WIND FARM IMPLEMENTATION
in
MATANE, QUÉBEC

IMPACT STUDY
ON TELECOMMUNICATIONS SYSTEMS
PHASE 2

Prepared for

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TABLE OF CONTENTS

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1 Introduction

Yves R. Hamel et Associés Inc, broadcast and telecommunications consultants have been mandated by the SNC-Lavalin's Division Ingénierie Générale Environnement Québec (IGEQ) in order to verify the impact of the deployment of a large scale wind farm on the telecommunication systems' operation in the Matane region, Québec.

This report is following the phase 1 report which identified the different telecommunication systems in the vicinity of a planned wind farm in the Matane region and potentially suffering interference problems from the deployment of the planned wind farm. It presents the results of the detailed analysis done on the previously identified systems, evaluates the importance and extent of the identified systems' degradation, define the limits of the exclusion areas required by some operating systems and recommend alternative solutions as the case may be.

For clarity and self completeness, some parts of the phase 1 report are repeated in this phase 2 report.

2 Discussion

The following systems were identified in the phase 1 report as potentially suffering interference from some of the wind turbines in the Matane wind farm project. The wind turbine positions considered in this study are the positions provided by the project promoter based on the planning status as of the 26th of October 2004 and latitude and longitude coordinates in NAD 27, zone 19 projection, are presented in Appendix 1.

2.1 TV reception interference

A total of 8 TV stations theoretical service area overlap the wind farm project area, these stations are CBGAT, CBGAT-1 and CBGAT-7, all belonging to the Société Radio-Canada, CIVB-TV and CIVF-TV belonging to Télé-Québec, CFER-TV and CHAU-TV-1, affiliated to the TVA network and CJBR-TV, affiliated to the Radio-Canada network. The analysis showed that the realistic service area of the CBGAT-1, CBGAT-7 and CHAU-TV-1 stations were smaller than the theoretical service contour, due to local topography, and have very limited coverage within the wind farm area. The realistic service contour of these 3 stations are presented in the Appendix 2 and since they are not really covering the population in the wind farm area, no further studies of these stations were executed.

The impact study on the coverage of the other stations is presented in section 3 of this report.

2.2 PTP microwave link

Only three microwave links crossing or terminating within the wind farm project area have been identified. The detailed analysis showed that the 7 GHz microwave link belonging to Hydro-Québec and linking the Nemtaye site to the Matane sub-station is using a passive repeater located 8 km east of Matane. Therefore, it is not penetrating the wind farm area and no further study of that link is required.

However, an additional point to point link to be implemented by the MMDS station operator has been identified, linking the MMDS station to the Mont Comi site and has been added to the study and presented in section 7.

2.3 MMDS station

One MMDS wireless cable TV station is located near the northern limit of the wind farm area, in proximity of the turbines number 99, 92, 72 and 96. This system is using a modulation similar to the TV broadcast transmission at much higher frequency and the impact of the wind turbine may be much stronger. As the assessment approach developed by Senior and Sengupta is not applicable at these high frequencies, a new conceptual approach need to be used, however the concept is only theoretical and is not validated by any real field conditions or measured simulations.

This analysis is presented in the section 8 of this report.

2.4 Meteorological radar station

A meteorological radar station operated by Environment Canada is located in Val d'Irène, approximately 20 km south of the wind farm area. The visibility of the wind turbines have been verified and the impact on the radar response has been evaluated with the collaboration of Environment Canada's specialists. The results are presented in the section 9 of this report.

2.5 DTH satellite reception

The potential interference of the wind turbines with the Direct to Home satellite TV services has been evaluated for a few populated area within the wind farm project area presenting a higher risk of interference to satellite reception. Investigation of the potential obstructing effect of the wind turbine on the Satellite TV reception showed that with the current wind turbine locations, there is no impact for the populated area on the reception of any satellite's signal up to the western most Canadian satellite. In a general case and assuming flat earth, the wind turbine would not cause interference to satellite TV reception at a distance of 500 meters, even if the satellite is located over the west coast in the same azimuth as the wind turbine.

3 TV Reception Interference

This section presents an overview of the problematic of the wind turbine interference with TV reception and the evaluation of the TV reception interference zone associated with the proximity of wind turbines in the Matane wind farm project. Not all wind turbines in the project have been evaluated, but only the wind turbines most susceptible of affecting some of the populated area within or near the wind farm area. The evaluation has been made for the 5 TV stations mentioned previously and considered as covering the wind farm area.

