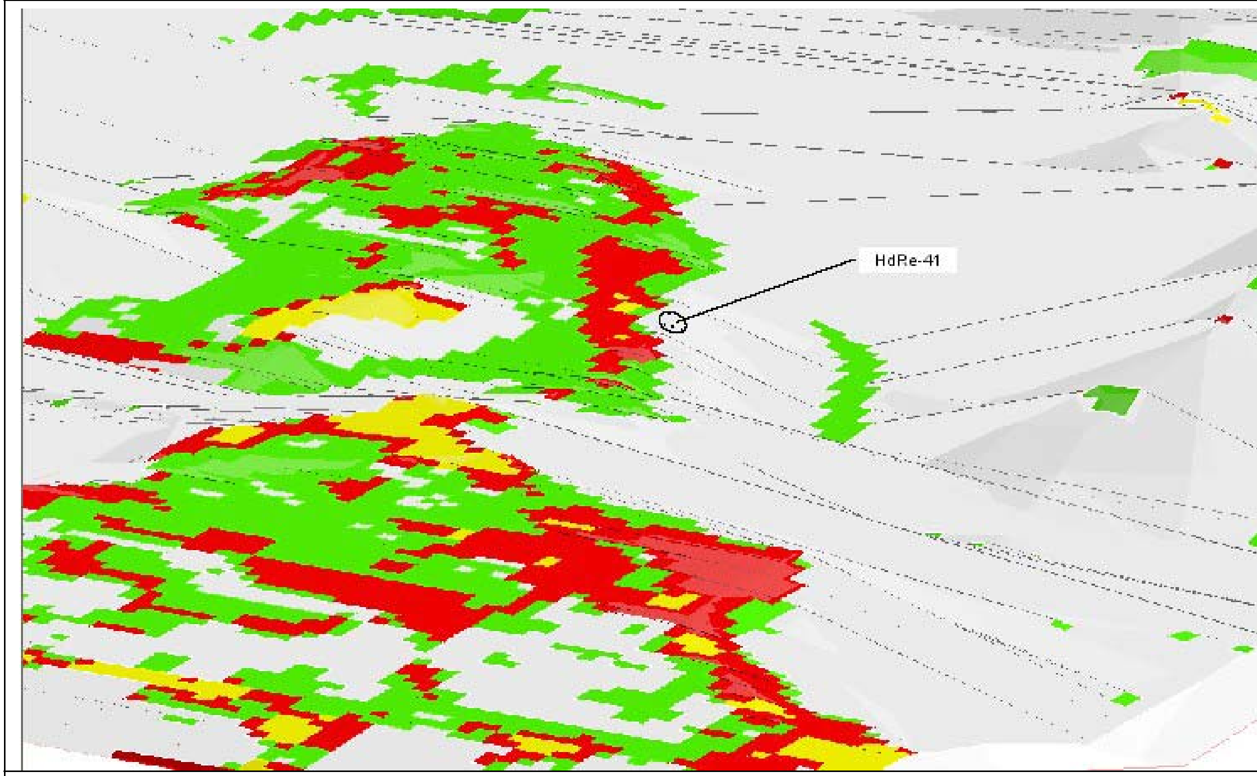


Figure 50. Location of site HdRe-41 with respect to High potential areas.

HfRd-7

This subsurface lithics site is also located in the Clear Hills on a low pine-covered knoll covered with mosses and lingonberry, above swampy lowlands to the north, and undifferentiated spruce and aspen to the south. Although only a single shovel test was positive, the approximate boundary of the small pine-covered knoll is considered to be the site boundary.

Ground potential: High **Model potential:** Medium

Comment on potential: The site lies approximately 17m north of high potential area.

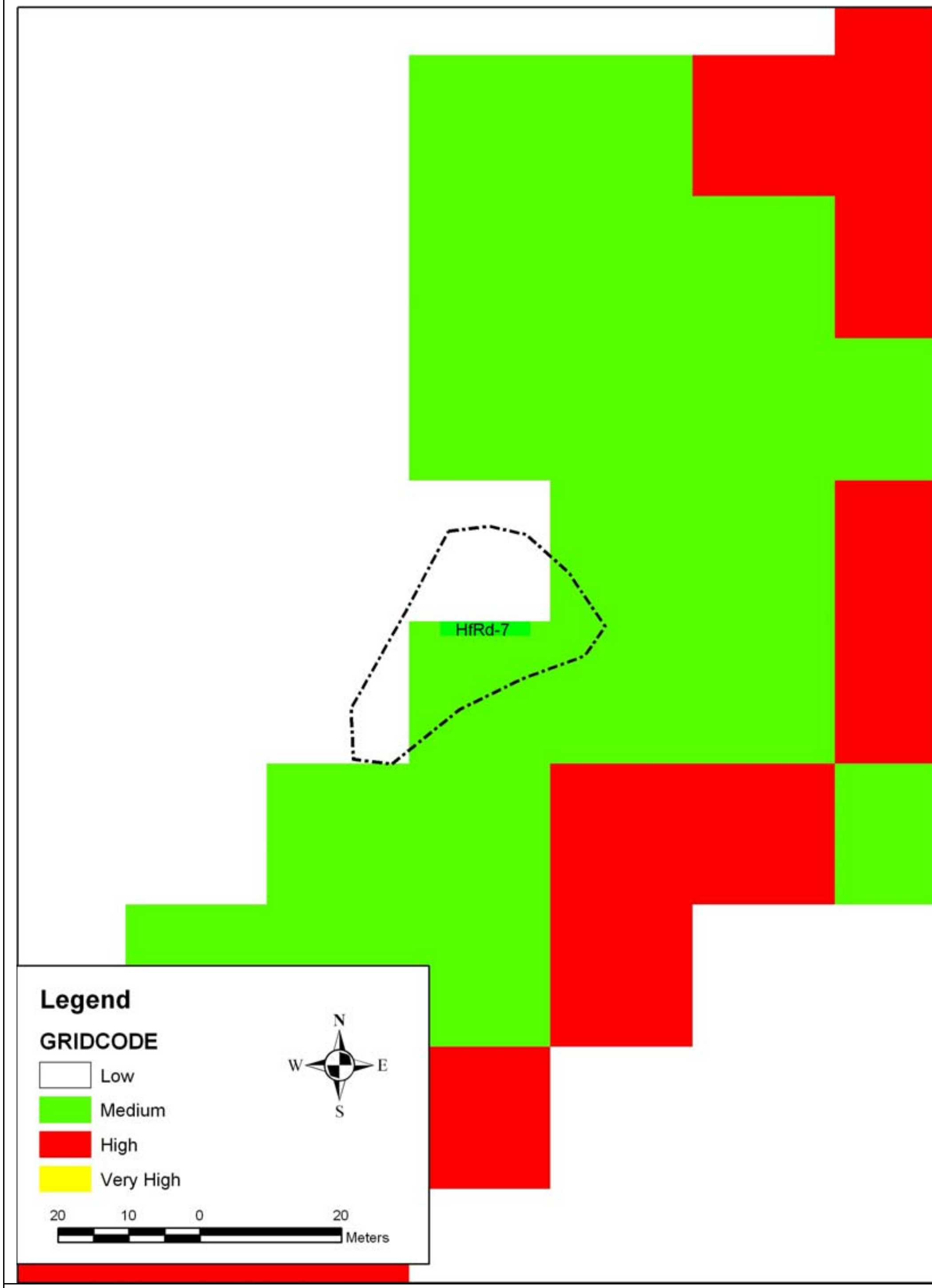


Figure 51. Location of site HfRd-7 with respect to High potential areas.

HfRd-8

Located in the Clear Hills, this subsurface lithics site is lies between 50 and 100 meters north of Little Beaverdam Creek, atop two low pine-covered knolls. It is separated from the creek by a marshy low floodplain and old meander channels. The site was originally recorded as two sites, under temporary site numbers CLH2 and CLH3. However, subsurface testing in the swale between them revealed that they were probably the same site.

Ground potential: High **Model potential:** Low/Medium

Comment on potential: The site is lies approximately 13 m to the north of a High potential area.

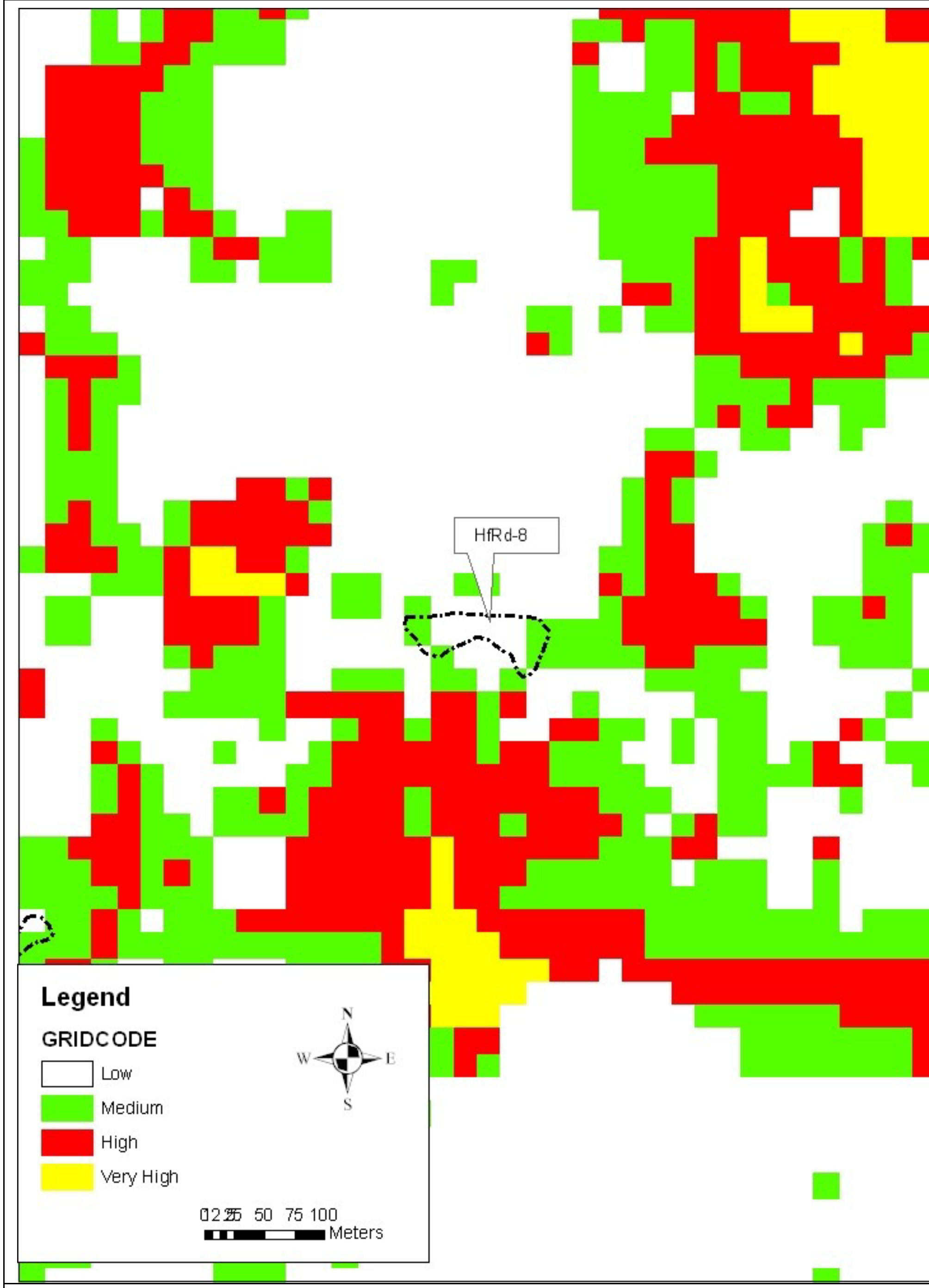


Figure 52. Location of HfRd-8 with respect to High potential areas.

Figure 53. View of the west part of HfRd-8 from marshy area. Note the taller pines on the site area.

Petitot Plateau

IjRe-1

The site lies consists of a pre-contact subsurface lithic scatter located on a small south-north running knoll near the south bank of a small lake 3 km north of Kimea Creek in the Petitot Plain.

Ground potential: High **Model potential:** Low

Comment on potential: The site is falls only about 2.5 m north of High potential area.

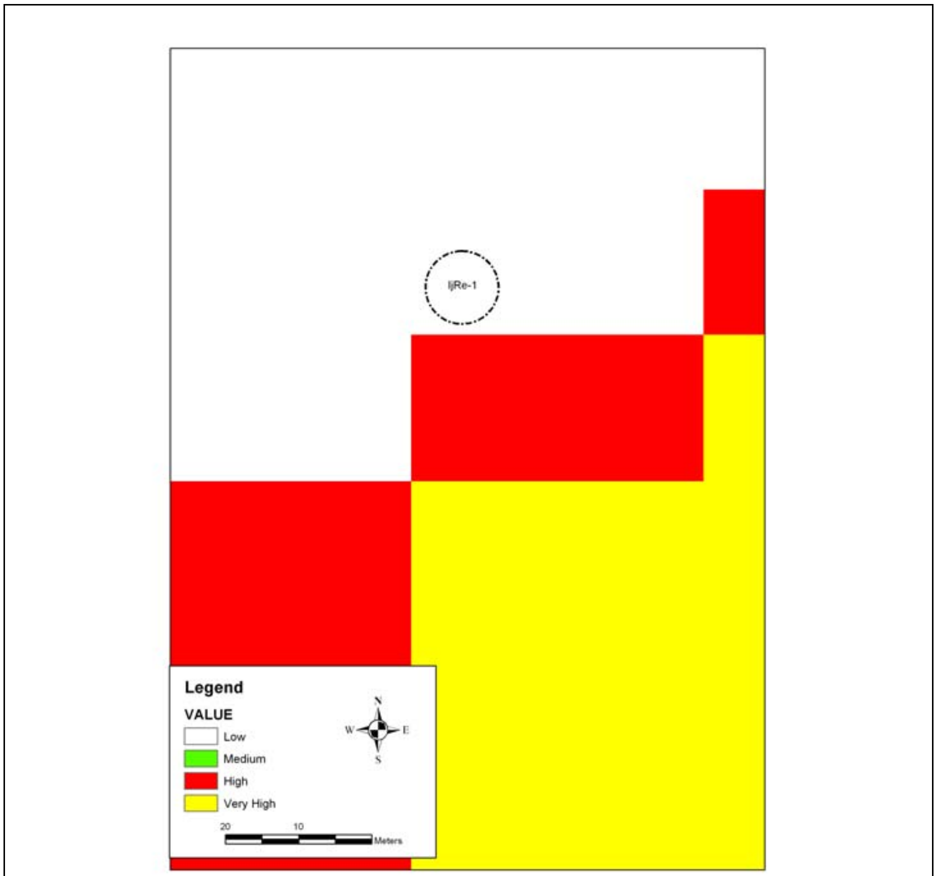


Figure 54. Location of IjRe-1 with respect to High potential areas.

IjRi-2

The site is located in the Petitot Plain, on the east bank of the Tsea River near the confluence with the Petitot River. The site consists of both pre-contact chert flakes and a historic cabin.

Ground potential: Very High **Model potential:** High

Figure 55. Cabin remains at IjRi-2. Lithics were found nearby.

Figure 56. View of Tsea River from IjR1-2.

Model Performance for Survey Points

Over the course of field work, 642 survey points were collected to assess the efficacy of the terrain tool and archaeology potential model. As discussed above, the rating given was to some degree subjective – for instance the difference between "high" and "very high". Also, many of the "moderate" potential field ratings could be considered to be really "low" potential – these tended to be in the large, well drained landforms away from any slope breaks or other micro-topographic features where, while there was no reason to categorically exclude the presence of a site, neither was there any particular reason to suspect one was present, either.

It soon became apparent that the terrain model was doing an excellent job of capturing terrace edges along major creeks and rivers, so the more subtle topographic features were targeted for survey. This, in turn, may have reduced the apparent efficacy of the model – surveying the major terraces would have recovered many sites and would have created a large sample of "high field potential – high model potential" points. The data collected was the basis for the modification of the terrain modelling process, which was changed to include rectangular vertical and horizontal windows (7x1, 9x1, and 25x1) that could capture more subtle landforms (Figure 57).

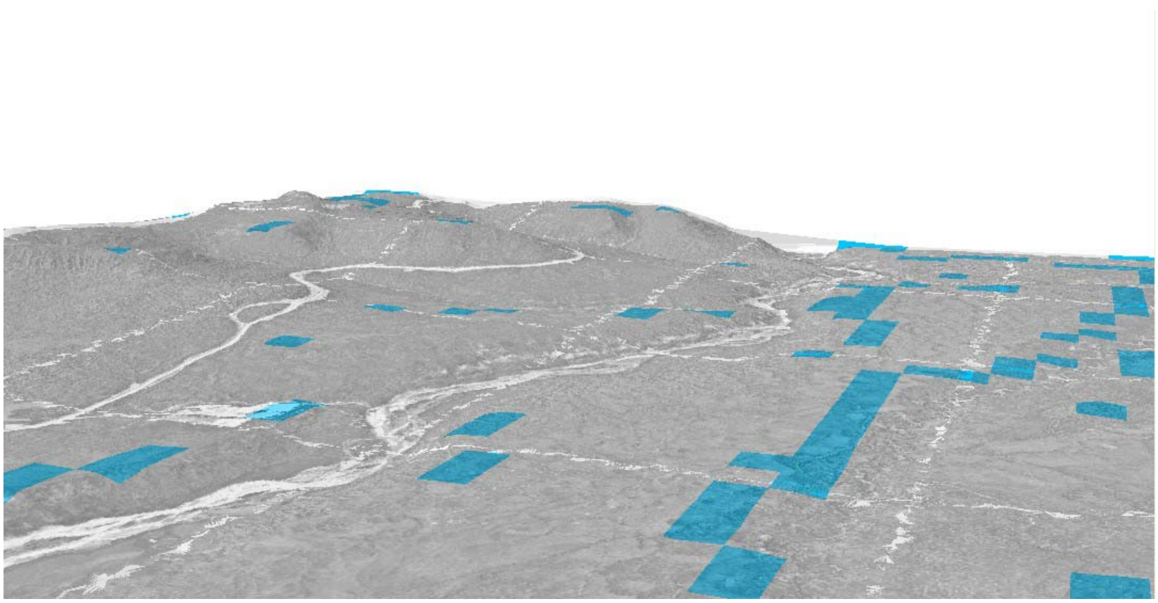


Figure 57. Landforms in MUP captured by rectangular analysis windows.

