nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

March 4, 2011

Mayor Mike Natomagan
Northern Village of Pinehouse
Box 130
Pinehouse Lake, SK S0J 2B0

Re: **Adaptive Phased Management Initial Screening –Northern Village of Pinehouse**

Dear Mayor Natomagan,

Further to your request to Learn More about the Adaptive Phased Management program and request for an initial screening, I am pleased to attach a report outlining the findings from the initial screening, as described in the *Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel* (May, 2010). As you know, the purpose of the initial screening in Step 2 of the process is to determine whether, based on readily-available information and five screening criteria, there are any obvious conditions that would exclude the Northern Village of Pinehouse from further consideration in the site selection process.

As the report indicates, the review of readily-available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Northern Village of Pinehouse from further consideration in the NWMO site selection process for the deep geological repository for Canada's used nuclear fuel. Should your community choose to continue to explore its potential interest in the project, your area would be the subject of progressively more detailed assessments against both technical and social factors to confirm the suitability of your community. Several years of studies would be required to confirm whether a site within your area could be demonstrated to safely contain and isolate used nuclear fuel.

The process for identifying an informed and willing host community for a deep geological repository for the long-term management of Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future. The NWMO expects that the selection of a preferred site would take between seven to ten years. It is important that any community which decides to host this project base its decisions on an understanding of the best scientific and social research available and its own aspirations. Should the Northern Village of Pinehouse continue to be interested in exploring the project, over this period there would be ongoing engagement of your community, surrounding communities and others who may be affected. By the end of this process, the Northern Village of Pinehouse as a whole community would need to clearly demonstrate that it is willing to host the repository in order for this project to proceed.

The next evaluation step would be to conduct a feasibility study as described in Step 3 of the site selection process. This feasibility study would focus on areas selected in collaboration with the community. As your community considers whether it is interested in advancing to the feasibility study phase, the NWMO encourages you to continue community discussion and further learning

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about the project. Your community has already begun the process of visioning and considering whether this project is consistent with achieving that vision and you are currently engaging your community in learning more about this project through programs and resources available through the Learn More Program.

Once again, I thank you for taking the time to learn about Canada's plan for the safe, secure management of Canada's used nuclear fuel.

Sincerely,

Kathryn Shaver

Kathryn Shaver,
Vice President, APM Public Engagement and Site Selection

February 2011

INITIAL SCREENING FOR SITING A DEEP GEOLOGICAL REPOSITORY FOR CANADA'S USED NUCLEAR FUEL

Northern Village of Pinehouse, Saskatchewan

Submitted to:
Nuclear Waste Management Organization
22 St. Clair Avenue East, 6th Floor
Toronto, Ontario
M4T 2S3

REPORT

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EXECUTIVE SUMMARY

On August 17, 2010, the Northern Village of Pinehouse, Saskatchewan and the Kineepik Métis Local expressed interest in learning more about the Nuclear Waste Management Organization (NWMO) site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel (NWMO 2010). This report summarizes the findings of an initial screening, conducted by Golder Associates Ltd., to evaluate the potential suitability of the Pinehouse area against five screening criteria using readily available information. The purpose of the initial screening is to identify whether there are any obvious conditions that would exclude the Pinehouse area from further consideration in the site selection process. The five initial screening criteria are defined in the site selection process document (NWMO, 2010) and relate to: having sufficient space to accommodate surface and underground facilities, being outside protected areas and heritage features, absence of known groundwater resources at repository depth, absence of known natural resources and avoiding known hydrogeologic and geologic conditions that would make an area or site unsuitable for hosting a deep geological repository.

The surface area within the boundaries of the Northern Village of Pinehouse would not be sufficient to accommodate the repository surface facilities. Therefore, as per discussions between NWMO and the community, the initial screening was conducted to assess whether there are areas at the periphery of the Northern Village that would meet the initial screening criteria. In the following, the periphery of the Northern Village of Pinehouse is also referred to as the "Pinehouse area".

The review of readily available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Northern Village of Pinehouse from being further considered in the NWMO site selection process. There are areas at the periphery of the Northern Village of Pinehouse that are potentially suitable for hosting a deep geological repository. However, the areas to the southwest of Pinehouse are excluded from further consideration as the potentially suitable rock is covered by about 100 m of sedimentary rocks of the Western Canada Sedimentary Basin, which would greatly reduce the ability to characterize it. Potential suitability of the areas not excluded would need to be further assessed during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

It is important to note that the intent of this initial screening is not to confirm the suitability of the Northern Village of Pinehouse to host a deep geological repository, but rather to provide early feedback on whether there are known reasons to exclude it from further consideration. Should the community of Pinehouse remain interested in continuing with the site selection process, more detailed studies would be required to confirm and demonstrate whether the Pinehouse area contains sites that can safely contain and isolate used nuclear fuel. The process for identifying an informed and willing host community for a deep geological repository for Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future.

A brief summary of the assessment against each of the initial screening criterion is provided below.

Availability of Land

The Pinehouse area contains land and geological formations that are sufficient to accommodate the surface and underground facilities associated with a repository and that could be accessible for construction and field investigation activities. Apart from the Northern Village itself and roadways, the Pinehouse area is largely undeveloped, with no major infrastructure present. No obvious topographic features that would prevent construction and site characterization have been identified.

Protected Areas, Heritage Sites, Provincial Parks and National Parks

Based on the review of readily available information, the Pinehouse area contains sufficient land outside protected areas to accommodate facilities associated with the repository. There are two recreational sites (Gordon Lake and Besnard Lake Recreational Sites) and several known heritage sites within the Pinehouse area. These protected areas occupy a very small fraction of the available land within the Pinehouse area. The absence of other locally protected areas would need to be confirmed in discussion with the community and Aboriginal peoples in the area during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

Absence of Known Groundwater Resources at the Repository Depth

The review of available information did not identify any known groundwater resources at repository depth (approximately 500 m) in the Pinehouse area. Water wells found within the Pinehouse area obtain water from the overburden at depths ranging from 10 m to 20 m. Based on experience in similar crystalline rock settings in the Canadian Shield, the likelihood of the existence of exploitable aquifers at typical repository depth in the Pinehouse area is low. Active groundwater systems in comparable geological settings are usually limited to shallow fractured zones. The absence of groundwater resources at repository depth would need to be confirmed during subsequent site evaluation stages, if the community remains interested in the site selection process.

Absence of Economically Exploitable Natural Resources as Known Today

The Pinehouse area contains sufficient areas, free of known economically exploitable natural resources, to accommodate the required repository facilities. The review of known mineral deposits, exploration activity, and mineral potential for the area indicates that the Pinehouse area has a generally low economic mineral potential. There is no evidence of past or present exploration or development activities associated with oil and gas resources. There are currently no operating or past producing mines within the Pinehouse area. Several coal claim blocks within the sedimentary rocks to the south of Pinehouse are being explored, but no known reserves have been identified. Only a few mineral occurrences have been identified in the Pinehouse area. The nearest metallic mineral claims are associated with copper-uranium and are located approximately 30 km east of Pinehouse. No record of non-metallic mineral resources exploitation was found within the Pinehouse area, although potential for limestone has been recognized 20 km south of Pinehouse.

No Known Geological and Hydrogeological Characteristics that Would Prevent the Site from Being Safe

The review of readily available geoscientific information did not identify any obvious geological or hydrogeological conditions that would clearly exclude the entire Pinehouse area from further consideration in the site selection process. The felsic gneiss that dominates the geology of the area seems to possess geometric, structural and hydraulic characteristics that are potentially suitable for hosting a deep geological repository. The southwestern portion of the Pinehouse area, where the felsic gneiss are covered by about 100 m of sedimentary rocks, was excluded from further consideration, as the presence of the sedimentary rock cover could reduce the ability to characterize the bedrock at repository depth.

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1.0 INTRODUCTION

On August 17, 2010, the Northern Village of Pinehouse, Saskatchewan and the Kineepik Métis Local expressed interest in learning more about the Nuclear Waste Management Organization (NWMO) nine-step site selection process to find an informed and willing community to host a deep geological repository for Canada's used nuclear fuel (NWMO, 2010). This report presents the results of an initial screening conducted by Golder Associates Ltd. (Golder) to evaluate the potential suitability of the Pinehouse area against five screening criteria using readily available information.

The surface area within the boundaries of the Northern Village of Pinehouse would not be sufficient to accommodate the repository surface facilities. Therefore, as per discussions between NWMO and the community, the initial screening was conducted to assess whether there are areas at the periphery of the Northern Village that would meet the initial screening criteria. In the following, the periphery of the Northern Village of Pinehouse is also referred to as the "Pinehouse area".

1.1 Background

The ultimate objective of Adaptive Phased Management (APM) is long-term containment and isolation of used nuclear fuel in a deep geological repository in a suitable rock formation. The NWMO is committed to implementing the project in a manner that protects human health, safety, security and the environment, while fostering the long-term well-being of the community and region in which it is implemented (NWMO, 2005).

In May 2010, the NWMO published and initiated a nine-step site selection process to find an informed and willing community to host the repository (NWMO, 2010). The site selection process is designed to address a broad range of technical, social, economic and cultural factors as identified through dialogue with Canadians, and draws from experiences and lessons learned from past work and processes developed in Canada to site facilities for the management of hazardous material. It also draws from similar projects in other countries pursuing the development of deep geological repositories for used nuclear fuel. The suitability of potential candidate sites will ultimately be assessed against a number of site evaluation factors, both technical and social in nature.

The geoscientific suitability of candidate sites will be assessed in three main phases over a period of several years, with each step designed to evaluate the site in progressively greater detail upon request of the community. The three site evaluation phases include: Initial Screenings to evaluate the potential suitability of the community against a list of initial screening criteria, using readily available information (Step 2); Feasibility Studies to determine if candidate sites within the proposed areas are potentially suitable for developing a safe deep geological repository for used nuclear fuel (Step 3), and Detailed Site Evaluations, at one or more selected sites, to confirm suitability based on detailed site evaluation criteria (Step 4). It is up to the communities to decide whether they wish to continue to participate in these steps in the process.

1.2 Objectives and Approach for Conducting Initial Screenings

The overall objective of the initial screening is to evaluate proposed geographic areas against a list of screening criteria using readily available information. Initial screening criteria (NWMO, 2010) require that:

1) The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

2) This available land must be outside of protected areas, heritage sites, provincial parks and national parks.

3) This available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

4) This available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.

5) This available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the safety factors outlined in Section 6 of the Site Selection Document (NWMO, 2010).

The initial screening step involves the systematic consideration of each of the five Initial Screening Criteria on a qualitative basis using readily available information from provincial, federal, municipal and other sources of information. It is not the intent of the initial screening study to conduct a detailed analysis of all available information, but rather to identify any obvious conditions that would exclude a community from further consideration in the site selection process. For example, a site with known economically exploitable natural resources or geological or hydrogeological characteristics that are clearly unfavourable would be excluded from further consideration.

For cases where readily available information is limited and assessment of some of the criteria is not possible at the screening stage, the area would be advanced to the feasibility study stage for more detailed evaluation, provided the community remains interested in participating in the siting process.

The initial screening commences with an analysis of readily available information in order to develop an overall understanding of the geoscientific and other relevant characteristics of the site. The initial screening criteria are then applied in a systematic manner based on the understanding of the proposed area or site. The tasks involved include the following:

- Reviewing the regional and local physical geography, geology, seismicity, structural geology and Quaternary geology (surface geology);
- Reviewing the hydrogeology, including, regional groundwater flow, deep and shallow aquifers and hydrogeochemistry;
- Reviewing the economic geology, including petroleum resources, and metallic and non-metallic mineral resources;
- Applying the screening criteria; and
- Summarizing the findings with regards to potential suitability.

2.0 PHYSICAL GEOGRAPHY

2.1 Location

The Northern Village of Pinehouse is situated in north-central Saskatchewan, on the western shore of Pinehouse Lake (Figure 2.1). Pinehouse is located 80 km northeast of Beauval, 93 km northwest of La Ronge, and 250 km north of Prince Albert, Saskatchewan. Access to Pinehouse is from the south via Highway 914, which is connected to Highway 165 and Highway 2 leading to the City of Prince Albert. The geographic extent of the Northern Village of Pinehouse itself is approximately 1 km^2 in size.

2.2 Topography

Pinehouse is located on the boundary of the Canadian Shield and the Boreal Plain physiographic regions. The Canadian Shield outcrops northeast of Pinehouse Lake, while the Boreal Plain terrain occurs to the southwest. Lakes and ridges in the shield region are generally aligned in a northeast-southwest direction, indicating the direction of past glacial-ice movements. In the shield areas, bedrock and thin moraine veneer are typical. South of the shield, moraine plain and organic plain are more common; these areas tend to have smaller lakes, dendritic drainage patterns, and more abundant peatland terrain. These features are generally visible on the satellite imagery for the Pinehouse area, shown on Figure 2.2. The topography of the Pinehouse area is defined by the surficial geology and geomorphology of the region. The organic and moraine plains southwest of Pinehouse have the greatest relief, while numerous lakes and peatlands occur in low-lying areas. For example, surface elevations range from a high of 460 m at a location 20 km west of Pinehouse Lake to a low of 370 m on the Churchill River 25 km north of Pinehouse, as shown in the Digital Elevation Model on Figure 2.3.

2.3 Drainage

The Pinehouse area lies within the Churchill River Basin, whose main water course flows eastward through Saskatchewan and Manitoba, until it enters Hudson Bay. Subbasins, streamflow directions, and major lakes in the Pinehouse area are provided on Figure 2.4. The Churchill River Basin is characterized by numerous lakes, joined by rapids and fast-flowing narrows. Major tributaries that enter the Churchill River system north (upstream) of Pinehouse Lake include the Haultain River, Belanger River, and Foster River. Major inflows to Pinehouse Lake itself include the Churchill, Massinahigan, Tippo, and Smoothstone Rivers, while the outlet of the lake is the Churchill River. Drainage patterns in the shield region tend to conform to bedrock landforms, while drainage patterns on the plains are dendritic and appear to be defined by slope and physiography.

2.4 Protected Areas

Parks and Reserves

There are two protected areas in the Pinehouse area: the Gordon Lake Recreation Site, located 27 km north on the south shore of Gordon Lake and the Besnard Lake Recreation Site, located 35 km southeast along the west shore of Besnard Lake (Figure 2.1). Both the Gordon Lake and Besnard Lake recreation sites are small, with areas of 3.7 km^2 and 1.5 km^2 respectively.

Heritage Sites

The database for previously recorded heritage resources maintained by the Ministry of Tourism, Parks, Culture and Sport (TPCS, 2010) was consulted to identify previously recorded heritage sites found within the Pinehouse area. Heritage resources include all of Saskatchewan's Historic and Precontact archaeological sites, architecturally significant structures, and palaeontological resources. Heritage resources are property of the Provincial Crown, and as such, are protected under *The Heritage Property Act.*

The results of the database search indicate that 33 archaeological sites have been recorded within the Pinehouse area (Figure 2.5; Table 2.1). Precontact artifact find and scatter sites are the most common (n=24); followed by Pictographs or rock art (n=14); and artifact/feature combination sites (n=3). Two heritage resources have insufficient information to be given a site type designation. According to the site database, known heritage resources were recorded between 1960 and 1980 as part of various research and assessment projects. The majority of the sites are located on the Churchill River and associated tributaries and lakes. Twenty-three sites were recorded during the Key Lake Road assessment with sites associated with the Churchill and Haultain Rivers (Meyer, 1979). The remainder of the sites are found on Besnard and Pinehouse Lakes.

Table 2.1: Heritage Resources within the Study Area

Site Type	Definition	No. of Sites
Artifact find	Archaeological sites consisting of 5 or fewer artifacts. An artifact is any object used or modified by people (e.g. projectile point, pottery shards, lithic flakes).	9
Artifact scatter	Archaeological sites consisting of 6 or more artifacts.	15
Artifact/Feature combination	Archaeological sites consisting of both artifacts and features. A feature is the remains of any non-portable human activity that can not be removed from a site without disturbing it (i.e. hearth, cabin, cellar depression).	3
Pictograph	Rock art images painted with a natural pigment.	4
Unknown	Insufficient information to classify.	2
	Total	**33**

As indicated by these heritage resources, the Churchill River and its associated tributaries and lakes were a significant waterway during both Precontact and Historic times. Archaeological evidence indicates that people were occupying the Churchill River as early as 10,000 years ago (Meyer, 1995). During the early fur trade period, explorers and traders began travelling the Churchill River beginning in the late 1770’s. This was soon followed by the establishment of fur trade posts by both the English and French beginning in 1775 and continuing through to the 1930’s (Russell and Meyer, 1999). Posts were established not only on the Churchill River proper, but also in Lac La Ronge, Lac Ile-a-la-Crosse, Lac La Plonge, and Pinehouse Lake.

The absence of locally protected areas would need to be confirmed in discussion with the community and Aboriginal peoples in the area during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

3.0 GEOLOGY AND SEISMICITY

3.1 Regional Bedrock Geology

Pinehouse is located at the contact of the Hearne Province of the Canadian Shield and the Western Canada Sedimentary Basin as shown on Figure 3.1. Rocks of the Canadian Shield comprise the northern one third of Saskatchewan bedrock lithology, while the southern two thirds are covered by Phanerozoic rocks of the Western Canada Sedimentary Basin. The Hearne Province comprises the eastern portion of the Churchill Structural Province of the Precambrian Canadian Shield (SGS, 2003). The Canadian Shield rocks continue southward, deepening beneath the sedimentary rocks of the Western Canada Sedimentary Basin.

Canadian Shield

The Canadian Shield is a collage of Archean cratons, and accreted juvenile terranes and sedimentary basins of Proterozoic age. It was originally an area of very large mountains and intense volcanic activity, and was the first part of North America to be permanently elevated above sea level.

The Hearne Province is bounded to the west by the Rae Province along the Snowbird Tectonic Zone and to the east by the Reindeer Zone along the Needle Falls and Parker Lake Shear Zone, as shown on Figure 3.1. It is oriented in a northeast-southwest direction, which is the predominant alignment of major structural features and lithologies within the Precambrian in Northern Saskatchewan. The Hearne Province consists, from west to east, of the Virgin River, Mudjatik, Wollaston and Peter Lake Domains, which are primarily distinguished by changes in structural style (SGS, 2003). The Hearne Province generally is composed of 2.7 to 1.8 billion years old high grade metamorphic Archean to Paleoproterozoic rocks, such as gneissic granitoids, metasedimentary rocks and granite (SGS, 2003).

The Northern Village of Pinehouse lies within the Wollaston Domain, as shown on Figure 3.2. The Wollaston Domain is characterized as a northeast trending, tightly folded belt of Archean granitoid rocks and derived orthogneiss and Paleoproterozoic metasedimentary rocks with minor metavolcanic rocks (SGS 2003; Delaney 1993). Metasedimentary rocks form the Wollaston Supergroup (as defined by Yeo and Delaney 2007), which was deposited along the eastern edge of the Hearne Craton first in rift and passive margin settings and later in a foreland basin setting, during which most of the preserved rocks were deposited, due to closing of the Manikewan Ocean between the Hearne and Superior Cratons. The predominant Wollaston Supergroup metasedimentary gneiss in the north and central parts of the Wollaston Domain decline towards the south, where they become discontinuous in bands intercalated with Archean felsic (ortho)gneiss and younger granitoid rocks. The Wollaston Domain is separated to the east from the Wathaman Batholith Domain of the Reindeer Zone by the Needle Falls Shear Zone, while the western boundary with the Mudjatik Domain is marked by a transition in structural style from a linear fold belt to dome-basin fold interference (SGS, 2003; Delaney, 1993; Yeo and Delaney, 2007). The contact with the Needle Falls Shear Zone is sharp and distinct, whereas the transition with the Mudjatik zone is generally inferred (Munday, 1978), based on the degree of deformation.