3.1 Generalities

Television interference (TVI) from wind turbine generally occurs as video distortion taking the form of a jittering and flickering of the picture synchronized with the blades passage frequency. The impact on the aural channel is generally not perceptible as it is a frequency modulated (FM) subchannel.

There is no simple rule to determine the minimum separation, between wind turbines and TV transmitter or receiver, insuring interference free operation. The topographic information, the relative positions of the sites and frequency of operation are important parameters. Interference free operation have been encountered in some cases at relatively close distances of less than a kilometer, while unacceptable interference have been experienced at distances exceeding 10 km. Each case needs to be evaluated separately to consider the actual field conditions.

The operation of television transmitters is regulated and each television station has an associated protected service contour within which, interference having a significant impact on the quality of signal reception is not allowed. The deployment of wind turbines at proximity of a television station is problematic as it may degrade a large portion of the service contour area and special care should be taken as the distance between the wind turbine and the TV transmitter decrease. The implementation of a wind turbine at proximity of a TV transmitter will interfere in two different ways, first as a fixed structure, considering the tower and nacelle, and second as a moving structure, considering the blades movement and the rotation of the nacelle in azimuth. When the turbine is erected at close distance from the transmitter, say hundreds of meters, the fix component of the ghosting may be very important over a significant azimuthal sector and will have a permanent characteristic. At such close distance, the flickering ghosting associated with the rotation of the blades will also be important, but will mainly impact a smaller azimuthal sector since it is associated with the specular reflection off the blades. This small sector will move according to the rotation of the nacelle with the wind direction.

The deployment of wind turbines at larger distance from the transmitter within the station service contour will not have a significant fixed ghosting impact, however the flickering ghosting on receivers in the vicinity of the wind turbines may still be important. The importance of this ghosting will increase as the distance between the receiver and the turbine decrease, but its occurrence at a specific point will still be driven by the geometry of the transmitter position, receiver position, turbine position, wind direction, blade pitch and overall topography between these locations.

In this case of the Matane wind farm project, the closest operational television transmitters identified are the CBGAT-7 and CBGAT stations belonging to the Société Radio-Canada and respectively at approximately 12 and 15 km from the closest wind turbine. Considering the distance involved, we do not expect major impact relative to the fixed ghosting caused by the turbine towers and only the ghosting from the rotating blades on receivers in the vicinity of the wind farm project will be analysed in detail for the five TV stations covering the wind farm area.

3.2 Interference prediction model

The area around a wind turbine, susceptible of suffering objectionable ghosting interference from the rotating blades has been initially modelled in reference 5 and is also presented in reference 1. The interference area takes the shape of a mushroom, oriented on the line linking the TV transmitter and the wind turbine. The head of the mushroom (a cardioid shape) is oriented toward the TV transmitter and is called the back scattering zone because in this area the signal is scattered back from the wind turbine blade. The tail of the mushroom (a narrow ellipsoid) is oriented away from the TV transmitter and is called the forward scattering zone, as the signal is scattered in the forward direction.

The maximum distances between the wind turbine and the limit of the interference zone, in the back scattering zone and in the forward scattering zone are located on the line linking the transmitter and the wind turbine. Based on the model, the entire interference zone can be defined when these two maximum distances are known. Without getting into detailed mathematical demonstration which can be found in the references, these two distances are related to the blade characteristics, the wavelength, the field strength at the wind turbine height and also to the direct path field strength at the receiver located at the considered distance.

The original model suggest to use arbitrary distances depending on the distance of the wind turbine from the transmitter and the frequency involved, assuming a smooth flat earth condition. As the wind turbine in this project are installed in relatively hilly area, it is more adequate to include some topographic consideration in the model. Since the values of field strength involved can be easily predicted with a relatively good precision using modern propagation tools based on detailed topographic information, these predicted field strength information will be used to determine the maximum distance involved and consequently the extent of the interference zone for each analysed wind turbine.

In order to use a field strength value representative of the resulting interference area and eliminate the large variation sometimes associated with sharp topographic variation, an average value of the field strength within a polygon representative of the expected resulting back scattering and forward scattering interference zones are used. It is clear that this model does not pretend to identify all potential interfering zone and similarly, some portion of the identified interfering zone, benefiting from favourable conditions may never experience any interference. The resulting interference areas are indicative of the area where potential interference is most probable.

