4.0 SITE SELECTION

This chapter outlines the site selection process used to determine the Final Preferred Route (FPR) for the Project. The objectives of the site selection process were to determine a route that minimized adverse biophysical and socio-economic effects, with consideration to technical and cost requirements and included external input. The process considered a broad range of environmental, socio-economic, technical, stakeholder, and public information to determine a balanced route.

Manitoba Hydro used Multi-Criteria Evaluation (MCE) and Least Cost Path Analysis (LCPA) in a Geographic Information System (GIS) to accomplish the objectives. The integration of MCE techniques with GIS provides a means to evaluate various alternatives based on multiple and conflicting criteria and objectives (Carver 1991).

GIS is a robust decision support tool for processing large amounts of geospatial data with the power to analyze and assess information containing multi-criteria inputs. Linear project routing techniques have been developed and implemented in GIS workflow models for a wide variety of corridor applications (Abdi et al. 2009; Atkinson et al. 2005; Chandio et al. 2012; Yildirim et al. 2012), including transmission lines (Bagli et al. 2011).

Multi-criteria evaluation (MCE) is perhaps the most fundamental of decision support operations in GIS (Jiang and Eastman 2000). The basic aim of MCE analysis techniques is 'to investigate a number of possibilities in light of multiple criteria and conflicting objectives' (Voogd 1983).

The computation of least-cost paths is considered the most useful tool available for determining the optimal path from one or more origin points to one or more destination points (Lee & Stucky, 1998). Least-cost path analysis (LCPA) allows users to find the “optimal” way to connect two locations (Bagli et al 2011).

The steps of the site selection process included:

- Multi-Criteria Evaluation
  - Identification of routing criteria (factors/constraints)
    - Creation of geospatial data layers
  - Standardization of Factors
  - Determination of Factor Weight
    - Analytic Hierarchy Process
  - Aggregation of Factors Layers
    - Weighted Linear Combination

- Least Cost Path Analysis
- Preferred Route Development

The following sections describe each of these processes in detail.

4.1 MULTI-CRITERIA EVALUATION

4.1.1 Identification of Routing Criteria

Criteria are measurable attributes that can be combined and evaluated in the form of a decision (Eastman 2005). Criteria can either be a factor or a constraint. Factors allow for varying degrees of suitability for routing a transmission line (highly suitable, moderately suitable etc.).

Constraints are factors that are converted to Boolean statements (Eastman 2005), an area is either suitable or unsuitable. These factors are “Areas of Least Preference”. Areas of Least Preference are features to avoid when siting a transmission line due to physical constraints (extreme slopes, long water crossings), regulations limiting development (protected areas), or areas that would require extensive mitigation or compensation.

The Project Study Team was involved in the determination of routing criteria. Through internal and external meetings, discussions, review of previous projects, previous experience and input from stakeholders, 15 factors (Table 4-1) and a list of areas of least preference were developed (Table 4-2).

The study team considered Traditional Knowledge (TK) an important input into the model. However, no TK was collected in time for input into the model. Manitoba Hydro will use TK to help inform environmental protection planning for the project.

4.1.1.1 Creating Factor Data Layers

The site selection process requires that each factor be represented by a geospatial data layer. A geospatial data layer was created for each factor (see Map 4-1 for an example) and a combined geospatial data layer was created for the areas of least preference (Map 4-2).

Team members created (e.g., regionally rare habitat types were identified from enhanced Forest Land Inventory data) or gathered (ie. Areas of Special Interest / Provincial Park data was downloaded from Provincial Databases) the required geospatial data to represent each factor layer. In some cases, habitat models (e.g., Canada warbler) were developed to create the dataset layer (Map 4-3).

Table 4-1: Site Selection Factors used for routing the Pointe du Bois Transmission Line

No.	Name	Score	Description	Rationale
1	Aquatics	Very High	N/A	High quality riparian areas maintain high quality fish habitat, which is protected by legislation (federal Fisheries Act).
		High	N/A	
		Medium	N/A	
		Low	Suitable locations (disturbed riparian areas) to have transmission line crossing Pinawa Channel.	
2	Forestry	Very High	Tree Improvement Sites	Provincial seed orchard or family test site for producing improved seed for reforestation projects. Sites with high amounts of financial and labour investment.
		High	Permanent sample plots. 100 m buffer applied.	Long term monitoring sites to measure forest growth and yield.
			Ecosystem Monitoring Plots	Long term monitoring sites to assess ecosystem development and/or effects of treatments or environmental incidents
		Medium	Woodlots	Comprehensive resource management plans that promote sustainable woodlot management for environmental, economic, and social benefits on private land. Compensation required.
			Trees for Tomorrow	Afforestation sites on private land requiring high implementation costs. Compensation required.
		Low	High Value Silviculture Sites	Reforestation sites requiring high implementation costs. Compensation required through the MCWS Forest Damage Appraisal and Valuation Policy.
3	Priority Habitat	Very High	Rare and/or sensitive vegetation communities.	Priority Habitat Types include terrestrial habitats that are of high concern. This factor is a proxy for other ecosystem issues and some wildlife species. It included known locations or critical habitat for endangered or threatened plant species and S1 or regionally rare plant species if not locally well distributed.
		High	N/A	
		Medium	Uncommon vegetation communities	
		Low	N/A	
4	Common Habitat	Very High	N/A	Common habitat was considered an opportunity for routing as removal of habitat types that are common within and surrounding the study area will have a smaller impact than removal of rare habitat types.
		High	N/A	
		Medium	N/A	
		Low	N/A	
		Very Low	Regionally common habitat types (routing opportunity)	
5	Intactness	Very High	A core dataset was developed by obtaining the areas remaining after buffering existing human features by 500m. Ratings were determined from a combination of core area size, shape and distance from developed areas.	Intactness is a proxy indicator for many ecosystem and wildlife issues of concern. Intactness is the degree to which an ecosystem remains unaltered by human features that remove habitat and increase fragmentation. Fragmentation affects ecosystem processes as well as species. Fragmentation reduces the size of interior areas, isolates habitat/reduces connectivity and creates
		High		
		Medium		
		Low		