Table 1 summarize the survey points for each ecosection, and the overall model.

Table 1. Field points/model results per ecosection

	Ground/Model matches			Points under-represented by model			Points over-represented by model			TOTALS	
Model	**#**	**%***	**%****	**#**	**%***	**%****	**#**	**%***	**%****	**#**	**%****
CLH	30	41%	45%	18	3%	3%	25	34%	4%	**73**	**11%**
ETP	44	31%	7%	50	8%	8%	50	35%	8%	**144**	**22%**
FNL	59	32%	9%	38	6%	6%	85	47%	13%	**182**	**28%**
HAP	42	38%	6%	26	4%	4%	44	39%	7%	**112**	**17%**
MUF	6	33%	1%	2	0%	0%	10	56%	1%	**18**	**3%**
MUP	11	21%	2%	11	2%	2%	30	58%	5%	**52**	**8%**
PEP	22	33%	3%	17	3%	3%	27	41%	4%	**66**	**10%**
OVER ALL	214		33%	162		25%	266		41%	**642**	**100%**
%* Represents percentage within ecosection **%**** Represents overall model percentage											

Of the 642 field points, 214 points exactly match the model, 33.3% out of the total survey points. In these cases the model is accurately predicting the presence or absence of terrain features or archaeological potential. The model is over-representing potential 41.4% of the whole, perhaps predicting terrain features which aren't there. The model is under-representing ground potential in 25.2% of the time. Of greatest concern is the latter case, where terrain features with the potential for archaeological sites may not be captured. While these statistics suggest that the model is not performing all that well, this is due to the division into four classes and field evaluation is partly subjective, so a mismatch is counted as a failure regardless of type, which is not really the case.

Model performance is better when the matches are grouped – for instance, if High as a ground potential rating and Very High as a map rating are considered essentially equivalent. In other words, when a location is rendered by the model as Very High potential and the ground observations indicated that it should be High potential (a subjective distinction), there is a slight over-representation in the model but the error is of no consequence. We term these as "non matches of little concern" in the following discussion. The converse pair (modelled High and ground Very High) would also be inconsequential. "Non-matches of other concern" are locations that appear to be overrated by the model. These affect the productivity of the model, but the error does not endanger archaeological remains. Finally, non-matches of archaeological concern occur when the model under-rates a location as being Low and field observations indicate that it has Very High, High, or Medium potential. In this case there is the risk of a site being missed. And if Medium field potential were considered Low, for reasons discussed above, the model performance rating would be considerably improved, but we have not made this adjustment. These results are summarized in Tables 2 and 3.

Table 2 Overall model performance matrix for field points.

Score	VH	H	M	L
VH	**13**	6	6	8
H	32	**48**	37	39
M	32	66	**45**	66
L	21	52	63	**108**
Columns = map potential rating; rows = field potential rating. **Bold** numbers indicate exact match between field points and model Underlined numbers indicate non-matches of little concern Blue numbers indicate non-matches of other concern Red numbers indicate non-matches of archaeological concern				

Table 3 Field points/model performance

	Matches and non-matches of little concern			Non-matches of other concern			Non-matches of archaeological concern			TOTALS	
Model	**#**	**%***	**%****	**#**	**%***	**%****	**#**	**%***	**%****	**#**	**%****
CLH	42	58	7	17	23	3	14	19	2	**73**	**11%**
ETP	85	59	13	26	18	4	33	23	5	**144**	**22%**
FNL	100	55	16	55	30	9	27	15	4	**182**	**28%**
HAP	57	51	9	39	35	6	16	14	2	**112**	**17%**
MUF	11	61	2	6	33	1	1	6	0	**18**	**3%**
MUP	17	33	3	26	50	4	9	17	1	**52**	**8%**
PEP	43	65	7	10	15	2	13	20	2	**66**	**10%**
PEP	43	65	7	10	15	2	13	20	2	**66**	**10%**
OVERALL	355		55	174		27	113		18	**642**	**100%**
%* Represents percentage within ecosection %** Represents overall model percentage											

These results show matches and non-matches of little concern as 55%, non-matches of other concern to 27%, while dropping the non-matches of archaeological concern to 18% (Figure 58). The non-matches of archaeological concern values are very close to the results of testing the model against known sites (see "Model Performance for Archaeological Sites" below).

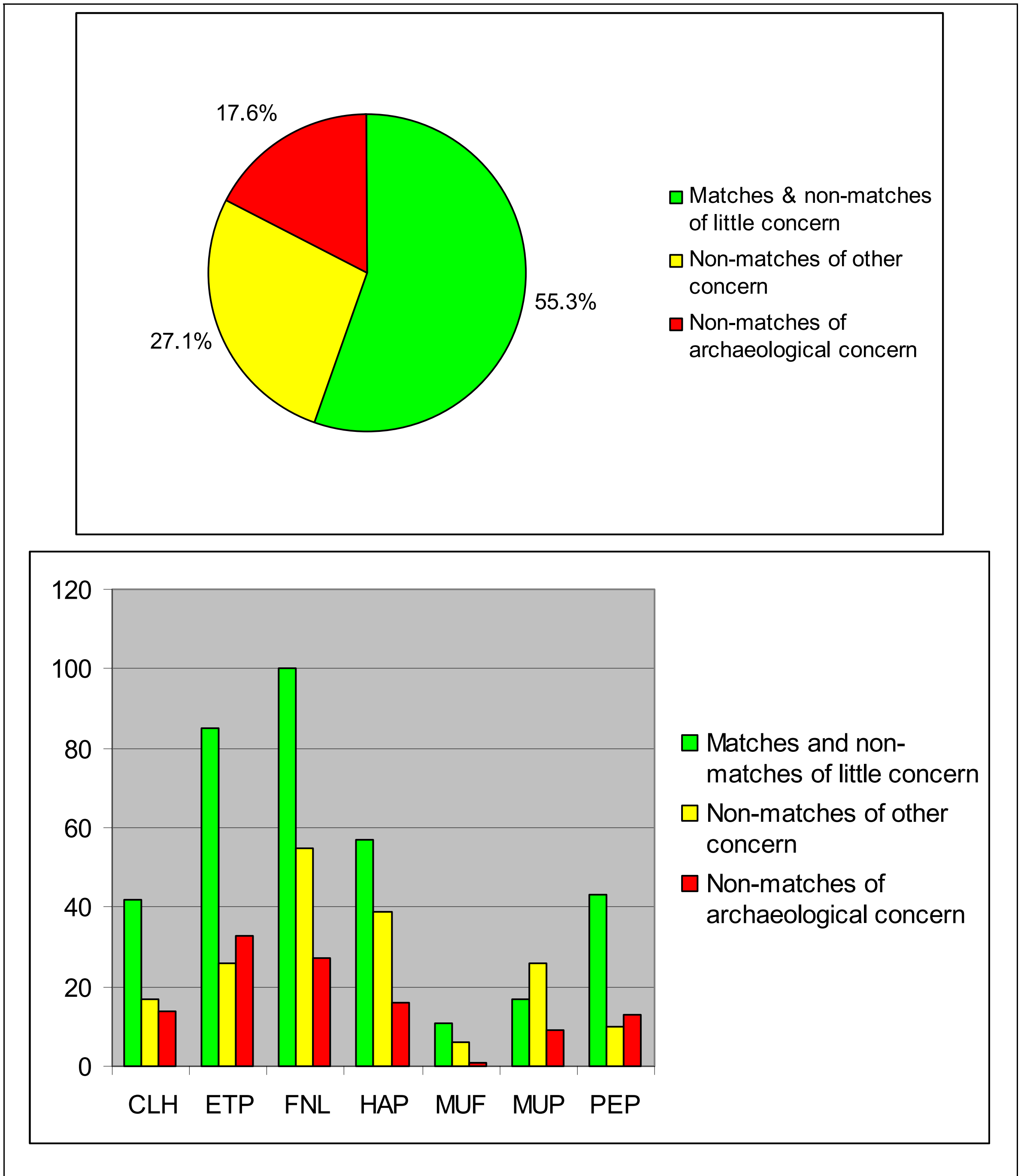
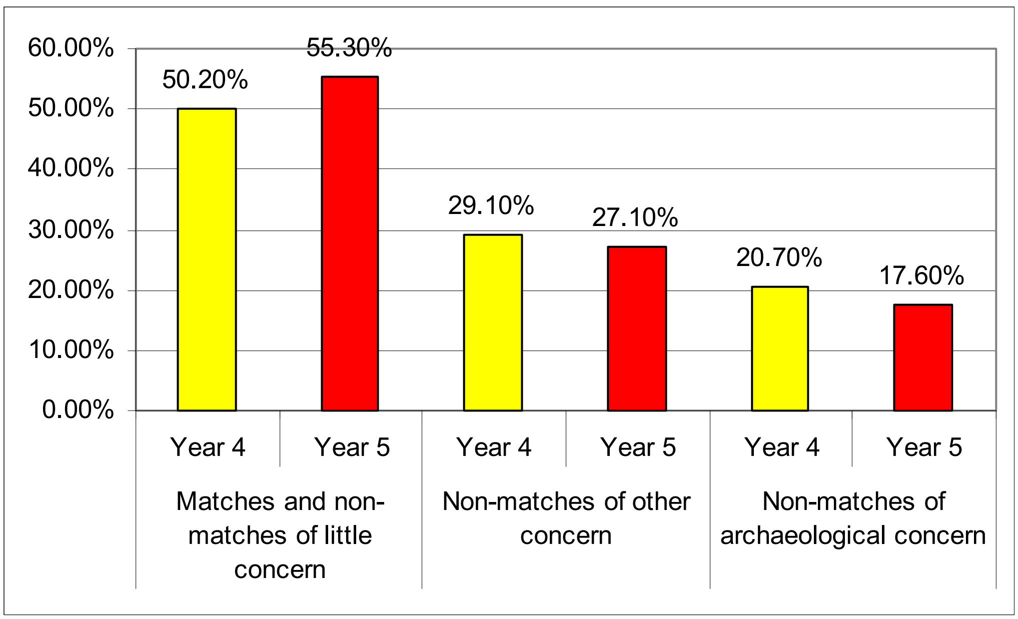


Figure 58. Model performance results overall model and by ecosection.

Table 4 and Figure 59 show a comparison of the performance results between the Year Four and Year Five models. These show an increase in Year Five models of 5.1% in positive identifications (Matches and non-matches of little concern), while at the same time the non-matches of archaeological concern drop 3.1%. It became apparent that including the rectangular windows to model for terrain features had a modest but positive effect on the overall model performance.

Table 4. Comparison between Year Four and Year Five models.

	Matches and non-matches of little concern		Non-matches of other concern		Non-matches of archaeological concern	
Model	***Year Four***	***Year Five***	***Year Four***	***Year Five***	***Year Four***	***Year Five***
CLH	48%	58%	36%	19%	16%	19%
ETP	55%	59%	20%	23%	25%	23%
FNL	53%	55%	28%	15%	20%	15%
HAP	38%	51%	50%	14%	13%	14%
MUF	71%	61%	16%	6%	13%	6%
MUP	32%	33%	45%	17%	23%	17%
PEP	55%	65%	10%	20%	35%	20%
OVERALL	50%	55%	29%	27%	21%	18%



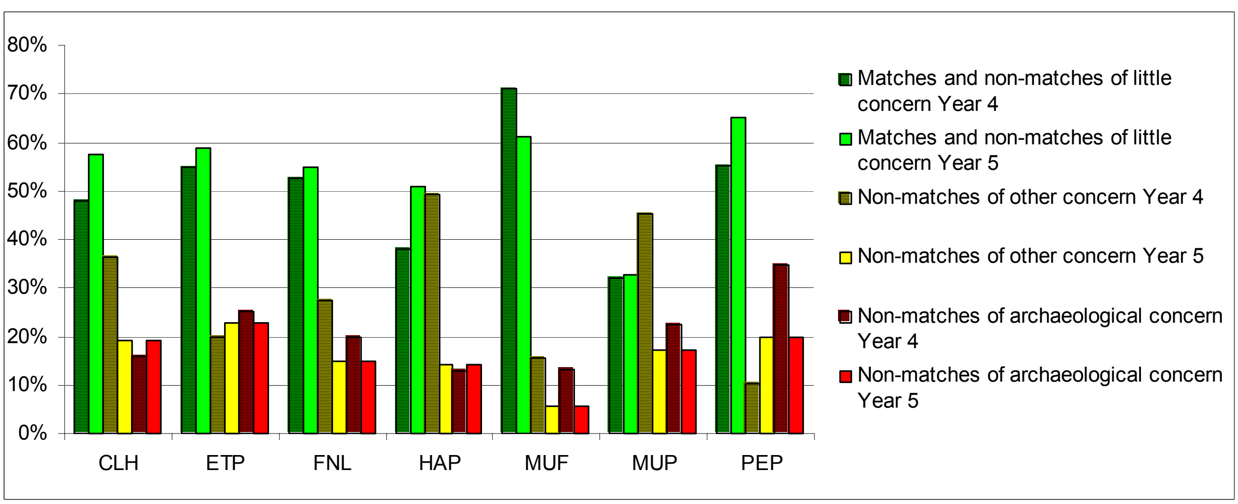


Figure 59. Model performance comparison between Year Four and Year Five models.

Looking at the models by ecosection it becomes apparent that in terms of field points the model performs better at FNL and ETP, which also have the highest number of ground observations (182 and 144 respectively). Only in MUF did the Year Four model slightly outperform the Year Five, but this may be due to the small number of field observations recovered for this ecosection (18 out of 642). Figure 60 shows the distribution of field points and archaeological sites by ecosection.

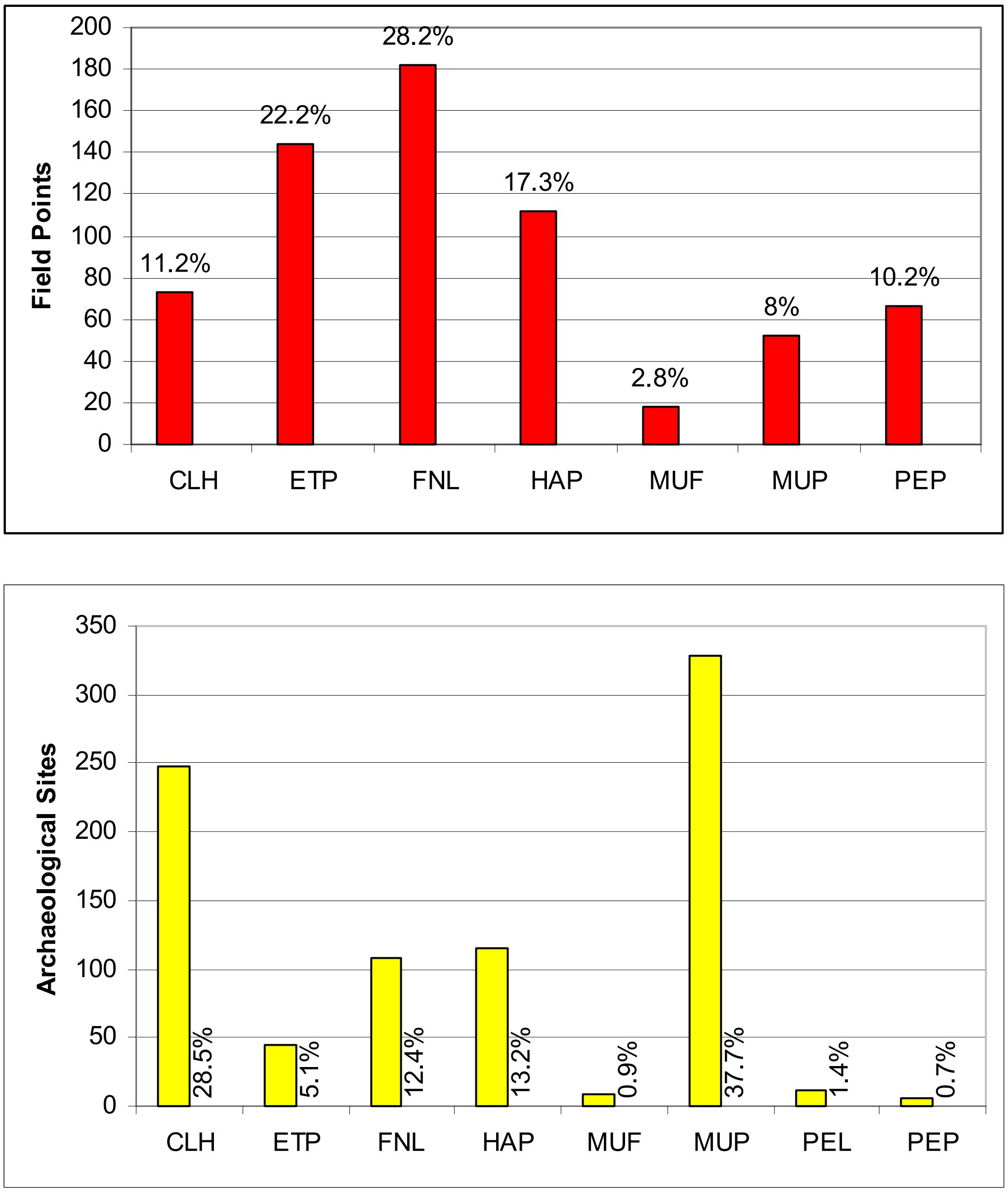


Figure 60. Distribution of field points and archaeological sites by ecosection.

While FNL and ETP have the highest number of field observations comprising both 50.4% of the total, it is MUP and CLH with 328 and 248 sites respectively that account for 66.2% out of the overall 869 sites recorded for the study area.

Model Performance for Archaeological Sites

As mentioned above the location of a total of 869 archaeological sites, which included the 32 newly recorded sites, was used to assess the accuracy of the models in identifying areas of archaeological potential by ecosection. However, it is important to note that the polygonal nature of many sites meant that a site could fall in a combination of archaeological potential values (Figure 61).