As mentioned earlier, only the wind turbine presenting the highest risk of affecting populated area are analysed. Furthermore, affected receiver located in the back scattering zone can easily eliminate the interference problem by using a commercially available directional receive antenna. The characteristic front to back ratio of this type of antenna is in the range of 15 to 20 dB. When properly oriented to the transmitter, it will reduced the largest back scattering zone to less than a few hundred meters, a distance generally shorter than the Typical minimum distance kept from habitations. However the use of this type of antenna in the forward scattering zone is useless.

3.3 Results

The results of the analysis for the five stations, namely CBGAT, CIVB-TV, CFER-TV, CJBR-TV and CIVF-TV are presented in Appendix 3. Contrarily to the situation where an exclusion zone would be required at proximity of a TV transmitter station, the local interference zones at proximity of television receivers are not an exclusion zone, but an area where interference will be occasionally detectable and sometimes at a level sufficient to be objectionable to long term viewing.

For each station, the analysed wind turbine were selected with regards to their position relative to the transmitter and to the main residential area within the wind farm and the possibility of the associated forward scattering zone to reach these residential locations.

There is basically no solution to the interference in the forward scattering zone, unless as it is the case for CIVB-TV and CIVF-TV, two or more stations broadcasting the same programme are available at the viewing location. In such a case, the receiver antenna can be turned to the alternative station when the reception of the usual transmitter is suffering interference. The probability that both stations will suffer interference simultaneously is very remote.

The interpretation of the results should be done carefully. Except at very close distance from the wind turbine, say 200 meters, the interfering area around a wind turbine does not mean that interference will occur in the entire zone at any given time. It only means that given a specific condition of wind direction and blade pitch, a smaller azimuthal sector of this interference area will suffer interference. Considering a single wind turbine, the probability of interference at any given point within the interference area would be in the range of 1% to 2% of the time. In presence of multiple wind turbines, most literature consider the worst case scenario where all wind turbines are in synchronicity and propose a method of adding the scattered energy from each turbine, resulting in an extension of the interference area. As the blade rotation and the azimuth involved will not generally present the synchronicity conditions, we prefer to approach the multiple wind turbine scenario as an addition of the interference probability.

As a result of this probability addition, a given viewing location which would be within the forward scattering zone of five turbines, would see its probability of suffering interference to increase up to 10% of the time. Viewing locations near a major airport, would suffer similar interference conditions in presence of scattering from a low flying jumbo jet. In these conditions, the interference duration would generally be relatively frequent, depending on air traffic density, but of short duration of a few tens of second at the most, which makes it more tolerable. There is no specific duration tolerance threshold mentioned in any study, but as the wind speed and direction are generally not changing very rapidly, interference period at a given location near a wind farm may have a few hours duration. This is almost certainly above the tolerance level of most viewers, especially if it happens during their preferred TV show.

From the level of picture's degradation point of view, different literature propose similar threshold using different approach. We used the approach proposed by Senior and Sengupta in reference 5, with modulation index values of 0.15 in the back scattering zone and because of the much lower delay involved, a value of 0.35 in the forward scattering zone. These values are approximately equivalent to an unwanted video signal component at –15 dB in the back scattering zone and of –10 dB in the forward scattering zone.

3.3.1 CBGAT station

The CBGAT station is operating from a site located east of the town of Matane, at more than 20km from the centre of the wind farm. It operates on channel 6 with a visual carrier frequency of 83.25 MHz. The results presented in Appendix 3 show that only a few existing households in the forward scattering zone of a turbine would occasionally suffer interference when watching this station. These locations are highlighted with red houses symbols and the turbines involved are the No. 99, 83 and 77. The turbines No. 72 and 92 could also cause interference to some nearby households, considering the lower than average direct signal level to these viewer locations. Many more locations are within the back scattering zone, but these locations can easily solve the problem by installing a directional receive antenna.

This station is the local station of the Radio-Canada network and is also probably the station with the largest audience, considering its local content programming. However, considering the relatively small extent of the problematic interference zones and the relatively small number of households affected, this case is not considered as suffering major impact. Note that the yellow interference areas associated with turbine No. 2, 26 and 35 are unrealistic and show an overreaction of the model as the analysed station's coverage quality is weak in the signal sampling area, especially along the Matane river.