6	Wetlands	Very High	Trumpeter Swan habitat (Large ponds, marshes, lakes, and occasionally rivers).	Manitoba's Water Protection Act recognizes the need to conserve wetlands. Wetlands were also used as a proxy indicator for many wildlife species, including several Species At Risk. Avoidance of these wetland sites will have a smaller impact on these and other bird populations, including waterfowl and waterbirds.
		High	Species-at-Risk Habitat (Sedge Fens / Productive Marsh / Shallow Water Lakes). Species at Risk in these habitat types may include Yellow Rail, Least Bittern, Horned Grebe, Short-eared Owl, Rusty Blackbird, Olive-sided Flycatcher and Northern Leopard Frog. Productive marshes and lakes may also include migation feeding habitat for Peregrine Falcon.	
			Sandy beaches on large lakes and rivers (potential breeding habitat for other Species at Risk including Piping Plover and Common Snapping Turtle). May include migration feeding habitat for Red Knot.	
		Medium	N/A	
		Low	N/A	
7	Grasslands	Very High	N/A	
		High	N/A	
		Medium	Habitat for Species at Risk including Loggerhead Shrike, Red-headed Woodpecker, Bobolink and American Badger.	Pastures were used as a proxy indicator for some wildlife species including Species at Risk.
		Low	Habitat for Species at Risk including Bobolink.	Hay Lands were used as a proxy indicator for one Species at Risk - Bobolink. Boblink habitat is locally common and widespread in the region, the suitability for routing the transmission line was low.
8	Canada Warbler Habitat	Very High	N/A	Threatened species. Relies on particular forest type (deciduous dominated mixed forest). Because Canada Warbler habitat is locally common and widespread, the suitability for siting transmission line was high as opposed to very high.
		High	Available habitat in study area considered to be highly suitable for Canada Warblers.	
		Medium	N/A	
		Low	N/A	
9	Linear Infrastructure	Very High	30 m buffer applied to act as road right-of-way (ROW).	Following existing linear infrastructure was treated as an opportunity, reducing fragmentation of the landscape.
		High	N/A	
		Medium	N/A	
		Low	N/A	
		Very Low	60 m road buffer applied beyond the 30 m ROW; 30 m buffer applied to transmission lines.	
10	Parks and Protected Areas	Very High	N/A	
		High	Areas of Special Interest, Parks classified as Resource Management, Recreational Development and Access as well as protected Wildlife Management Areas.	ASIs identified for protection by PAI but not under Legislation, Parks classified as Resource Management, Recreational Development & Access; and ASIs identified by PAI but not protected under Legislation.
		Medium	Forest Reserves and Non Protected WMAs	Forest Reserves and WMAs are not protected under Legislation.
		Low	N/A	

11	Recreation	Very High	N/A	The Snoman Snowmobile Trails and the Trans Canada Trail traverse the Project Study Area and the Preferred Route will cross the trail system at some point. Identification of important trail locations or viewscapes was sought from trail representatives. The cross country ski trails are located adjacent to Pinawa and contain warming huts along their outer extent. Scoring and buffers applied to the warming huts and the Town of Pinawa encompassed the ski trail system. The issue is impairment of aesthetics.
		High	N/A	
		Medium	Snoman trails, cross country ski trails, TransCanada trail.	
		Low	N/A	
12	Outfitters	Very High	N/A	Meetings were held with several outfitters in the area and sensitive areas were determined. These areas were considered important in maintining the viability of the operations, therefore were considered important in routing.
		High	Sensitive areas identified during meetings with local outfitters.	
		Medium	N/A	
		Low	N/A	
13	Public Engagement Input	Very High	N/A	Sensitive areas gathered during public open houses and other meetings were gathered. These areas were considered important in maintining the viability of the operations, therefore were considered important in routing.
		High	Sensitive areas identified during public engagement	
		Medium	N/A	
		Low	N/A	
14	Trapping	Very High	Trappers cabins	Meetings were held with several trappers in the area and sensitive areas were determined. These areas were considered important in maintining the viability of the operations, therefore were considered important in routing.
		High	Sensitive trapping areas identified during meetings with local trappers	
		Medium	N/A	
		Low	N/A	
15	Geotechnical	Very high	N/A	Increasing levels of design, material and construction (cost) are required with increasing depth to mineral material or bedrock.
		High	> 2.8 m to mineral material or bedrock	
		Medium	2.1 m to 2.8 m to mineral material or bedrock	
		Low	< 2.1 m to mineral material or bedrock	
Background		Very Low	Applied to cells without overlap from any suitability values from the fator layer (highest opportunity for routing within that layer).	

Table 4-2: Areas of Least Preference for the Pointe du Bois Transmission Line	
Description	
Provincial parks and protected Wildlife Management Areas	
Recreation - Warming Huts (along snowmobile trails) (100 m buffer)	
Town Boundaries - Lac du Bonnet.	
Structures (buildings) - (100 m buffer*)	
Airports - (1500 m buffer)	
Towers - (200 m buffer)	
Zoning: Relevant zoning designations	
Registered Heritage Sites (protected under the Heritage Resources Act)	
First Nation Lands - Reserve and TLE Lands	
Active Mining Operations	
Public Input	Snake hibernacula – (100 m buffer)
	Stick nests
	Homestead and park with petroform and burial ground
	Trappers' cabins – (100 m buffer)
Water bodies > 300 m (require special design and construction).	
*Buffers were based on regulations, previous experience and comparison with previous projects	

4.1.1.2 Standardization of Factors

Standardization of factors is required to make comparisons between factors possible. Suitability values for each factor were scored on a common scale.

The study team scored various components of their factor layer(s) on a scale from low (most suitable for routing a transmission line) to very high (least suitable for routing a transmission line). Areas not covered by a component of that layer were scored as background (very low). The scores of very low to very high were then converted to a numeric scale between 1 (very low) and 255 (very high).