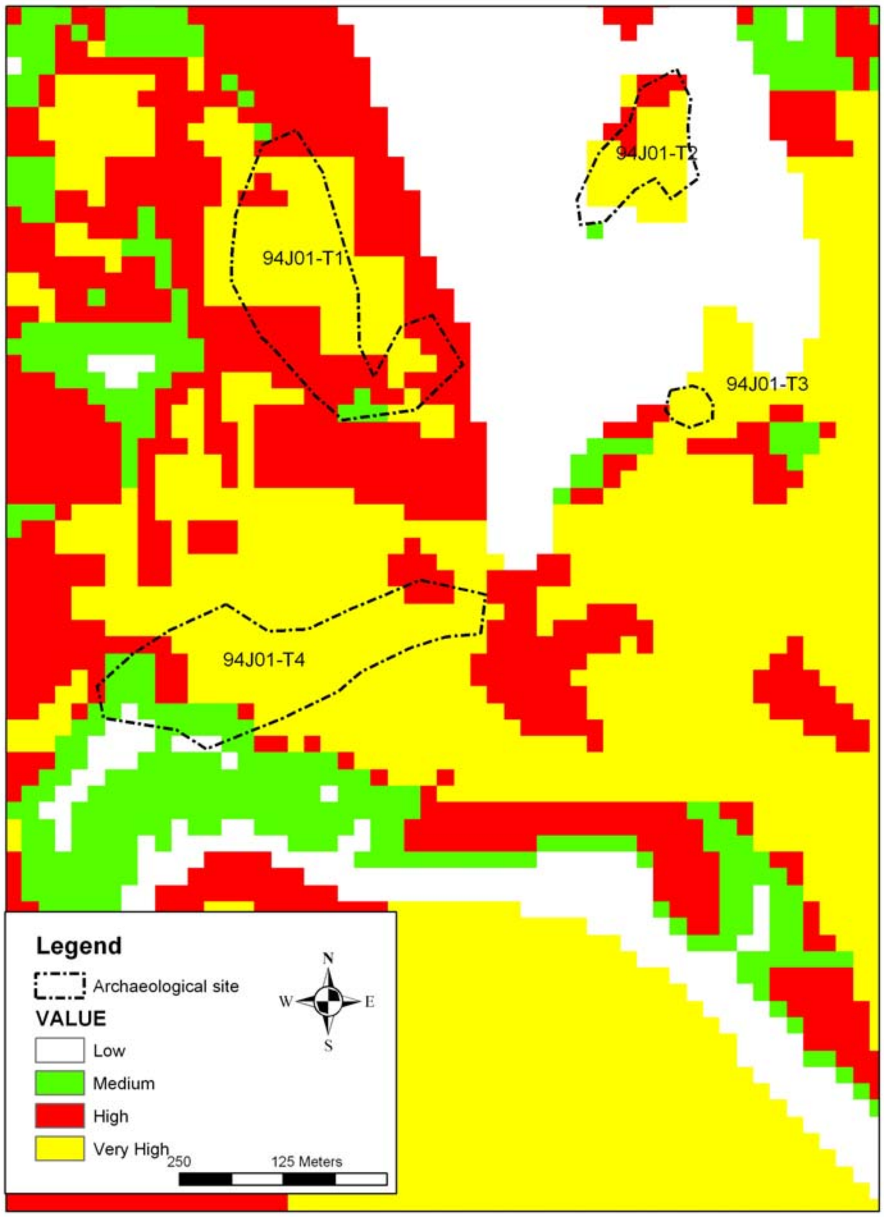


Figure 61. Example of archaeological sites with combined model potential.

Table 5 and Figures 62 summarise the results, while Figures 63 shows the results for the overall model and by ecosection. Table 5 shows that, for instance, there are 13 sites in the Clear Hills that are modelled as completely within "Very High" potential, and that this comprises 13% of the 248 sites in this ecosection. Near the other end of the table, 89 sites, or 36% of the total, fall in several potential zones ("combined potential"). The pie chart of Figure 62 summarizes the results for the entire study area, as percentages of all sites combined that fall in the different potential ratings.

Table 5 Model results for archaeological sites.

	VH		H		M		L		Combined potential*		TOTAL #
Ecosection	#	%	#	%	#	%	#	%	#	%	
CLH	13	5%	43	17%	35	14%	68	28%	89	36%	**248**
ETP	9	20%	15	35%	5	11%	8	18%	7	16%	**44**
FNL	15	14%	29	27%	9	8%	36	33%	19	18%	**108**
HAP	6	5%	27	23%	24	21%	23	20%	35	31%	**115**
MUF	1	12%	1	13%	0	0%	1	13%	5	62%	**8**
MUP	36	11%	67	20%	69	21%	67	20%	89	28%	**328**
PEL	1	8%	2	17%	1	8%	2	17%	6	50%	**12**
PEP	1	17%	2	33%	0	0%	2	33%	1	17%	**6**
TOTAL#	**82**		**186**		**143**		**207**		**251**		**869**

Sites captured by model: 660 or 76%
Sites including VH and/or H potential: 448 or 51.5%

*This field collapses any combination of VH, H, M, and L values

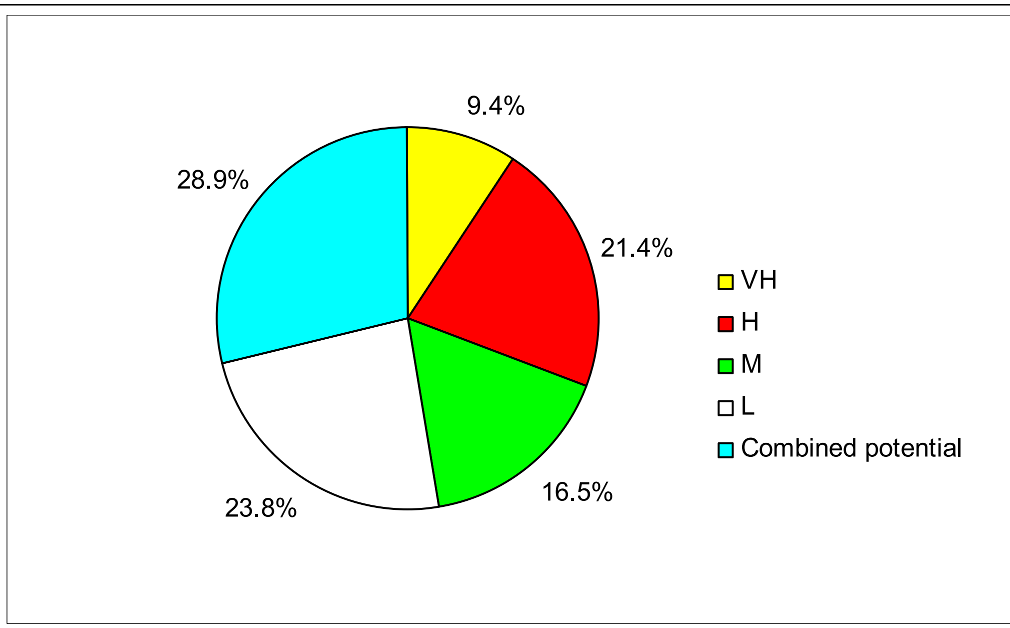


Figure 62. Overall model results for known archaeological sites.

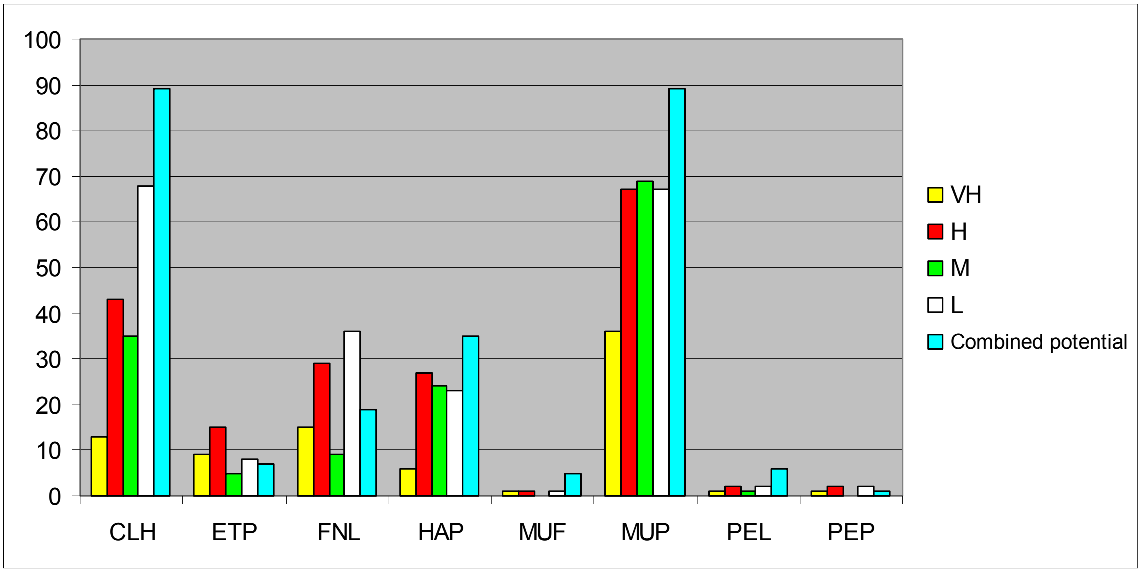


Figure 63. Model results for known archaeological sites by ecosection.

Of the 869 recorded archaeological sites in the study area, 451 or 52% fall within a Very High to High potential area, 212 or 24.4% fall within Medium potential, and 207 or 23.8% fall in Low potential. This means that 662 or 76% of the total number of archaeological sites were captured by the model (with sites falling in Low considered not captured or missed). However, of the 207 sites missed some 87 lie within 1 to 20 meters of a Medium, High or Very High potential area identified by the models. This distance range is considered insignificant as it is less then the resolution at which the model is produced, and the mapped site locations may easily be this much in error or more. These sites are so close to modelled terrain features that they would likely be noticed by crews surveying the modelled areas. Planners using the model to minimize risk of conflicts with archaeological sites should place developments at least 40 m from modelled features. Perhaps a little less than 20% of the sites are completely missed by the model, a number similar to that noted by the ground potential ratings discussed above. This is primarily due to the inability to model for micro-topographic features with the data available to this project.

Conclusions

During the 2003 field season, a potential assessment was assigned to each survey point based on field observations. Prior to fieldwork the archaeological potential model was developed for the different ecosection, we were able to compare the field assessed potential against it. In the Year Four model the two assessments were in agreement approximately 79.3% of the time, while in the Year Five model the agreement was of 82.4% (529 out of 642 survey points), with some leeway given to the field assessed potential due to its subjective nature (if it was within one potential rating of the model's assessment, the two were considered to be in agreement, except where the model assessed an area as low and the field assessment was moderate or higher).

Fieldwork was successful in achieving its main objective, which was to ground-truth the model developed by Millennia Research. Thirty-two new sites were also recorded in the process. Further, the information gathered while ground-truthing the terrain model was also helpful in assessing the archaeological potential model for the different ecosections, and new landform detection algorithms were developed subsequent to the fieldwork that enhanced the performance of the Year Five models.

The improved terrain model accurately captured virtually all of the hilltops, most of the knolls, and ridges, the terraces along major rivers and creeks, and many of the more subtle landforms in areas where the previous versions of the models were found to be working less effectively, including hummocky land, swamp edges, and areas with largely undifferentiated terrain such as those found in the Fort Nelson Lowlands.

There were some instances where the terrain model failed to identify topographic features which were identified in the field. Many of these features are captured by the potential model, of through proxy variables such as forest cover. This is discussed in more detail in the section on model development.

Site Location Corrections

Although no further site location corrections took place during Year Four and Five of the project, it is useful to briefly recap on some of the most relevant aspects of this process. Detailed site information for 869 archaeological sites in the study area was obtained. As discussed in previous reports, errors in site location were often too great for requirements of modelling. A model must be effective in distinguishing between areas that probably contain archaeological remains and areas with low likelihood of archaeological deposits; this process is integral to modelling as even a 50 m error in site location can make many sites fall outside high potential zones. 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. Where reliable information was available, site locations were checked and corrected against the detail maps accompanying the siteforms. The relative location of the site to orthophotos and mapped features such as seismic lines, roads, water bodies, well site, or pipelines was also compared to that on the detailed site map.

Sites were changed from points to polygons. 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.

In September 2004, updated boundaries for 336 sites were provided to the Archaeology and Registry Services Branch as a shapefile so their records could reflect new boundaries and corrected locations.

Modelling for Palaeo-Indian Sites

In keeping with the directive of producing a model that could identify and protect Palaeo-Indian sites (sites that pre-date 8000 BP), Millennia Research continued its modelling efforts towards this end. These sites are often only represented archaeologically by a single projectile point base, yet Palaeo-Indian sites represent significant evidence of ancient occupations in the northeast and throughout the province of British Columbia. They also present a unique challenge to modellers because as we have noted before, their patterning is generally not associated with modern drainage.

Palaeo-Indian sites tend to be associated with the retreat of the last major glaciers. During the retreat of the Wisconsin Laurentide and Cordilleran ice, massive lakes covered much of the landscape. Even into the early Holocene, these lakes formed a dominant feature of the landscape (Fladmark, et al. 1988). Much of the southern study area was covered by Glacial Lake Peace, which in its later stages drained through the Peace River valley and was dammed by the retreating Laurentide ice to the east. The most recent stage of Glacial Lake Peace is the Clayhurst Phase, when the lake was at 660 to 690 m ASL (Mathews 1978). Clayhurst is the phase assumed to correlate with human occupation in the area. The shore of this lake and the post-glacial landscapes of the northeast supported human groups who were (re)populating this region from the south.

After the recession of the glaciers, the landscape looked very different than it does today. A succession of herbs, grasses, and mosses to a deciduous forest preceded the establishment of coniferous forests in the southern portion of the region. The open grassland probably supported a comparatively large number of human occupants; big game hunting with stemmed projectile points was an important economic activity that is recognizable thousands of years later. As mentioned above, as these sites have a particular significance due to their age and distinctiveness, the most recent developments of Millennia's model has continued the efforts to model for them specifically by emphasising terrain over water courses.

An important characteristic of modelling for Paleo-Indian sites is that the distribution of these sites is usually completely independent of modern hydrography. Changing hydrographic conditions in the last 10,000 years have caused rivers and other bodies of water (especially muskeg swamps in the last 6,000 years) to appear and disappear. Instead, Millennia has used the actual terrain to isolate locations with potential for sites dating to Palaeo-Indian times (see previous section on terrain identification). As peri- and post-glacial levels of glacial lakes are known in this region, it is also possible to identify terrain that might be associated with glacial lake strandlines.

In an attempt to determine whether or not our model was capturing Palaeo-Indian sites, a visual inspection of the GIS model and the site locations was carried out on screen using ArcMap GIS. Twelve Palaeo-Indian sites (we have included some lanceolate points that may date to the early archaic, or just after the true Palaeo-Indian time period) were identified in the study area; five fall in the Muskwa Plateau, four in the Clear Hills, two in the Halfway Plateau, and one in the Muskwa Foothills (see Table 6).

Table 6. Paleo-Indian sites in the study area.

Site	Point Types	Location	Ecosection	Model Potential	Reference
HiRn-5	-**Oxbow** type point	At a break in slope near the base of a hill.	MUP	**M**	Siteform
HiRp-5	-**lanceolate** point	Ridge.	MUP	**H**	Siteform
HjRm-11	-"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.	MUP	**H-L**	Siteform
HkRo-2	-**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.	MUP	**L**	(Walde and Handley 1994) (Walde 1997: p5-41)
IaRn-3	"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.	MUP	**H**	Siteform
HdRe-14	-**lanceolate** point,	Low topographical rise.	CLH	**VH**	(Hutchings and Walde 1998)
HeRc-7	-**lanceolate** point, 5.5 x 2.8 x 0.5 cm "possible Palaeo-Indian provenience"	Raised pine-covered feature with distinct break nearby.	CLH	**L**	Siteform by Walde, and presumably (Walde 2000)
HhRb-2	-Scottsbluff style point	Low knoll.	CLH	**M**	Siteform
HiRi-1	-**lanceolate** point fragment (medial) with parallel flake scars	Break in slope with good view.	CLH	**L**	(Walde 1995) (Walde and Coates 1997)
HkRe-1	**Expanding-stem** point	On a small ridge overlooking a swampy lake.	CLH	**L**	Siteform (Bussey 2003)
HdRi-1	-chert **macroblade**, "may indicate a Palaeo-Indian component at this site" (Zibauer)	Low knolls on SW-facing second terrace of the Blueberry River.	HAP	**VH**	Siteform by D. Zibauer (Walde 1994)
HgRq-1	-**thin, roughly leaf-shaped, parallel flaked biface**	Creek bank (Wilson and Carlson 1987).	HAP	**H-M**	(Wilson and Carlson 1987) (Walde 1997)
HhRr-1	-**"Clovis" "fluted"**, -**Lerma**, -**Scottsbluff** type points, -**microblade core**	On prominent knoll 1 km N/NE from the N end of Pink Mountain.	MUF	**H**	(Walde 1992) (Wilson 1996)

Of the 13 sites, seven fell within High to Very High potential (HdRe-14, HdRi-1, HgRq-1, HhRr-1, HiRp-5, HjRm-11, and IaRn-3), two were Medium potential (HiRn-5 and HhRb-2) and four (HeRc-7, HkRe-1, HkRo-2, and HiRi-1) were missed by the model despite being located on well-defined landforms, according to their site forms.

HeRc-7 and HdRe-14 are both in reasonable proximity to Glacial Lake Peace Clayhurst Phase levels. To determine if these sites are possibly associated with this lake, the known elevation (660-690 masl) of the Clayhurst Phase was pulled from the spot elevations provided in TRIM (Mathews 1978). This area flanks the modern pathway of the Peace River and its larger tributaries. Neither site is conclusively associated with the lake or peri-glaciolacustrine deposits; however, HdRe-014 is on a terrace directly above the lowest (latest) level of Glacial Lake Peace Clayhurst Phase (Figure 58). If this site was occupied in very early post-glacial times, it would have been on the shoreline of this lake. However, Palaeo-Indian sites as we defined them date to as recent as 7,000 to 8000 years BP, while the most recent glaciation ended (in this area) well before 10, 000 BP (Catto, et al. 1996).