3.3.2 CFER-TV station

The CFER-TV station is operating from the site of Mont Comi located 50km west/south-west of the wind farm. It operates on channel 11 with a visual carrier frequency of 199.25 MHz. The results presented in Appendix 3 show that as expected with the higher operating frequency, the size of the interference zone is more important. Basically all households within or at proximity of the wind farm will suffer occasional interference from the wind turbines. Based on the latest census information, approximately 150 dwellings in St-Léandre and approximately 25 dwelling in St-Ulric-de-Matane would be occasionally affected while viewing this station.

Many of these locations are subject to suffer interference from more than one turbine, which increase their probability of suffering interference to more than 10% of the time in some cases. There is no simple solution to this situation, since all locations are within the forward scattering zone of more than one turbine. An alternative would be to install a repeater station on the east side of the wind farm, such that the viewers could turn a directional antenna to that new station when interference occur. It is doubtful that the operator would justify that investment for such a small market, especially when considering that many of these households are already receiving signals via DTH satellite receiver or other cable means. The conversion to DTH satellite systems would probably be the best alternative for these households suffering excessive interference from conventional reception.

3.3.3 CIVB-TV station

The CIVB-TV station is co-located with the CFER-TV on Mont Comi. It operates on channel 22 with a visual carrier frequency of 519.25 MHz. As expected the potential interference areas associated with the wind turbines are similar to the CFER-TV case, but with larger distance involved, due to the higher operating frequency. This situation is also fairly well in line with the results from Senior and Sengupta who predicted forward scattering distances in excess of 20 km at UHF frequencies.

A cluster of 11 wind turbines (49, 10, 5, 23, 43, 55, 94, 72, 92, 96 and 99) located in the northern part of the wind farm is located directly in line between the transmitter and the town of Matane. Each turbine taken separately, produce a forward scattering zone almost reaching the city and in case of blades rotation synchronicity of just 2 or 3 out of these eleven turbines, the combined scattering of these turbines would almost certainly have an impact in the city of Matane itself. The situation within the wind farm is similar to the CFER case, meaning that almost every household in the wind farm will be subject to occasional interference from more than one turbine, such that the probability of interference may sometimes exceed 10% of the time.

However, in the CIVB-TV case, an alternative station is available, the CIVF-TV station which is broadcasting the same programming (Radio-Québec). In this case, a directional antenna could be used and oriented to the CIVF-TV transmitter. As will be shown later, a few small areas within the wind farm will also be subject to interference in the CIVF-TV case as well, but to a much smaller extent, since it is operating at lower frequency. In these cases, a wideband log-periodic antenna could be used, along with an antenna rotor. It would then be possible to turn the antenna to the alternative station whenever interference occurs on one of the station, as the probability of having interference on both stations simultaneously is very low.

3.3.4 CIVF-TV station

As mentioned earlier, the CIVF-TV station is broadcasting the same signal as the CIVB-TV from a site located on the north shore of the St-Lawrence River in Baie-Trinité. It operates on channel 12 with a visual carrier frequency at 205.25 MHz. The results presented in Appendix 3 show that only two small populated areas will be subject to occasional interference. These areas associated with the turbines No. 11, 24, 41, 90 and 95 are highlighted with red house symbols and represent probably around 25 households or less.

As in the CIVB-TV case, a wideband log-periodic antenna could be used, along with an antenna rotor, in order to reorient the antenna to the alternate station when interference is present on the CIVF-TV station.

3.3.5 CJBR-TV station

The CJBR-TV station is operating from the site of Pic Champlain located 100km west/south-west of the wind farm. It operates on channel 3 with a visual carrier frequency of 61.25 MHz. The results presented in Appendix 3 show that the coverage of this station visible in semi-transparent blue is covering only about half of the wind farm area. The portion covered includes most of the populated area, however the forward scattering zones associated with this station are very limited in size, mainly because of the low VHF frequency involved and no identified populated area are expected to suffer from interference, unless exceptional conditions. Therefore, we do not foresee any significant impact within that station’s service area.