For example (Figure 4-1), within the Priority Habitat factor layer, rare/sensitive habitat types were scored very high and uncommon habitat was scored medium. This means that when routing a transmission line, it is more important to protect rare/sensitive habitat types then uncommon habitat types. On this same layer, anything within the study area not considered rare/sensitive or uncommon, would be considered background and therefore get the lowest score, most preferred for routing.

Areas of Least Preference were scored either suitable (Value of 1) or less preferable (Value of 0) for routing.

4.1.1.3 Determination of Factor Weight

Weights allow specification of the perceived importance of individual factors relative to the others included in the evaluation (Carver 1991).

The Analytic Hierarchy Process (AHP) was used to determine the relative weights of each factor layer. The AHP provides a framework for evaluating alternative options. Each option is analyzed independently. The AHP produces a best fit set of weights (Eastman et al 1995) for the factors. The weights given to each factor represent the perceived importance of each criterion (Atkinson et al 2005).

Manitoba Hydro held a workshop to facilitate the AHP process. Each of the team members who provided factor layers attended the workshop. The project team systematically evaluated each factor by comparing them to one another (Figure 4-2) with respect to their suitability for routing a transmission line.

The AHP converts these evaluations to numerical values. A numerical weight is derived for each factor, allowing the factors to be compared to one another in a rational and consistent way.

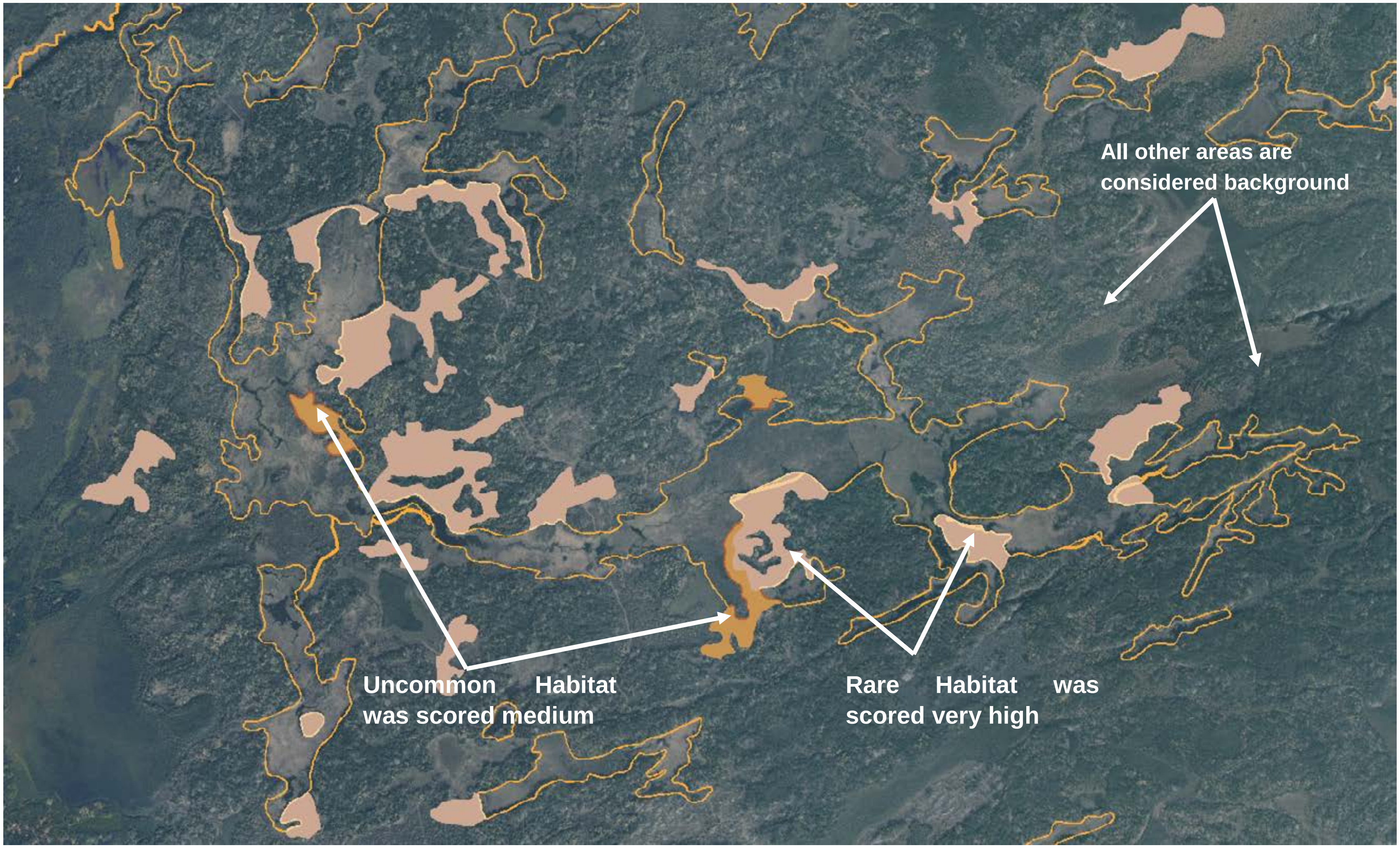


Figure 4-1: Portion of the Priority Habitat Factor Layer

Factor Weighting

When siting a transmssion line, is it more important to consider Factor A or Factor B

Extremely More Important				Equally Important				Extremely More Important
9	7	5	3	1	-3	-5	-7	-9

Designated Recreational Areas								Canada Warbler Habitat
9	7	5	3	1	-3	-5	-7	-9

Figure 4-2: Example of a Pair-wise Comparison for Input into the AHP Process

4.1.1.4 Aggregation of Factors

The final step in the Multi-Criteria Evaluation is to create the suitability surface. The suitability surface was created by combining the individual layers (factors and areas of least preference) into one layer (Figure 4-3). Manitoba Hydro used Weighted Linear Combination (WLC) (Voogd 1983) for the aggregation of the factor layers.