The Mudjatik Domain boundary is located approximately 35 km to the northwest of Pinehouse. In general, the rock units within the Mudjatik Domain are similar in to those of the Wollaston Domain. The majority of the Mudjatik Domain consists of extensive granitic to granodioritic felsic gneiss with interspersed metasedimentary gneiss (Thomas and Slimmon, 1985). The Wathaman Batholith occurs approximately 35 km to the east of Pinehouse, within the Reindeer Zone, bounded to the west by the Needle Falls Shear Zone. The Wathaman Batholith is a continental magmatic arc composed of numerous large plutons. It is approximately 900 km long and 15 km to 150 km wide (Corrigan et al., 1999), and 1.862 to 1.85 billion years in age (SGS, 2003). Both the Mudjatik and Wathaman Domains are shown on Figure 3.2.

Within the Pinehouse region, rocks of the Wollaston and Mudjatik Domains are characterized by high metamorphic grades and complex deformation. Four phases of deformation have been identified. The first phase defines the main regional foliation, which was followed by tight to isoclinal folding in the second phase (Yeo and Delaney, 2007). The third phase comprises open to tight, northeast-trending folds. The fourth phase consists of a series of open, upright shears, northwest-trending folds and late sinistral north to northwest trending brittle faults (SGS, 2003). The foliation within the Wathaman Batholith is parallel to the regional southwest-northeast trend and there is a broad correspondence between regional deformation and magma emplacement (Corrigan et al., 1999).

Two phases of metamorphism have been recorded in the Wollaston Domain. The first is associated with the emplacement of a 1.84 to 1.82 billion year old group of granites and gabbroic rocks, some of which may be crustal melts, relating to accretion of the La Ronge Arc to the eastern Hearne Craton margin and other plutons derived from ongoing subduction. The second phase is associated with 1.82 to 1.80 billion year old anatectic granites, pegmatites, and metamorphic mineral growth relating to terminal collision between the Hearne, Sask and Superior cratons in the Trans-Hudson Orogeny (SGS, 2003).

Geophysics is an important tool in mapping geologic structures within the Precambrian provinces and zones of northern Saskatchewan (Hajnal et al., 2005; White et al., 2005). Geophysical surveys in the region include airborne magnetic, gravity, airborne radiometric, audio magnetotelluric and deep seismic surveys conducted as part of Lithoprobe (Lewry et al., 1994). Residual total magnetic field, Bouguer gravity and radiometric (equivalent uranium) survey data sets are contoured and presented on Figures 3.3 to 3.5, respectively.

With reference to Figures 3.3 to 3.5, the Mudjatik Domain rocks are typified by a low magnetic response, a low gravity response and a variable to high radiometric response. By contrast, the rocks of the Wollaston Domain are typified by alternating bands of high and low magnetism, a moderate and somewhat variable gravity response, and a variable radiometric response that ranges from low in the west along the contact with the Mudjatik Domain, to high in the east at the contact with the Needle Falls Shear Zone. East of the Needle Falls Shear Zone, the rocks of the Wathaman Batholith show a higher magnetic response than the rocks immediately to the west in the Wollaston Domain, but a lower gravity and radiometric response. The magnetic trends of these domains can be traced to the south beneath the Phanerozoic cover (White et al., 2005), particularly the magnetic high of the Wollaston Domain.

The variations in magnetic and radiometric responses are largely due to compositional variations in the rocks (White et al., 2005), while the variation in gravity response is in part a result of the density differences between rock types, but is also in part related to variations in deeper structures, including crustal roots (White et al., 2005). Coupled geophysical modelling by White et al. (2005) along a west-east geophysical transect located approximately 50 km south of the Pinehouse area estimates the thickness of rocks of the Wollaston Domain to range from approximately 6 km in the west, to 10 km in the east at the Needle Falls Shear Zone. In that same model, the Wathaman Batholith is estimated to be 10 km thick in the west but pinches out in the east, and is replaced by the rocks of the Rottenstone Domain.

Western Canada Sedimentary Basin

The Western Canada Sedimentary Basin is part of a northward thinning sedimentary basin which covers much of the Canadian and American prairies and stretches from the Gulf of Mexico to the Arctic Ocean. Sedimentary rocks within the Western Canada Sedimentary Basin range in age from Cambrian to Neogene (approximately 550 million to 5 million years), and unconformably overlie the Precambrian Canadian Shield. The Western

Canada Sedimentary Basin dips to the southwest at approximately 4 m/km, and has a maximum thickness of approximately 3,200 m in Southeastern Saskatchewan (SGS, 2003), and a minimum thickness along its northern contact with the Precambrian Canadian Shield. The Western Canada Sedimentary Basin represents an interlayering of marine and terrestrial sequences that resulted from sedimentation in marine transgressive and regressive cycles.

Two major tectonic phases have been recognized in the deposition of the Western Canada Sedimentary Basin. Generally, the initial phase reflects a passive continental margin which consists of basal clastic units and thick sequences of carbonates and evaporites (SGS, 2003). The second phase reflects a convergent-margin phase resulting in a foreland basin consisting of thick clastic sediments associated with the Cordilleran Mountain Belt (SGS, 2003). Stratigraphy within the Western Canada Sedimentary Basin was also strongly influenced by downwarping, reactivation of basement structures, and sea level changes.

The lithostratigraphy of the Western Canada Sedimentary Basin can be simplified into three main sections. The lowermost section is composed of a Paleozoic basal clastic succession of sandstone, conglomerate and shales. The second section consists of interlayered Paleozoic and Mesozoic age carbonates and evaporites. The third section is represented by a series of Mesozoic sandstones and shales overlain by Cenozoic sandstone, shale units, and conglomeratic material, which are generally limited to the southern portion of the basin.

3.2 Local Bedrock Geology

3.2.1 Lithologies

The Northern Village of Pinehouse is located along the unconformity between the Precambrian Canadian Shield and the Western Canada Sedimentary Basin. Bedrock geology in the area consists of a range of Phanerozoic to Archean rocks, and is shown on Figure 3.6.

In the Pinehouse area, Archean felsic gneiss is the main rock type present. Within approximately 2 km to the south and west of the Northern Village of Pinehouse, Phanerozoic rocks are present. Metasedimentary rocks (Wollaston Supergroup) are found to the northeast as linear bands within the Archean felsic gneiss (Figure 3.6).

The lithologies found in the Pinehouse area are further described below. Precambrian units are discussed first, followed by Phanerozoic units.

Archean Felsic Gneiss and Amphibolite

The felsic gneiss formed by metamorphism of granitic plutons and minor amounts of sedimentary rocks. Late Archean felsic gneiss within the Pinehouse area range between 2.65 billion years to 2.5 billion years in age (Yeo and Delaney, 2007). These rocks are laterally widespread and underlie metasedimentary rocks of the Wollaston Supergroup. Although the exact thickness of these rocks is unknown in the Pinehouse area, Wollaston Domain rocks are expected to be 6 to 10 km thick, as interpreted from regional geophysical studies (White et al., 2005; Hajnal et al., 2005).

Five assemblages of Archean gneiss can be identified. These include quartz monzocharnockite, a monzonite-granite-granodiorite suite, a granodiorite-tonalite suite, amphibolites, and a heterogeneous assemblage of intrusive and metasedimentary rocks (Yeo and Delaney, 2007). Felsic gneiss can be described as fine to medium grained, equigranular, and massive to well-foliated to banded (Thomas and Slimmon, 1985). Mineral associations can include biotite, hornblende, hypersthene, diopside, garnet, and magnetite. These rocks occur around the Northern Village of Pinehouse, and are generally the most common unit in the area.

Archean amphibolite occurs approximately 13 km and 16 km to the east and north of Pinehouse, respectively (Figure 3.6). These rocks are limited in extent, and cover areas less than 1 km^2.

Metasedimentary Rocks of the Wollaston Supergroup

Metasedimentary rocks are formed by the metamorphism of sedimentary rocks. Metasedimentary rocks of the Wollaston Supergroup overlie the Archean felsic gneiss, and are generally seen on geologic maps as linear northeast-southwest trending bands (Figure 3.6). These rocks are characterized by four unconformity bounded Paleoproterozoic siliciclastic metasedimentary rock formations (Yeo and Delaney, 2007) that were deposited in rift, passive margin and foreland basin settings. Broad similarities between these sequences can be recognized.

Although there is no readily available information in the Pinehouse area to differentiate these on a map area, the metasedimentary Wollaston Supergroup is divided into four groups that are as follows, listed from oldest to youngest (Yeo and Delaney 2007): Courtenay Lake Group, Souter Lake Group, Daly Lake Group, and Geikie River Group. Of these, the Daly and Geikie River Groups, representing the foreland basin sediments, are the most extensive. It is unknown which of these groups is represented in the Pinehouse area due to a lack of information, although it is likely that the metasedimentary rocks in the Pinehouse area are either of the more common Daly Lake or Geikie River Groups due to their proximity to the Cup Lake-Keller Lake area (Daly Lake) and Duddridge Lake area (Geikie River). The general rock types associated with each of the four groups are discussed below. Although there is no information regarding the true thickness of these rock units in the Pinehouse area, the combined thickness of the metasedimentary gneiss and felsic gneiss is expected to be 6 to 10 km, as interpreted from regional geophysical studies (White et al., 2005; Hajnal et al., 2005).

The rocks of the Courtenay Lake Group consist of lenses of arkose, conglomerate, quartzite, pelite and metavolcanic rocks. The Souter Lake Group contains quartzite, argillite, orthoquartzite, and arkose. The Daly Lake Group is comprises pelite and psammopelite, calcareous and noncalcareous argillite, calc-silicate rocks, psammite, biotite schist, arkose, quartzite, and minor marble. The Geikie River Group consists of a sucession of conglomerate, arkose, calc-silicate rocks, and marble (Yeo and Delaney, 2007). Rocks found within the Pinehouse area are difficult to subdivide (Card pers. comm., 2010); therefore, the specific units discussed have not been correlated to specific groups within the Wollaston Supergroup, due to insufficient available information.

In the Pinehouse area, metasedimentary pelitic to psammopelitic gneiss shown on Figure 3.6 are fine to medium grained, generally well foliated to gneissic in texture, and biotite rich. These gneisses commonly can include cordierite, garnet and sillimanite porphyroblasts and accessory graphite and magnetite (Thomas and Slimmon, 1985). This unit occurs in or near linear configurations trending northeast-southwest within the Archean felsic gneiss unit, and is primarily found to the north and east of Pinehouse Lake. This unit is approximately from less than 1 km to 3 km in width, and is extensive in length. In the Pinehouse area, psammitic to meta-arkosic gneiss consist of fine to medium grained, massive to foliated rocks, which can be locally colour banded. This unit can include quartz, feldspar, biotite, muscovite, sillimanite, cordierite, garnet, diopside, epidote, andalusite, interbanded calc-silicates, and pelitic gneiss (Thomas and Slimmon, 1985). It is found on the north end of Pinehouse Lake, as well as south of Sandfly Lake to the west of the Needle Falls Shear Zone (Thomas and Slimmon, 1985). These rocks occur in bands that trend similarly to the pelitic and psammopelitic gneiss in the Pinehouse area, shown on Figure 3.6. They range in width from approximately 5 km to 8 km, and are extensive in length.

Metasedimentary calc-silicate rock and marble occur primarily along the western margin of the Needle Falls Shear Zone, approximately 35 km to 40 km east of Pinehouse (Figure 3.2). This unit is medium to coarse grained to pegmatitic, massive to well layered, and generally diopsidic. It can also contain hornblende, actinolite-tremolite, biotite, phlogopite, scapolite, quartz, feldspar and dolomite (Thomas and Slimmon, 1985). These rocks are not extensive, and do not appear to be present within the Pinehouse area (Figure 3.6).

Phanerozoic Rocks of the Western Canada Sedimentary Basin

Five lithostratigraphic units, ranging from Cambrian to Lower Cretaceous in age, make up the Phanerozoic outcrops on the northern edge of the Western Canada Sedimentary Basin within the southwestern portion of the Pinehouse area, as shown on Figure 3.2 and Figure 3.6. These units are generally mappable across the entire Western Canada Sedimentary Basin within Saskatchewan. The Northern Village of Pinehouse is not situated on Phanerozoic rocks; however, they are located within 2 km to the southwest of Pinehouse. A conceptual lithostratigraphic column of the Phanerozoic deposits in the Pinehouse area is shown in Table 3.1.

Table 3.1: Conceptual Lithostratigraphic Column of the Phanerozoic Deposits

Phanerozoic Deposits	Age[(a)]	Approximate Regional Thickness[(b)]	Approximate Local Thickness[(c)]
Morainal Plain	Quaternary	55 m	20 m[(d)]
Mannville Group	Lower Cretaceous	28 m	3 m
Elk Point Group - Winnipegosis Formation	Middle Devonian	15 m	10 m
Elk Point Group - Upper Meadow Lake Formation	Lower Devonian	25 m	23 m
Elk Point Group - Lower Meadow Lake Formation	Lower Devonian	13 m	N/A
Deadwood Formation	Upper Cambrian - Lower Ordovician	16 m	29 m[(e)]

Wavy line indicates unconformable contact; N/A = not available

(a) from SIR, 1999; (b) from Fuzesy, 1976; (c) interpreted from Smith et al., 2003; (d) based on local knowledge of Pinehouse area;

(e) interpreted from Thomas and Slimmon, 1985.

The base of the Phanerozoic rocks in the Pinehouse area is composed of the Late Cambrian to Early Ordovician Deadwood Formation. The Deadwood Formation consists of granular sandstones, quartz arenites, siltstone-shales, argillaceous limestones and shales, and flat-pebble conglomerates (Greggs and Hein 2000). The Deadwood Formation can reach thicknesses of 500 m in the Western Canada Sedimentary Basin, with localized thinning and thickening reflective of the Precambrian topography or local uplift prior to deposition. The Deadwood Formation thins along the northern edge of the Western Canada Sedimentary Basin. It can be found within 2 km to the south and west of the Northern Village of Pinehouse. Based on a regional survey conducted between Lac La Ronge (approximately 100 km to the southeast of Pinehouse) and Pinehouse Lake, the average thickness of the Deadwood Formation is approximately 16 m (interpreted from Fuzesy 1976). Locally, the Deadwood Formation has a thickness of approximately 30 m, but appears to rapidly thicken to the west (interpreted from Thomas and Slimmon 1985).

The Middle Devonian Elk Point Group near Pinehouse consists of the Upper and Lower Members of the Meadow Lake Formation, as well as the Winnipegosis Formation. In southern Saskatchewan, the Elk Point Group also includes the Ashern and Praire Evaporite Formations (SIR 1999). The Lower Member of the Meadow Lake Formation consists of light grey to brown, commonly argillaceous and silty dolomite with local interbedded mudstone, sandstone and limestone. Based on the regional investigation between Lac La Ronge and Pinehouse Lake, the Lower Member has an average thickness of 13 m (interpreted from Fuzesy 1976), although the local thickness is unknown due to a lack of information specific to this unit.

The Upper Member of the Meadow Lake Formation consists of a lower white to grey, laminated limestone with interbedded dolomite and mudstone, a middle argillaceous dolomite with minor mudstone and dolomitic limestone, and an upper mudstone that is mottled, dolomitic and pyritic. This upper portion can contain quartz, anhydrite, gypsum and plagioclase. Based on information from a regional investigation undertaken between Lac La Ronge and Pinehouse Lake, the Upper Meadow Lake Formation Member has an approximate thickness of 25 m (interpreted from Fuzesy, 1976). At the Massinahigan River limestone occurrence (see Figure 5.1), located approximately 30 km to the southwest of Pinehouse, the Upper Meadow Lake Formation Member has an approximate thickness of 23 m (interpreted from Smith et al., 2003), which represents the best local information available for this unit.

The Winnipegosis Formation is mainly dolomite and limestone. The lower part of this formation consists of mottled, highly argillaceous, nodular carbonate and calcareous shale, whereas the upper part consists of laminated and massive carbonate (Thomas and Slimmon, 1985). Regionally, between Lac La Ronge and Pinehouse Lake, the Winnipegosis Formation has an approximate thickness of 15 m (interpreted from Fuzesy, 1976), although the approximate average thickness at the Massinahigan River limestone occurrence approximately 30 km to the southwest of Pinehouse is 10 m (interpreted from Smith et al., 2003).

The Lower Cretaceous Mannville Group consists of grey to brown, variably argillaceous and carbonaceous quartzose sands and poorly consolidated sandstones. These rocks are locally interbedded with mudstone and lignite (Thomas and Slimmon, 1985). In southern Saskatchewan, the Mannville Group consists of the Pense and Cantuar Formations (SIR, 1999), although these are undifferentiated along the northern margin of the Western Canada Sedimentary Basin. Regionally, between Lac La Ronge and Pinehouse Lake, the approximate thickness of the Mannville Group is 28 m (interpreted from Fuzesy, 1976). In the vicinity of the Massinahigan River limestone occurrence, approximately 30 km southwest of Pinehouse, the Mannville Group appears to have an average thickness of approximately 3 m (interpreted from Smith et al., 2003).

The thickness of the Phanerozoic cover is somewhat variable within the Pinehouse area but generally thickens from the northern margin to the south and west across Saskatchewan (PTRC, 2010). Where the Mannville Group is present, thickness of the entire Phanerozoic cover varies from approximately 60 m to 115 m about 20 km to the west of Pinehouse to approximately 30 to 160 m at a location about 22 km to the south of Pinehouse (Thomas and Slimmon, 1985). Where the Mannville Group is absent and Elk Point Group units make up the Phanerozoic outcrop, thickness of the Phanerozoic ranges from approximately 40 m to 55 m about 12 km to the southwest of Pinehouse (Thomas and Slimmon, 1985). It should be noted that comprehensive data for the thickness of the Phanerozoic rocks in the Pinehouse area is sparse and that thicknesses were interpreted from limited borehole information presented on the map by Thomas and Slimmon (1985).

3.2.2 Metamorphism and Deformation

All Precambrian rocks in the Pinehouse area show evidence of metamorphism, regardless of domain. Metamorphism appears to have reached upper-amphibolite to lower-granulite facies conditions (Yeo and Delaney, 2007). Hypersthene is common in mafic rocks and felsic gneiss (Munday, 1978). Corderite, sillimanite, biotite, K-feldspar, magnetite and garnet are common in pelitic rocks (Munday, 1978; Yeo and Delaney, 2007). Calc-silicate rocks contain hornblende, diopside, tremolite/actinolite, biotite, and calcite or dolomite (Yeo and Delaney, 2007).

Moving eastwards, along the margin of the Needle Falls Shear Zone, metamorphic grade declines. Low grade schists with lower amphibolite facies assemblages formed during an initial phase of deformation then retained their mineral assemblages throughout later deformations. It is presumed that recrystallization occurring after the first deformation phase was most likely retrogressive over some of the transition zone between the lower and higher grade metamorphic assemblages (Munday, 1978).

Across all domains in the Hearne Province, several deformational events occurred. Although the age of these deformations is hard to determine, within the Wollaston Domain, four phases of deformation can be identified that post date the 2.1 billion years to 1.8 billion years metasedimentary Wollaston Supergroup rocks (Yeo and Delaney, 2007). An early isoclinal deformation (D1) formed a mineral foliation (Yeo and Delaney, 2007) characterized by rootless isoclinal hinges, transposed compositional layering and rare boudins. A second deformation (D2) is prominent within the Mudjatik Domain, but not as evident in the Wollaston Domain (Delaney, 1993). D2 is characterized by west-northwest to north-northeast upright folds (Yeo and Delaney, 2007). A third deformational event (D3) reoriented the D1 foliation into a series of doubly plunging but northeasterly trending structures. Similar folding is present within the rocks adjacent to the Needle Falls Shear Zone (Munday, 1978), which suggests this feature postdates the D1 and either postdates or is concurrent with the D3 events.

The Needle Falls Shear Zone is located approximately 30 km to the east of Pinehouse (Figure 3.2). It is a northeast-trending, subvertical, ductile shear system that has an exposed length of approximately 400 km, an approximate width of 1 to 2 km (Stauffer and Lewry, 1993). The relatively narrow zone of rocks has been reworked and metamorphosed by displacement along the shear system.