3.3.6 TV reception summary

As previously mentioned, five TV stations offer a good coverage quality in the wind farm area. From these five stations, three will be suffering very minimal interference from the wind turbines scattering, namely CBGAT, CJBR-TV and CIVF-TV. For these three stations, we do not expect a high level of complaint from television viewers in the wind farm area. For the other 2 stations, CFER-TV and CVIB-TV, located on Mont Comi, the probability of suffering from scattering interference for most viewer's location within the wind farm is sometimes reaching a level in the range of 10% of the time.

In the case of CFER-TV, we estimate that less than 200 households will be affected, while in the case of CVIB-TV, the number of affected household could exceed 1000, especially if the model prove to be optimistic with the northern turbine cluster. We are confident that the interference areas predicted for these five stations include some operational margin, however some areas with lower than average received signal level may suffer interference even if not included in the predicted area.

4 Other broadcast systems

4.1 FM broadcast station

Previous studies and simulations in laboratories have shown that FM broadcast reception is generally not affected by the wind turbine operation, as long as a minimum distance of a few hundred meters from the wind turbine is maintained. Perception of FM reception degradation would take the shape of a background "hissing noise" synchronised with the blades rotation. Noticeable degradation would typically only happen on the fringe of the coverage area of a station, as the signal to noise ratio is already marginal (<12dB) and at close proximity to the wind turbine. These conditions would happen outside the protected service contour and within the Matane wind farm project area, we do not expect any significant interference with FM broadcast reception.

4.2 AM broadcast station

Just like television signals, AM broadcast signals are amplitude modulated and as such could experience interference from wind turbine operation. However, the AM broadcast systems operate at very low frequency with wavelength much longer than TV signals and thus are not reflected by wind turbine components. The reception of AM broadcast signals will not be affected, unless the receiver is very close to the wind turbine itself (less than a few meters). One should note that the construction of any metallic vertical structure near an AM antenna system (within a few wavelengths) would modify the radiation pattern of the antenna system, as the new structure will react as a secondary radiator. The closest AM station distance from the Matane wind farm project exceeds 8 kilometers and will not be affected by the construction of the wind turbines.

5 Navigational aid systems

5.1 VOR system

The VOR (VHF Omnidirectional Range) use frequencies in the 108-118 MHz band and a combination of amplitude and frequency modulation to facilitate aircraft short-range navigation. The VOR ground stations are generally located within the boundaries of airports but are sometimes located along main navigation corridors for en route navigation. A clear area of approximately five hundred meters around ground stations should be maintained for proper operation and precision of the airborne receiver. Tall buildings or structures should be avoided at larger distance from the station to avoid distortion of the variable azimuthal signal. Previous investigation have shown that wind turbine structures can be considered as static structures with regards to VOR operation and the Transport Canada Aeronautical Obstruction Clearance should be obtained as for any other tall structure.

The Matane wind farm project area is not located near any VOR station, hence we do not expect any interference to this type of navigational aid system.

5.2 LORAN-C system

The LORAN-C (Long-Range Navigation System: version C) is a maritime navigational aid system also used for aircraft navigation on trans-oceanic flights. The LORAN-C systems use very low frequencies in the range of 100 kHz and theoretical investigation have shown that wind turbine construction at distances greater than 250 meters from a transmitter or receiver would not impact the performance of the system. As there is no LORAN-C station close to the Matane wind farm project, no interference with these systems is expected.

5.3 Defence systems

As the information regarding the national defence systems are not published in publicly accessible database, contact was established with Industry Canada defence systems co-ordinator and a formal query conducted by IC. There was no military installation identified within 100 km from the wind farm area, therefore we do not foresee any impact on any military system.

6 Mobile systems

All mobile systems operating in the VHF, UHF bands as well as the Cellular or PCS systems in the 800 and 1900 MHz bands use some form of frequency or phase modulation which similarly to the FM broadcast systems, are not considered susceptible to wind turbine interference. Even if interference is theoretically possible at very close distances from the wind turbine under weak signal conditions, there is no reference in the literature describing any encountered real case. We do not expect any significant interference with that type of systems.

7 Point to Point systems

The point to point radiocommunication systems are used to link broadcast stations to their associated studio as well as for a multitude of applications associated with different utilities. The telephony and data networks use microwave point to point links and especially with the expansion of the cellular systems, microwave links are used to link every base station to their associated switching centre. At UHF and microwave frequencies, point to point links require clear line of sight between communicating stations. The presence of structures on each side along the path may cause signal reflection partially cancelling the direct signal to the point where the communication may be interrupted.