Weighted Linear Combination

The weighted linear combination (WLC) aggregation method multiplies each standardized factor layer (i.e., each grid cell within each map) by its factor weight and then sums the results (Drobne and Lisec 2009).

The WLC procedure involved each factor layer being: (simplified example provided in Figure 4-4):

- Multiplied by an assigned weight (from the AHP process)
- Summed and averaged as a continuous surface
- Masked by the Areas of Least Preference layer

The WLC process produces a suitability surface (see Figure 4-5 for the Pointe du Bois suitability surface). The suitability surface is represented by a map in which each grid cell is given a value that defines the suitability of that area for routing a transmission line. Based on the size of the study area, 5 m grid cells were determined to be the optimal resolution for analysis.

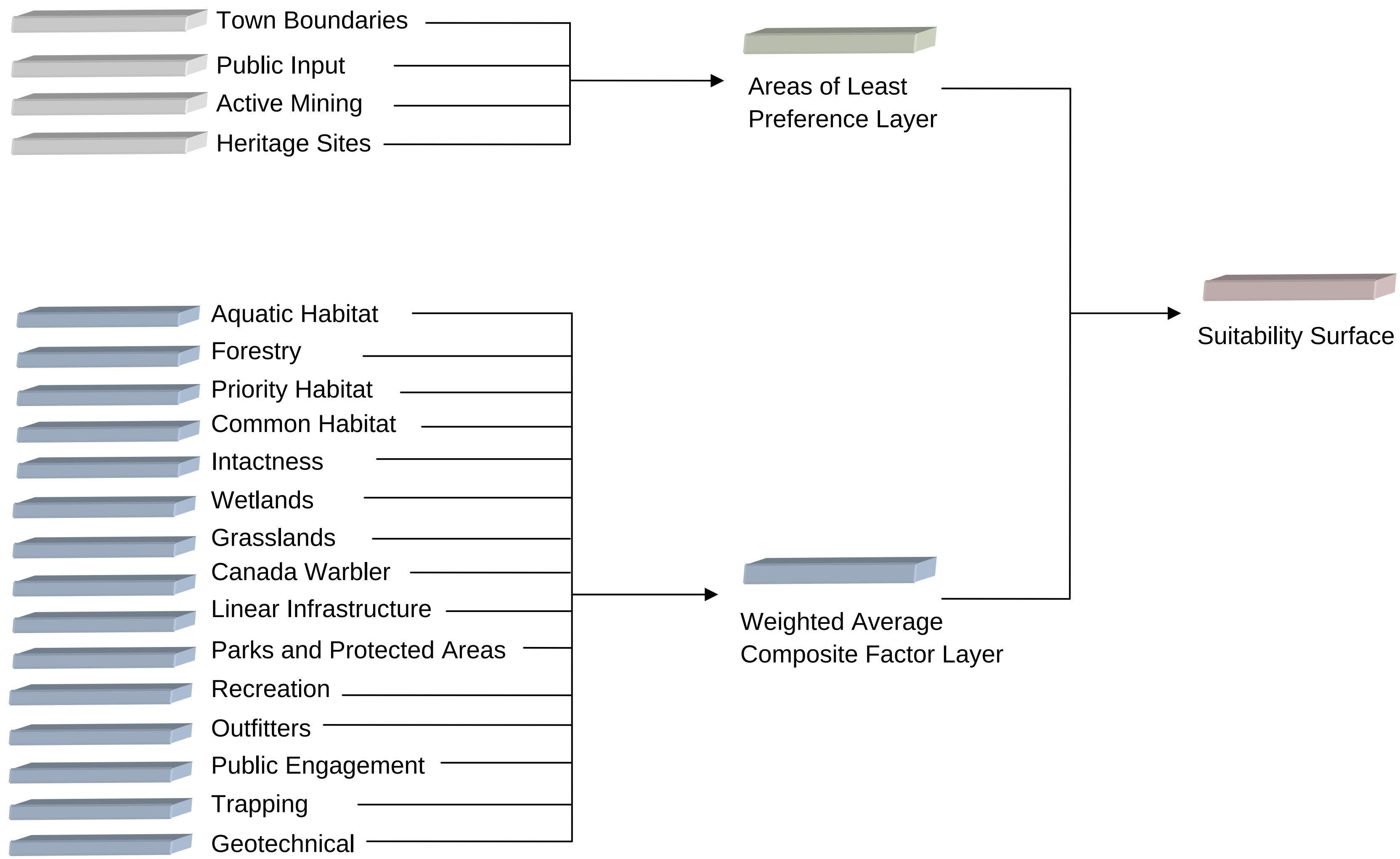


Figure 4-3: Combining the Factor Layers and Areas of Least Preference Layer into the suitability Surface

Factor Layer A

3	6	6	9	End
6	9	9	9	9
9	9	9	9	9
9	1	1	1	1
Start	6	3	1	1

X weight 0.75

+

Factor Layer B

1	1	1	1	End
3	3	3	6	1
3	6	9	9	9
6	9	9	9	9
Start	9	9	9	9

X weight 0.25

=

Suitability Surface

2.5	4.75	4.75	7	End
5.25	7.5	7.5	8.25	7
7.5	8.25	9	9	9
8.25	3	3	3	3
Start	6.75	4.5	3	3

$$(\text{suitability}_1 \text{ x weight}_1) + (\text{suitability}_2 \text{ x weight}_2) + \ldots + (\text{suitability}_n \text{ x weight}_n) = \text{Suitability Surface}$$

Figure 4-4: Diagram of the Aggregation Process for Combining Factor Layers into the Suitability Surface