Uplift of the Needle Falls Shear Zone occurred after the deformation events, from 1.85 to 1.80 billion years, near the peak of thermotectonism associated with the Trans-Hudson Orogen (Stauffer and Lewry, 1993). Kinematic data suggests oblique, east side up, dextral, strike-slip displacement (Fedorowich et. al., 2003) of approximately 40 km (+/- 20 km) (Stauffer and Lewry, 1993). This created a series of shears and faults oriented northeast across the Pinehouse region, as shown on Figure 3.2; however, no further information describing these structures is available. Approximately 4 km to the northeast of the Northern Village of Pinehouse an inferred fault trace runs along the strike of Pinehouse Lake in a northeast-southwest direction, as shown on Figure 3.2 and Figure 3.6. This fault is characterized by a brecciated crush zone with fluorite mineralization. Also shown on Figures 3.2 and 3.6 are a set of northwest trending inferred fault structures. It is likely that these inferred faults are related to the Tabbernor Fault system, a major regional fault system located along the eastern side of Saskatchewan; however, no readily available information was found specific to these structures in the Pinehouse area.

Within the Western Canada Sedimentary Basin rocks, there are no known deformational features present in the Pinehouse area, based on readily available information.

3.3 Local Quaternary Geology

Figure 3.7 shows the local Quaternary geology of the Pinehouse area. The Quaternary geology is mostly composed of glacial deposits. The main glacial deposits include morainal plains, galciofluvial plains, and glaciolacustrine plains to the south. Rock outcrop becomes more prominent to the north of Pinehouse Lake. Marshy areas also occur throughout the region. Moraines were formed through lodgement and ablation processes and vary from flat to hummocky. Glaciofluvial plains mainly consist of outwash plains that were incised through the morainal deposits as the glaciers receded and meltwaters drained. Both of these landforms are primarily sandy with variable silt and clay fractions (Schreiner, 1984a).

The regional Quaternary geology originates from the Wisconsinan glaciation. Most of the hard crystalline rocks of the Canadian Shield resisted glacial erosion. Glacial evidence includes scouring, roche moutonees, drumlinoids and striae. Rugged local relief was enhanced as glaciers eroded low lying areas and polished resistant bedrock knobs (Schreiner, 1984a).

Sandstone from the Athabasca Group north of Pinehouse was extensively eroded by glaciations. This resulted in sandy tills being created and deposited to the southwest of the Athabasca Basin, including those within the Pinehouse area. These glacial deposits can consist of sandy to very sandy tills, large drumlins, eskers, and outwash deposits (Schreiner, 1984a). Main glacial landforms present in the Pinehouse area are shown on Figure 3.7.

There is also evidence that glacial Lake Agassiz covered the Pinehouse area about 9,900 years ago (Fisher and Smith, 1994). Rapid discharge of this lake created the Clearwater-lower Athabasca spillway, located north of Lac La Loche. This spillway created a northwestern outlet for glacial waters from Lake Agassiz to flow through glacial Lake McConnell and the Mackenzie River to the Arctic Ocean. This is evidenced by strandlines and glaciolacustrine sediments. The majority of these strandlines and glaciolacustrine sediments are mapped to the north and west of Pinehouse and have not been found to be present near Pinehouse. It is unknown what processes may have obscured evidence of Lake Aggassiz in the Pinehouse area.

The glacial cover deposited in thick till plains on top of the Phanerozoic rocks at the northern margin of the Western Canada Sedimentary Basin becomes less sandy in composition (Schreiner, 1984a). This change in composition is due to the changing bedrock composition and reflects the sandstone, siltstone, mudstone, limestone and dolomite that make up the Phanerozoic material.

Thickness of the Quaternary strata is variable and is generally thicker down ice (southwest) of the Athabasca Basin, and can vary from veneer to drumlinoid (Schreiner, 1984a). Thickness data for the Quaternary geology in the Pinehouse area is sparse, but it is estimated that it is likely to range from 0 m at the north of end of Pinehouse Lake (Schreiner, 1984b) to approximately 20 m within about 30 km south of Pinehouse, based on local knowledge of the area.

3.4 Neotectonic Activity

Neotectonics refers to recent stress and strain in the earth's crust, some of which are still occurring. The most significant neotectonic events within the Pinehouse area are numerous glacial cycles during the last million years (Shackleton et al., 1990; Peltier, 2002). During the last glaciations (Wisconsinan), most of Saskatchewan was covered by the Laurentide ice sheet that flowed from Hudson Bay, located to the northeast. The thickness of the Laurentide ice sheet across Saskatchewan is unknown, although it likely thinned to the southwest at the edges of the flow. The thickness of ice that covered the Pinehouse area is unknown.

The Pinehouse area has been ice free for approximately 8,000 years and since the regression of the Laurentide ice sheet, isostatic rebound has been occurring. The amount of depression of the earth's crust in the Pinehouse area and the rate of rebound are unknown due to lack of data from the continental interior, but generally both are thought to diminish with distance from Hudson Bay (Lambert et al., 1998). Crustal uplift models suggest that the rate of rebound across the Prairie Provinces may be as much as 5 mm/year (Lambert et al., 1998). As a result of the glacial unloading, horizontal stresses are created locally in shallow bedrock. Natural stress release features include elongated compressional ridges or pop-ups such as those described in White et al. (1973) and McFall (1993).

Based on readily available information, no neotectonic structural features are known to occur within the Pinehouse area, although the same stress history and glacial unloading that occurs throughout Saskatchewan also applies to the Pinehouse area.

3.5 Seismicity

Saskatchewan is one of the most seismically stable regions in North America (NRC, 2010). Historically, very few earthquakes (magnitude >3) have occurred within Saskatchewan and none in the Pinehouse area, as shown on Figure 3.8. The largest earthquake ever recorded in Saskatchewan occurred in 1909 in the southern portion of the province near the USA border, and measured a magnitude of 5.5 (NRC, 2010).

Generally, a significant portion of the seismicity measured in Saskatchewan is due to mining activities near Wollaston Lake, Esterhazy, and Saskatoon (Gendzwill and Unrau, 1996). Of the 43 seismic events with a magnitude greater than 1.8 in the period between 1985 and 2008 in Saskatchewan, 30 of those are identified as anthropogenic (man-made). The remaining 13 have been documented by Natural Resources Canada as natural earthquakes (NRC, 2010). A query of the Geological Survey of Canada's Nation Earthquake Database found no earthquakes in the Pinehouse area for their period of active monitoring, 1985 through present.

In summary, the available literature and recorded seismic events indicate that Saskatchewan is located within an area of low seismicity. Specifically, there were no earthquakes recorded near Pinehouse from 1985 through 2010 and there is no evidence of historical earthquakes prior 1985 from available sources.

4.0 HYDROGEOLOGY

The Northern Village of Pinehouse has a population of 1,076 according to the 2006 census (Statistics Canada, 2010), and obtains its potable water from Pinehouse Lake through Pinehouse Waterworks.

Information about groundwater resources in the Pinehouse area was found in the Saskatchewan Watershed Authority (SWA) Water Well Record (WWR) database (SWA, 2009). There are only two water wells recorded in the Pinehouse area dating back to 1980 and 1996, approximately 26 and 38 km from the village near Besnard Lake and Patuanak, respectively. Both wells were terminated in glacial drift. One of the wells was drilled as a water test hole, with stratigraphy consisting of alternating layers of till, sand and gravel. The total depth of this test hole was 22 m and there is no record of water encountered within this test hole. The other well was a withdrawal well completed to a depth of 10 m. Stratigraphy in this well was reported to be sand and gravel, with a static water level of 3.7 m below ground surface. Details of these wells are summarized in the following table. No well yield results were reported.

Table 4.1: Water Well Record Details

Water Well Type	Number of Wells	Total Well Depth (m)	Static Water Level (m below surface)	Tested Well Yield (L/min)	Depth to Top of Bedrock (m)
Water Test Hole	1	22	N/A	N/A	N/A
Withdrawal	1	10	3.7	N/A	N/A

N/A = not available

4.1 Quaternary Aquifers

In Saskatchewan, Quaternary aquifers are typically composed of well sorted glaciofluvial sand and gravel, whereas the extensive till deposits typically comprise aquitards. There is no available information on the presence, extent or other characteristics of the Quaternary aquifers in the Pinehouse area.

As noted in Section 3.4, the main Quaternary deposits of the region include morainal plains, glaciofluvial plains, and glaciolacustrine plains to the south, with estimated thicknesses likely to range from 0 to approximately 20 m. The groundwater table is expected to be very shallow in low-lying, marshy areas and it is expected that shallow unconfined groundwater flow generally parallels surface water drainage patterns.

4.2 Bedrock Aquifers

The Lower Cretaceous Mannville Group is present throughout the Phanerozoic subsurface of Saskatchewan at depths of greater than 1,200 m in the south of the Province, which shallows towards the north. It consists of siliciclastic sandstones and siltstones, from which sandstones make up the aquifer portion of the unit (known as the Mannville Aquifer) (Maathuis and Thorleifson, 2000). However, the thickness of the Mannville Group in the Pinehouse area may range from approximately 3 m to 28 m, which is much less than the typical repository depth of 500 m.

Canadian Shield bedrock formations in Saskatchewan do not readily permit groundwater flow, except as fracture flow. There is little known about their hydraulic properties as very few boreholes have been completed in the crystalline rock of the Canadian Shield in this part of Saskatchewan. No information is available on deep bedrock groundwater conditions in the Pinehouse area. Experience from other areas in the Canadian Shield, however, has shown that active groundwater flow is generally confined to localized shallow fracture systems. In Ontario, Singer and Cheng (2002) studied the groundwater movement in shallow bedrock of the Canadian Shield and reported that it is controlled by the secondary permeability created by fractures. Everitt et. al. (1996)

reported that in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth. It is expected that groundwater flow within Canadian Shield rocks in Saskatchewan will be similar to that found in other locations within the Canadian Shield.

4.3 Hydrogeochemistry

No information on hydrogeochemistry was found for the Pinehouse area. Although the Mannville Group contains saline water over much of its extent, there is a possibility that the Mannville Group aquifer may yield potable water where it outcrops south of the Canadian Shield contact; however, there is no information on water quality from the Mannville Group in the Pinehouse area.

Groundwater quality in the Canadian Shield formations of Saskatchewan would likely be similar to that found elsewhere. Gascoyne et al. (1987) investigated the saline brines within Precambrian plutons and identified a chemical transition at around 300 m depth marked by a uniform and rapid rise in total dissolved solids and chloride. This was attributed to advective mixing occurring above 300 m with a shift to diffusion-controlled flow below that depth. It was noted that major fracture zones within the bedrock can, where present, extend the influence of advective processes to greater depths.

In the deeper regions, where groundwater transport in unfractured or sparsely fractured rock tends to be very slow, long residence times on the order of a million years or more have been reported (Gascoyne et al., 2000; 2004). Groundwater research carried out in AECL's Whiteshell Underground Rock Laboratory (URL) in Manitoba found that crystalline rocks from depths of 300 m to 1000 m have total dissolved solids (TDS) values ranging from 3 to 90 g/L (Gascoyne et al., 1987; Gascoyne, 2000 and 2004). Total dissolved solids exceeding 250 g/L, however, have been reported in some regions of the Canadian Shield at depths below 500 m (Frape et al., 1984).

5.0 ECONOMIC GEOLOGY

5.1 Petroleum Resources

The Pinehouse area is primarily located in a crystalline geological setting where the potential for petroleum resources is negligible and no current exploitation or exploration activities occur. Although in Southern Saskatchewan petroleum resources can be associated with various formations within the Western Canada Sedimentary Basin, these formation configurations are not known to exist near Pinehouse. Oil and natural gas have been produced from the Mannville Group in west-central Saskatchewan, and tar sands have been associated with the Mannville Group rocks in northern Alberta and Saskatchewan; however, there are currently no known hydrocarbon deposits in the Pinehouse area (Thomas and Slimmon, 1985).

Several coal dispositions are present to the south of Pinehouse, within the Western Canada Sedimentary Basin (Figure 5.1). Limited information is available on these dispositions; however, these coal seams are located within the lower Mannville Group. The coal seams are relatively continuous, and can be used as stratigraphic markers (SGS, 2003).

There are no known methane or shale gas sources within the Pinehouse area.

5.2 Metallic Mineral Resources

There is no record of metallic mineral production near the Northern Village of Pinehouse. Past exploration has occurred to the east near the Needle Falls Shear Zone where occurrences of thorium, uranium, copper and iron have been noted (Delaney, 1993). Figure 5.1 shows areas of active exploration and mining claims in the Pinehouse area, as well as mineral occurrences (Saskatchewan Energy and Resources Atlas of Saskatchewan, 2010a).

Gold, Precious Metals, Iron and Base Metals

There are currently no producing gold mines near Pinehouse, however, there is a gold occurrence located just south of the Phanerozoic unconformity, approximately 12 km to the southwest of Pinehouse (Figure 5.1). This occurrence is located within Canadian Shield gneiss, at a depth of approximately 55 m (Saskatchewan Energy and Resources, 2010b). While most of the gold deposits known within Saskatchewan are located in the Canadian Shield, there are no known gold exploration projects currently being undertaken in the Pinehouse area.

Base metal and precious metal occurrences in the Pinehouse area include iron, pyrite, copper, and silver. Some occurrences have undergone limited trenching and drilling exploration (Saskatchewan Energy and Resources, 2010b), although there is no information available to indicate if these occurrences have any economic potential. In general, mineralization tends to be associated with the metasedimentary rocks (Wollaston Supergroup) or along inferred faults (Figure 5.1). Overall, the diversity of mineralization types within the Wollaston Domain suggests some potential for base metal deposits (Delaney, 1993).

Copper mineralization is primarily associated with metasedimentary rocks, which occur in the Pinehouse area at the north end of Pinehouse Lake. Copper mineralization is disseminated in outcrop occurrences on the north end of Pinehouse Lake (Munday, 1978) approximately 12 km to the northeast of Pinehouse. Copper mineralization has been associated with thorium-uranium occurrences in carbonaceous arkose near Duddridge Lake (Delaney, 1993), approximately 30 km to the east of Pinehouse. Iron mineralization, in the form of pyrite and pyrrhotite, has been associated with metasedimentary and granitic rocks near Knee Lake and northeast of

Besnard Lake. The nearest iron occurrence to Pinehouse is located approximately 12 km to the northeast, and is associated with the copper occurrence on the north end of Pinehouse Lake.

Fluorite was discovered disseminated throughout brecciated rock east of Santo Island in the north end of Pinehouse Lake, approximately 12 km northeast of Pinehouse. The fluorite mineralization is considered to be hydrothermal (Munday, 1978), and is located within the same general area as the copper and iron occurrences on the north end of Pinehouse Lake. There is no readily available information to indicate further exploration of these fluorite occurrences after initial discovery.

Uranium

In the Pinehouse area, uranium mineralization has been identified in the Duddridge Lake area as part of a thorium-uranium-copper prospect found in metasedimentary rock. This is shown as an active mineral claim on Figure 5.1. Uranium in this area is associated with a lower north-northeast trending sandstone sequence, which dips steeply to the west. Carbonaceous arkose is the primary host for uranium mineralization. Mineralization occurs as uraninite and exists as separate grains dispersed throughout the sequence, or as concentrated aggregates along bedding, fracture or schistosity planes (Delaney, 1993). In addition, some pegmatites within the Duddridge Lake area contain anomalous concentrations of uranium. Radioactive pegmatites associated with graphitic pelites are common throughout the Wollaston and Mudjatik Domains.

Uranium is the second most significant mineral resource in Saskatchewan. The Athabasca Basin hosts the world’s largest deposits of high-grade uranium. Virtually all of the Athabasca Basin has been staked for the purpose of uranium exploration, with three producing operations and several other properties under advanced development. The Athabasca Basin is located several hundred kilometres to the north of Pinehouse, such that the closest operating uranium operating property to the Northern Village of Pinehouse would be the Key Lake Operation, located approximately 250 km to the north. Key Lake was an open pit mining operation. Although uranium extraction no longer takes place there, uranium ore from other mine sites (like McArthur River) are currently processed at Key Lake.

Rare Metals

There are no known rare earth metal occurrences within the Pinehouse region.

5.3 Non-Metallic Mineral Resources

Known non-metallic mineral resources within the Pinehouse region include limestone, sand and gravel, and peat.

Limestone

Devonian Elk Point Group limestones 35 km to the south of Pinehouse may have economic significance (Fuzesy, 1976). The relatively shallow Missi Island and Sleeping Giant limestone deposits are shown as the limestone potential mineral deposit with reserves on Figure 5.1. The limestone potential of this area was first discovered in 1977, and several subsequent drill programs have been undertaken. The most recent exploration activities were conducted in 2007 by the Northern Village of Pinehouse under the organization of Pinehouse Business North Development Inc. The limestone deposits are found within the Elk Point Group Meadow Lake and Winnipegosis Formations at a depth of approximately 80 m.

Sand, Stone, and Gravel

Sand and gravel deposits consist of deposits related to the most recent glaciations. These resources occur in abundance, and with the ease of development, they are often taken for granted. There is approximately one small sand and gravel prospect per 26 km^2 and one large prospect for every 2,600 km^2 throughout Saskatchewan (SGS, 2003).

Peat

The major peatlands of Saskatchewan occur on the northern margin of the Western Canada Sedimentary Basin. Peatlands west of La Ronge and south of Pinehouse contain large quantities of well-humidified sedge fuel peat, generally with a sphagnum cover (SGS, 2003).

Only one peat moss producer operates within Saskatchewan, near Carrot River, approximately 510 km to the southeast of Pinehouse (SGS, 2003). Although unknown at this time, there may be potential for expanding this industry in the future.

Diamonds

Diamond-bearing kimberlites have been identified and are currently under development east of Prince Albert, approximately 260 km southeast of Pinehouse (SGS, 2003). Currently, kimberlites are not known to be present in the Pinehouse area.

Building Stone

Building stone is not currently exploited as a resource in Saskatchewan. However, there is potential for economic resources, especially in marble, granite, dolomite, amphibolites, and gabbro-diorite rock types. The majority of this potential occurs to the La Ronge region, but given the nature of the Canadian Shield rocks in the Pinehouse area, this resource cannot be completely disregarded in this region.

6.0 INITIAL SCREENING EVALUATION

This section provides an evaluation of each of the five initial screening criteria (NWMO, 2010) for the general Pinehouse area, based on the readily available information presented in Sections 2 to 5.

Initial screening criteria (NWMO, 2010) require that:

1) The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

2) This available land must be outside of protected areas, heritage sites, provincial parks and national parks.

3) This available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

4) This available land must not contain economically exploitable natural resources as known today, so that the repository site is unlikely to be disturbed by future generations.

5) This available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the outlined safety factors in Section 6 of the site selection document (MWMO, 2010).

The intent of this evaluation is not to conduct a detailed analysis of all available information or identify specific potentially suitable sites, but rather to identify any obvious conditions that would exclude the Pinehouse area from the site evaluation process. For cases where readily available information is limited and where the assessment of some of the criteria is not possible at the initial screening stage, the area would be advanced to the feasibility study stage for more detailed evaluation, provided the community remains interested in participating in the siting process.

The surface area within the boundaries of the Northern Village of Pinehouse is only 1 km^2 and would not be sufficient to accommodate the repository surface facilities. Therefore, as per discussions between NWMO and the community, the initial screening was conducted to assess whether there are areas at the periphery of the Northern Village that would meet the initial screening criteria. In the following, the periphery of the Northern Village of Pinehouse is also referred to as the “Pinehouse area”.

6.1 Screening Criterion 1: Land Availability

The site must have enough available land of sufficient size to accommodate the surface and underground facilities.

Surface facilities associated with the deep geological repository will require a surface land parcel of about 1 km by 1 km (100 ha) in size, although some additional space may be required to satisfy regulatory requirements. The underground footprint of the repository is about 1.5 km by 2.5 km (375 ha) at a typical depth of about 500 m. Available areas should be accessible to allow for the construction of surface facilities (about 100 ha) and for the various field investigations that are necessary to characterize the rock volume required to accommodate the footprint of the repository (e.g. drilling of boreholes).

Availability of land was assessed by identifying areas in the Pinehouse area where surface facilities are unlikely to be built due to constraints such as the presence of natural features (e.g. large water bodies, topographic constraints), land use (e.g. developed areas, infrastructure), accessibility and construction challenges based on the information presented in Section 2.