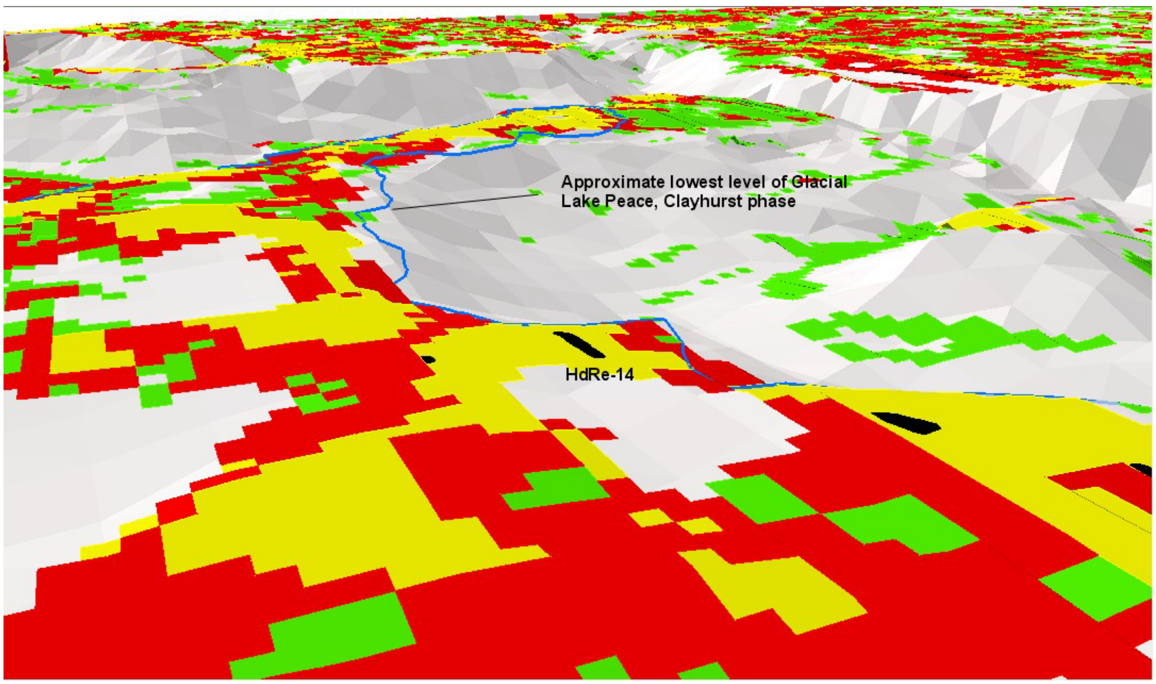


Figure 64. Location of Palaeo-Indian site HdRe-14 in relation to Glacial Lake Peace lowest level ca. 10,000 BP.

Figure 64 displays the location of site HdRe-14, recorded as an 850 sq m site on a small topographical rise above nearby black spruce muskeg. This site contained a burinated lanceolate point as well as lithic debitage and tools. The small rise that the site was on is all captured as high, but muskeg to the south and larger muskegs to the east and west were categorized as low.

Figures 65 to 69 show the location of the remaining Palaeo-Indian sites that were captured by the model in High to Very High archaeological potential areas.

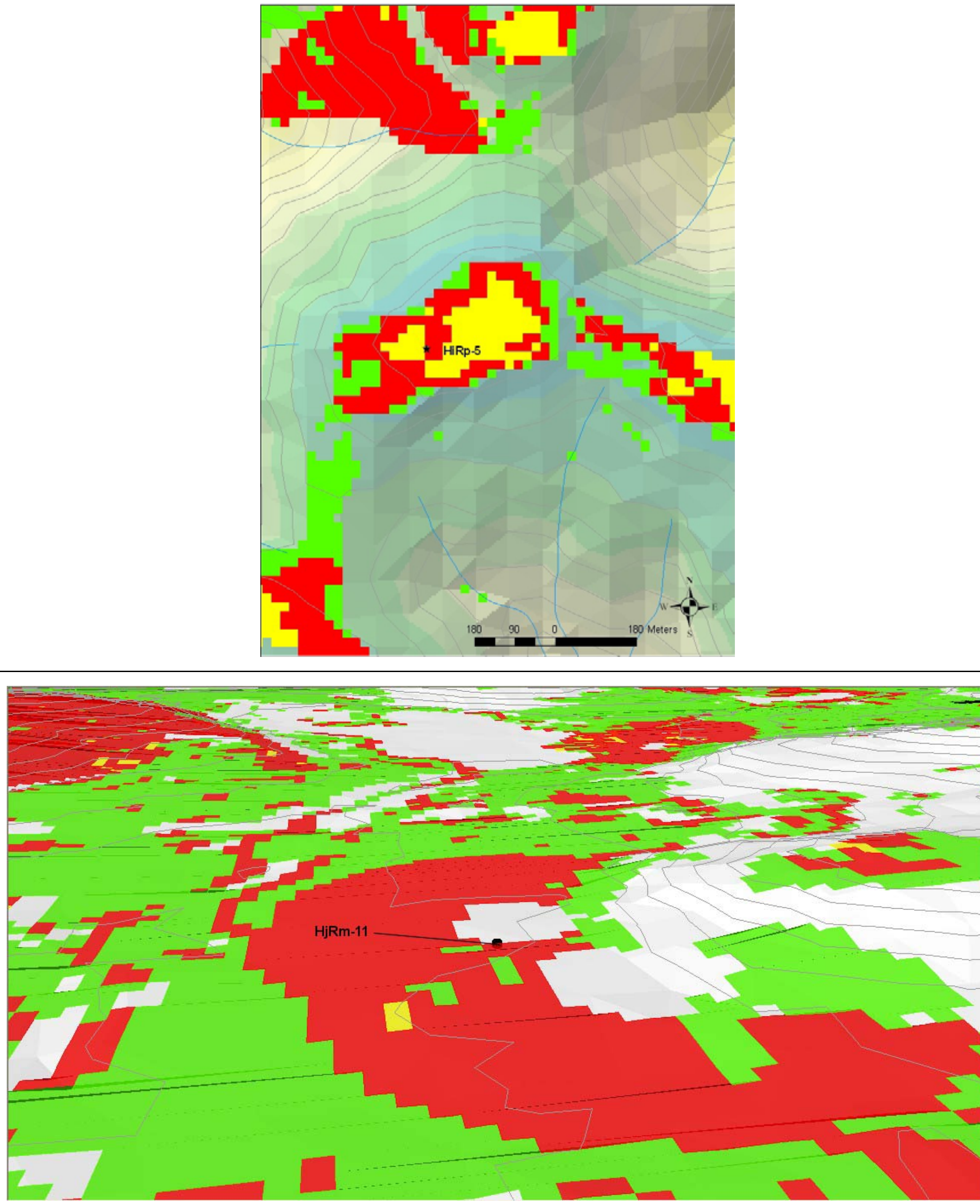


Figure 65. Palaeo-Indian sites HiRp-5 and HjRm-11 plotted on MUP model.

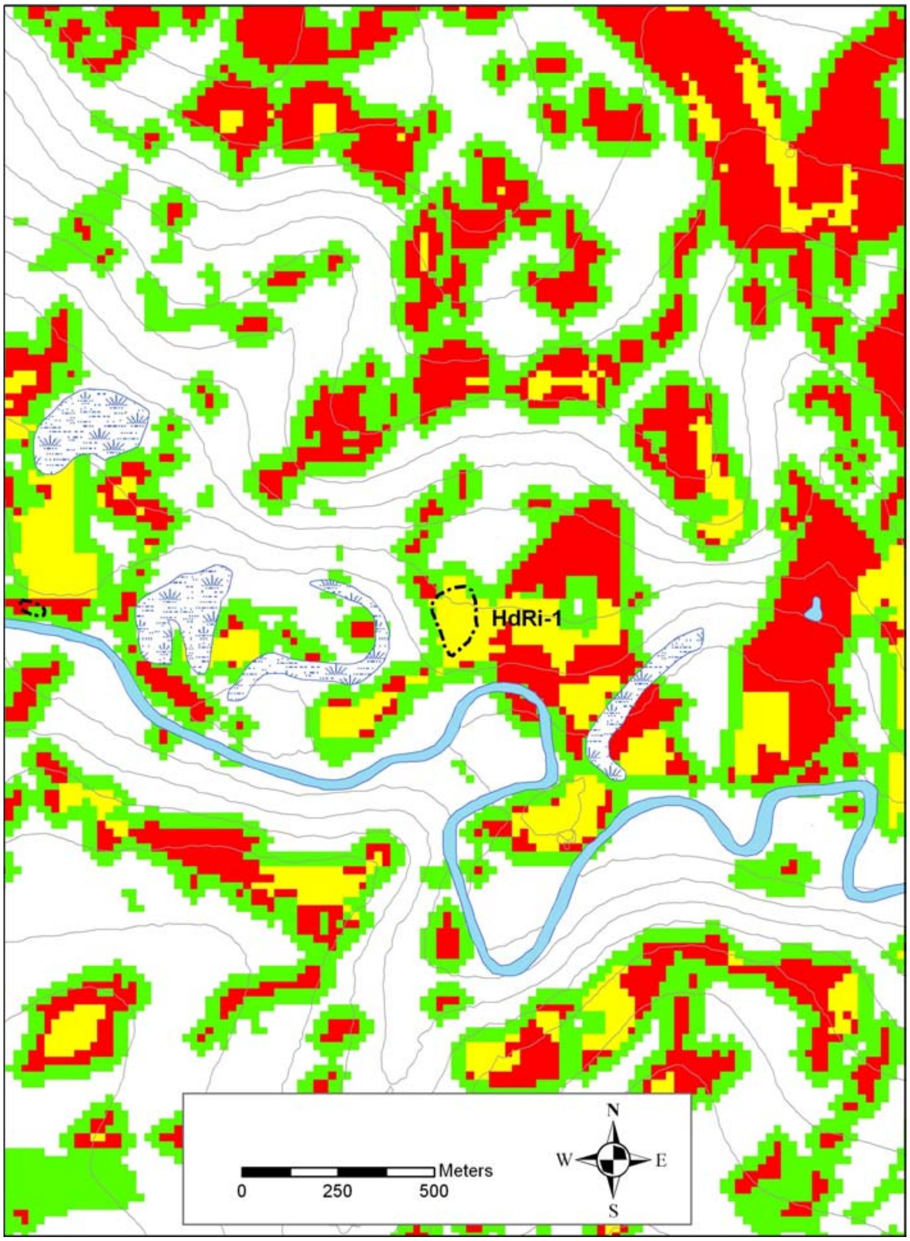


Figure 66. Palaeo-Indian sites HdRi-1 and HgRq-1 plotted on HAP model.

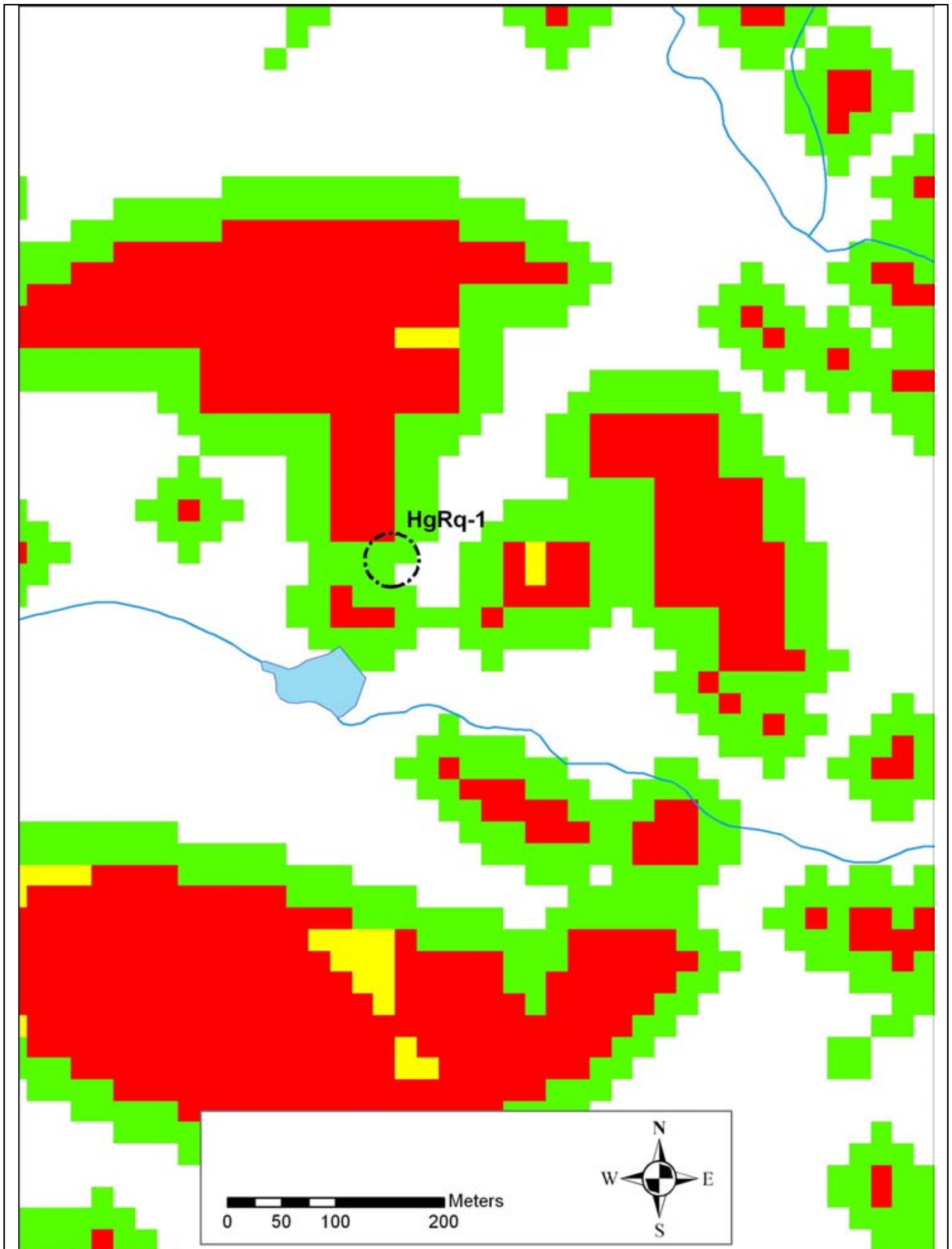


Figure 67. Palaeo-Indian site HgRq-1 plotted on HAP model.

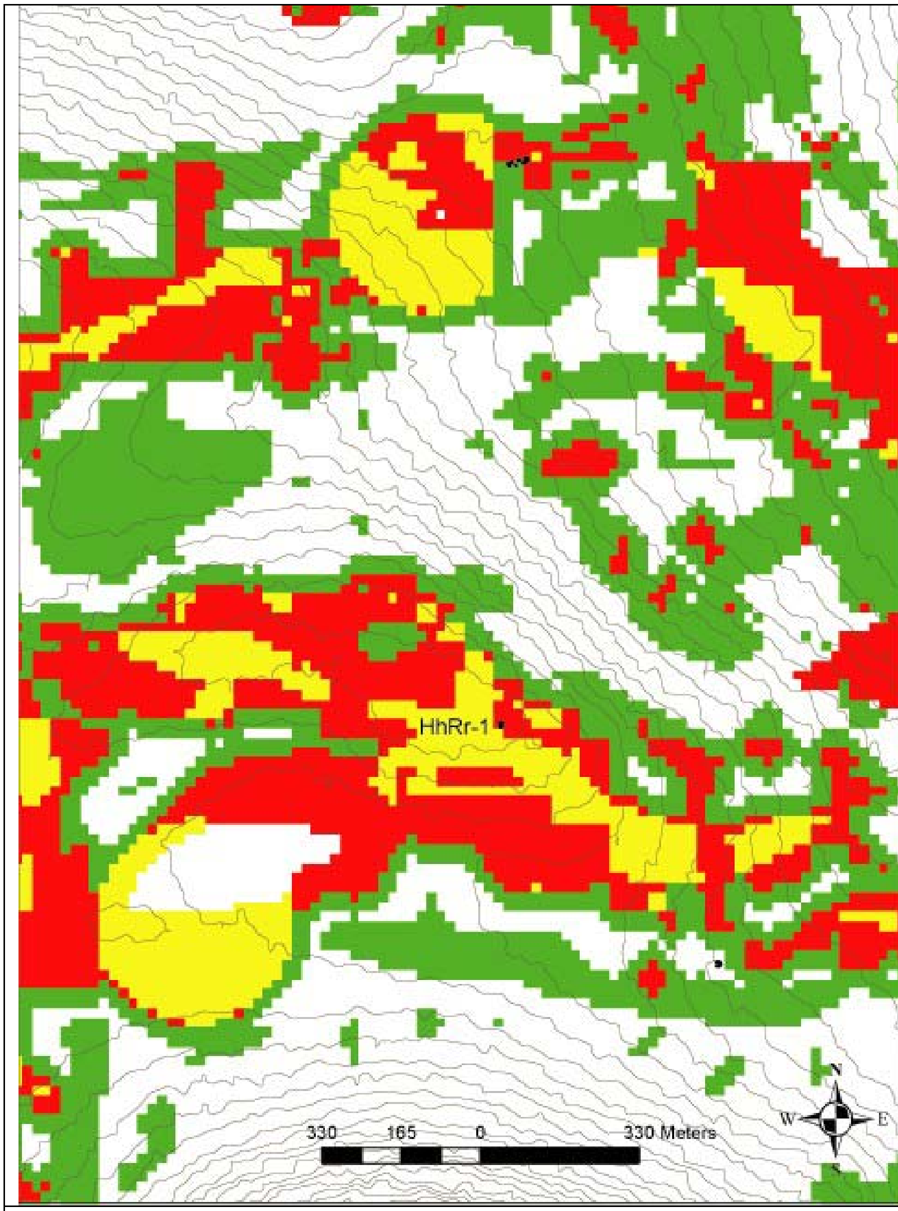


Figure 68. Palaeo-Indian site HhRr-1 plotted on MUF model.