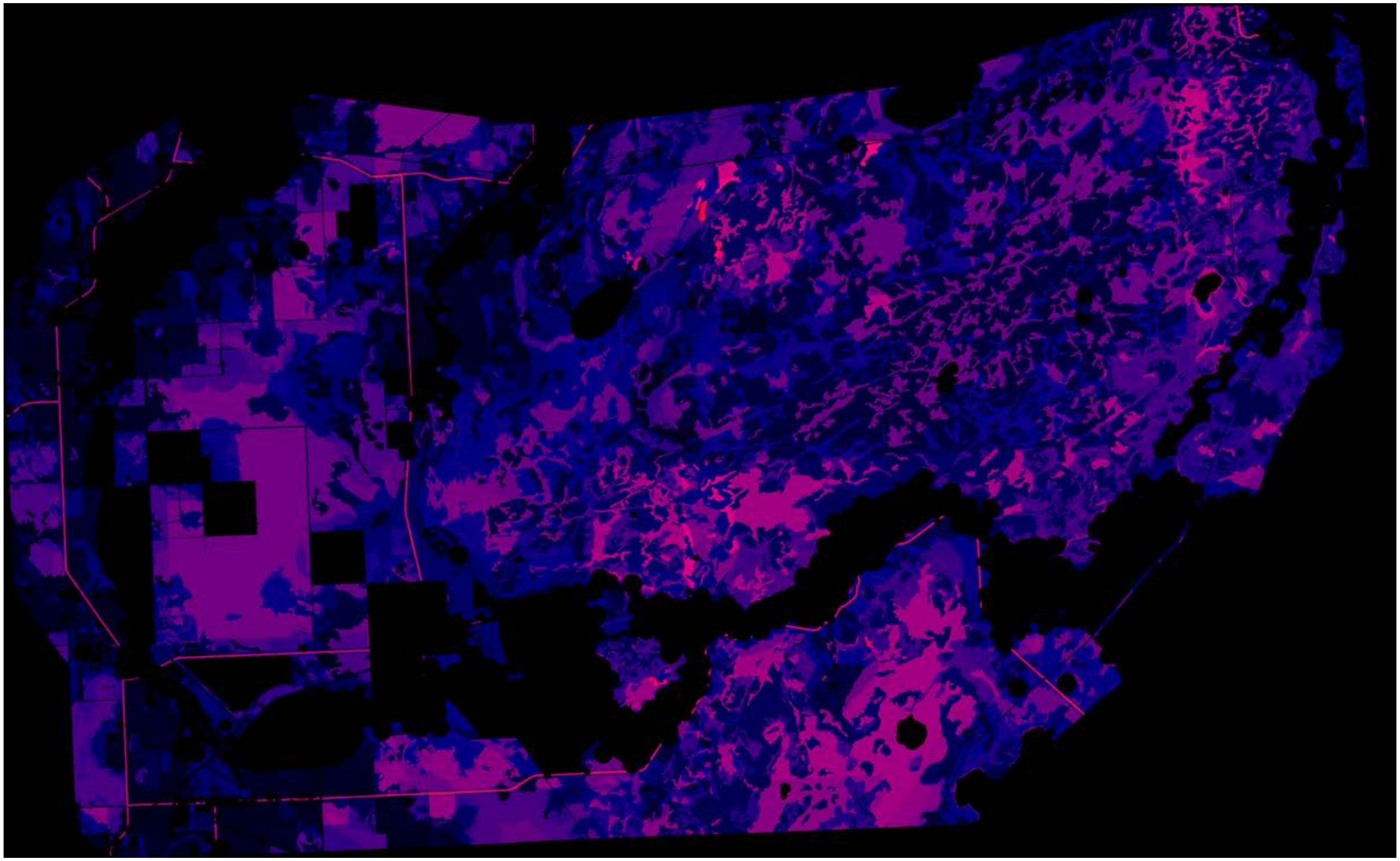


Figure 4-5: Suitability Surface for Pointe du Bois. Black areas are "areas of least preference". Color Scale Goes from Light Pink (very low) to Dark Purple (very high)

4.1.1.5 Least-Cost Path Analysis

The least-cost path, in GIS, is guaranteed to be the "optimal" route relative to the "suitability values" defined by the "suitability surface" input into the weighted-distance tool (ESRI 2013).

An algorithm is used to find the "cost" of every possible path (route) between the two end points. A path is any continuous string of grid cells, 5 x 5 m in size, connecting the existing Whiteshell Station to the Pointe du Bois Station.

The "cost" is the accrual of values of those grid cells (Figure 4-6). Lower summed values indicate relatively suitable paths, whereas higher summed values indicate relatively less suitable paths. The resulting path is considered optimal for all criteria considered (Lee & Stucky, 1998).

Suitability Surface

2.5	4.75	4.75	7	End
5.25	7.5	7.5	8.25	7
7.5	8.25	9	9	9
8.25	3	3	3	3
Start	6.75	4.5	3	3