As mentioned above, the surface area within the boundaries of the Northern Village of Pinehouse is only 1 km^2 and would not be sufficient to accommodate the repository surface facilities. However, the review of available mapping and satellite imagery (Figures 2.1 and 2.2.) shows that there are areas in the periphery of the Northern Village that have no constraints that would prevent the development of these facilities. The Northern Village of Pinehouse domestic and industrial infrastructure covers a small surface area that is limited mainly to the community itself, as well as Provincial Road 914. The Pinehouse area is largely undeveloped, with no major infrastructure present. Despite the presence of major lakes and permanent water bodies such as Pinehouse Lake, there are large portions of land well in excess of the surface area needed for the development of the facilities associated with a deep geological repository. Therefore, the Pinehouse area contains sufficient land to potentially accommodate the repository surface facilities.

As discussed in Section 2, topography is moderately variable with the most relief occurring to the southwest of Pinehouse and marshy areas occurring within topographic lows in the area (Figure 2.3). Although topographic relief is variable across the areas, no obvious topographic features that would prevent construction and characterization have been identified, although access to the marshy lowlands would need further investigation. The Pinehouse area is accessible by Provincial Road 914.

As discussed further in section 6.5, the Pinehouse area has the potential of containing sufficient volumes of appropriate host rock to accommodate the underground facilities associated with a deep geological repository. This would have to be confirmed in subsequent site evaluation stages.

Based on the review of readily available information, it is concluded that the Pinehouse area contains sufficient land to accommodate the repository surface and underground facilities.

6.2 Screening Criterion 2: Protected Areas

Available land must be outside of protected areas, heritage sites, provincial parks and national parks.

The assessment of this criterion is needed to confirm that the remaining available land, after excluding protected areas, is of sufficient size to allow for the construction of the repository facilities. Protected areas are considered to be ecologically sensitive or significant areas, as defined by Provincial or Federal authorities.

The Pinehouse area was screened for federal, provincial and municipal parks, conservation areas, nature reserves and national wildlife areas, and heritage sites using available data from federal and provincial databases.

Figures 2.1 and 2.5 show that there are two recreational areas within the Pinehouse area: the Gordon Lake Recreation Site and the Besnard Lake Recreational Site, located approximately 27 km north and 35 km southeast of the Northern Village of Pinehouse respectively. These recreational sites are small and cover less that 4 km^2 each. In addition to these recreation sites, several heritage sites were identified near the Northern Village of Pinehouse. These sites are small and generally concentrated along the Churchill River and along Provincial Road 914 north of Pinehouse. There are no known wildlife or nature reserves in the area. Apart from the areas identified above, the Pinehouse area contains large parcels of land that are outside of protected areas, provincial parks and national parks.

The absence of locally protected areas would need to be confirmed in discussion with the community and Aboriginal peoples in the area during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

Based on the review of readily available information, the Pinehouse area contains sufficient land outside of protected areas, heritage sites, provincial parks and national parks to accommodate the repository's facilities.

6.3 Screening Criterion 3: Known Groundwater Resources at Repository Depth

Available land must not contain known groundwater resources at the repository depth, so that the repository site is unlikely to be disturbed by future generations.

In order to minimize the future risk of human intrusion during the long post-closure period, the repository should be sited in a host rock formation that does not contain significant groundwater resources at repository depth (approximately 500 m) that may encourage future generations to access those resources and potentially compromise the long-term performance of the repository.

The review of available information did not identify any known groundwater resources at repository depth in the Pinehouse area. As discussed in Section 4.0, the Saskatchewan Watershed Authority (SWA) Water Well Record (WWR) database shows that the closest water wells known in the area obtain water from overburden at depths ranging from 10 m to 20 m.

The geology in the Pinehouse area at typical repository depth is dominated by the crystalline bedrock from the Canadian Shield, including the south-western portion that is covered by a relatively thin layer of sedimentary rocks of the Western Canada Sedimentary Basin. Experience from other areas in the Canadian Shield has shown that active groundwater flow is generally confined to shallow fractured localized systems (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet Batholith, groundwater movement is largely controlled by a fractured zone down to about 200 m depth (Everitt et al., 1996). In deeper regions, hydraulic conductivity tends to decrease as fractures become less common and interconnected (Stevenson et al., 1996; McMurry et al., 2003).

Saskatchewan Watershed Authority Water Well Records indicate that no potable water supply wells are known to exploit aquifers at repository depths in the Pinehouse area. Groundwater at such depths is generally saline and very low groundwater recharge at such depths limits the potential yield, even if suitable water quality were to be found. The absence of groundwater resources at repository depth in the Pinehouse area would, however, need to be confirmed during subsequent site evaluation stages, if the community remains interested in continuing with the site selection process.

The review of available information did not identify any groundwater resources at repository depth in the Pinehouse area. Experience in similar geological settings suggests that the potential for deep groundwater resources at repository depths is low. The absence of groundwater resources at *repository depth would, however, need to be confirmed during subsequent site evaluation stages if the community remains interested in the site selection process.*

6.4 Screening Criterion 4: Known Natural Resources

Available land must not contain economically exploitable natural resources, as known today, so that the repository site is unlikely to be disturbed by future generations.

As with the assessment of groundwater resources, the need to minimize the risk of future human intrusion requires that the repository be sited in a host rock formation having a low potential for economically exploitable natural resources. Readily available information on the past and potential future occurrence of natural resources such as oil and gas, metallic and non-metallic mineral resources was reviewed in Section 5.

The review indicates that there is no evidence of past or present exploration or development activities associated with oil and gas resources. There are currently no operating or past producing mines within the Pinehouse area. There are several coal claim blocks within the Mannville Group in the sedimentary rocks of the Western Canada Sedimentary Basin to the south of Pinehouse that are being explored, but no known reserves have been identified.

Only a few metallic mineral occurrences have been identified in the Pinehouse area. Mineral occurrences in the area appear to be primarily associated with inferred fault traces, and metasedimentary rocks (Figure 5.1). The nearest metallic mineral claims are associated with copper-uranium and are located approximately 30 km east of Pinehouse, in the Duddridge Lake area.

No record of non-metallic mineral resources exploitation was found within the Pinehouse area. Potential for limestone has been recognized in the sedimentary rocks, approximately 20 km south of Pinehouse. As well, sand and gravel resources are abundant throughout Saskatchewan and are expected to be present near Pinehouse. Commercial potential for peat exists in some low-lying areas (Figure 5.1), but no peat extraction has occurred in the Pinehouse area.

In summary, the Pinehouse area has a generally low economic mineral potential. There are no known deposits of economically exploitable natural resources within the Pinehouse area.

Based on the review of readily available information, the Pinehouse area contains sufficient areas, free of known economically exploitable natural resources, to accommodate the required repository facilities. The absence of natural resources would need to be confirmed during subsequent site evaluation stages, if the community remains interested in the site selection process.

6.5 Screening Criterion 5: Unsafe Geological or Hydrogeological Features

Available land must not be located in areas with known geological and hydrogeological characteristics that would prevent the site from being safe, considering the safety factors outlined in Section 6 of the site selection document (NWMO, 2010).

This criterion requires that the site not be located in a known area of geological or hydrogeological features that would make the site unsafe, as per the following five geoscientific safety-related factors identified in the site selection process (NWMO, 2010):

1) Safe containment and isolation of used nuclear fuel. Are the characteristics of the rock at the site appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances?

2) Long-term resilience to future geological processes and climate change. Is the rock formation at the site geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially affected by natural disturbances and events such as earthquakes and climate change?

3) Safe construction, operation and closure of the repository. Are conditions at the site suitable for the safe construction, operation and closure of the repository?

4) Isolation of used fuel from future human activities. Is human intrusion at the site unlikely, for instance, through future exploration or mining?

5) Amenable to site characterization and data interpretation activities. Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

At this early stage of the site evaluation process, where limited data at repository depth exist, the five safety-related geoscientific factors are assessed using readily available information, with the objective of identifying any obvious unfavourable hydrogeological and geological conditions that would exclude the Pinehouse area from further consideration. These factors would be gradually assessed in more detail as the site evaluation process progresses and more site specific data is collected during subsequent site evaluation phases, provided the community remains interested in the site selection process.

In the southwestern portions of the Pinehouse area, the crystalline rock of the Canadian Shield is covered by about 100m of sedimentary rocks of the Western Canada Sedimentary Basin (Figure 3.2). A deep geological repository in that area would be developed in crystalline rock at a depth of about 500 m. One of the key criteria in assessing the suitability of a site relate to having a host rock that is amenable to site characterization in order to develop a good understanding of the geoscientific characteristics of the site and a robust safety case. Because of the nature of the structural characteristics of crystalline rock (e.g. fractures geometry and frequency), the presence of a thick sedimentary cover would greatly reduce the ability to adequately characterize the crystalline rock at repository depth. Therefore, the southwestern portion of the Pinehouse area is excluded from further consideration as it would not be amenable to site characterization and data interpretation activities.

The evaluation of this screening criterion will focus on the remaining areas where the crystalline rock of the Canadian Shield is not covered by sedimentary rocks from the Western Canada Sedimentary Basin (Figure 3.2).

Safe Isolation and Containment Function

The geological and hydrogeological conditions of a suitable site should promote long-term isolation and containment of used nuclear fuel and retard the movement of any potentially released radioactive material. This requires that the repository be located at a sufficient depth, around 500 m, in a sufficient rock volume with characteristics that limit groundwater movement. Readily available information on the regional and local geology and hydrogeology was reviewed in Sections 3 and 4, respectively.

The geology of the Pinehouse area is dominated by felsic gneiss, with the presence of narrow, linear, northeast-southwest trending bands of metasedimentary rocks known as the Wollaston Supergroup (Figure 3.6). The felsic gneiss predominantly formed by metamorphism of precursor plutonic rocks and are mostly granitic in composition. The metasedimentary rocks formed by metamorphism of various types of sedimentary rocks that were originally deposited on the felsic gneiss. Folding and thrusting may have, locally, deeply buried these narrow metasedimentary rock bands to substantial depth. The overall combined thickness of these two geological units in the Pinehouse area is expected to be up to 10 km.

As discussed in Section 3.2.2, faulting in the Pinehouse area has been inferred on a frequency of 10 km to 20 km and is in a predominantly northwest (and secondary northeast) direction (Figure 3.2). Sufficient volumes of rock to host the repository exist between these faults. There is no readily available information that suggests fracturing in the rock at depth between the inferred faults. This would need to be assessed in subsequent site evaluation stages.

From a hydrogeologic perspective, the review of readily available information did not reveal the existence of known deep fracture systems or deep aquifers in the crystalline rock within the Pinehouse area. Crystalline rocks, such as those found in the area, generally have hydraulic properties that would limit groundwater flow except where extensive fracturing is present. The presence of active deep groundwater flow systems in crystalline formations is controlled by the frequency and interconnectivity of fractures at depth. Experience from other areas in the Canadian Shield indicate that active groundwater flow tends to be generally limited to shallow fractured systems, typically less than 300 m. In deeper rock, fractures are less common and less likely to be interconnected, leading to very slow groundwater movement with residence times that could reach a million years or more (McMurray et al., 2003; Gascoyne, 2000, 2004).

Based on the above, there are areas within the felsic gneiss rocks that do not have known geological and hydrogeological conditions that would not meet the containment and isolation requirements. Given their granitic composition, their lateral extent and depth, the felsic gneiss rocks might be considered as potential host rock for a deep geological repository. While the metasedimentary rock bands may fulfill the safe isolation and containment function, it is uncertain whether they have sufficient volume to host a deep geological repository.

Other geoscientific characteristics that may have an impact on the containment and isolation functions of a deep geological repository such as the mineralogy of the rock, the geochemical composition of the groundwater and rock porewater, the thermal and geomechanical properties of the rock would also need to be assessed during subsequent site evaluation stages.

Long-term Stability

A suitable site for hosting a repository is a site that would remain stable over the very long term in a manner that will ensure that the performance of the repository will not be substantially altered by geological and climate change processes, such as earthquakes or glaciation. A full assessment of this geoscientific factor requires detailed site specific data that would be typically collected and analyzed through detailed field investigations. The assessment would include understanding how the site has responded to past glaciations and geological processes and would entail a wide range of studies involving disciplines such as seismology, hydrogeology, hydrogeochemistry, paleohydrogeology and climate change.

At this early stage of the site evaluation process, the long-term stability factor is evaluated by assessing whether there is any evidence that would raise concerns about the hydrogeological and geological long-term stability of the Pinehouse area. The review of readily available information did not reveal any obvious characteristics that would suggest this.

Pinehouse is located in the Hearne Province of the Canadian Shield, where large portions of land have remained tectonically stable for the last 1.8 billion years (SGS, 2003). No earthquakes have been recorded near Pinehouse from 1985 through 2010 and there is no evidence of historical earthquakes prior to 1985. As discussed in Sections 3.1 and 3.2, there is no evidence that the Needle Falls Shear Zone (located approximately 30 km east of Pinehouse) or the smaller scale northwest and northeast trending faults have been significantly active in the last 1.8 billion years.

The geology of the Pinehouse area is typical of many areas of the Canadian Shield, which has been subjected to numerous glacial cycles during the last million years. This is a significant past perturbation that will likely occur in the future. However, findings from studies conducted in areas of the Canadian Shield suggest that deep crystalline formations, particularly plutonic intrusions, have remained largely unaffected by past perturbations such as glaciations. Findings of a comprehensive paleohydrogeological study of the fractured crystalline rock at the Whiteshell Research Area, located within the Manitoba portion of the Canadian Shield (Gascoyne, 2004) indicated that the evolution of the groundwater flow system was characterized by periods of long-term hydrogeological and hydrogeochemical stability. Furthermore, there was evidence that only the upper 300 m appeared to have been altered within the last million years. Several studies conducted in a number of plutons in the Canadian Shield and in the crystalline basement rocks in Western Ontario (McMurry et al., 2003) show that fractures below a depth of several hundred metres in the plutonic rock were ancient features. Additionally, subsequent geological processes such as plate movement and continental glaciation have caused reactivation of existing zones of weakness rather than the formation of large new zones of fractures. In Northern Saskatchewan, studies suggest that the crystalline rock formations of the Canadian Shield were resistant to erosion by the glaciers (Schreiner, 1984a).

In summary, the review did not identify any obvious geological or hydrogeological conditions that would clearly not satisfy the long term stability function of a potential repository within the Pinehouse area. As mentioned above, the long-term stability function would need to be further assessed through detailed multidisciplinary geoscientific site investigations.

Potential for Human Intrusion

The site should not be located in areas where the containment and isolation functions of the repository are likely to be disrupted by future human activities such as exploration or mining. Therefore, the repository should not be located within rock formations containing exploitable groundwater resources (aquifers) at repository depth and economically exploitable natural resources such as gas/oil, coal, minerals and other valuable commodities as known today.

This factor has already been addressed in Sections 6.3 and 6.4 which concluded that the potential for deep groundwater resources at repository depths and known economically exploitable natural resources is low throughout the Pinehouse area. However, the metasedimentary rock units are associated with the known mineral occurrences in the Pinehouse area. This may be of concern and would require further assessment.

Amenability to Construction and Site Characterization

The characteristics of a suitable site should be favourable for the safe construction, operation, closure and long-term performance of the repository. Beside the requirement for space discussed in Section 6.1, this requires that the strength of the host rock and in-situ stress at repository depth are such that the repository could be safely excavated, operated and closed without unacceptable rock instabilities; and that the soil cover depth over the host rock should not adversely impact repository construction and site investigation activities. Similarly, the host rock geometry and structure should be predictable and amenable to site characterization and interpretation activities. The review of readily available information did not reveal any obvious conditions that would exclude the extensive felsic gneiss in the Pinehouse area from further consideration.

From a constructability perspective, limited site specific information is available on the local rock strength characteristics and in-situ stresses for the Pinehouse area. However, there is abundant information at other locations of the Canadian Shield that could provide insight into what should be expected for the Pinehouse area in general. Available information suggests that crystalline rock formations within the Shield such as the felsic gneiss generally possess geomechanical characteristics that are good to very good and amenable to the type of excavation activities involved in the development of a deep geological repository for used nuclear fuel (Chandler et al., 2004; McMurry et al., 2003; Everitt, 1999; Arjang and Herget, 1997).

In terms of predictability of the geological formations and amenability to site characterization activities, the review of readily available information on the bedrock geology and Quaternary geology for the Pinehouse area (Sections 3.2 and 3.4) indicate that conditions which could make the rock mass more difficult to characterize and predict may be present in localized areas. For example, available information on overburden thickness shows that Quaternary deposits are typically between 0 m to 20 m thick. Low lying areas in the Pinehouse area are covered with muskeg. This muskeg becomes less predominant moving northward and outcrops of crystalline bedrock are observed on Hwy 914 within less than 20 km of Pinehouse. The degree to which these factors might affect the characterization and data interpretation activities would require further assessment during subsequent stages of the site selection process.

Based on the review of readily available geological and hydrogeological information, the Pinehouse area comprises areas of land that do not contain obvious known geological and hydrogeological conditions that would make the area unsuitable for hosting a deep geological repository. These areas include the crystalline felsic gneiss rocks that dominate the Pinehouse area. The southwestern portion of the Pinehouse area where the felsic gneisses are covered by about 100 m of sedimentary rocks was excluded from further consideration as the presence of the sedimentary rock cover could reduce the ability to adequately characterize the underlying bedrock at repository depth.

7.0 INITIAL SCREENING FINDINGS

This report presents the results of an initial screening to assess the suitability of the Pinehouse area against five initial screening criteria using readily available information. As outlined in NWMO's site selection process (NWMO, 2010), the five initial screening criteria relate to: having sufficient space to accommodate surface facilities, being outside protected areas and heritage features, absence of known groundwater resources at repository depth, absence of known natural resources and avoiding known hydrogeologic and geologic conditions that would make an area or site unsuitable for hosting a deep geological repository.

The surface area within the boundaries of the Northern Village of Pinehouse is only 1 km^2 and would not be sufficient to accommodate the repository surface facilities. Therefore, as per discussions between NWMO and the community, the initial screening was conducted to assess whether there are areas within the periphery of the Northern Village (the Pinehouse area) that would meet the initial screening criteria.

The review of available information and the application of the five initial screening criteria did not identify any obvious conditions that would exclude the Northern Village of Pinehouse from further consideration in the NWMO site selection process. There are areas at the periphery of the Northern Village of Pinehouse that are potentially suitable for hosting a deep geological repository. These areas include the felsic gneiss rocks that dominate the geology of the Pinehouse area. Potential suitability of these areas would need to be further assessed during subsequent evaluation stages, if the community remains interested in continuing with the site selection process.

The southwestern portion of the Pinehouse area was excluded from further consideration because the potentially suitable host rock formation, the felsic gneiss, lies under about 100 m of sedimentary rocks of the Western Canada Sedimentary Basin. Because of the nature of the structural characteristics of crystalline rock (e.g., fractures geometry and frequency), the presence of the sedimentary cover would greatly reduce the ability to adequately characterize the host rock.

It is important to note that at this early stage of the site evaluation process, the intent of the initial screening was not to confirm the suitability of the Pinehouse area, but rather to identify whether there are any obvious conditions that would exclude it from further consideration in the site selection process. Should the community of Pinehouse remain interested in continuing with the site selection process, more detailed studies would be required to confirm and demonstrate whether the Pinehouse area contains sites that can safely contain and isolate used nuclear fuel.

The process for identifying an informed and willing host community for a deep geological repository for Canada's used nuclear fuel is designed to ensure, above all, that the site which is selected is safe and secure for people and the environment, now and in the future.

8.0 REFERENCES

Arjang B. and G. Herget, 1997. In situ ground stresses in the Canadian hardrock mines: An update. International Journal of Rock Mechanics and Mining Sciences Vol 34. Issue 3-4. pp. 15.e1-15.e16.

Besnard Lake Lodge. 2010. Besnard Lake Lodge. URL:http://www.besnardlake.com.

Card, Colin, 2010. Personal Communications.

Chandler N., Guo R. and R., Read (Eds). 2004. Special issue: Rock Mechanics Results from the Underground Research Laboratory, Canada. International Journal of Rock Mechanics and Mining Sciences Vol 41. Issue 8. pp. 1221-1458.

Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 2010. Canadian Wildlife Species at Risk. Committee on the Status of Endangered Wildlife in Canada. URL:http://www.sararegistry.gc.ca

Corrigan, D., T.G. MacHattie, and J. Chakungal, 1999. The Wathaman Batholith and its Relation to the Peter Lake Doamain: Insights for Recent Mapping along the Reindeer Lake Transect, Trans-Hudson Orogen. In Summary of Investigations 1999, Volume 2, Saskatchewan Geological Survey, Saskatchewan Energy and Mines, Miscellaneous Report 99-4.2.

Delaney, G.D., 1993. A Re-examination of the Context of U-Cu, Cu and U Mineralization, Duddridge Lake, Wollaston Domain. In: Summary of Investigations 1993, Saskatchewan Geological Survey, Saskatchewan Energy and Mines, Miscellaneous Report. 93-4.

Everitt, R., J. McMurry, A. Brown and C.C. Davison, 1996. Geology of the Lac du Bonnet Batholith, inside and out: AECL's Underground Research Laboratory, southeastern Manitoba. Field Excursion B-5: Guidebook. Geological Association of Canada — Mineralogical Association of Canada, Joint Annual Meeting, 30 May 1996, Winnipeg, Manitoba.

Everitt R.A., 1999. Experience gained from the geological characterisation of the Lac du Bonnet batholith, and comparison with other sparsely fractured granite batholiths in the Ontario portion of the Canadian Shield. OPG Report 06819-REP-01200-0069-R00. OPG. Toronto. Canada.

Fedorowich, J.S., M.R. Stauffer, R. Kerrick, and J.F. Lewry, 2003. Thermochronology of the Needle Falls Shear Zone: a post-collisional high-strain zone of the Trans-Hudson Orogen. Canadian Journal of Earth Sciences, Volume 40, pp. 1009–1025. Natural Resources Canada.

Fisher, T.G., and D.G. Smith, 1994. Glacial Lake Agassiz: Its Northwest Maximum Extent and Outlet in Saskatchewan (Emerson Phase). Quaternary Science Reviews, Volume 13, pages 845 – 858.

Frape, S.K., P. Fritz and R.H. McNutt. 1984. The Role of Water–Rock Interactions in the Chemical Evolution of Groundwaters from the Canadian Shield. Geochimica et Cosmochimica Acta, Volume 48, pages 1617–1627.

Fung, K., 1999. Atlas of Saskatchewan 2nd Edition. University of Saskatchewan, Saskatoon, Saskatchewan, pp. 336.

Fuzesy, L.M., 1976. Sedimentary Geology and Mineral Evaluation in the Area between La Ronge and Pinehouse Lake.

Gascoyne, M., C.C. Davison, J.D. Ross, and R. Pearson., 1987. Saline groundwaters and brines in plutons in the Canadian Shield. Geological Association of Canada - Special Paper. 33:53-68

Gascoyne, M., 2000. Hydrogeochemistry of the Whiteshell Research Area. Ontario Power Generation, Nuclear Waste Management Division Report, 06819-REP-01200-10033-R00. Toronto, Canada.

Gascoyne, M., 2004. Hydrogeochemistry, groundwater ages and sources of salts in a granitic batholith on the Canadian Shield, southeastern Manitoba. Applied Geochemistry, 19: 519-560.

Gendzwill, D. and J. Unrau, 1996. Ground Control and Seismicity at International Minerals and Chemical (Canada) Global Limited. CIM Bulletin, Volume 89, pages 52 – 61.

Greggs, D.H., and F.J. Hein, 2000. The Sedimentology and Structure of the Lower Paleozoic Deadwood Formation of Saskatchewan. In Summary of Investigations 2000, Volume 1, Saskatchewan Geological Survey, Saskatchewan Energy and Mines, Miscellaneous Report 2000-4.1.

Lambert, A., T.S. James and L.H. Thorleifson, 1998. Combining Geomorphological and Geodetic Data to Determine Postglacial Tilting in Manitoba. Journal of Paleolimnology, Volume 19, pp. 365–376.

Maathuis, H. and L.H. Thorleifson, 2000. Potential Impact of Climate Change on Prairie Groundwater Supplies: Review of Current Knowledge. Saskatchewan Research Council Publication No. 11304-2E00.

McFall, G. H., 1993. Structural Elements and Neotectonics of Prince Edward County, Southern Ontario; Géographie physique et Quaternaire, vol. 47, no 3, 1993, pp.303-312.

McMurry, J., D.A. Dixon, J.D. Garroni, B.M. Ikeda, S. Stroes-Gascoyne, P. Baumgartner and T.W. Melnyk, 2003. Evolution of a Canadian deep geologic repository: Base scenario. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10092-R00. Toronto, Canada.

Meyer, D., 1979. Archaeology. In Key Lake Project Environmental Impact Statement, Appendix IX. Beak Consultants Ltd., Calgary.

Meyer, D., 1995. Churchill River Archaeology in Saskatchewan: How Much Do We Know? In The Churchill: A Canadian Heritage River, Conference Proceedings. P. Jonker (ed.). University Extension Press, University of Saskatchewan, Saskatoon.

Munday, R.J., 1978. The Shield Geology of the Ile-a-la-Crosse (East) Area Saskatchewan. Part of the NTS Area 73-0. Department of Mineral Resources, Saskatchewan Geological Survey, Precambrian Geology Sector.

Natural Resources Canada (NRC), 2010. Earthquakes Canada Website. URL:http://earthquakescanada.nrcan.gc.ca

NWMO, 2005. Choosing a way forward. The future management of Canada's used nuclear fuel. Nuclear Waste Management Organization. (Available at www.nwmo.ca)

NWMO, 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Nuclear Waste Management Organization. (Available at www.nwmo.ca).

Peltier, W.,R., 2002. On eustatic sea level history: Last Glacial Maximum to Holocene: Quaternary Science Reviews 21 (2002) pp. 377–396.

Petroleum Technology Research Centre (PTRC), 2010. Isopach Maps for the Mannville, Meadow Lake and Deadwood Formations. Western Saskatchewan Project Map Series, Regional Stratigraphic Framework for Western Saskatchewan. URL:http://www.ptrc.ca/publications.php?f_action=news_detail&news_id=14022

Russell, D. And D. Meyer, 1999. The History of the Fur Trade ca. 1682 – post 1821; Trading Posts pre-1959 – post 1930. In: Atlas of Saskatchewan. K.I. Fund (ed.) University of Saskatchewan, Saskatoon.

Saskatchewan Geological Survey (SGS), 2003. Geology, and Mineral and Petroleum Resources of Saskatchewan. Saskatchewan Industry and Resources. Miscellaneous Report 2003-7.

Saskatchewan Energy and Resources, 2010. Geological Atlas of Saskatchewan. URL:http://www.infomaps.gov.sk.ca/wesite/SIR Geological Atlas/viewer.htm

Saskatchewan Industry and Resources (SIR), 1999. Geological Map of Saskatchewan 1:1,000,000 scale.

Saskatchewan Watershed Authority (SWA), 2009. Water Well Database, May 2009.

Schreiner, B.T., 1984a. Quaternary Geology of the Precambrian Shield, Saskatchewan. Saskatchewan Geological Survey, Saskatchewan Energy and Mines, Report 221.

Schreiner, B.T., 1984b. Quaternary Geology of the Precambrian Shield Saskatchewan. Saskatchewan Geological Survey, Saskatchewan Engery and Mines, Map 221 A (to accompany Report 221).

Shackleton, N.J., A. Berger and W.R. Peltier, 1990. An alternative astronomical calibration of the lower Pleistocene timescale based on ODP Site 677: Transactions of the Royal Society of Edinburgh: Earth Sciences, 81, pp. 251-261.

Smith, D., G. Taylor, and P. Ogryzlo, 2003. The Pinehouse Limestone Project. Paper 14 from the Proceedings of the 35th Annual Meeting of the Canadian Mineral Processors, January 21-23, 2003.

Statistics Canada, 2010. URL:http://www.statcan.gc.ca/start-debut-eng.html

Stauffer, M.R., and J.F. Lewry, 1993. Regional Setting and Kinematic Features of the Needle Falls Shear Zone, Trans-Hudson Orogen. Canadian Journal of Earth Sciences, Volume 30, pp. 1338–1354.

Stevenson, D.R., E.T. Kozak, C.C. Davison, M. Gascoyne, and R.A. Broadfoot, 1996. Hydrogeologic characterization of domains of sparsely fractured rock in the granitic Lac du Bonnet Batholith, Southeastern Manitoba, Canada. Atomic Energy of Canada Limited Report, AECL-11558, COG-96-117. Pinawa, Canada.

Thomas, M.W. and W. L. Slimmon, 1985. Compilation Bedrock Geology, Ile-a-la-Crosse, NTS Area 73O. Saskatchewan Energy and Mines, Report 245 (1:250,000 scale map with marginal notes).

Tourism, Parks, Culture and Sport (TPCS) Government of Saskatchewan, 2010. Conserving Canadian Heritage Rivers System. URL:http://www.tpcs.gov.sk.ca/Conserving.

White, O.L, P.F. Karrow and J.R. Macdonald, 1973. Residual stress release phenomena in southern Ontario. Proceedings of the 9th Canadian Rock Mechanics Symposium, Montreal, December 1973, pp. 323-348.

Yeo, G.M., and G. Delaney, 2007. The Wollaston Supergroup, Stratigraphy and Metallogeny of a Paleoproterozoic Wilson Cycle in the Trans-Hudson Orogen, Saskatchewan. In EXTECH IV: Geology and Uranium Exploration TECHnology of the Proterozoic Athabasca Basin, Saskatchewan and Alberta, C.W. Jefferson and G. Delaney (eds), Geological Survey of Canada Bulletin 588, pp. 89–117.

9.0 REPORT SIGNATURE PAGE

GOLDER ASSOCIATES LTD.

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Geological Engineer

George Schneider, M.Sc.
Principal

Rashid Bashir, Ph.D., P.Eng.
Senior Geotechnical Engineer

EAM/RB/GS/MAT/GAM/pls/cjf

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FIGURES

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

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1721 8th Street East
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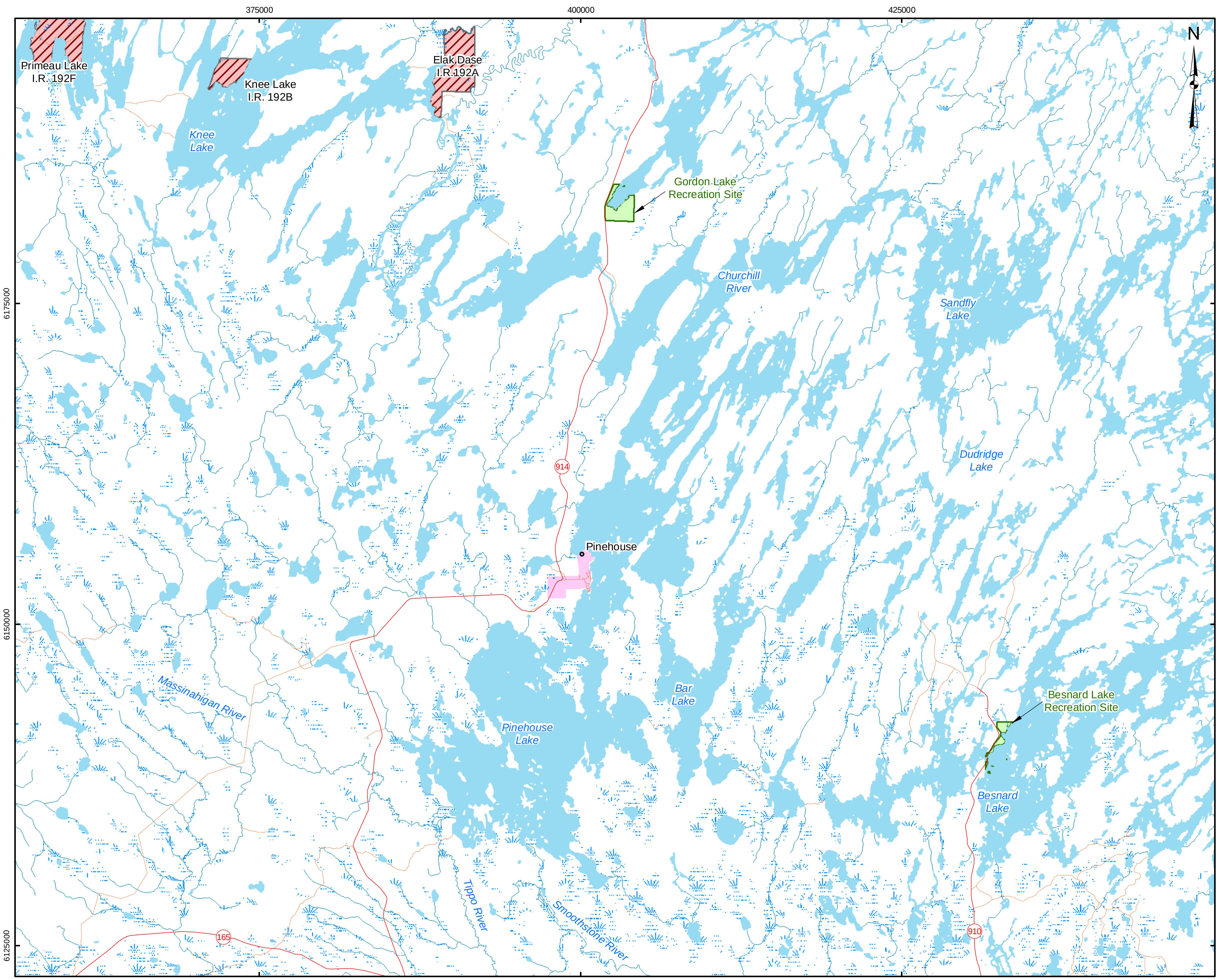
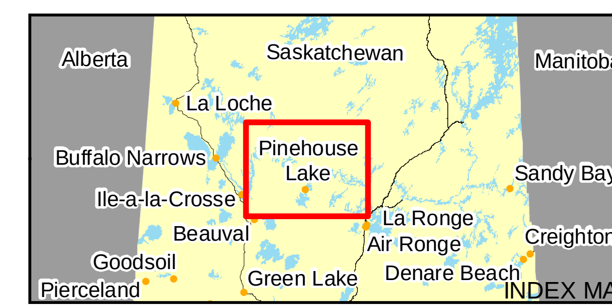
Golder Associates



LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve



INDEX MAP

REFERENCE

DMTI Highways and Roads
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

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SCALE 1:300,000 KILOMETERS

PROJECT

NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE

The Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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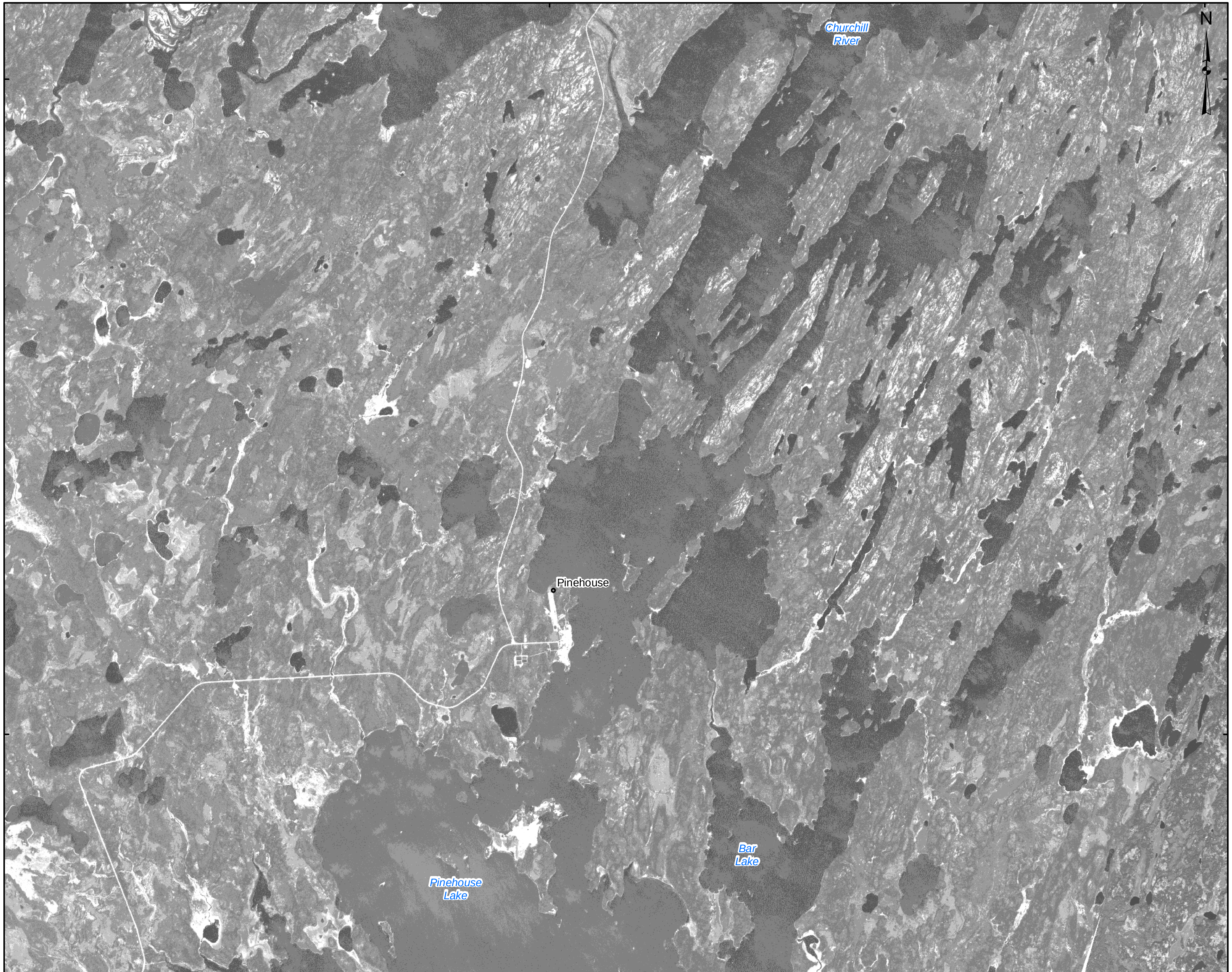
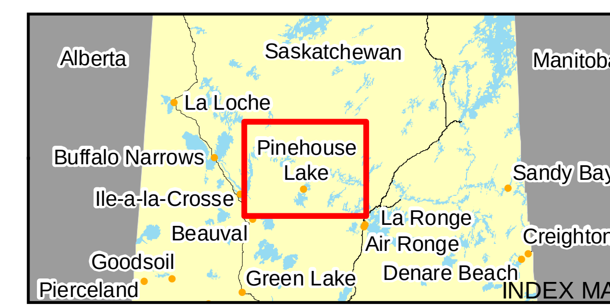


LEGEND

- Community



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SPOT Imagery Courtesy of GeoBase
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Datum: NAD 83 Coordinate System: UTM Zone 13