The construction of wind turbines at close proximity to a point to point path is even more damaging than a static structure, considering the amplitude modulation effect and the Doppler effect introduced by the rotation of the blades. Many references in the literature have evaluated the required clearance between the path optical line of sight and any wind turbine along the path and most references conclude that the minimum distance to be maintained to ensure an interference free operation is 3 times the first Fresnel zone radius. The first Fresnel zone radius depends on the frequency of operation of the link, the path length and the relative position of the wind turbine along the path.

The Phase1 report identified the presence of 3 PTP links crossing or terminating within the wind farm area, 2 belonging to Telus and one belonging to Hydro-Québec. The detailed analysis showed that the 7 GHz microwave link belonging to Hydro-Québec and linking the Nemtaye site to the Matane sub-station is using a passive repeater located 8 km east of Matane and is not penetrating the wind farm area. Therefore, no further study of that link is required.

However, an additional point to point link to be implemented by the MMDS station operator has been identified, linking the MMDS station to the Mont Comi site and has been added to the study as shown in the results presented in the Appendix 4. This link will be operating in the 2600 MHz MMDS band.

The two Telus links are operating in the 1700 -1900 MHz band and the red oval shapes constitute the area extending to a distance of 3 times the 1st Fresnel zone radius plus 1 rotor radius on each side of the direct path, as suggested by most literature.

The blue rectangular shapes are considering the excessive reflection/scattering zone as defined in the method proposed by David F. Bacon, assuming that a minimum C/I ratio of 60 dB needs to be maintained for this type of radio. The evaluation of this excessive reflection/scattering zone requires the value of the Radar Cross Section (RCS) of the wind turbine and associated supporting tower. As this value is generally not known for specific wind turbine, an alternative is to use the profile area of the turbine and as the RCS often exceeds the profile area, a margin factor is applied. A RCS value of 1200 m^2 has been assumed in this case.

Generally speaking, the deployment of wind turbine should avoid the proximity of telecommunication towers, especially the TV transmitter sites. The results show that at close distance from the Telus microwave site (less than 1 km), the turbines number 92, 96 and 99 are either in the Fresnel exclusion zone or the excessive reflection/ scattering exclusion zone or both, and should be moved a few hundred meters to clear these zones.

Between 1 and 2 km from the microwave site, the turbines number 5, 55 and 94, are also in the Fresnel exclusion zone or the excessive reflection/scattering exclusion zone or both, and should also be moved a few hundred meters or less eastward or westward to clear these zones.

Further away on the Telus microwave path to St-Cléophas, the turbine number 84 is also within the Fresnel exclusion zone and will need to be moved east or west to clear the exclusion zone.

8 MMDS station

Point to Multipoint systems are gaining in popularity in rural areas to offer services as telephony, internet access and wireless cable TV networks. These systems operate in different frequency bands from 1.5 GHz up to 40 GHz with many different types of modulations to accommodate the required bandwidth according to the offered service. One such system has been identified within the wind farm project area, operating in the 2.6 GHz MMDS band and offering wireless cable TV distribution service. As a matter of fact, this MMDS station is not yet in operation. The operator (Cablevision T.R.P. Inc.) owns the licence since 2001 and intend to begin operation in 2005.

Based on the information provided by the operator, the target market area is spread on a few kilometers wide strip along the St-Lawrence shore from the city of Matane in the east to Métis-sur-Mer in the west. They are planning to use a bi-directional antenna oriented in the 60° and 240° azimuth, which will radiate the maximum energy approximately in the Matane and Métis-sur-Mer directions. As this system is analog and broadcasting signals with the same modulation characteristics as the TV broadcasting, its susceptibility to interference from wind turbine scattering will even be worst, due to the much higher frequency involved.

The literature on the TV interference indicates that the model used for TV reception interference is not applicable above the 700 MHz UHF band, so a new approach need to be developed for this type of system. The system can be seen from the transmitter end as a broadcast TV transmitter, while from the receiver end it is more considered as a Point to Point link. The intent of the analysis is to avoid excessive scattering toward the target market area, such that new subscribers can be added to the system wherever they are, within the target market zone.