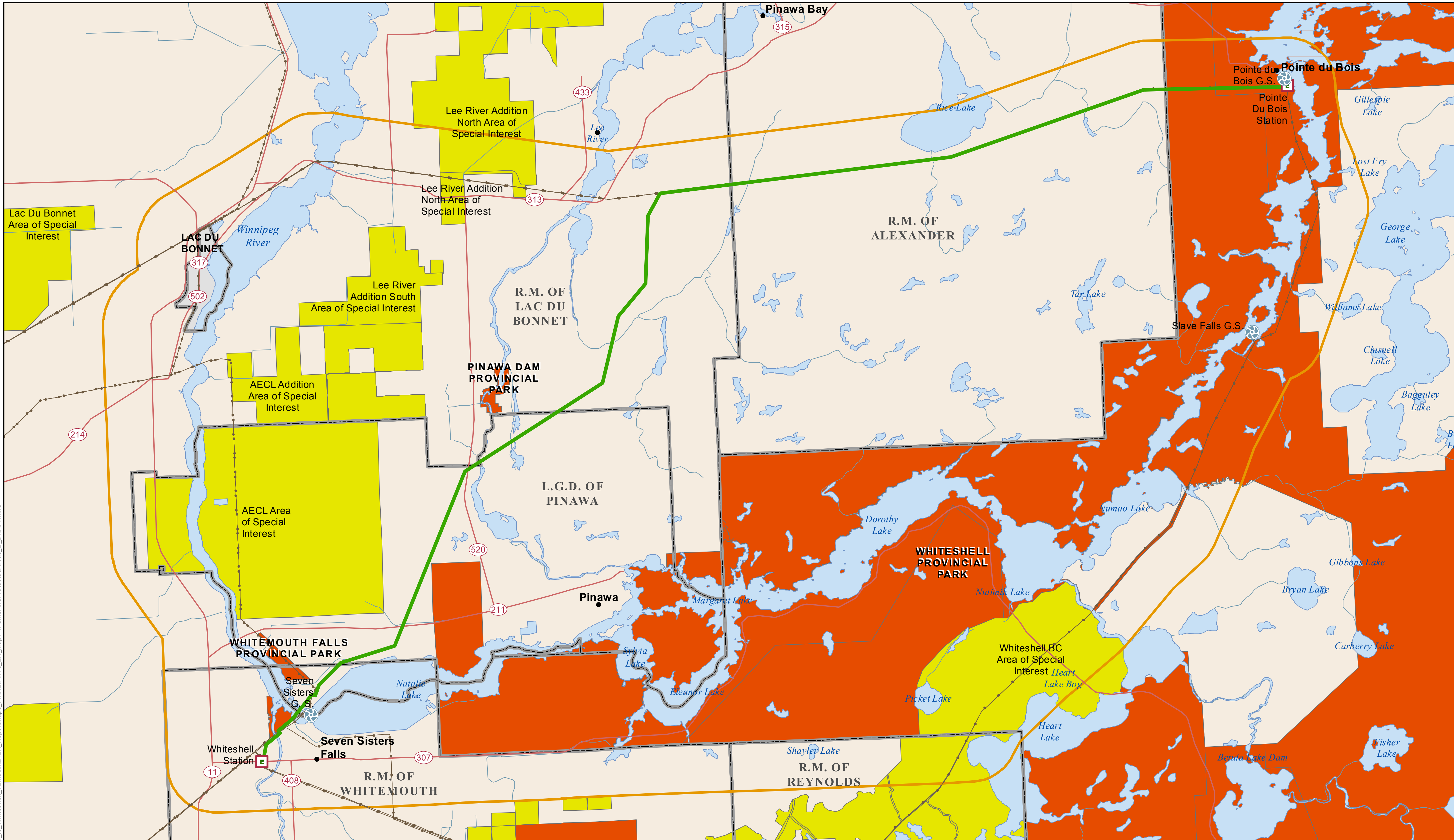
Green line shows the "least cost path" to get from the start to the end.

Figure 4-6: Diagram of the Least Cost Path Analysis. The sum of the "suitability values" for the green line will be lower than the sum of any other combination of grid cells to get from the start to the end

4.1.1.6 Developing a Preferred Route

The study team used the LCPA output as a starting point to create a preliminary Preferred Route. The modeled route was reviewed and various segments adjusted. The 5 m grid cell resolution produces a route that can turn every 5 m. Therefore, at a minimum, the route requires "straightening".

The preliminary Preferred Route was presented to the public for review at stakeholder meetings, public open houses and in letters to adjacent landowners. Based on this feedback, route adjustments were made to produce the Final Preferred Route (Map 4-4).



Manitoba Hydro

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, MMM, ProvMB, NRCAN
Date Created: January 14, 2014