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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Satellite Imagery of the Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
DESIGN				
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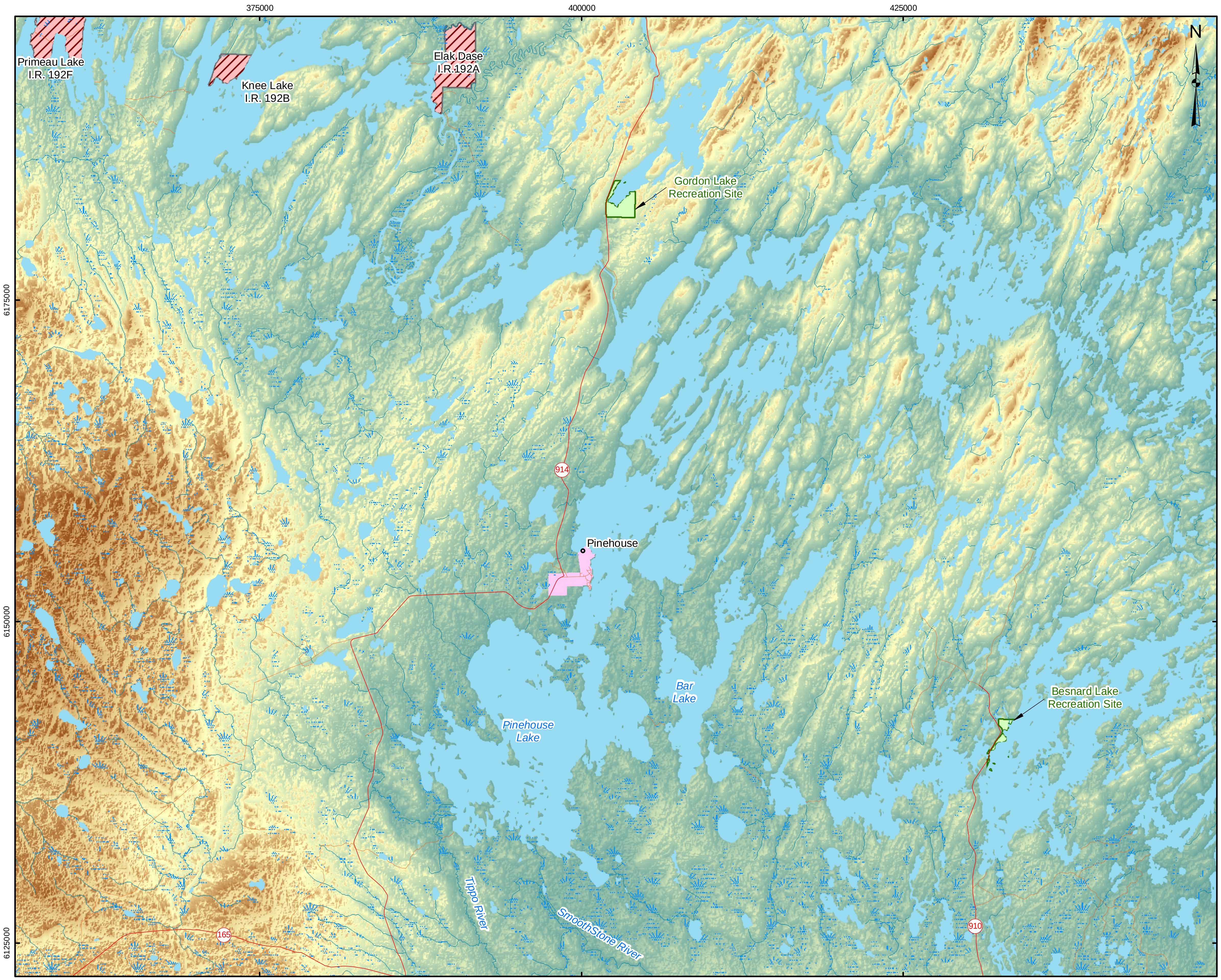


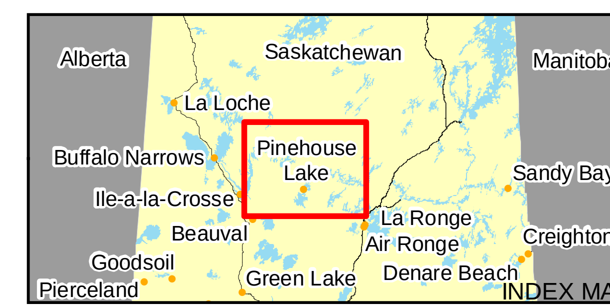
LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve

Elevation Model (masl)

High : 765

Low : 309



REFERENCE

DMTI Highways and Roads
NASA Digital Elevation Model
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

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SCALE 1:300,000 KILOMETERS

PROJECT

NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE

Digital Elevation Model
of the Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
DESIGN			FIGURE: 2.3	
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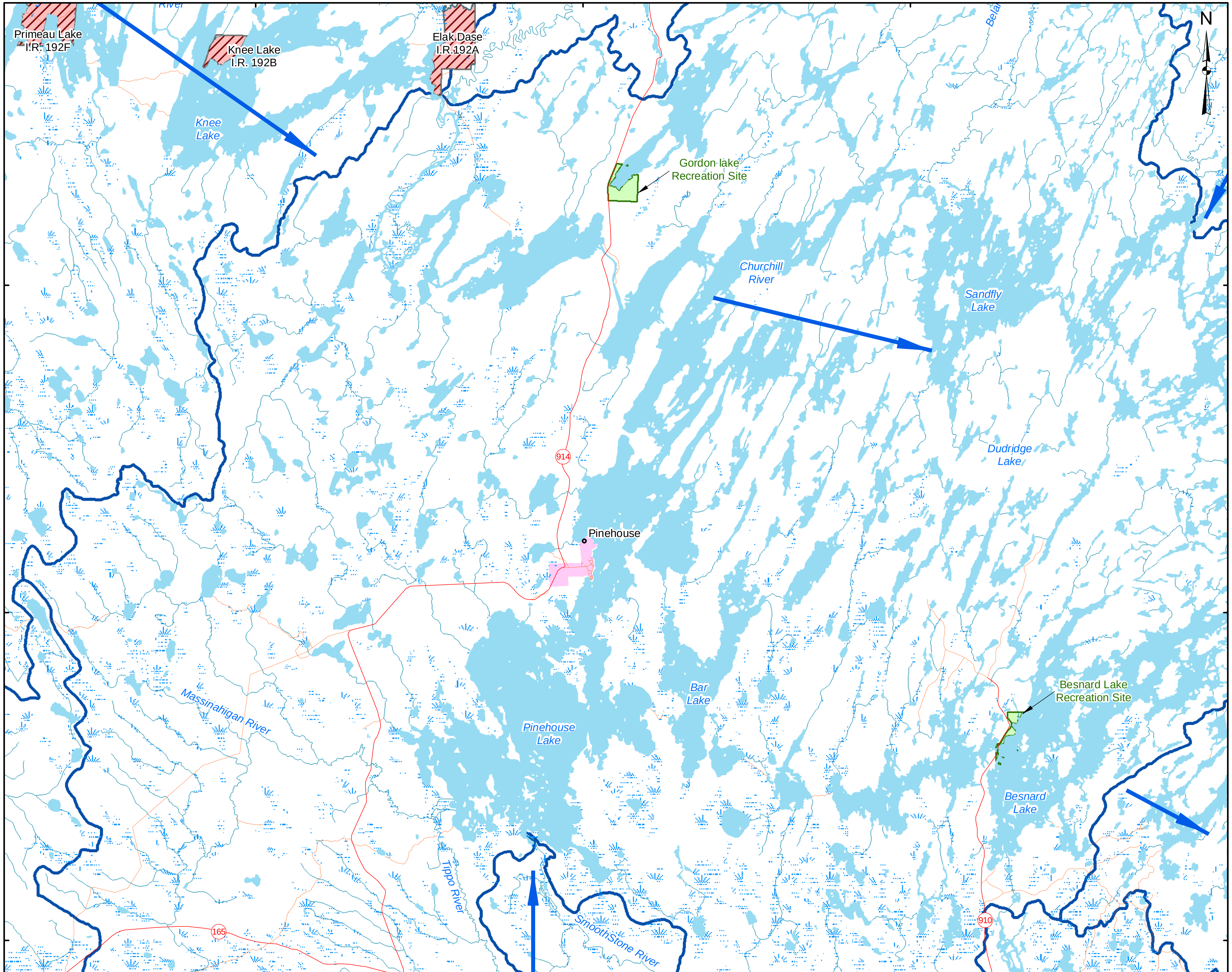
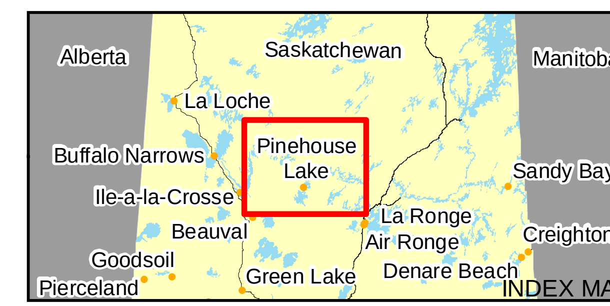


LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve
- Watershed Boundary
- Flow Direction



REFERENCE

DMTI Highways and Roads
PFRA, Agriculture Canada Watersheds
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Drainage Features
of the Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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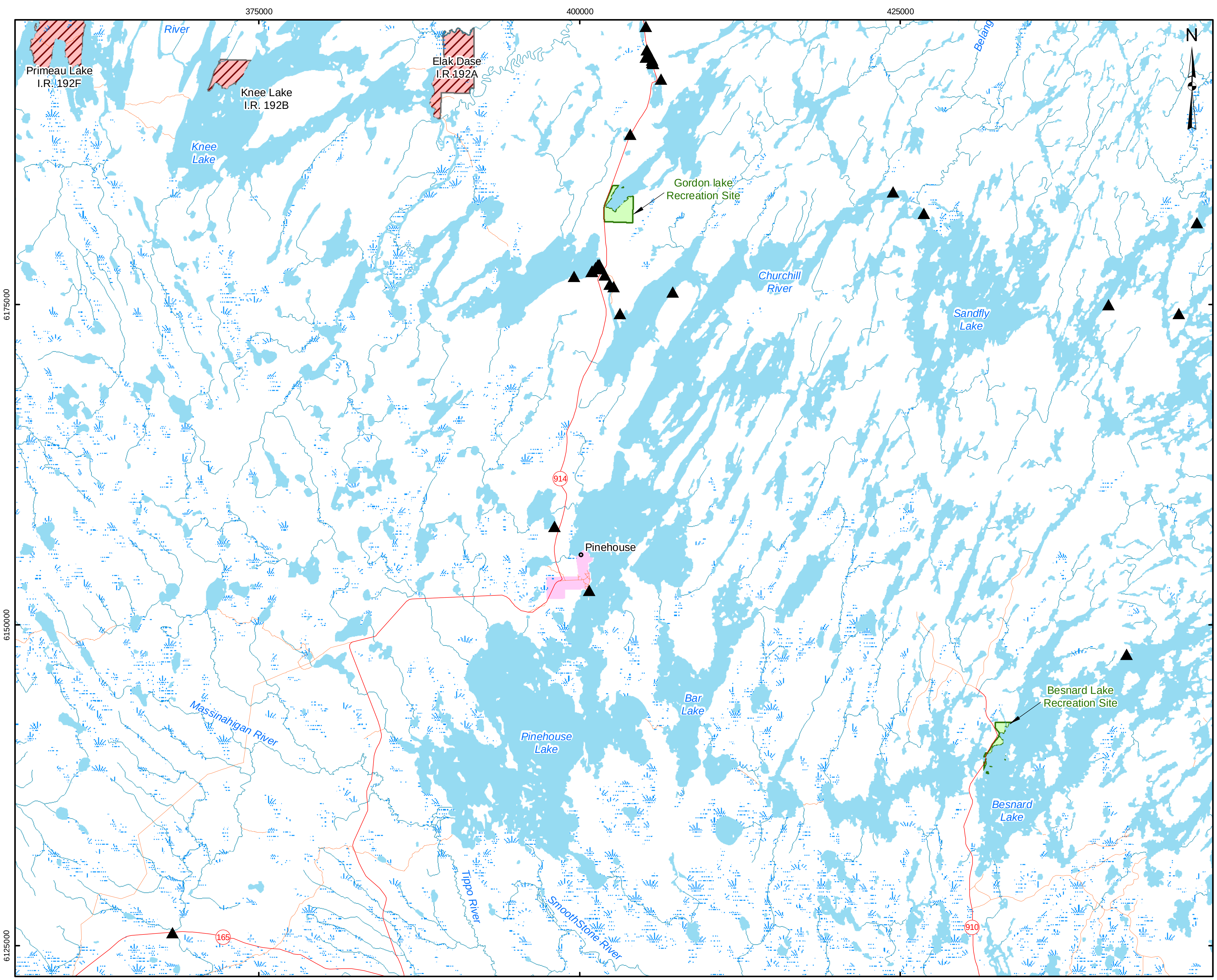
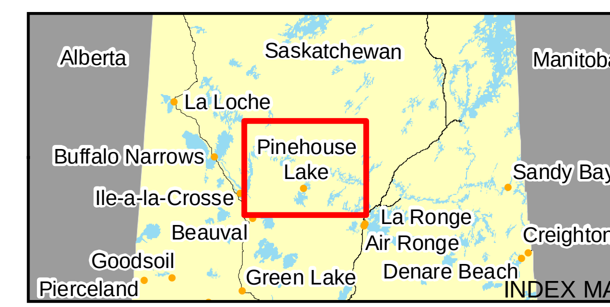


LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve
- Known Heritage Resource



REFERENCE

DMTI Highways and Roads
Heritage Branch, Ministry of Tourism, Culture, Parks and Sport, 2010
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

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SCALE 1:300,000 KILOMETERS

PROJECT

NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE

Known Heritage Resources
in the Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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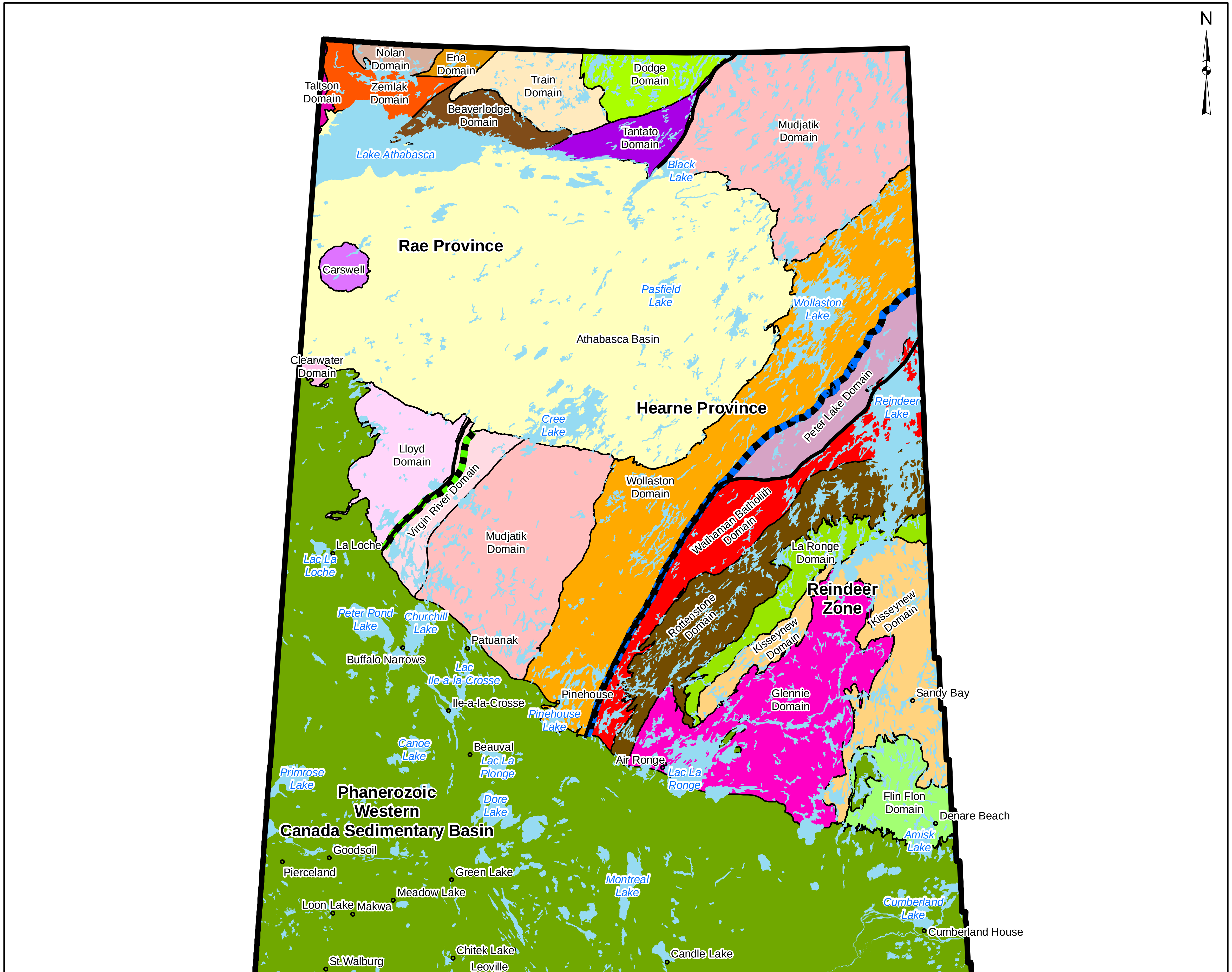
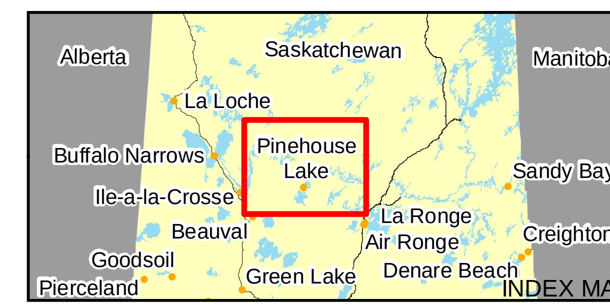


LEGEND

- Community
- Water Area, Permanent
- Phanerozoic Western Canada Sedimentary Basin
- Precambrian Geological Province
- Needle Falls Shear Zone
- Virgin River Shear Zone (Snowbird Tectonic Zone)

Lithotectonic Domain

- Athabasca Basin
- Beaverlodge Domain
- Carswell Domain
- Clearwater Domain
- Dodge Domain
- Ena Domain
- Flin Flon Domain
- Glennie Domain
- Kisseynew Domain
- La Ronge Domain
- Lloyd Domain
- Mudjatik Domain
- Nolan Domain
- Peter Lake Domain
- Rottenstone Domain
- Taltson Domain
- Tantato Domain
- Train Domain
- Virgin River Domain
- Wathaman Batholith Domain
- Wollaston Domain
- Zemlak Domain



REFERENCE

Geological Atlas of Saskatchewan, Saskatchewan Energy and Resources
Government of Canada, Natural Resources Canada, Centre for Topographic Information, 2001
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Datum: NAD 83 Coordinate System: UTM Zone 13

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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Geology of Northern Saskatchewan

Golder Associates
Saskatoon, Saskatchewan

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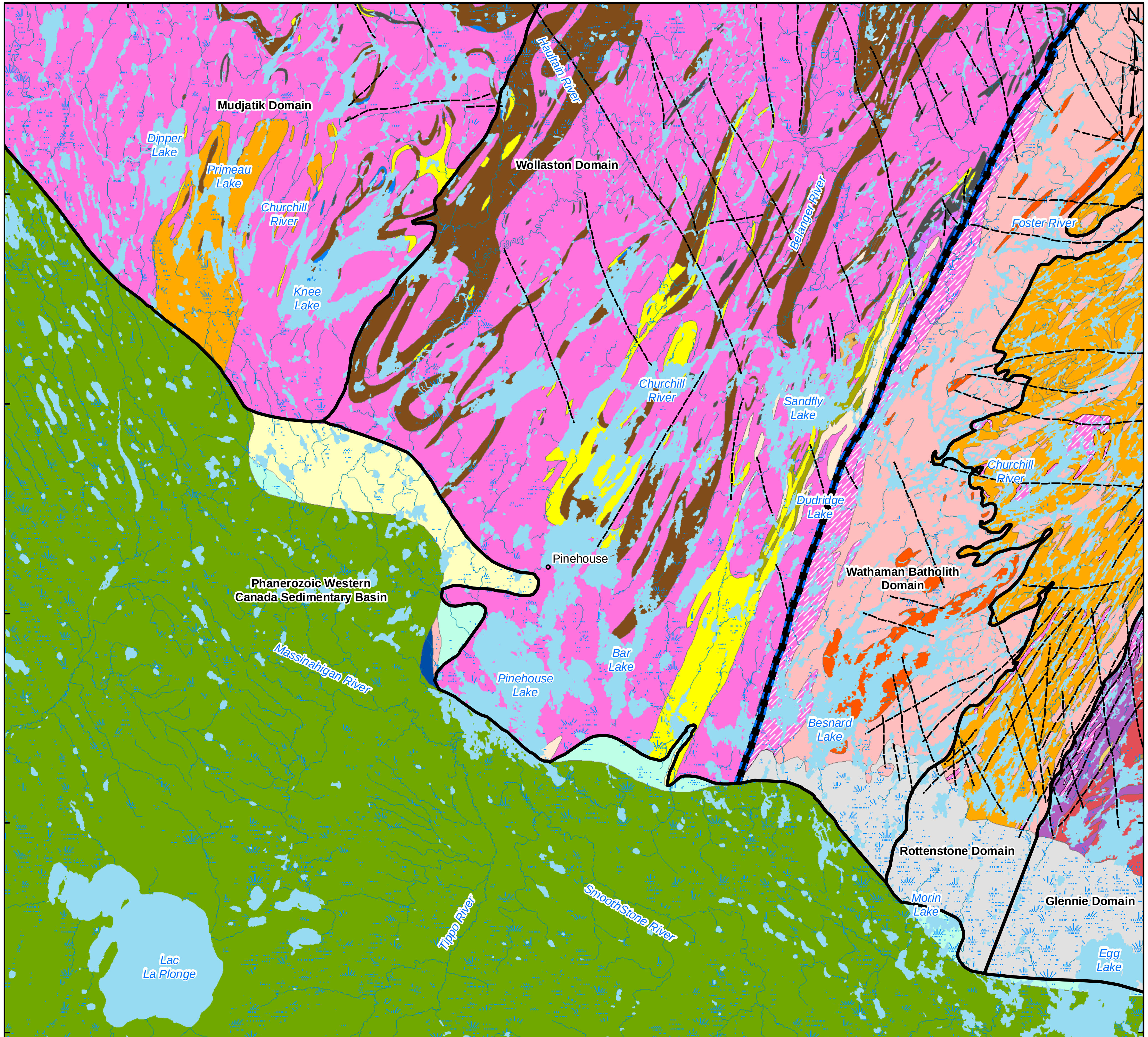