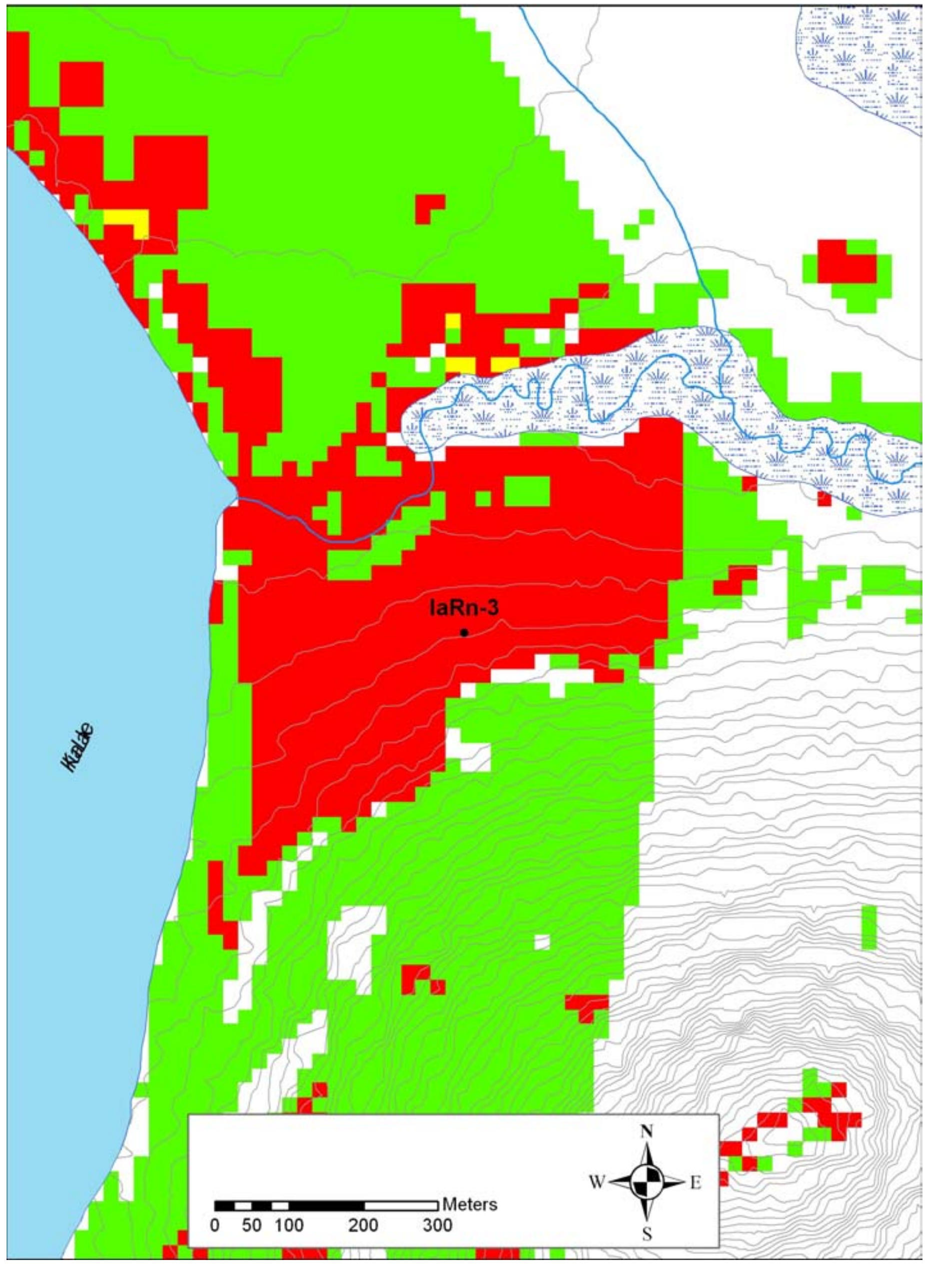


Figure 69. Palaeo-Indian site IaRn-3 plotted on MUP model.

Site HeRc-7 is located at less than 5 m from Very High and High potential areas and is very likely that it would have been picked up in the field.

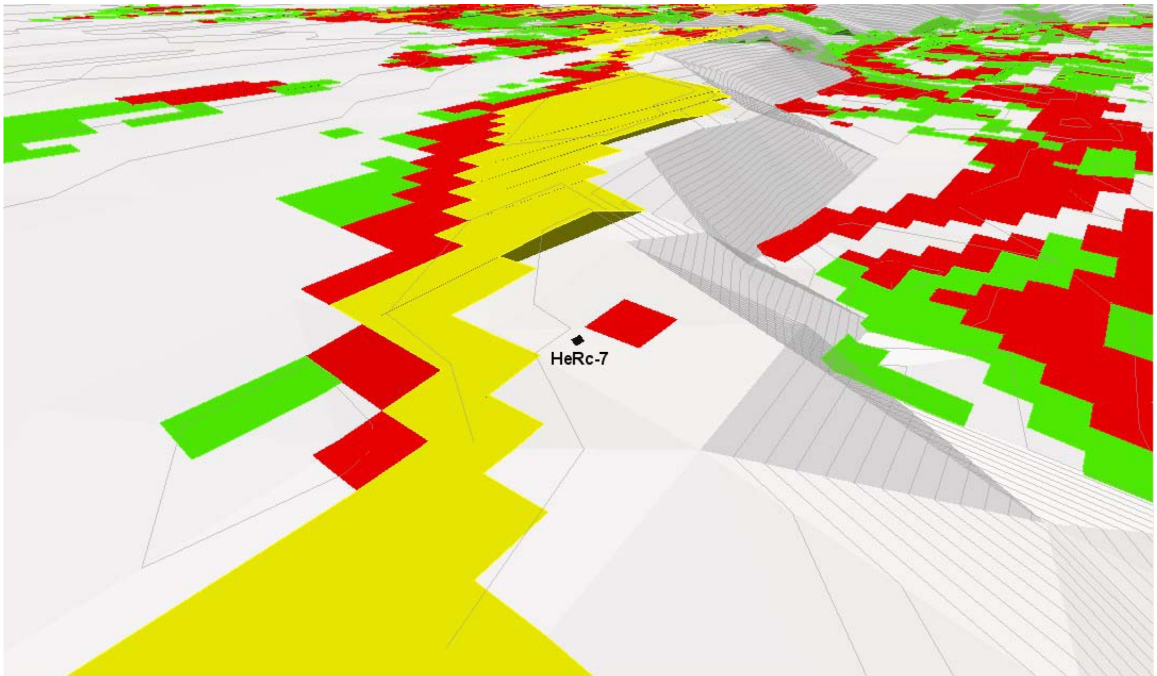


Figure 70. Location of site HeRc-7 in low potential but less than 5m from Very High and High potential areas.

In Figure 70, Palaeo-Indian site HeRc-7 is displayed with the Clear Hills model beneath it. This site flanks the modern Doig River valley running north-south. The site form indicates that the site is on a knoll with a break-in-slope. Note however, how the mapped site lies between a north-south running terrace classified by the model as Very High, and the knoll, represented by the High potential area. Some areas of the terrace edge appear to be missed by the model.

Site HkRe-1 is actually probably an Archaic site rather than a Palaeo-Indian site. It is located about 20 meters northeast of a small ridge overlooking a swampy lake (see Figure 71) that was classified by the model as of High and Very High potential. This east-west running ridge feature is associated with other ridge features in the area, including several that are running north-south.

It is pertinent to point out that these misses may be due to the spatial accuracy that the 1:20,000 NTS maps (and the 1:50,000 maps with which many were originally mapped) can afford. These were used to obtain the coordinates of both sites and expectedly would carry some degree of error, thus making it likely that the sites actually fall within the high potential areas identified by the model.

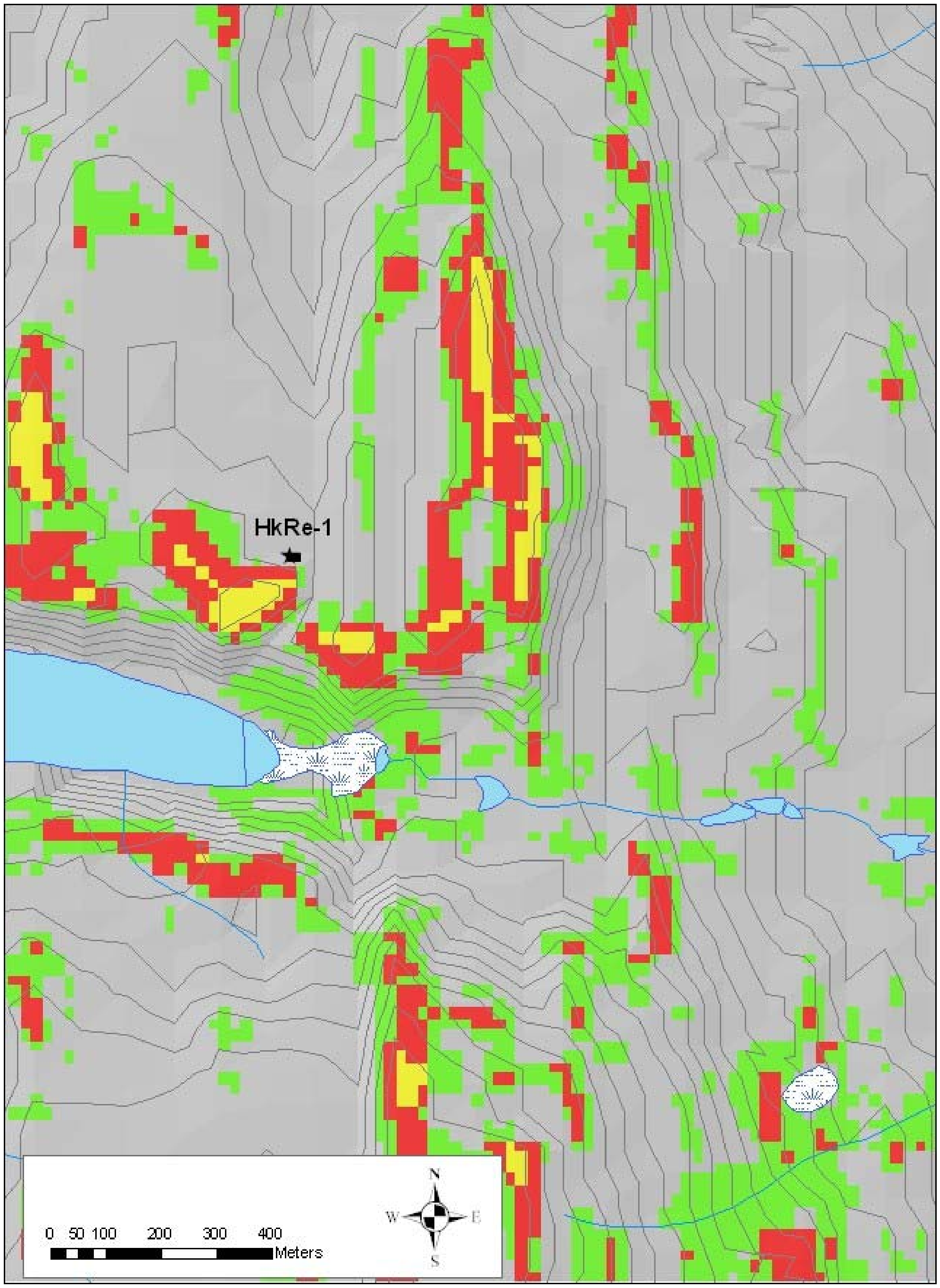


Figure 71. Location of HkRe-1. Note the proximity to a well-defined landform rated as High to Very High by the model.

The other missed sites (HkRo-2 and HiRi-1) illustrate one of the shortcomings of TRIM related to the precision of data used in landform modelling (discussed above in the landform modelling section). Figures 72 and 73 show the models and sites plotted along with the sampled elevation points from which the DEMs were derived. It becomes clear that with a 70 and 90 meters spacing between points, small landforms will inevitably be missed.

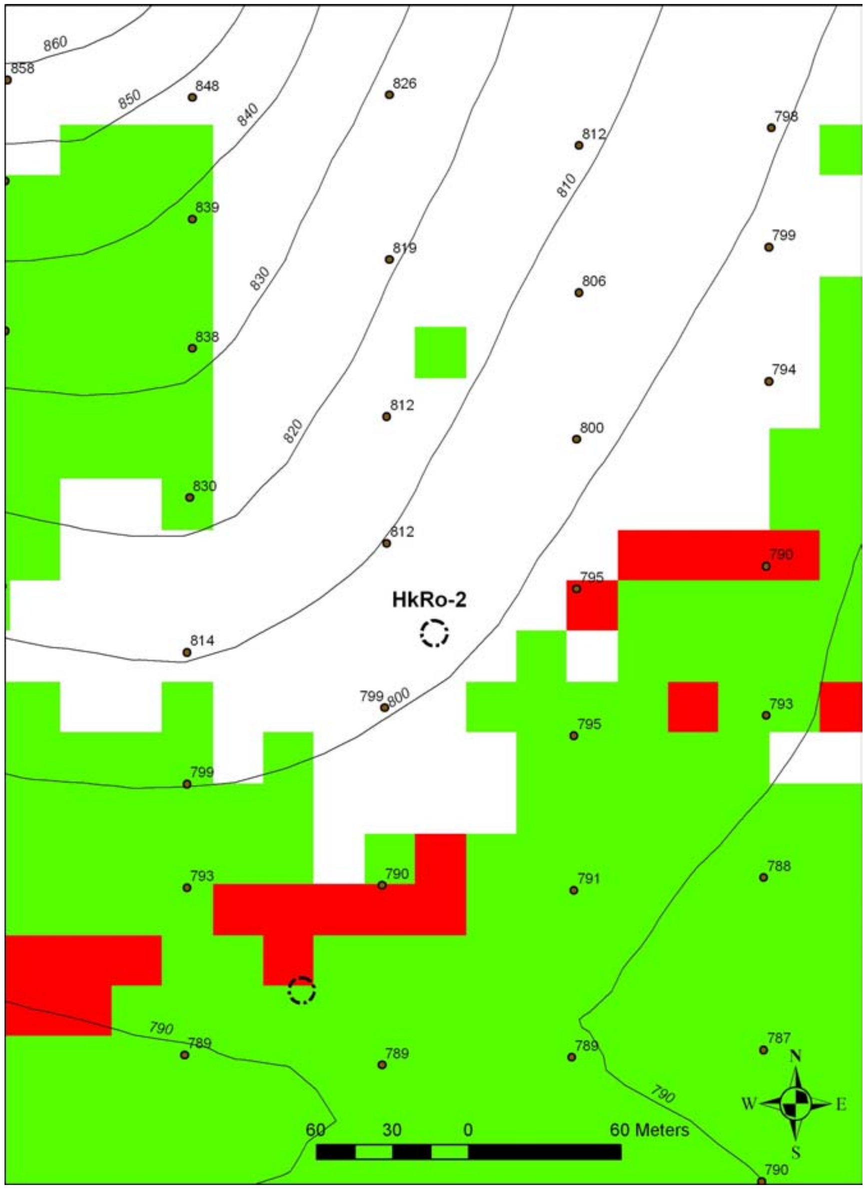


Figure 72. TRIM elevation points plotted along site HkRo-2. 10 m contour interval.

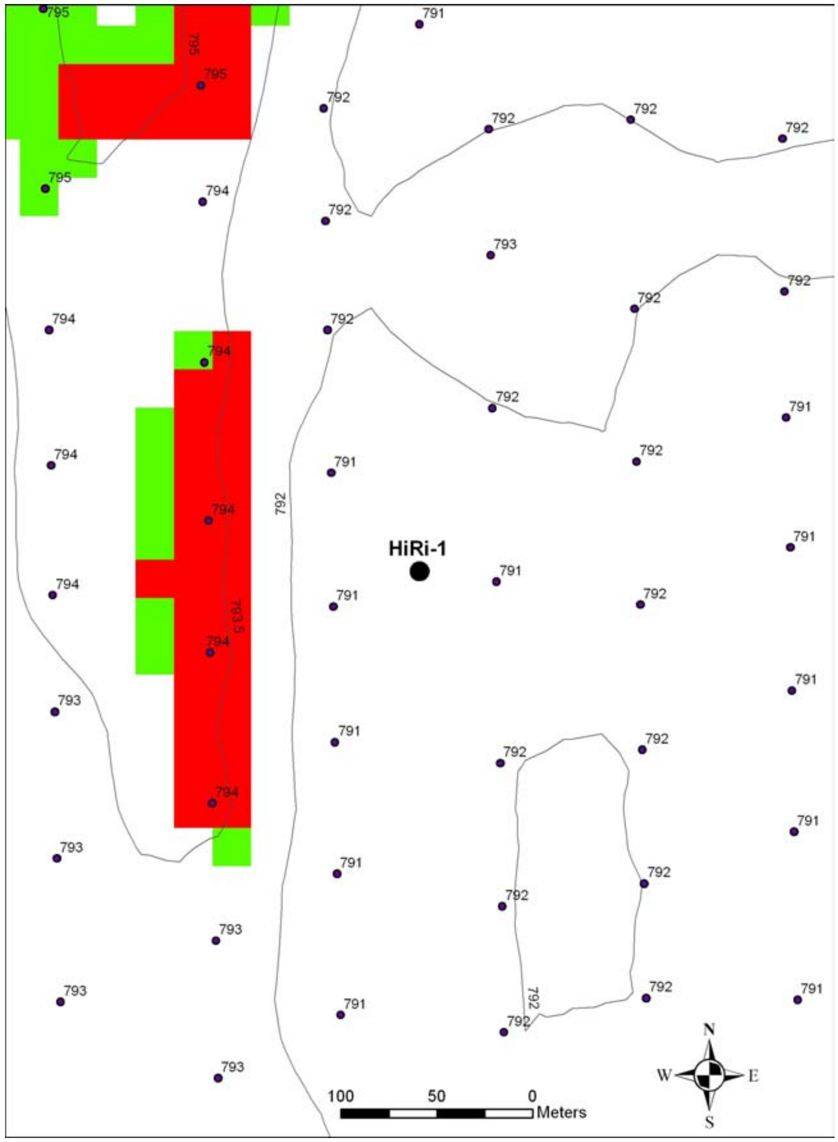
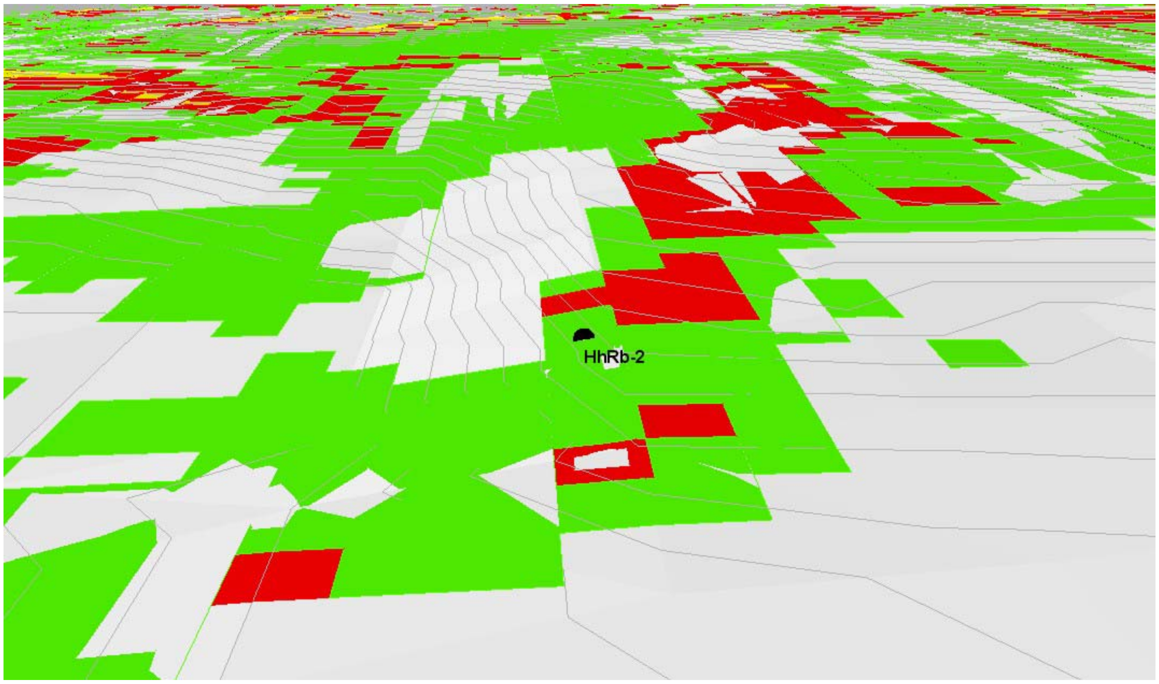


Figure 73. TRIM elevation points plotted along with Palaeo-Indian site HiRi-1 and model. A low ridge 80 m to the west is captured, but the small rise on which the site is located is missed.
Contour interval 1.5 m.