0 2 4 Kilometers
0 1 2 Miles

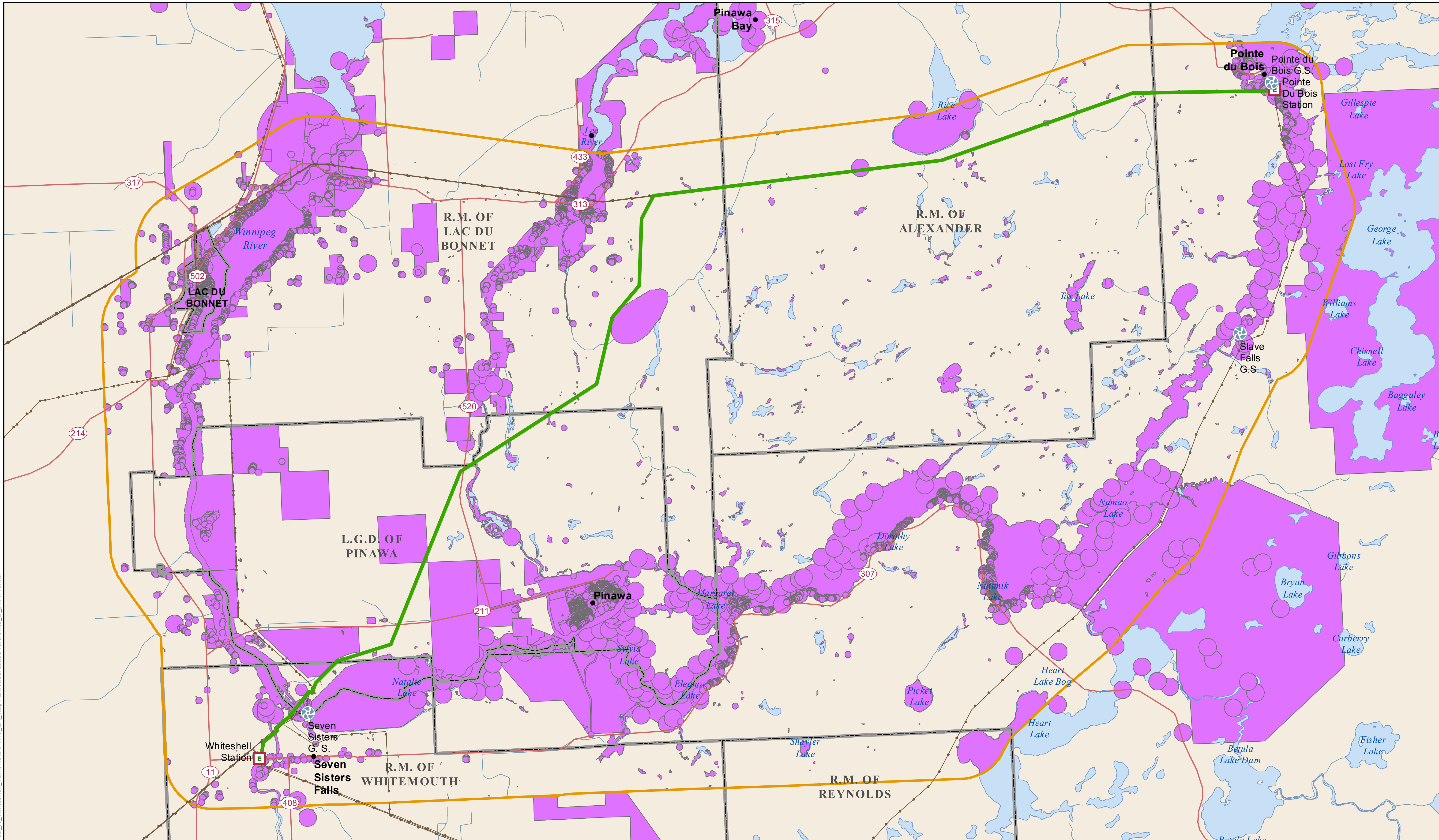
N

1:120,000

- Final Preferred Route
- Very High - Non-protected Provincial Parks and Forest Reserves
- High - Areas of Special Interest, Non-protected Wildlife Management Areas
- Project Study Area
- Generating Station
- Transmission Station
- Community
- Transmission Line
- Provincial HWY / Road
- Town
- Rural Municipality

Pointe du Bois Transmission Project
Map 4-1
Parks and Protected Areas Factor Layer

File Location: U:\Projects\5513030_PdB_to_Whiteshell_TLine\MXD\EA_ReportMaps_FINAL\PW75_EA_Map4-1ParksAndProtectedAreas_B_DRAFT.mxd



Manitoba Hydro

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, MMM, ProvMB, NRCAN, MASKWA, HATCH, ECOSTEM, NLHS
Date Created: March 17, 2014

0 2 4 Kilometers
0 1 2 Miles

N

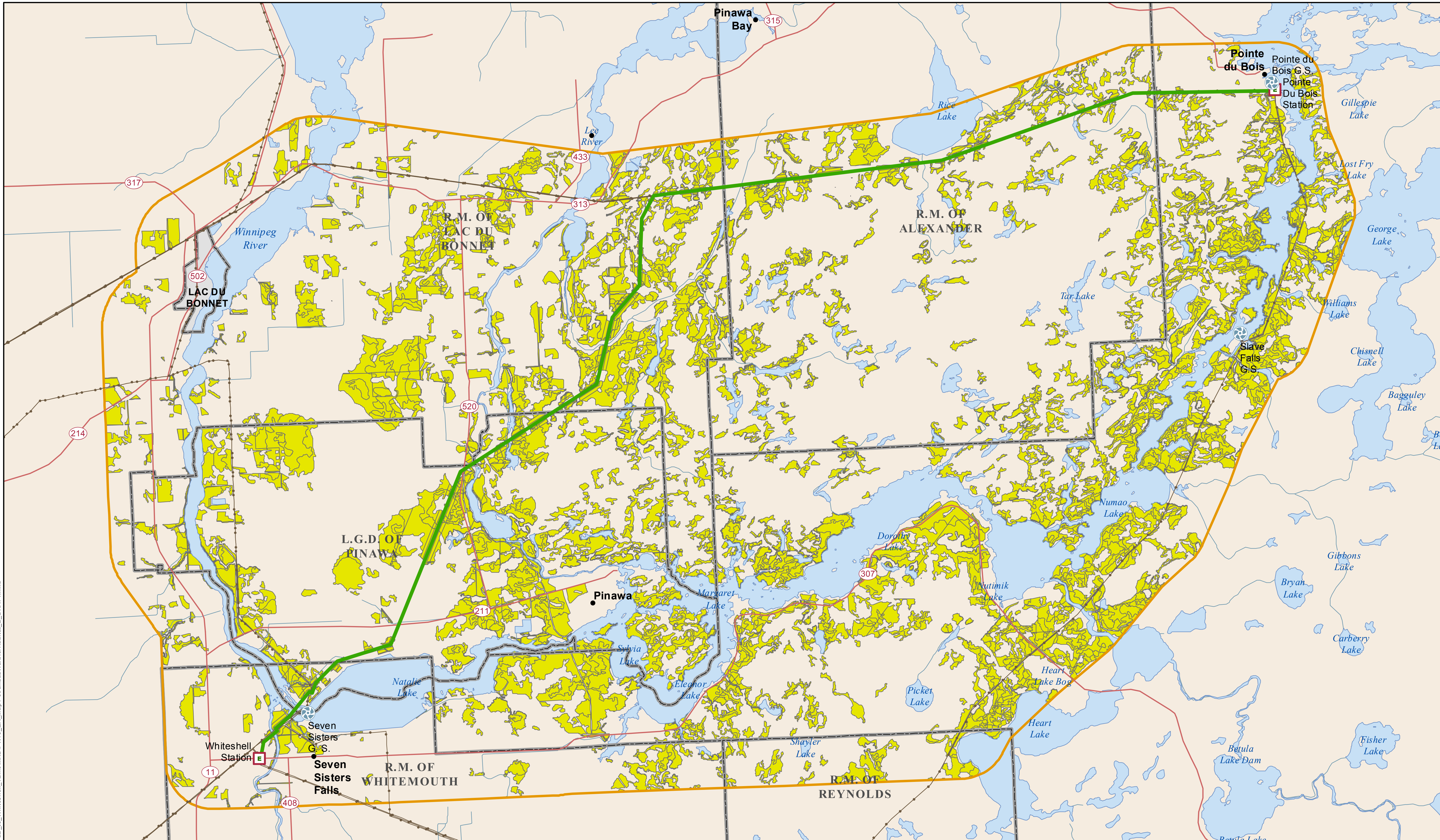
1:120,000

- Final Preferred Route
- Project Study Area
- Area of Least Preference
- Generating Station
- Transmission Station
- Community
- Transmission Line
- Provincial HWY / Road
- Rural Municipality