LEGEND

Phanerozoic

- Manville Group
- Winnipegosis Formation
- Meadow Lake Formation - Upper Member
- Meadow Lake Formation - Lower Member
- Deadwood Formation

Elk Point Group

- Needle Falls Shear Zone
- Inferred Fault

Mudjatik Domain

- Alaskite
- Calc - Silicate Rock
- Psammitic, Meta - Arkosic Gneiss
- Pelitic, Psammopelitic Gneiss
- Amphibolite
- Felsic Gneiss

Wathaman Batholith Domain

- Pelitic to Psammopelitic Gneiss and Derived Migmatite
- Augen Gneiss
- Megacrystic Granitoid
- Unexposed Precambrian Shield - Unknown Lithology

Rottenstone Domain

- Granodiorite, Quartz Diorite
- Augen Gneiss
- Pelitic to Psammopelitic Gneiss and Derived Migmatite
- Unexposed Precambrian Shield - Unknown Lithology

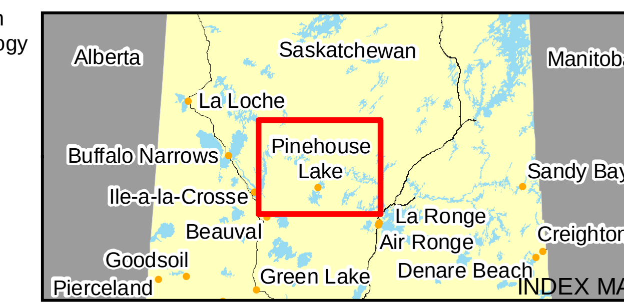
Glennie Domain

- Biotitic Metasediments
- Diorite - Quartz
- Mafic to Mafelsic Rocks
- Pegmatite
- Augen Gneiss
- Granodiorite Complex
- Unexposed Precambrian Shield - Unknown Lithology

Wollaston Domain

- Mylonite
- Leucogranite
- Calc - Silicate Rock, Marble
- Psammitic, Meta - Arkosic Gneiss
- Pelitic, Psammopelitic Gneiss
- Metaquartzite
- Biotitic Mafic Gneiss
- Amphibolite
- Felsic Gneiss
- Diorite

Wollaston Supergroup



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Geological Atlas of Saskatchewan,
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NTS Mapsheets 73 O/P 74 A/B
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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Regional Bedrock Geology of Pinehouse

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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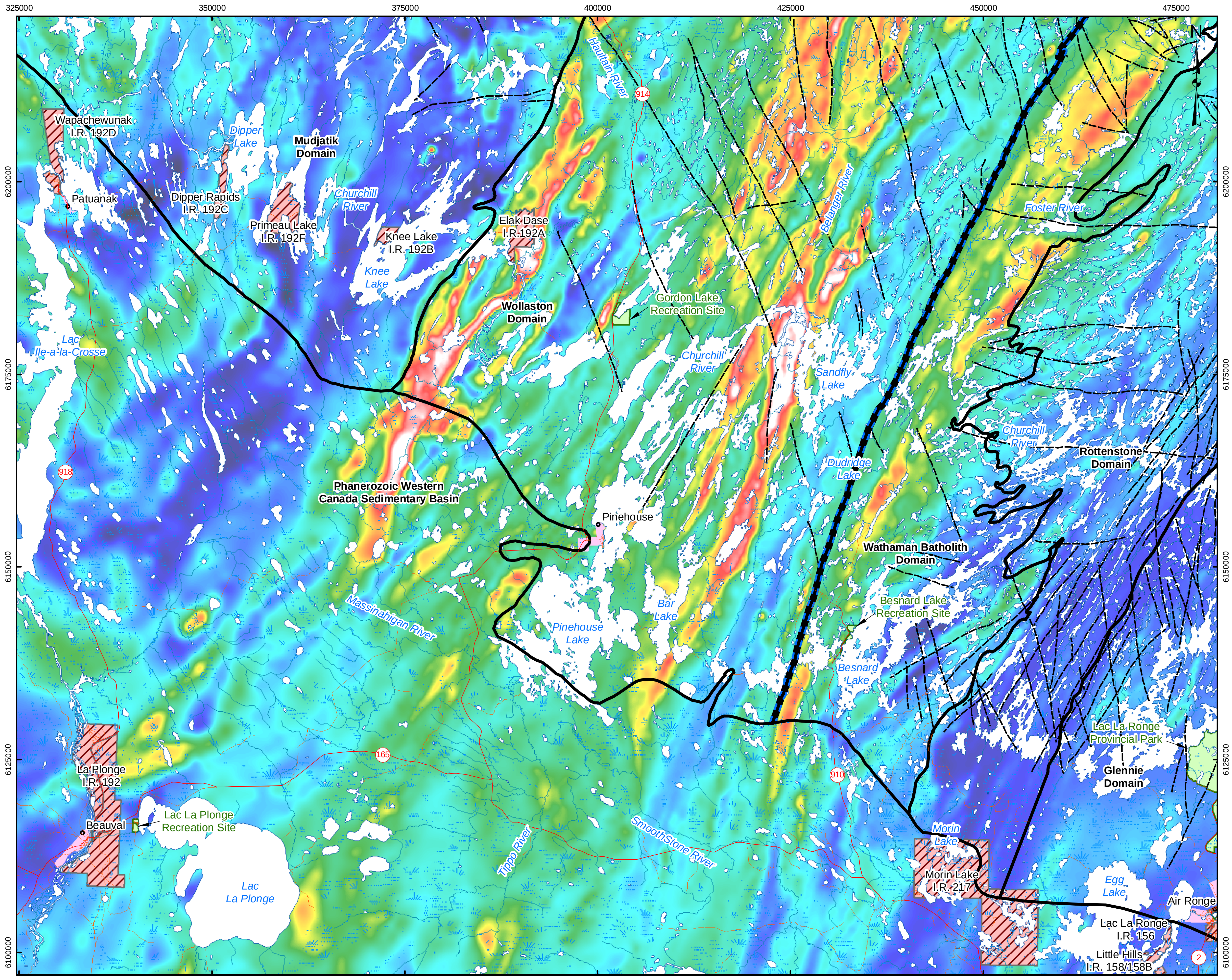
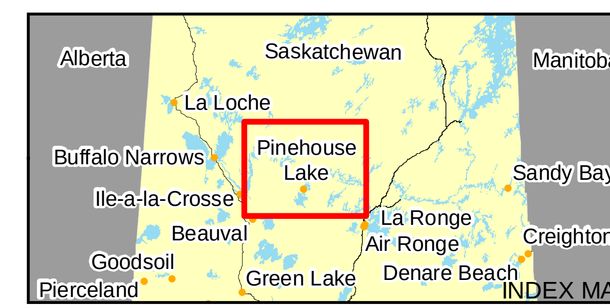


LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve
- Needle Falls Shear Zone
- Inferred Fault
- Domain Boundary

Residual Total Magnetic Field (nT)

1500, 1400, 1300, 1200, 1100, 1000, 900, 800, 700, 600, 500, 400, 300, 200, 100, 0, -100, -200, -300, -400



REFERENCE

DMTI Highways and Roads
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

10 5 0 10 20 30
SCALE 1:500,000 KILOMETERS

PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Regional Residual Magnetic
Total Field of Pinehouse

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
DESIGN				
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REVIEW	GS	18 Feb. 2011		

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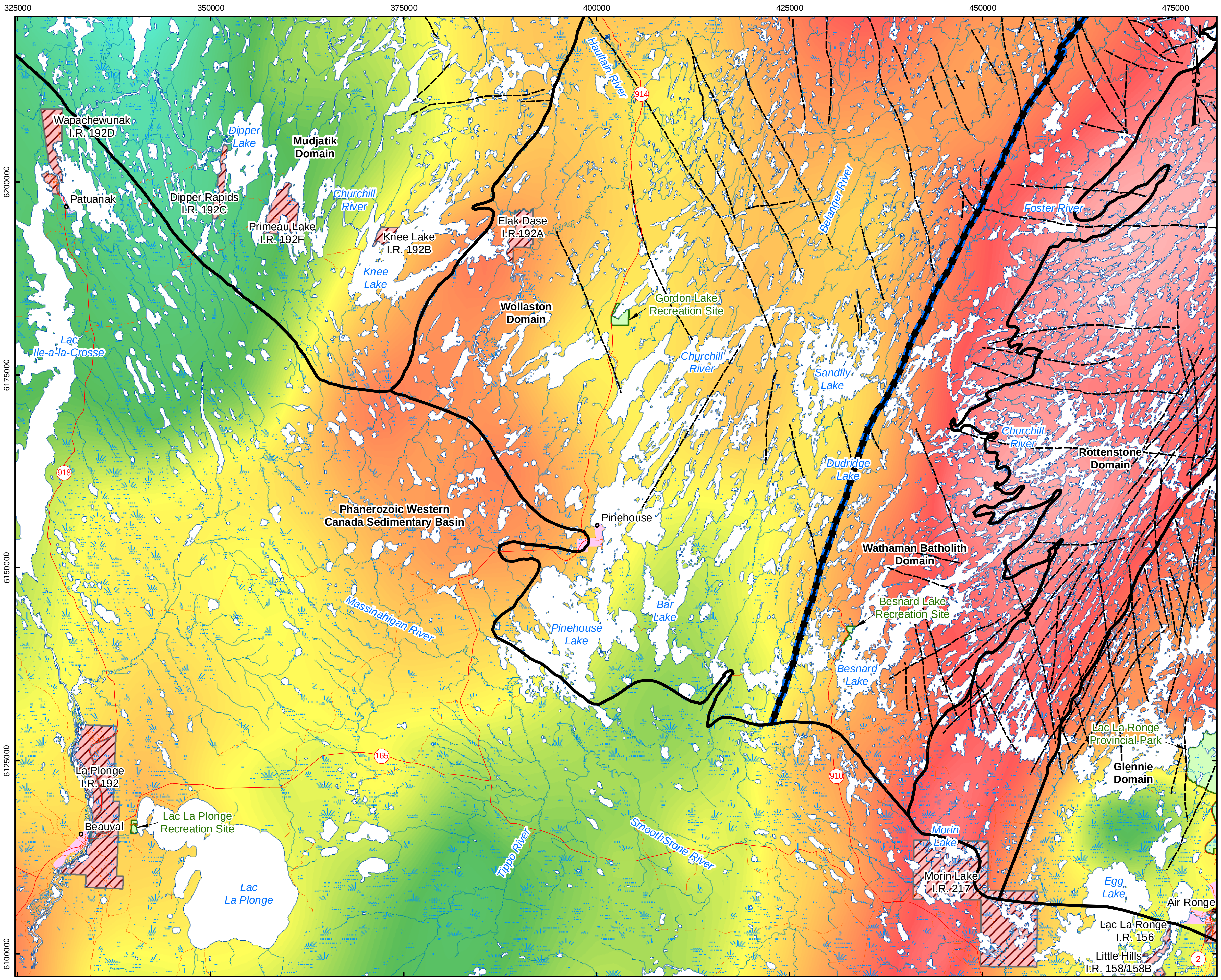

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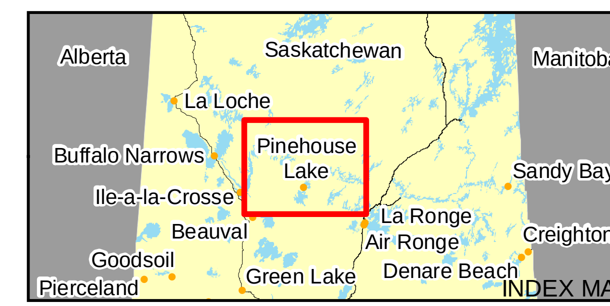
LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve
- Needle Falls Shear Zone
- Inferred Fault
- Domain Boundary

Gravity (mGal)

-40, -44, -48, -52, -56, -60, -64, -68, -72, -76, -80, -84, -88, -92, -96, -100



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Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
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Datum: NAD 83 Coordinate System: UTM Zone 13

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SCALE 1:500,000 KILOMETERS

PROJECT

NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE

Regional Bouguer Gravity of Pinehouse

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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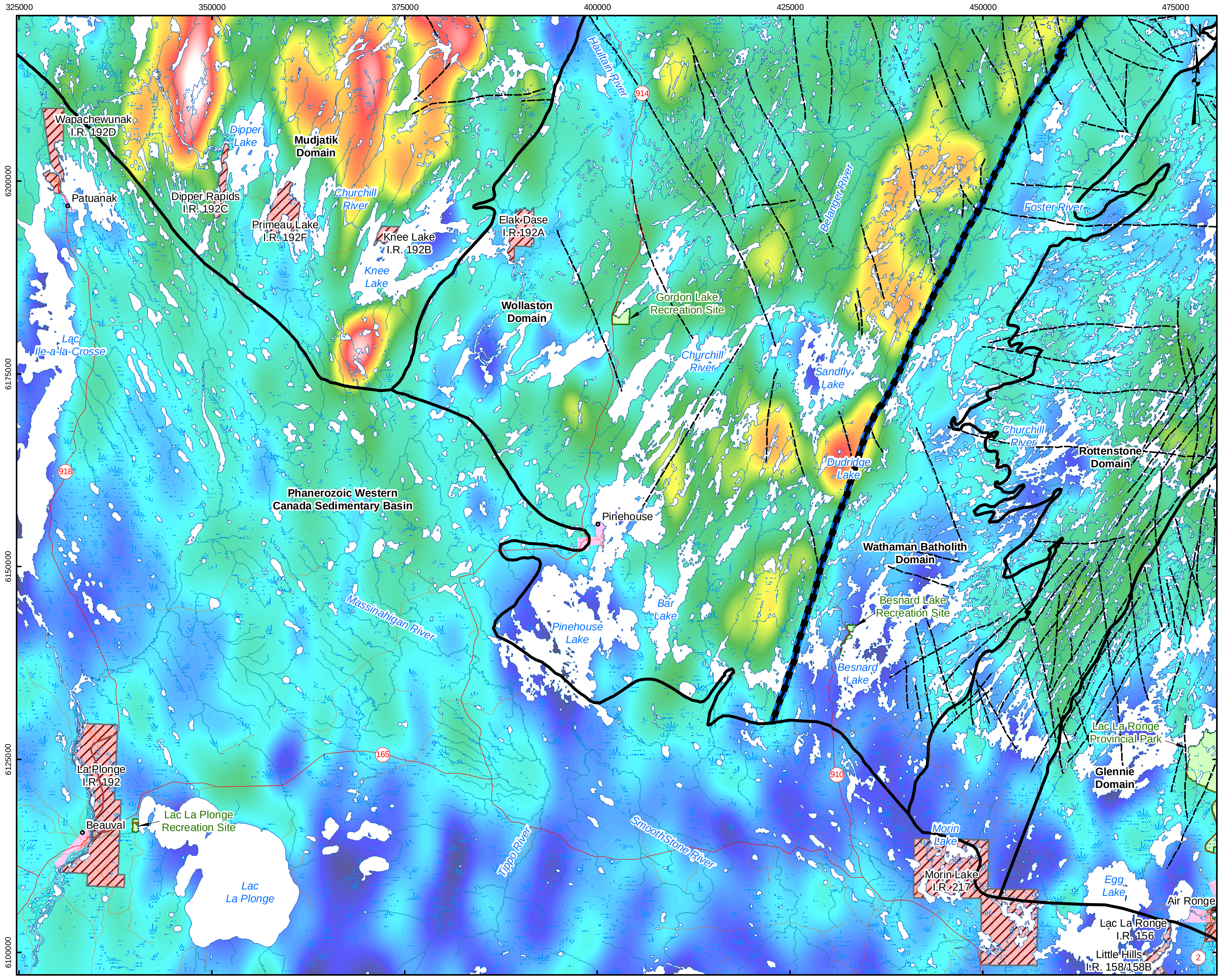
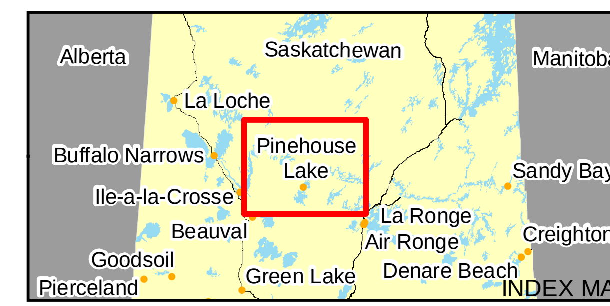


LEGEND

- Community
- Highway
- Road
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality
- Park and Recreation Area
- Indian Reserve
- Needle Falls Shear Zone
- Inferred Fault
- Domain Boundary

Equivalent Uranium (ppm)

2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00



REFERENCE

DMTI Highways and Roads
Saskatchewan Government, Ministry of Environment
Government of Canada, Natural Resources Canada, Earth Sciences Sector, Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Regional Airborne Radiometrics
(Equivalent Uranium) of Pinehouse

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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REVIEW	GS	18 Feb. 2011		