Figure 74 shows the last two Palaeo-Indian sites included in the analysis within the study area.



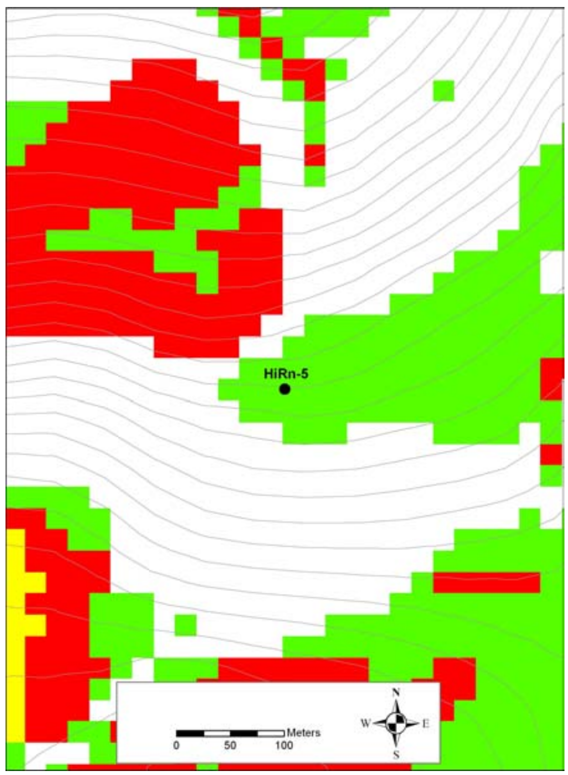


Figure 74. Palaeo-Indian sites HhRb-2 and HiRn-5 plotted on CLH and MUP models.

HhRb-2 is a Palaeo-Indian site along a pine ridge. The site is comprised of a single isolated find, a Scottsbluff point. Although the site falls within an area ranked by the model as of Medium potential, its proximity to a High potential area (about 8 meters) lends further support to the reliability of the model. HiRn-5 is a Palaeo-Indian (or Archaic) site represented by an Oxbow type projectile point. It is located at a break in slope near the base of a hill descending northward into the Sikanni

Chief River valley. This site was also captured within a Moderate potential area, about 46m southeast of a High potential area. Examination of the contours in Figure 74 suggests that the break in slope was recognised from the DEM. The green Moderate potential zone follows a slight widening of the contours (nearby High potential results from the addition of forest cover variables).

As stressed at the outset, Palaeo-Indian research was considered a high priority for Millennia Research as these significant sites were potentially missed by earlier models. We believe that the model will prove useful to palaeo-Indian researchers who wish to conduct site inventory. Features such as the parallel crescentic shapes on the report cover are probably low ridges resulting from beach berms and duning along a retreating glacial lake margin. Such a location has a very high potential for Palaeo-Indian sites, and this area has not been mapped for geomorphology; likewise, standard contour maps would also not show these features. The model represents a valuable tool for conducting Palaeo-Indian inventory work.

Recommendations

Guidelines on how to use the model are presented in Appendix 1. In general, it must be remembered that the present model (actually, a suite of models) uses a method of directly detecting high potential landforms that is quite effective for moderate and large features, but relies on proxy variables such as forest cover to identify smaller features. Distance to water features is also used, although the models are not as 'hydrocentric' as many previous ones. Some microtopographic features with archaeological potential will be missed completely, however, and around one-fifth to one-quarter of all known sites are missed by the current model. There is the potential to identify such small landscape features from other means (including LIDAR, orthophotos, and detailed large-scale development maps) during development planning.

Appropriate interpretation of the model is also critical. The people using the model may include an archaeologist determining the need for fieldwork or a planner routing a pipeline. In the case illustrated in Figure 70, the missed site clearly falls at the edge of a deeply incised river valley. The pixels of high potential form an obvious pattern following the edge of the drop-off. Due to computation peculiarities, some of the edge pixels were not captured by the model. Reference to an orthophoto or detailed plans may help define the precise boundaries of the feature, and any areas along the edge should be assumed to be high potential, even if pockets are rated as low by the model. For planners designing road or pipeline routes, the models can be used as a guide to reducing the amount of required fieldwork and potential conflicts. However, where possible it would be prudent to avoid 'shaving corners' but rather to avoid areas of potential by a fairly wide margin – at least 60 metres. This will reduce the problem of sites located a few metres outside potential zones due to mapping scale or other errors. Other sources of information must also be consulted in making a determination of the need for further archaeological study: see Appendix 1 for details.

Archaeologists using the model should be particularly aware of linear features not related to modern drainage features. In some cases, these may be groups of higher potential polygons that are non-contiguous, but may form patterns stretching for many kilometres. Such features, such as the possible glacial lake strand lines illustrated on the cover, may have formed during the late Pleistocene or early Holocene period and may have a particularly high potential for palaeo-Indian sites. Such features are often too subdued to be visible on topographic maps and may not be readily apparent on orthophotos.

The Steering Committee has had a long-standing concern that the model development not end with the completion of the contract, and that new data and analytical methods be introduced through time. We concur with this position, and can make a few recommendations. The main one is that LIDAR data should be obtained and used to model in lieu of the present data obtained principally from TRIM and Forest Cover Mapping. LIDAR DEM can provide not only the normal measures of elevation, slope, and aspect insolation, but also landform (including microtopographic features), and tree height. The last can produce maps on a measured tree-by-tree basis, unlike the generalized and often inaccurate Forest Cover mapping. This might be highly productive for modeling environmental boundaries this and the size of trees might be useful to fine-tune archaeological potential rating. Landform mapping using LIDAR would be quite sufficient on its own, however, for the next generation of archaeological potential maps. LIDAR modelling greatly reduces the proportion of land area modelled as having potential, yet includes high potential landforms and archaeological site locations that the TRIM based model misses. LIDAR modeling can be expected to increase the accuracy of the models by several orders of magnitude.

One of the areas which remains a data gap in the present model is aboriginal trails. Although many trails were obtained or digitized from historical sources, many more are not incorporated in the model. This variable produced the strongest association with archaeological sites of all in the analysis conducted in Year Two. A number of attempts to obtain additional data from First Nations in the area met with mixed results – several were willing to share their data with us, but for logistical reasons the data transfer never occurred. Filling this data gap would improve the current models.

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Appendix 1: Potential Map Interpretation

Model Interpretation – Consultants Version

The Millennia Research archaeological predictive model was completed on behalf of the Oil and Gas Commission for much of the NE oil patch. Details regarding the Archaeological Overview of which the model, including analytical methods and model development, are available from yearly reports online at millennia-research.com (Benson, et al. 2003; Dady, et al. 2001; Eldridge, et al. 2002). Other directions on fulfilling archaeological requirements can be found on the "Archaeological Definitions and Guidelines" and "Flowchart" produced by the OGC. This guide is limited to interpreting the map itself.

This guide is to be followed once the model has been installed and the maps are displaying correctly on your computer. Metadata, README instillation files, and text files detailing suggested display options are supplied separately in electronic format.

Definition of "Four-colour" and "Full-Range" Potential Maps and Hillshade Layer

As consulting archaeologists, you will have access to the four-colour and full-range potential maps to help assess whether fieldwork or additional evaluation should take place. It is necessary to know the differences between these map layers. You will probably find you will use the four-colour map as the basic guide, but will sometimes want to obtain additional information from the full range potential maps (Figure 66).

Full Range Potential Map - Definition

The full-range maps provide the full range of numeric scores for each ecosection model. Depending on the ecosection, the scores can range from –3 through 15, to -1 through 8. The higher numbers reflect higher site potential, and correspond to higher known site densities, and increasing risk of impacting archaeological sites for developers.

Four Colour Potential Map – Definition

The four-colour maps have had the full range model potential numeric scores divided into a standard "Low, Medium, High, Very High" categories. These categories have increasingly high site densities. Nearly half the known sites occur in Moderate potential, but High and Very High have large numbers of sites in a much smaller area.

Different Display Modes with Full Range Potential Maps

Figure 75 shows the model score with clearly separate colours for each score value. Sometimes it is more useful or interpretations are easier if this map is displayed using colours that consistently increase in hue with an increase in potential rating (Figure 76). This view allows a rapid assessment of "cool vs. hot" zones in the map, which can be compared to development locations or alternate routing options. This view also often highlights errors in the digital elevation model, which will be described below.

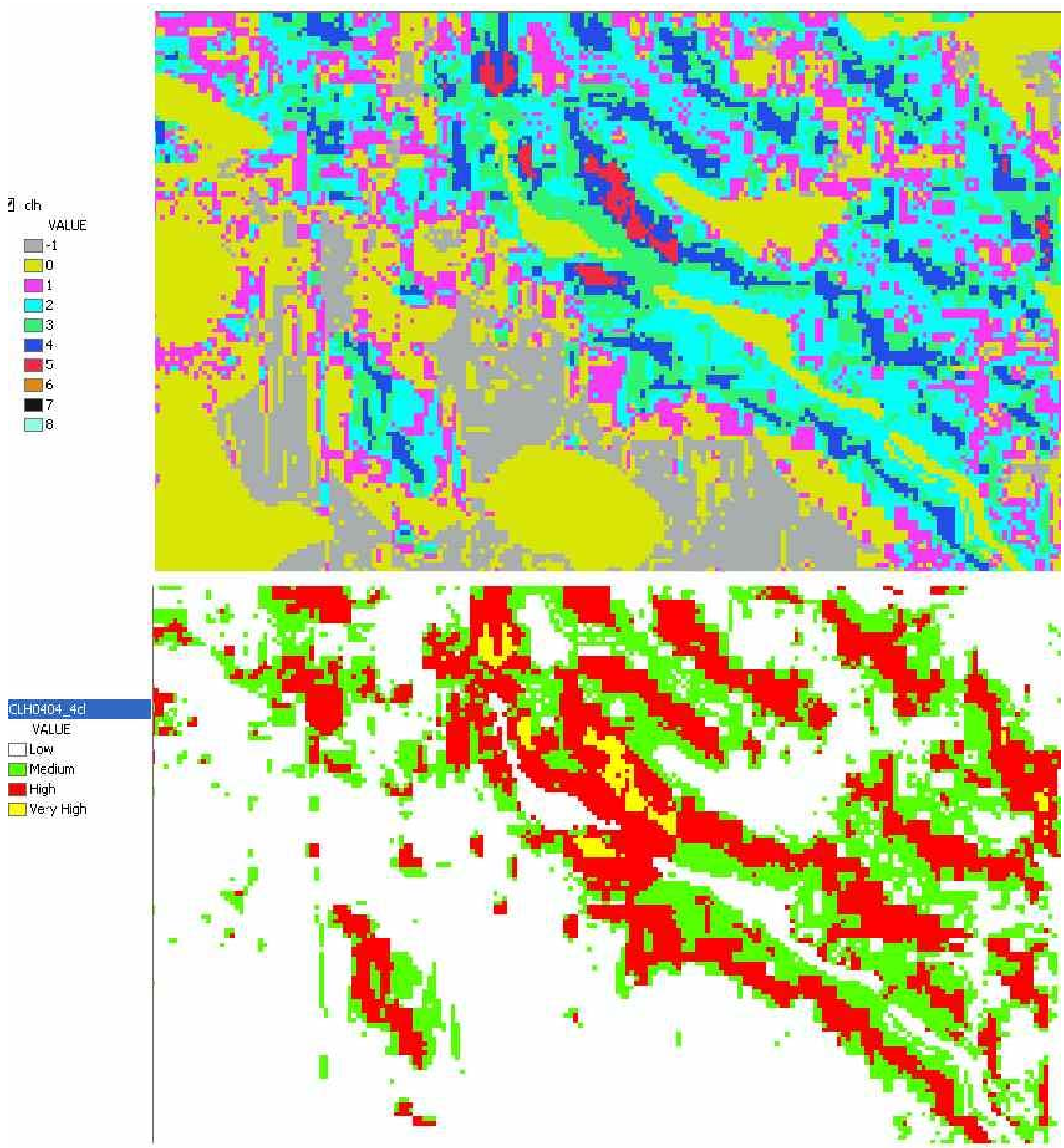

Figure 75. Contrast between Four-colour and Full Range Model Scores.
The Full Range scores show intermediate levels of potential within each of the four class model classes.

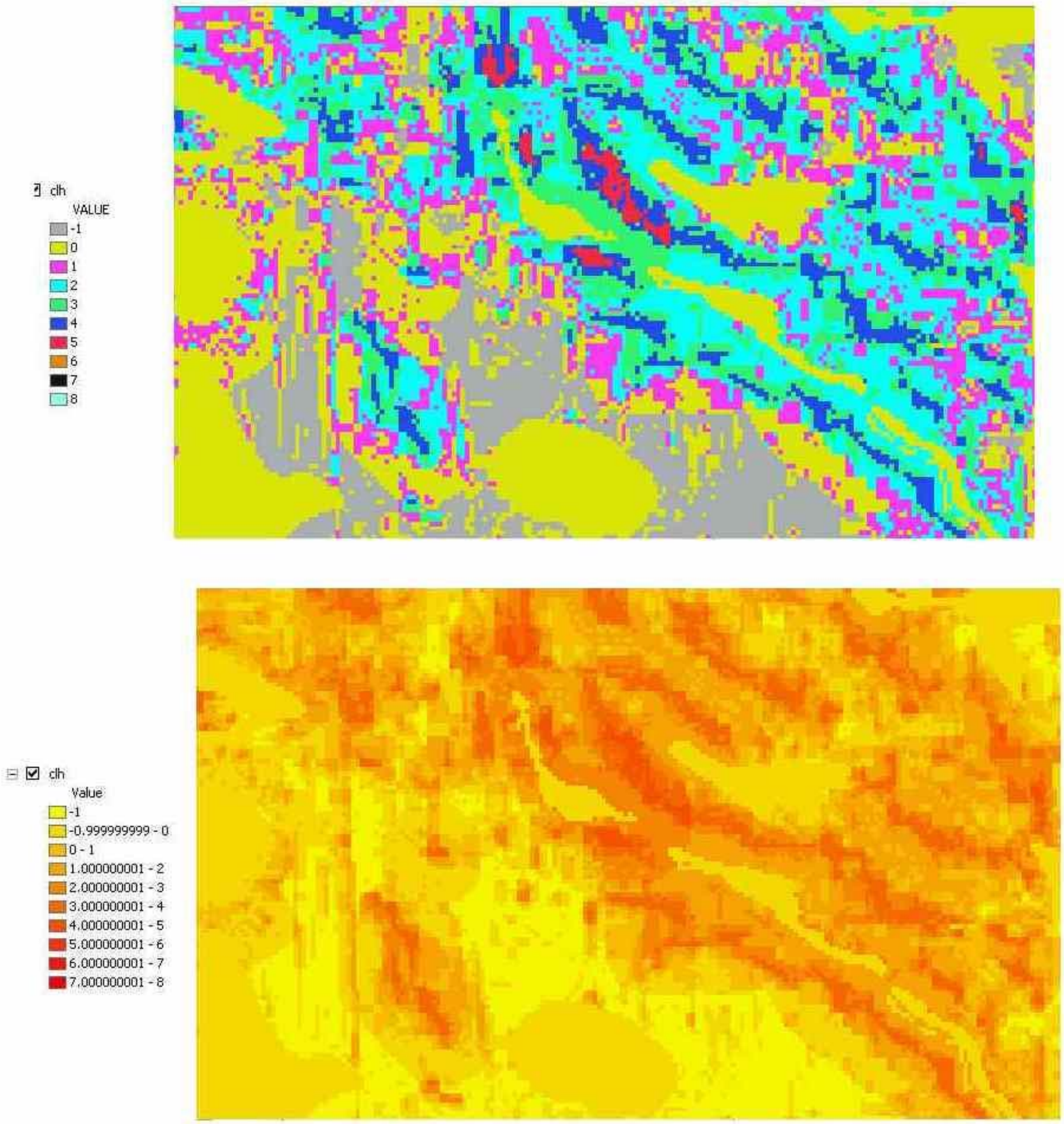

Figure 76. Contrast between Model Scores displayed as unique colours and graded colours. The model (raw) score can be displayed as unique colours to assist in identifying specific potential scores (top). However, it is more easily interpreted as a colour range, with lowest potential in one colour grading to highest potential in another (bottom, in this case yellow low to red high). This can enhance patterns that may be invisible using unique colours and less evident in the four-colour model. Most GIS software allows you to control the display in this way.

Hillshade Layer

A hillshade layer is provided as part of the model package. The hillshade represents the digital model of the land surface, shaded as if the sun was in the northwest at a 30 degree angle from the horizon. The hillshade layer highlights landforms and archaeologists have found it particularly useful in helping assess potential and interpreting the model (Arcas Consulting Archeologists Ltd. and Eagle Valley Research Ltd. 2004).