Intuitively, we can consider that any wind turbine installed directly between the MMDS station and the receiver would create an important forward scattering zone extending at very important distance. The width of that forward scattering zone will depend on the distance between the MMDS station and the wind turbine, increasing as the distance is reduced. Typically, we should avoid placing turbines in a sector between the station and the target market such that reflection from the turbine cannot be received at any receiver location within the market area.

From the receiver point of view, they are using directional antenna having a typical beamwidth opening of 10° or more, which means that any reflection from a wind turbine must be received with an incidence angle larger than 5° to minimise the impact of the reflected signal. For a receiver antenna located in Matane, approximately 17km from the station, the minimum azimuthal angle of 5° between the MMDS station and any wind turbine represent a distance of 1.3km south of the MMDS station. Furthermore, in order to reduce the risk of high reflection/scattering from wind turbine, they should be located as much as possible outside of the MMDS station antenna pattern, at least more than 5° in azimuth from the MMDS station as seen by the southernmost subscriber location.

An exclusion zone shown in Appendix 5 has been drafted, allowing the protection of a 4 to 5 km strip along the St-Lawrence shore and extending approximately 20 km east and west. This exclusion zone requires the displacement of the 11 turbines forming the northernmost cluster. Many of the turbines forming that cluster already have been identified as causing problem to the point to point systems, but the MMDS station proximity require a more important displacement.

As a consequence, either the wind turbines need to be moved out of the MMDS station exclusion zone or the MMDS station needs to be moved away from the wind farm. In this latter case, we were not able to identify a single site offering a similar coverage of the targeted market and it is probable that the station would need to be replaced by two stations, one in the Matane city vicinity and another one near Baie-des-Sables or Métis-sur-Mer.

9 Meteorological Radar systems

Radar systems generally operate in the microwave frequencies from 1 GHz to 10 GHz and more, and use the radio wave reflection to locate and identify any eventual target. Military and civil usage of radar systems is mainly related to air traffic control and meteorology to name a few applications. Any fix structure in the radar station line of sight will reflect a part of the signal emitted by the radar and return it to the radar receiver which will process it. The echo from the structure will be similar to the echo from an aircraft, but will show different particularities designated as its radar signature and processing can differentiate between a structure signature and an aircraft signature, even between two different type of aircraft.

When the structure is fix, filtration and processing can generally eliminate the structure signature from the radar display, reducing the impact for the radar operator. The navigational radar, especially the long range radar, typically have a slight positive antenna elevation angle, such that structures far enough from the radar station are not visible from the radar station position and generally do not cause any significant radar response. In the case of weather radar, an objective is to analyse the weather conditions as close as possible to the ground and negative elevation angles are not uncommon, especially when the radar site is at relatively high altitude. Moving structures like wind turbine cause additional disturbances to radar operation, since the signature is continuously changing according to rotor speed and wind direction. When many wind turbines are clustered in relatively large wind farm, the filtration and processing of these radar echos become virtually impossible.

The meteorological radar of Val d'Irène operates at 5625 MHz from a site located at 710m altitude. Its range exceeds the typical 240km in conventional mode and 120km in Doppler mode. It is located a little more than 25 km from the wind farm centre and the lowest scan elevation angle is –0.7° in Doppler mode during summer time. The antenna beamwidth is approximately 0.65° in the vertical plane.

The Appendix 6 presents an analysis of the radio visibility of the wind turbines from the radar platform point of view. It indicates that all wind turbines are visible, at least for their rotor part, and that for almost half of them, the tower is almost entirely visible. From the wind turbines point of view, the radar antenna is visible at an elevation angle ranging roughly between 0.7° to 1°, which correspond approximately to the tower tapering angle of 0.77°. In situation where radar platform and wind turbines are at the same altitude, this tapering angle reduces the signal reflected toward the radar receiver, since the radar signal is reflected upward. In this case, since the tapering angle of the tower almost coincide with the elevation angle to the radar, the reflection toward the radar receiver will remain very important.