Pointe du Bois Transmission Project

Map 4-2
Areas of Least Preference

File Location: U:\Projects\5513030_PdB_to_Whiteshell_TLine\MXD\PW75_EA_Map4-2AreasOfLeastPreference_B_DRAFT.mxd



Manitoba Hydro

Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, MMM, ProvMB, NRCAN, ECOSTEM
Date Created: March 17, 2014

0 2 4 Kilometers
0 1 2 Miles

N

1:120,000

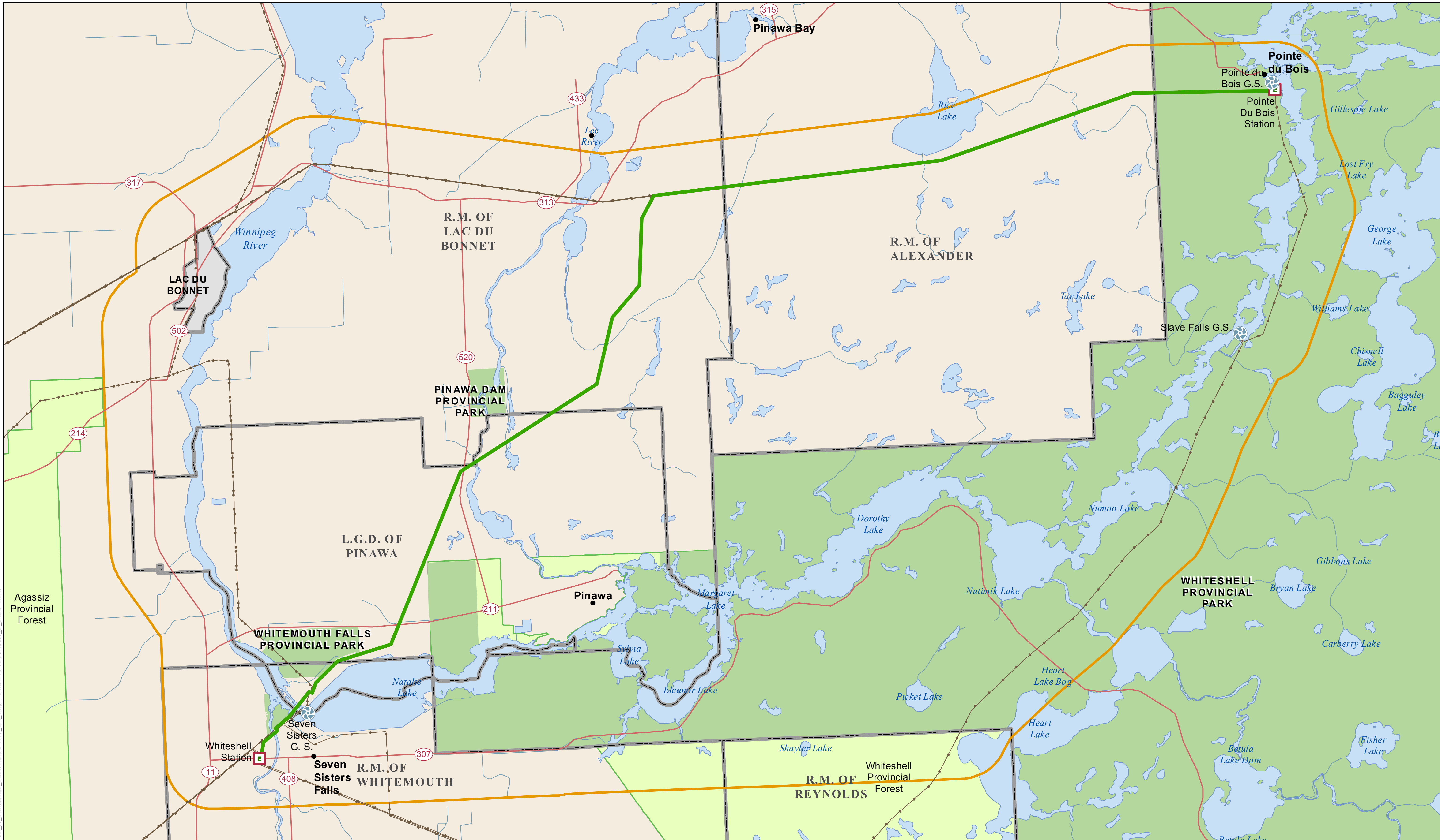
- Final Preferred Route
- Project Study Area
- High - Preferred Canada Warbler Habitat
- Generating Station
- Transmission Station
- Community
- Transmission Line
- Provincial HWY / Road
- Town
- Rural Municipality

Pointe du Bois Transmission Project

Map 4-3

Canada Warbler Habitat Factor Layer

File Location: U:\Projects\5513030_PdB_to_Whiteshell_TLine\MXD\PW75_EA_Map4-3CanadaWarblerHabitat_B_DRAFT.mxd



Coordinate System: UTM Zone 14N NAD83
Data Source: MBHydro, MMM, ProvMB, NRCAN,
Date Created: March 14, 2014

0 2 4 Kilometers
0 1 2 Miles

1:120,000

N

- Final Preferred Route
- Project Study Area
- Generating Station
- Transmission Station
- Community
- Transmission Line
- Provincial HWY / Road
- Town
- Provincial Park
- Provincial Forest
- Rural Municipality

Pointe du Bois Transmission Project

Map 4-4
Final Preferred Route