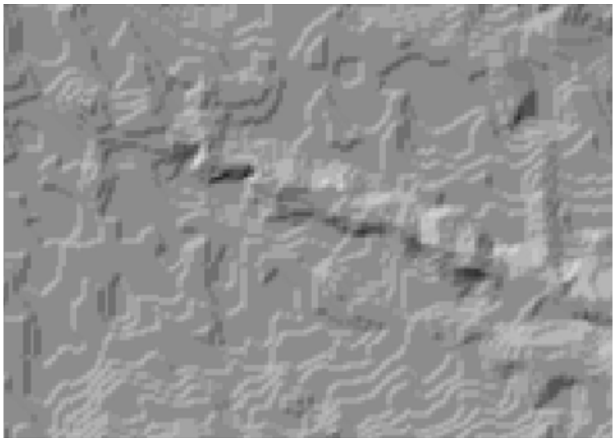

Figure 77. Hillshade at 1:20,000 scale.

A ridge feature is visible, but is unclear when the hillshade is viewed at 1:20,000 scale. Gradual slopes tend to look like small terraces with 1 m steps.

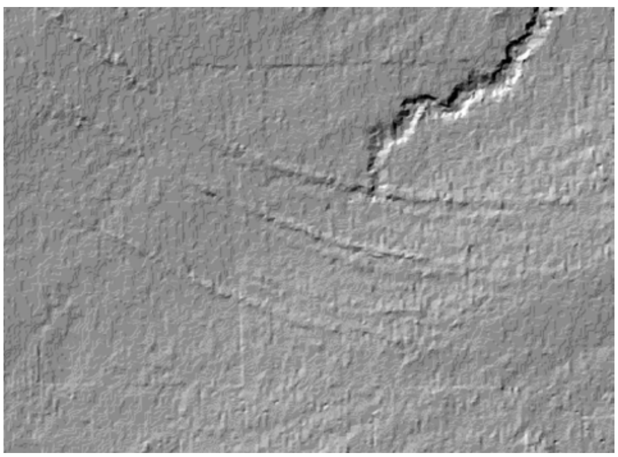

Figure 78. Hillshade at 1:100,000 scale.

Same area as above zoomed out to 1:100,000 scale. The ridge feature is shown to be one of a series of parallel crescentic features, perhaps a series of glacial lakeshores at different stillstands. A modern creek begins at one of the ridges and proceeds to the northeast out of the frame. In general, the features and landforms appear smoother and are easier to see at this scale compared to 1:20,000 scale.

Due to the nature of TRIM data, the hillshade is best viewed at scales of about 1:100,000 (Figure 78), although larger scales can provide useful detail once overall patterns have been identified.

Examples Where the Model may Under Represent Archaeological Potential.

High potential microtopographic features cannot be modelled for using TRIM data, and may be modelled as Low potential. Microtopographic features are discussed briefly below and in more detail in the NE Overview annual reports.

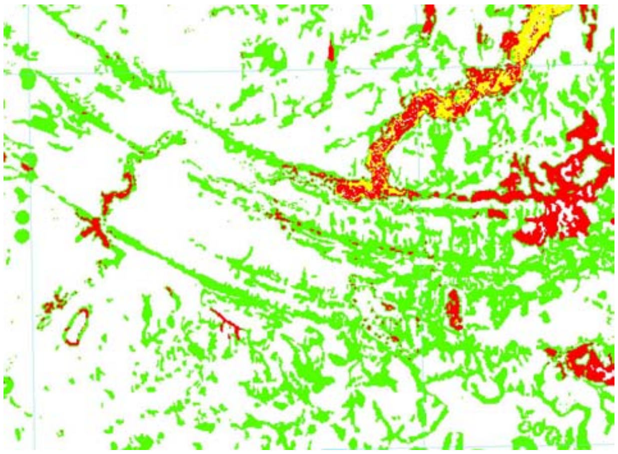

Figure 79. Crescentic features modelled as moderate potential.

Same area as Figure 78. The parallel crescentic ridge features are caught by the model, but they are shown mostly as moderate potential. The parts with the highest relief are high or very high potential. These are long features, about 20 km long each, and they may have served as travel corridors. Almost certainly sites are concentrated along their crests. Such features should be considered to have high, rather than moderate, potential, along their entirety. Note that sections of these features are included in the model where they are virtually invisible or very subtle in the hillshade.

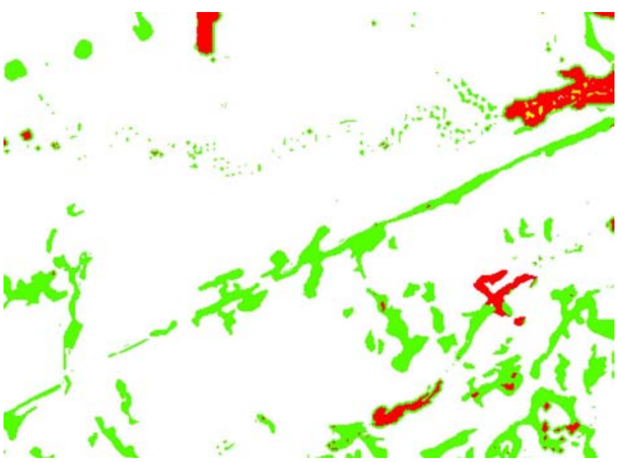

Figure 80. Linear feature modelled as moderate potential.

This figure shows a prominent linear feature running NE to SW. Such perfectly straight features should be examined with care, since they could be an artifact of DEM errors, or an anthropogenic feature. Scale is about 1:50,000.

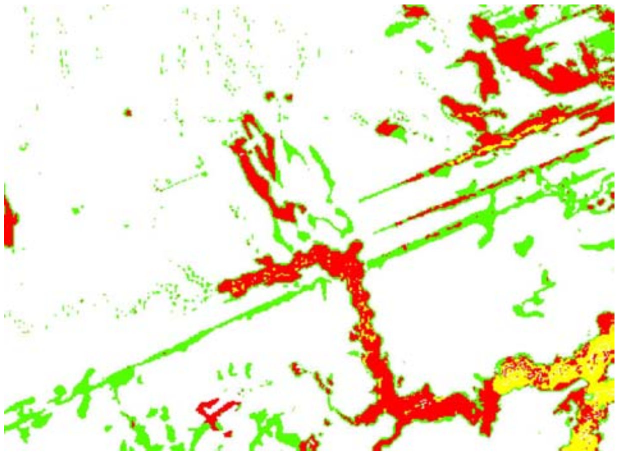

Figure 81. Linear feature displayed at a smaller scale.

Same area as above zoomed out to 1:75,000 scale. The linear feature is actually one of a series of parallel linear ridges. The parts of this ridge shown as moderate potential should probably be considered high potential. The converse may also be true: straight features shown as moderate or high potential may be actually low potential if they are DEM errors (see below).

Instances Where the Model may Over Represent Potential

In general, the model is somewhat conservative and tends to over represent potential. Features with high archaeological potential will tend to be buffered. Comparison with lidar hillshading (see below) shows generally good correspondence for modelled features, but the size of the actual feature is often much smaller than the area modelled as high potential. Particularly on ridged topography, the ridge top will have high or very high mapped potential; the flanks of the ridge may also be modelled as moderate or high potential that is actually low. This can be taken into account where a linear development such as a pipeline parallels two clear ridges, but is well offset from both crests. It may be appropriate to determine that the archaeological potential and risk of impact is actually low for this particular situation. As with every instance, multiple sources of information should be used to make this determination.

Misclassification of landforms due to TRIM DEM (digital elevation model) inaccuracies are a major source of locations with overrepresented potential. These locations are often relatively easy to identify. Many occur along map sheet boundaries; others occur as a result of a 'waffle' pattern in the data.

The nature of the TRIM DEM is that the precision is often greater than the accuracy. This manifests in a 'waffle' pattern often visible in the hillshades. Square areas are precise relative to internal readings, but jump several metres in elevation where they join another square area – all within the acceptable TRIM accuracy targets (Figure 82, Figure 83).

 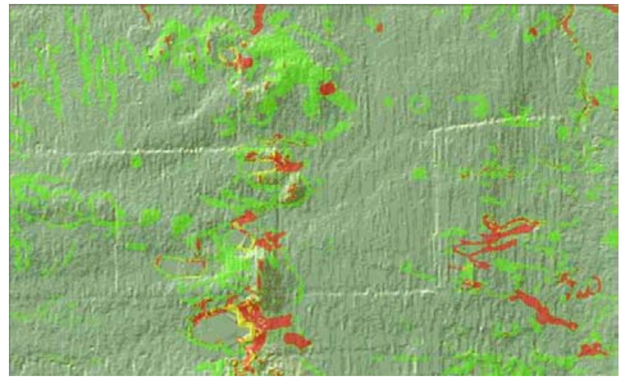

Figure 82. TRIM DEM 'Noise' features.

The left image shows a characteristic 'waffle' pattern in the hillshaded DEM, where 'tiles' of data are several metres offset in elevation to each other. In this case, it did not affect the potential model (right image, overlaying the potential model), because the change in elevation was below the threshold the model was instructed to identify.

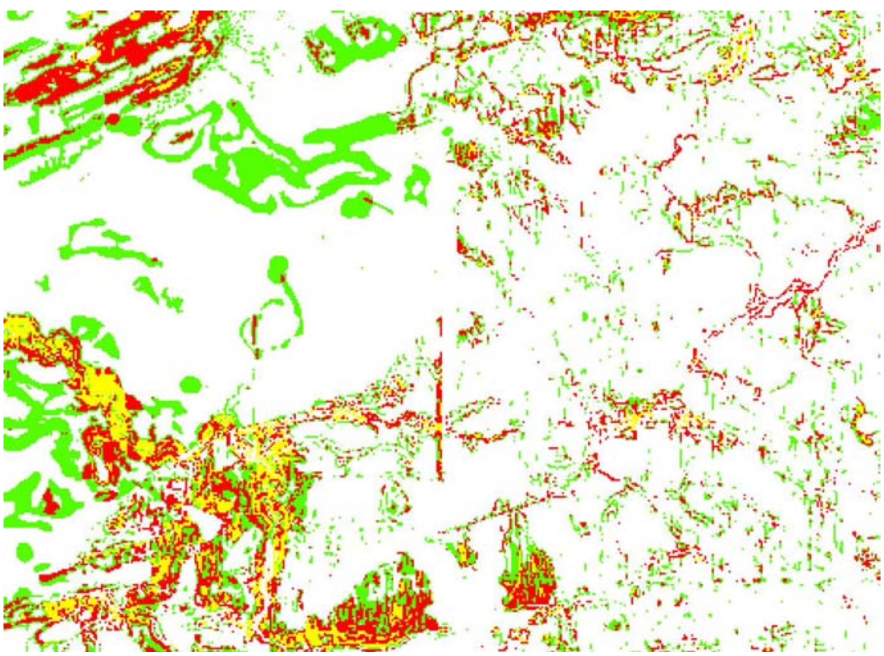

Figure 83. TRIM DEM 'Noise' features.

The model over represents potential along some waffle boundaries in this figure (see arrows). For a development falling along such a feature, it would be appropriate to interpolate from other modelled features bracketing the error.

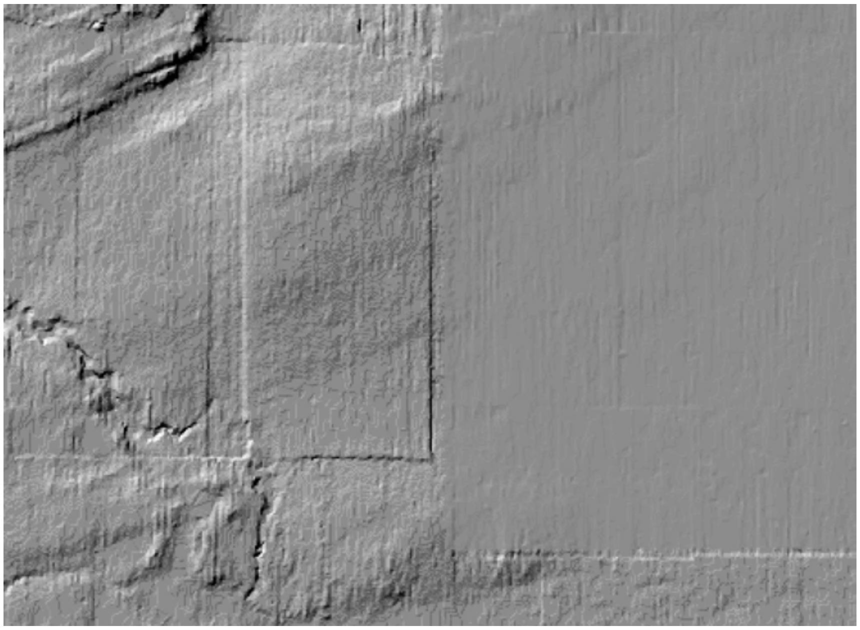

Figure 84. TRIM DEM 'Noise' features.

The hillshade for the previous figure area makes the overrepresentation easy to confirm. Also note the variation in the level of detail in different parts of the DEM.

If higher potential occurs in straight lines following this 'waffle' pattern, then the higher levels of potential should be discounted, and a potential rating interpolated from the values on both sides of the line. Ensure that regularly spaced north-south ridges (which occasionally occur in the area) are not present. Such features will be evident in vegetation changes or shadows visible in orthophotos, whereas DEM noise will have no correlation with ground vegetation. With practice, you will be able to distinguish these without reference to the orthophotos.

The use of forest cover as a proxy for terrain results in moderate potential assessed for areas that actually have low potential. In some parts of the study area, operational use of the model found that many areas mapped moderate potential were covered by aspen (poplar) but a lack of differentiated terrain meant that they had low archaeological potential (Arcas Consulting Archaeologists Ltd. and Eagle Valley Research Ltd. 2004). These could be reassessed as low potential if there is other information confirming the lack of topographical features.

Considering Model Variables when Interpreting Model

Archaeologists using this model (or any model, for that matter) often want to know why the model scores a piece of land as it does (AH Stryd, personal communication 2004). Knowing why an area scores moderate or higher potential can help determine the level of effort recommended for further study.

Ideally, consultants would have access to all the data that contributes to the model to determine how, exactly, a certain grid cell obtained its potential rating. Unfortunately, the model uses too many layers of information for this to be reasonable, and would require a very large amount of computer storage space. However, broad categories of attributes contribute to potential: landforms, water bodies, forest cover, and cultural features, and an informed guess can usually be made regarding the reasons for a potential rating.

Proximity to water.

Proximity to water bodies will be evident from the hillshade or in a comparison with topographic maps.

Landforms

Landforms are generally ridges, hilltops, terrace edges, or other slope breaks. Landforms can provide a range of additional values: for instance, a local hilltop situated on a terrace edge may be scored on several individual landform variables. The model comes with separate slope and hillshade layers (Figure 86, Figure 85). When displayed under the potential ratings, these two layers should allow visual identification of many landforms that contribute to potential. Some landforms may not be evident under certain lighting conditions (and if Figure 78 and Figure 79 are compared, the crescentic landforms are more continuously emphasised in the model and appear more interrupted in the hillshade). Comparison of the TRIM hillshading with an orthophoto (most are available through RAAD) is also very helpful for interpretation.

Microtopographic landforms cannot be derived from TRIM digital elevation points, which are about 80 m apart: the DEM interpolates these to 20 m cells. The minimum size landform recognized will be about 100 m or more across in both east-west and north-south dimensions, except in unusual circumstances. LIDAR, if available, should be used to identify microtopographic features (Figure 85).

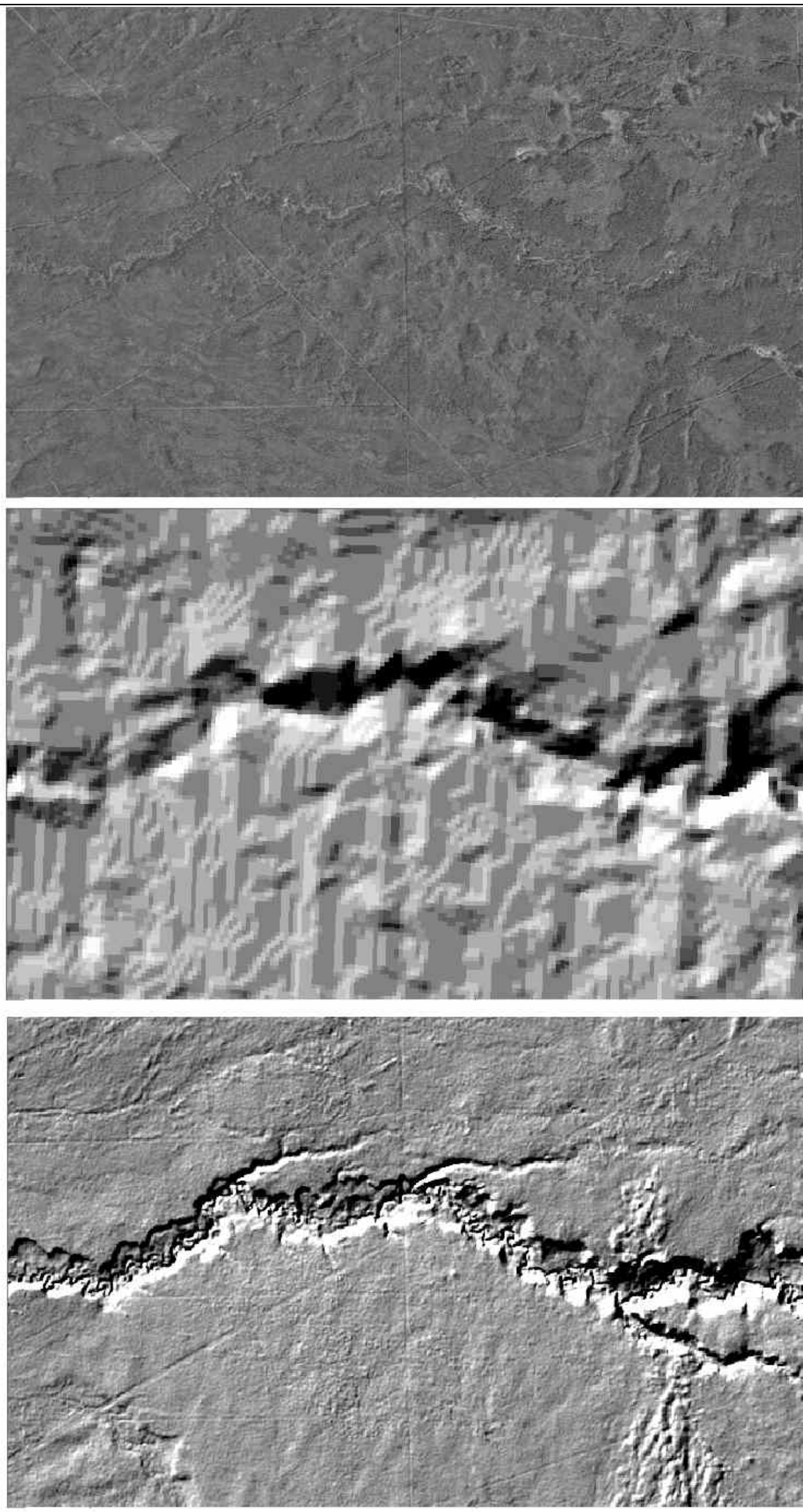

Figure 85. Orthophoto (top) compared to TRIM hillshaded DEM (middle) and to LIDAR bare-earth hillshaded DEM (bottom).
Actual LIDAR is nine to 36 times more detailed. This illustrates why microtopographical features can be modelled for in LIDAR but not in TRIM, and can be invisible or difficult to interpret from orthophotos. Scale about 1:10,000.