FIGURE: 3.5

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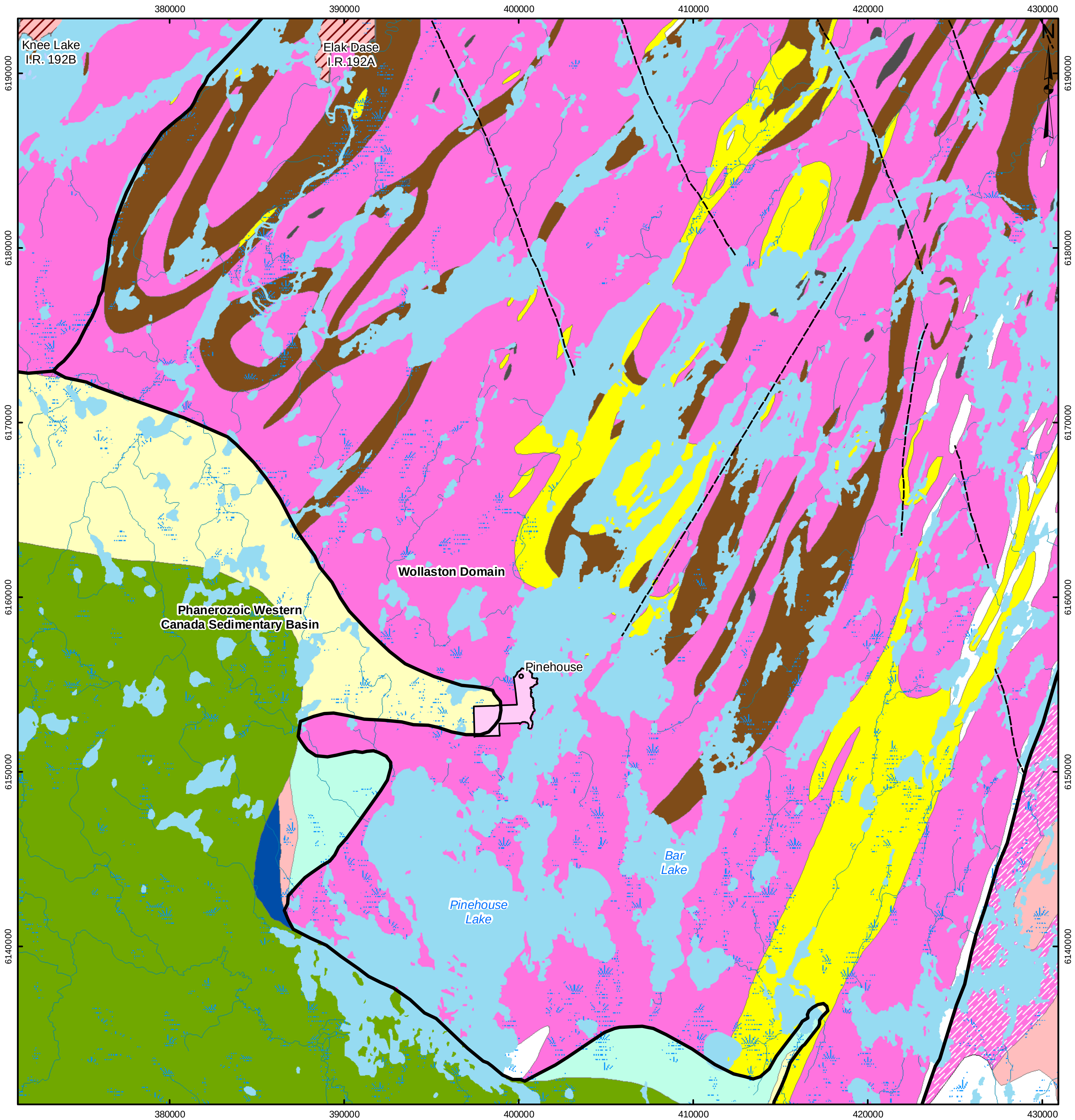


LEGEND

- Community
- Inferred Fault
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Urban Municipality

Phanerozoic

- Manville Group
- Winnipegosis Formation (Elk Point Group)
- Meadow Lake Formation - Upper Member (Elk Point Group)
- Meadow Lake Formation - Lower Member (Elk Point Group)
- Deadwood Formation

Mudjatik Domain

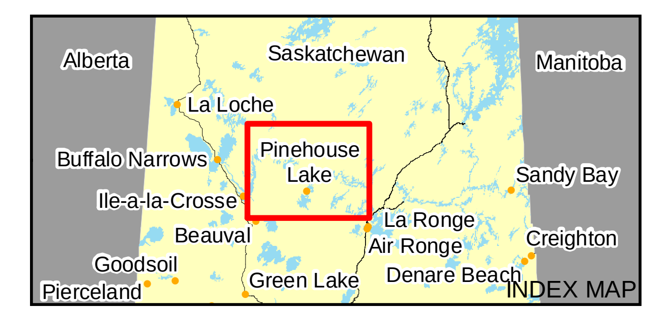
- Calc-silicate Rock
- Psammitic, Meta - Arkosic Gneiss
- Pelitic, Psammopelitic Gneiss
- Felsic Gneiss

Wollaston Domain

- Psammitic, Meta - Arkosic Gneiss (Wollaston Supergroup)
- Pelitic, Psammopelitic Gneiss (Wollaston Supergroup)
- Amphibolite (Archean)
- Felsic Gneiss (Archean)

Wathaman Batholith Domain

- Augen gneiss
- Megacrystic Granitoid



REFERENCE

Geological Atlas of Saskatchewan,
Saskatchewan Energy and Resources
NTS Mapsheet 73P
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PROJECT

NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE

Local Bedrock Geology of Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
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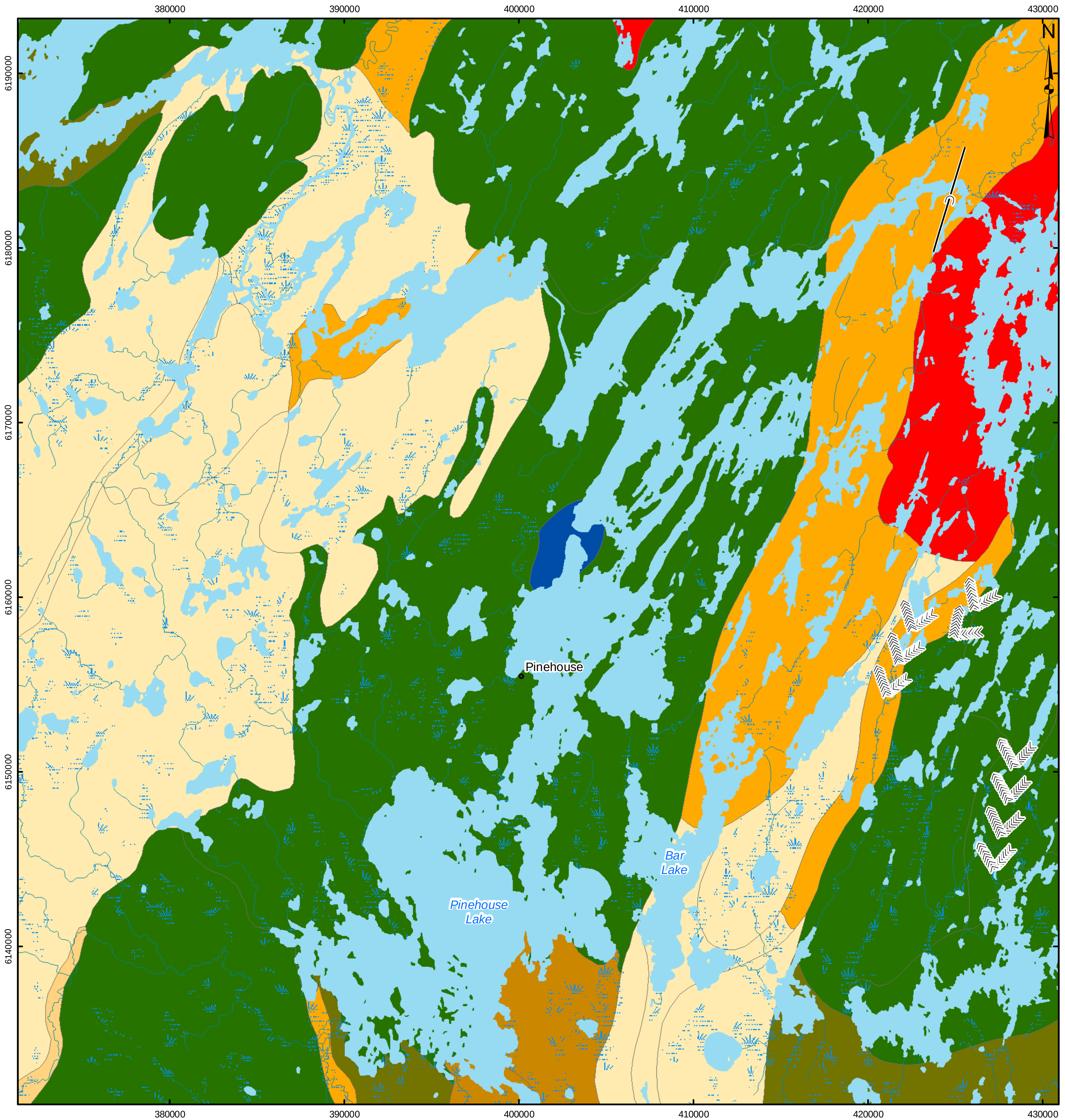
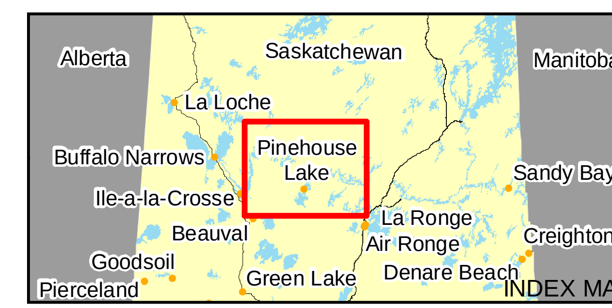


LEGEND

- Community
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Glaciofluvial
- Glaciofluvial Hummocky
- Glaciofluvial Outwash Plain
- Glaciolacustrine
- Hummocky Moraine
- Morainal Plain
- Organic Plain
- Rock
- Esker
- Striation



REFERENCE

Geological Atlas of Saskatchewan,
Saskatchewan Energy and Resources
NTS Mapsheet 73P
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Datum: NAD 83 Coordinate System: UTM Zone 13

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PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Quaternary Geology
of Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

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REVIEW	GS	18 Feb. 2011		

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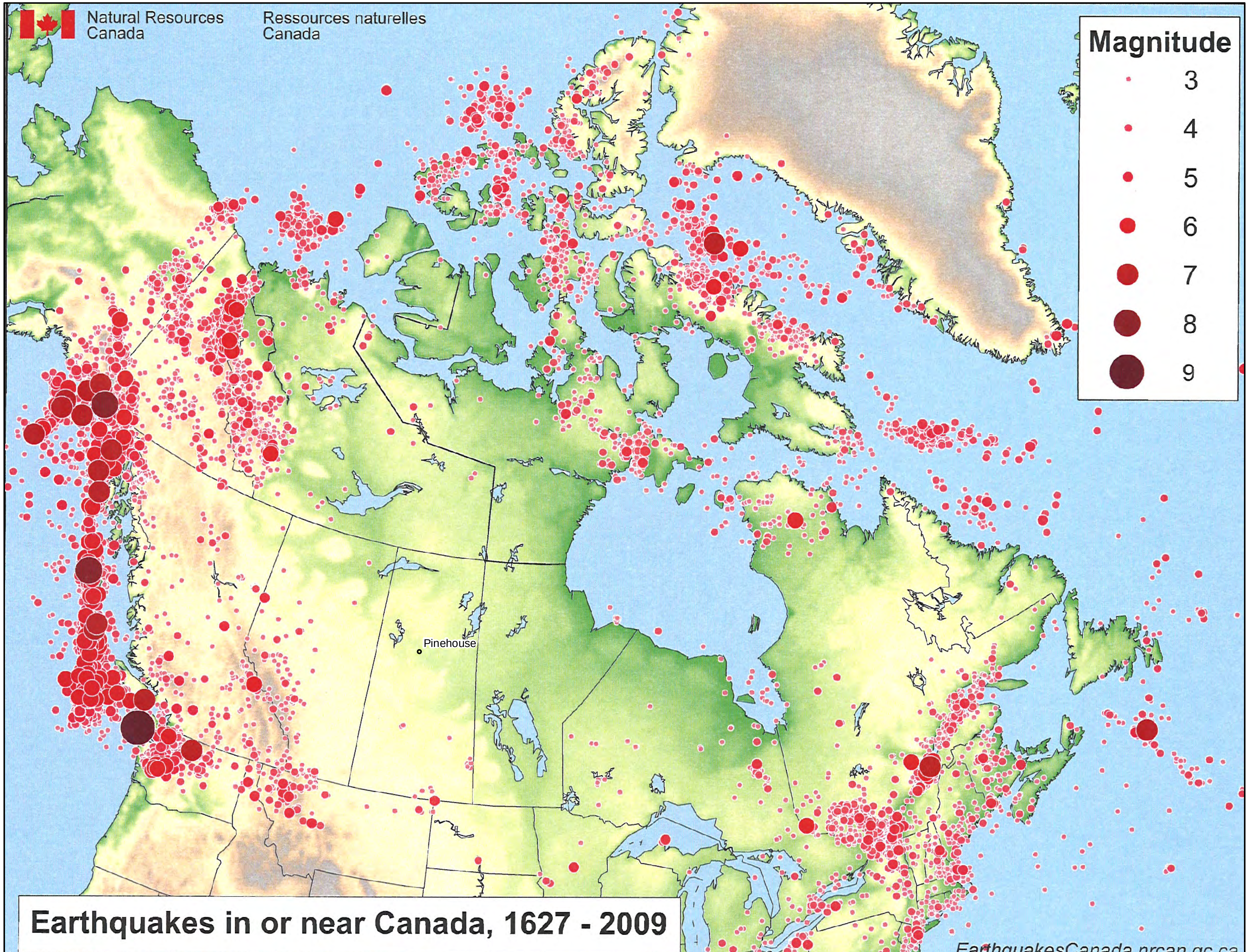
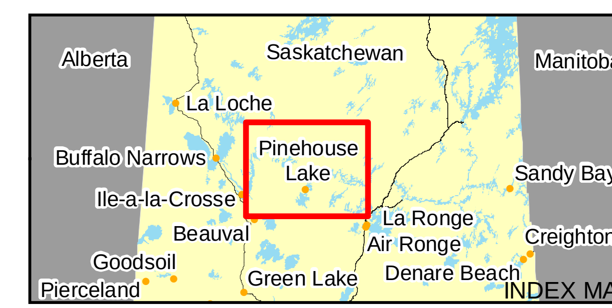


LEGEND

∘ Community



REFERENCE

EarthquakesCanada.nrcan.gc.ca
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

250 125 0 250 500 750
SCALE 1:20,000,000 KILOMETRES

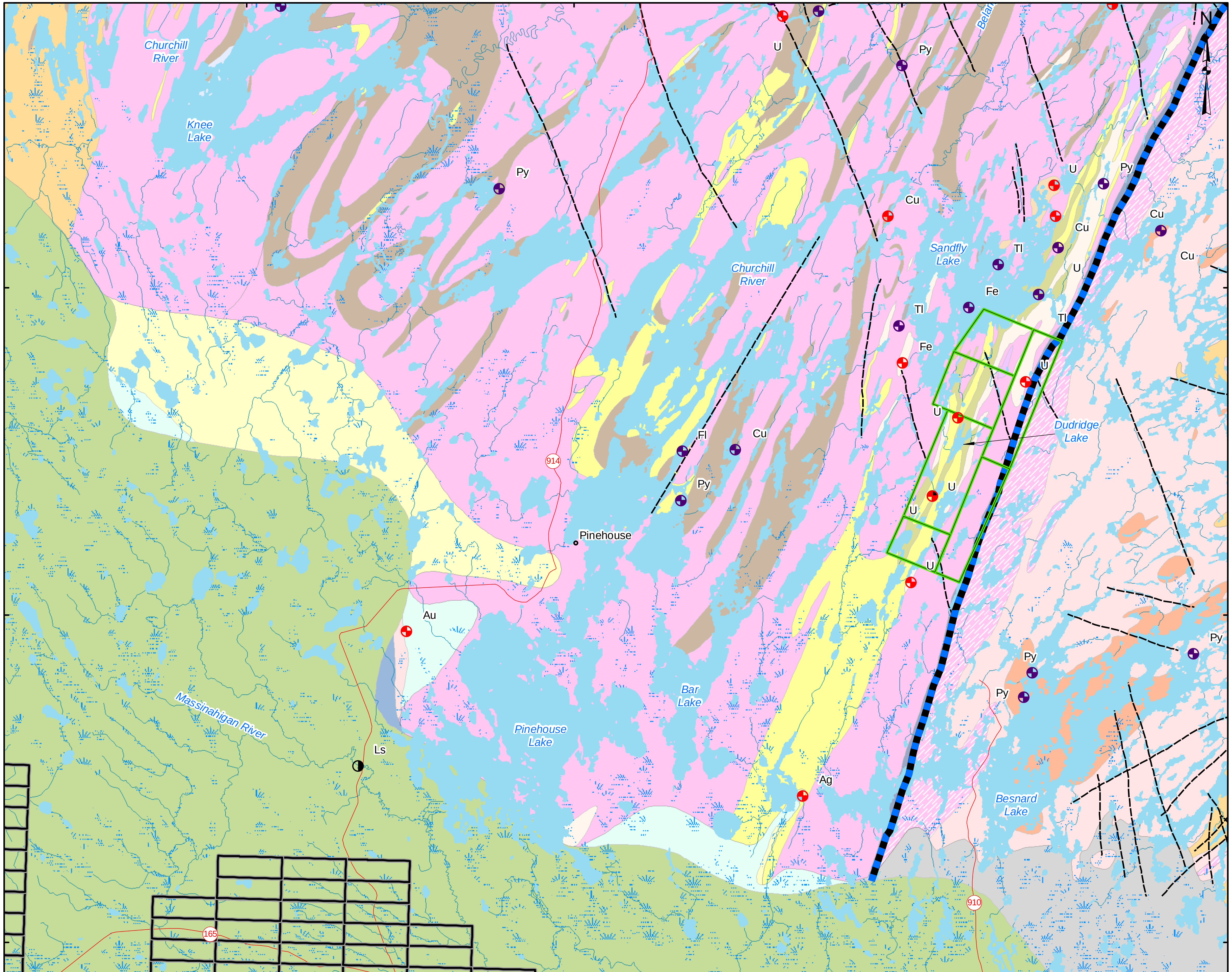
PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Earthquakes Map of Canada, 1627 - 2009

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
DESIGN			FIGURE: 3.8	
GIS	MGD	18 Oct. 2010		
CHECK	EM	20 Oct. 2010		
REVIEW	GS	18 Feb. 2011		

G:\2010\1152\10-1152-0110 NWMO Initial Site Screening\Phase 3000 - Pinehouse Sask\GIS\MXDs\Reporting\10-1152-0110-3000-011Pinehouse Canadian Earthquakes within Study Area.mxd



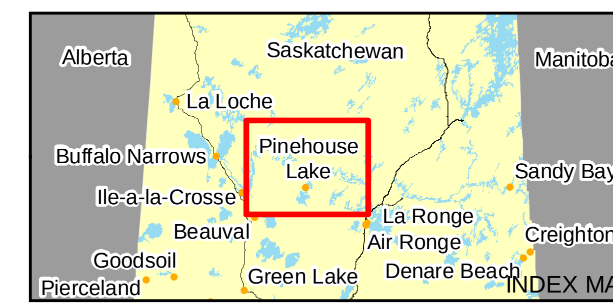
LEGEND

- Community
- Highway
- Watercourse, Permanent
- Water Area, Permanent
- Flooded Area
- Wetland, Permanent
- Potential Mineral Deposit with Reserves
- Showing Mineral Potential
- Showing Mineral Potential with No Assay
- Needle Falls Shear Zone
- Inferred Fault
- Active Mineral Claim
- Active Coal Permit

Ag - Silver
Au - Gold
Cu - Copper
Fe - Iron
Fl - Fluorite
Ls - Limestone
Py - Pyrite
Tl - Tourmaline
U - Uranium

NOTE:

For the purposes of this report, the term "showing" equates with the term "occurrence".



REFERENCE

DMTI Highways and Roads
Saskatchewan Government, Ministry of Environment
Geological Atlas of Saskatchewan,
Saskatchewan Energy and Resources
Mineral Disposition Data Date: October 15, 2010
Coal Disposition Data Date: September 16, 2010
Government of Canada, Natural Resources Canada, Earth Sciences Sector,
Geomatics Canada, Surveyor General
NTS Mapsheet 73P
Projection: Universal Transverse Mercator
Datum: NAD 83 Coordinate System: UTM Zone 13

5 2.5 0 5 10 15
SCALE 1:300,000 KILOMETERS

PROJECT
NWMO Desktop Level Initial Screening
Pinehouse, Saskatchewan

TITLE
Mineral Showings and Dispositions of
The Pinehouse Area

Golder Associates
Saskatoon, Saskatchewan

PROJECT No. 10-1152-0110			SCALE AS SHOWN	REV. 0.0
DESIGN				
GIS	MGD	26 Nov. 2010	FIGURE: 5.1	
CHECK	EM	18 Feb. 2011		
REVIEW	GS	18 Feb. 2011		

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