Forest Cover

Irregular polygons of moderate or higher potential are likely due to forest cover that correlates with site location, especially if no landforms or water features can be seen (Figure 86). Where forest cover co-occurs with landforms or proximity to water features, then the potential may be increased to high or very high.

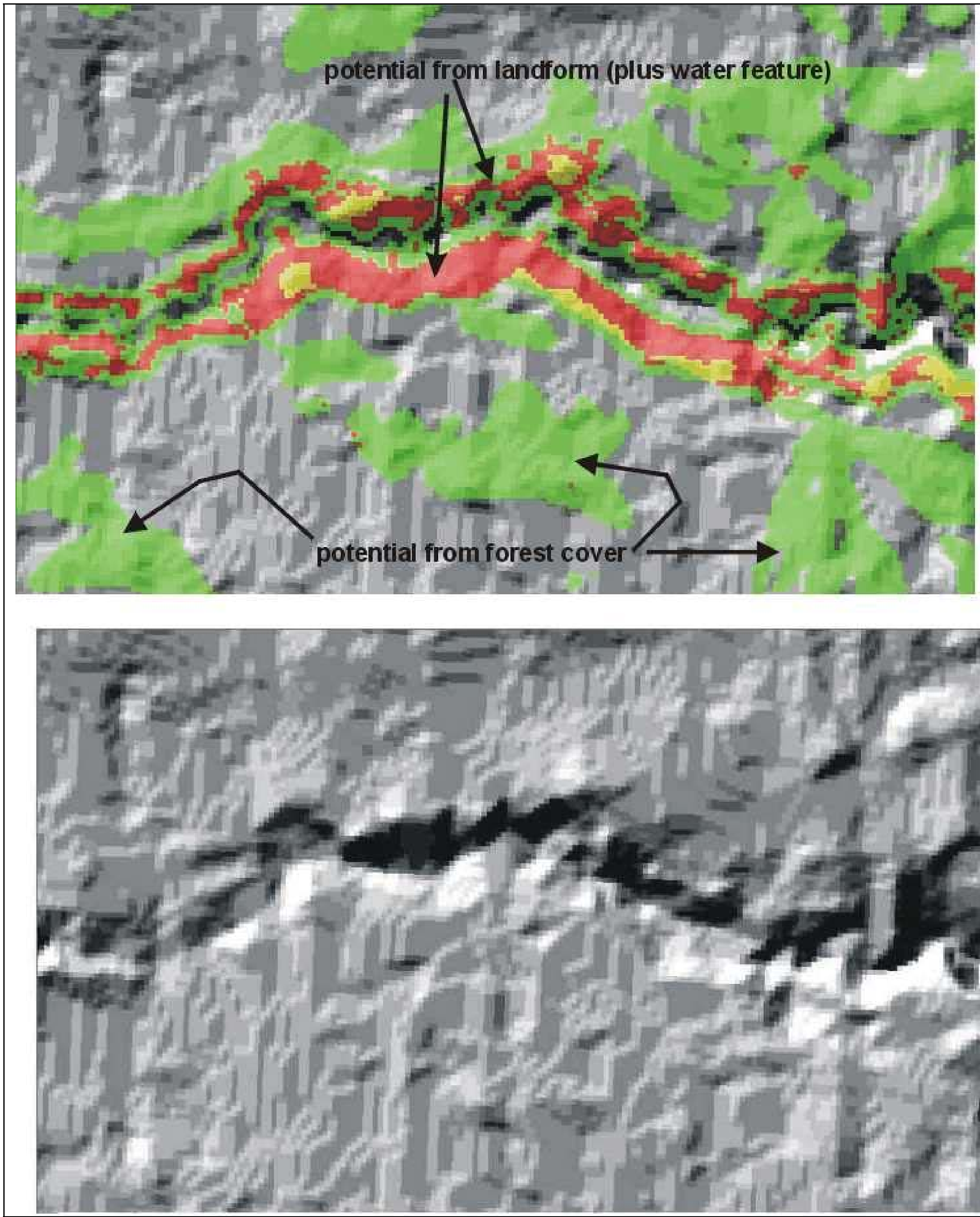

Figure 86. Landform and forest cover potential interpretation. Four colour map and hillshading shown.

Trails

Trails will often be evident from linear bands of higher potential (Figure 87).

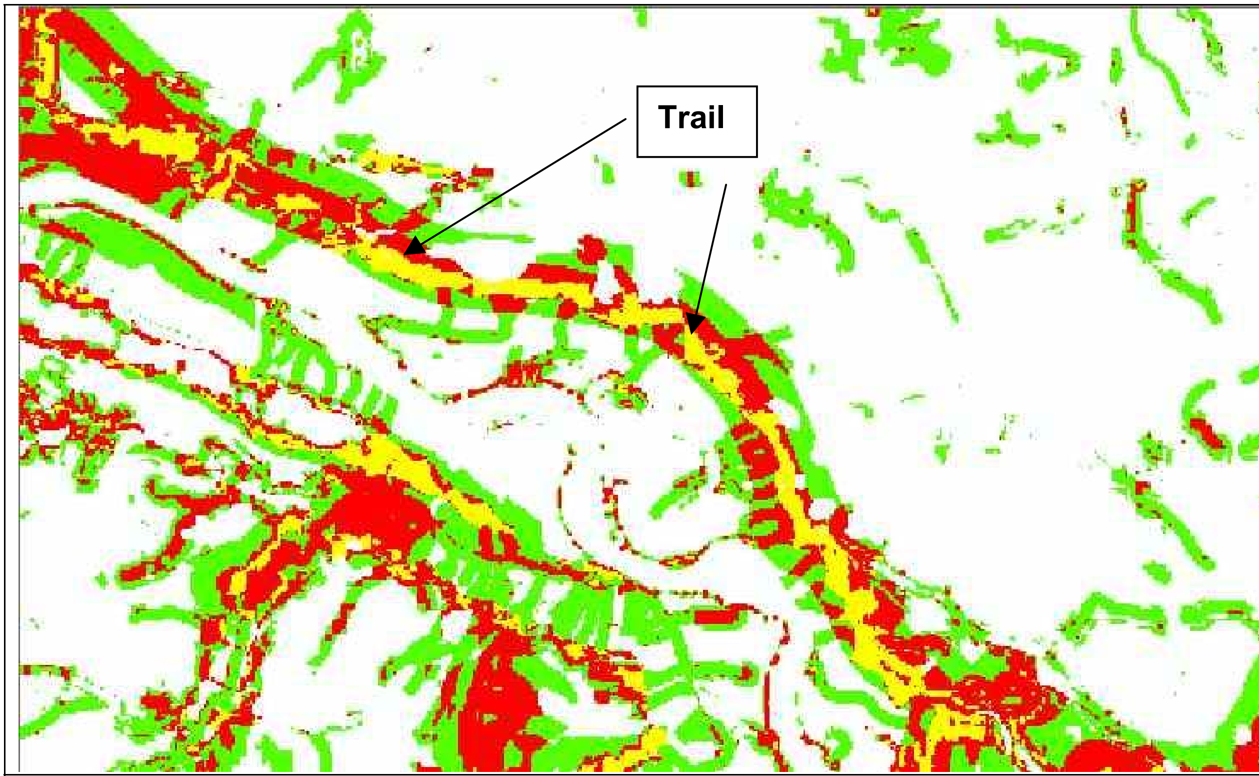

Figure 87. Trail.
Trail is evident following north terrace of meandering river. Potential values derived from landforms, forest cover, etc. are increased in two buffer widths. Scale about 1:50,000.

If you are conducting an AOA or pre-AIA review and know the locations of aboriginal trail features that aren't evident on the potential maps, you should increase the potential classes of moderate and higher to high or very high within a few hundred metres of such a trail. Trails are strong predictors of archaeological site locations.

Model Interpretation – Industry Version: Binary Model

The Millennia Research archaeological predictive model was completed for much of the NE oil patch for the Oil & Gas Commission. Details regarding the Archaeological Overview of which the model is a part are available online at http://millennia-research.com/reports.htm . Other directions on fulfilling archaeological requirements can be found on the "Archaeological Definitions and Guidelines" and "Flowchart" produced by the OGC. This guide is limited to interpreting the map itself.

The map provided to industry has two levels of potential: low and high. The 'cutpoint' between these values has been set so that about 85% of known archaeological sites fall in the 'high' zone. The zone rating is one of the key steps in following the "Flowchart". Generally, if a proponent's development includes "high" then the services of an archaeological consultant must be obtained for further Overview level work to determine if fieldwork is necessary. If the development is all in "Low", then other factors must be evaluated to determine if further assessment by an archaeologist is necessary, but the services of an archaeological consultant are not necessarily required to make this decision (Table 7).

Table 7. Basic Map Interpretation

LOW	Consider other factors to determine if further archaeological assessment is necessary
HIGH	Obtain services of archaeological consultant to determine if fieldwork is necessary.

In a few situations, however, the model may clearly misrepresent archaeological potential, and proponents can override the model in these specific cases. These situations occur along or adjacent to some joins of TRIM 1:20,000 scale mapsheets. They are the result in errors in the TRIM DEM in mapsheet overlap areas (the DEM for each mapsheet extends for several hundred metres onto the adjacent mapsheet). The following give some examples of how these errors will appear on your system. Figure 88 shows a join error viewed at 1:150,000 scale. Note: you should see the virtually identical view on your system: ensure that "1 to 20K" shapefile is turned on and the "1 to 50K" and "Borden" shapefiles are turned off. The error is seen as a white strip going due east-west beside the mapsheet boundary.

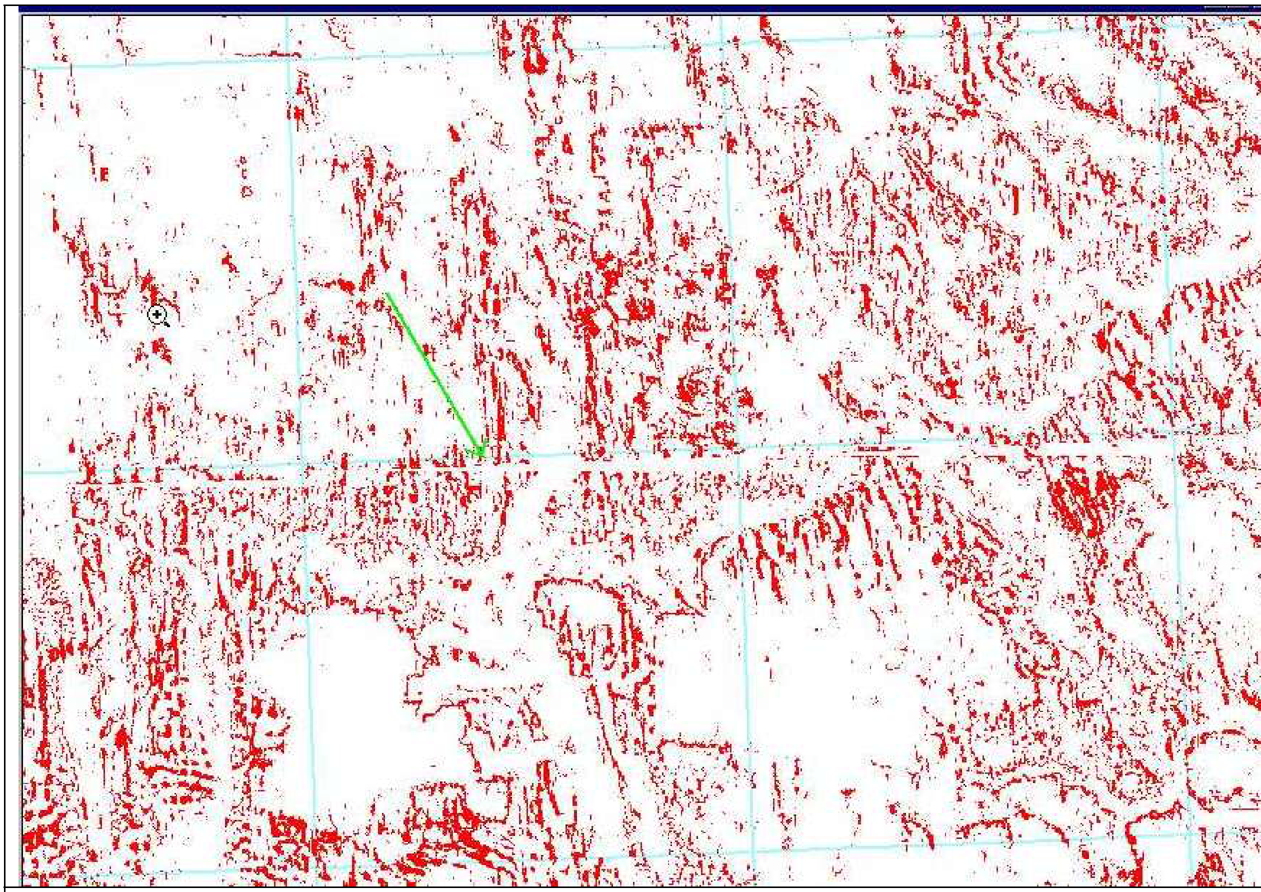

Figure 88. Example of map sheet join error, visible as a horizontal white strip (green arrow indicates location). Scale about 1:50,000.

In many of these areas, clear patterns are present on both sides of the errors, and interpolations are safe to make. In Figure 89, the map is being viewed at about 1:40,000 scale. The low potential (white) areas labelled "1" in the green boxes are safe to interpret as "low", but those labelled as “2” are uncertain, and should be considered “high”, since the patterns to the north and south are either high or mixed high and low and therefore uncertain. The risk of making interpretation errors that adversely impact protected archaeological remains is relatively low, provided that subsequent steps are followed as shown in the flow charts for the evaluation of “Low” potential (examination of other data sources).

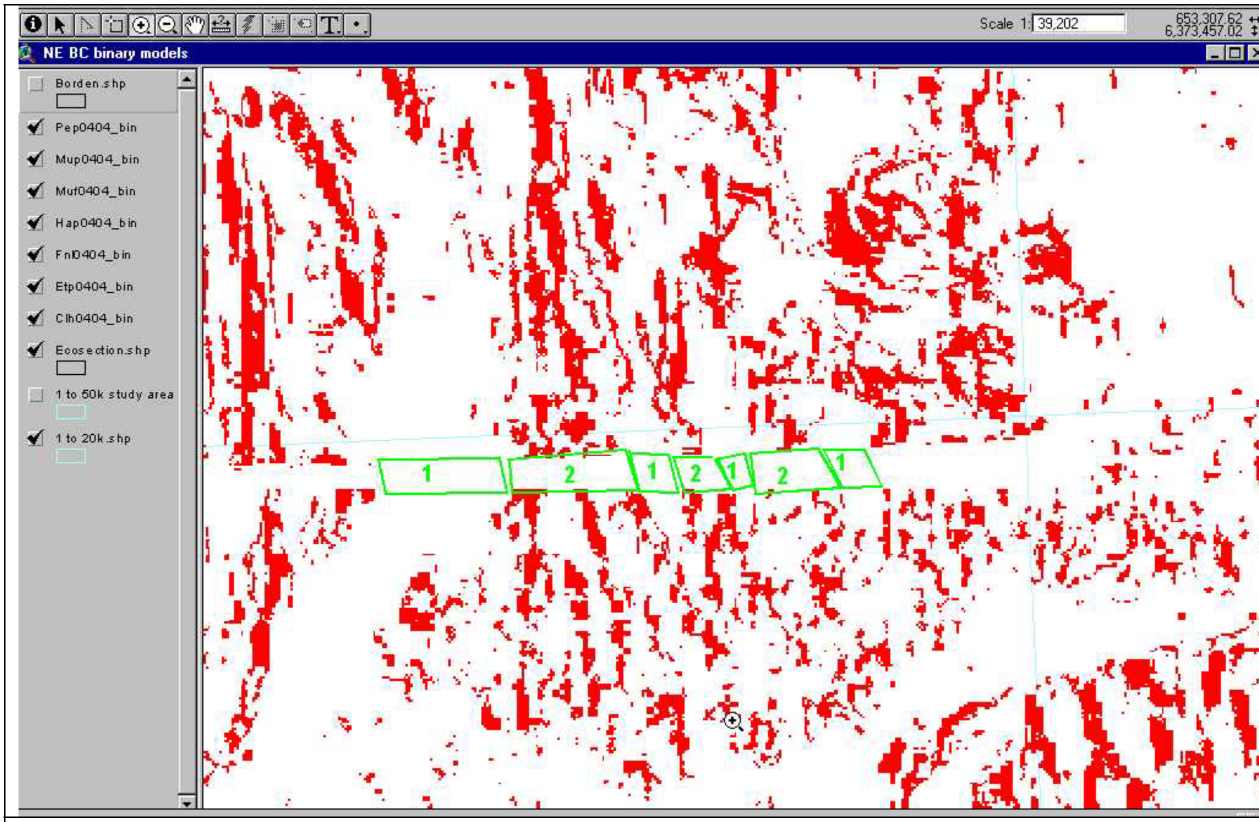

Figure 89. Error correction.
In boxes labelled “1”, a clear pattern of low potential is found on both sides of the error strip. In these cases, interpolation as ‘low’ is justified. In the boxes labelled “2”, potential is high or mixed high and low with no clear pattern. In these cases, a “high” potential rating should be assumed.

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