In conventional mode, the lowest scan is at –0.5° elevation angle and at that angle the radar beam is just passing above the highest turbines. Even if the main beam is clearing the turbines, there is still energy transmitted at a wider angle than the main beam and this energy will be reflected by the tower, the nacelle and the rotor. In this mode, the turbines will be seen as fixed obstacle and be filtered out by the ground clutter algorithm. As the wind farm area is already characterised by its ground clutter, the consequence will be an additional loss of radar data in the wind farm area and in a sector located behind the wind farm, but not of major importance. This loss of data could potentially happen on the 2 or 3 lower scan elevation, which means that information below approximately 500 meters over the wind farm and immediately behind could be altered or loss. For some applications like precipitation detection, the impact can be mitigated by extrapolation or other means. If rain is detected at 500m altitude, chances are good that it is also raining at ground level, however for some other applications the loss data may lead to an incomplete information as it happens in some other area like behind the mountains.

In Doppler mode the filtration of the radar return from the moving blades is more difficult to achieve. False detection of meteorological phenomenon is probably the most susceptible impact of the wind turbines. As an example, the movement of the blades could, under certain conditions, be interpreted as a small tornado, which in itself is not dramatic, knowing the existence of the wind farm. However a tornado beginning behind the wind farm as seen by the radar may be unnoticed for some times and tornado alert could potentially be delayed for some period of time.

According to the initial opinion of Environment Canada specialists, the impact of the new wind farm, even if degrading the quality of the radar data is not considered as having a major impact on the data collected from the Val d'Irène radar station. For the reader's information, a response E-mail from the manager of the National Radar Program is attached in Appendix 7. The reader should note that this preliminary conclusion should be considered as an educated opinion and is not based on any exhaustive scientific evaluation.

10 CONCLUSION

The detailed analysis of the telecommunications systems identified in the phase 1 report has been completed and even if problematic situation exist, action can be taken to remedy the situation before construction and minimise the impact of the planned wind farm on co-located systems and the local population.

As a general conclusion, wind turbine siting process should avoid the proximity of microwave station and especially TV transmitter stations. In most cases, many turbines planned within 2 km of a significant telecommunication station have to be moved or displaced. In the case of a TV transmitter, the distance could even be larger depending on the population distribution around the station and the technical parameters of the station.

To accommodate the point to point microwave links terminating at the Rivière-Blanche site, 6 wind turbines located within approximately 2 km from the telecommunication site need to be moved by at least a few hundred meters in order to clear the direct paths by a sufficient margin.

To accommodate the MMDS station, these same 6 wind turbines plus 5 more need to be move as much as 2 km away for some of them. Furthermore, that same cluster of 11 wind turbines could have a potentially significant impact of the CIVB-TV reception within or on the periphery of the city of Matane.

As a consequence, unless this cluster located at proximity of the Rivière-Blanche site is vital to the success of the wind farm project, in which case we could evaluate some costly and elaborate solutions, we recommend to displace the entire cluster to some other area of the wind farm, preferably in the southern part which is less populated.

According to the initial conclusion of the Environment Canada specialists in charge of the National Radar Program, the planned wind farm will not have a significant impact on the Val d'Irène radar station operation. As they didn't have sufficient time for a complete analysis, they expect to pursue the analysis in more details and keep us informed if new findings modify this initial conclusion.

In most cases, the TV reception will be impaired for some of the populated area included in the wind farm area. The extent of the interference area may look very important, however the affected population is limited to approximately 200 dwelling or less and in many cases, the probability of occurrence of the interference is relatively low, in the range of a 1% to 2% of the time. The worst cases are for the stations located on Mont Comi for which the probability of occurrence may reach an unacceptable level. In all cases, a good quality TV signal may be received by some other means like Direct to Home satellite TV services, for which we didn't identify any significant impact.

.

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2- Heemskirik Wind Farm DPEMP, Chapter 19 : Electric and Magnetic Fields and Electro-magnetic Interference, Heemskirk Wind Farm DPEMP, Vol.1, 2003.

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6- M. M. Butler, D. A. Johnson, “Feasibility of mitigating the effect of wind farm on primary radar”, DTI PUB URN No. 03/976, 2003.

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8- Agence Nationale des Fréquences, “Perturbation de la réception des ondes radioélectriques par les éoliennes”, ANF Report, 2002

9- Industry Canada TB-5 “Report on predicting television ghosting interference and picture quality”, Issue 2, July 1989

10- Industry Canada BC-9 “Television ghosting interference analysis”, Issue 1, July 1996

Appendix 1

Position of the wind turbines evaluated

ANALYSED TURBINE COORDINATES (NAD 27 projection)

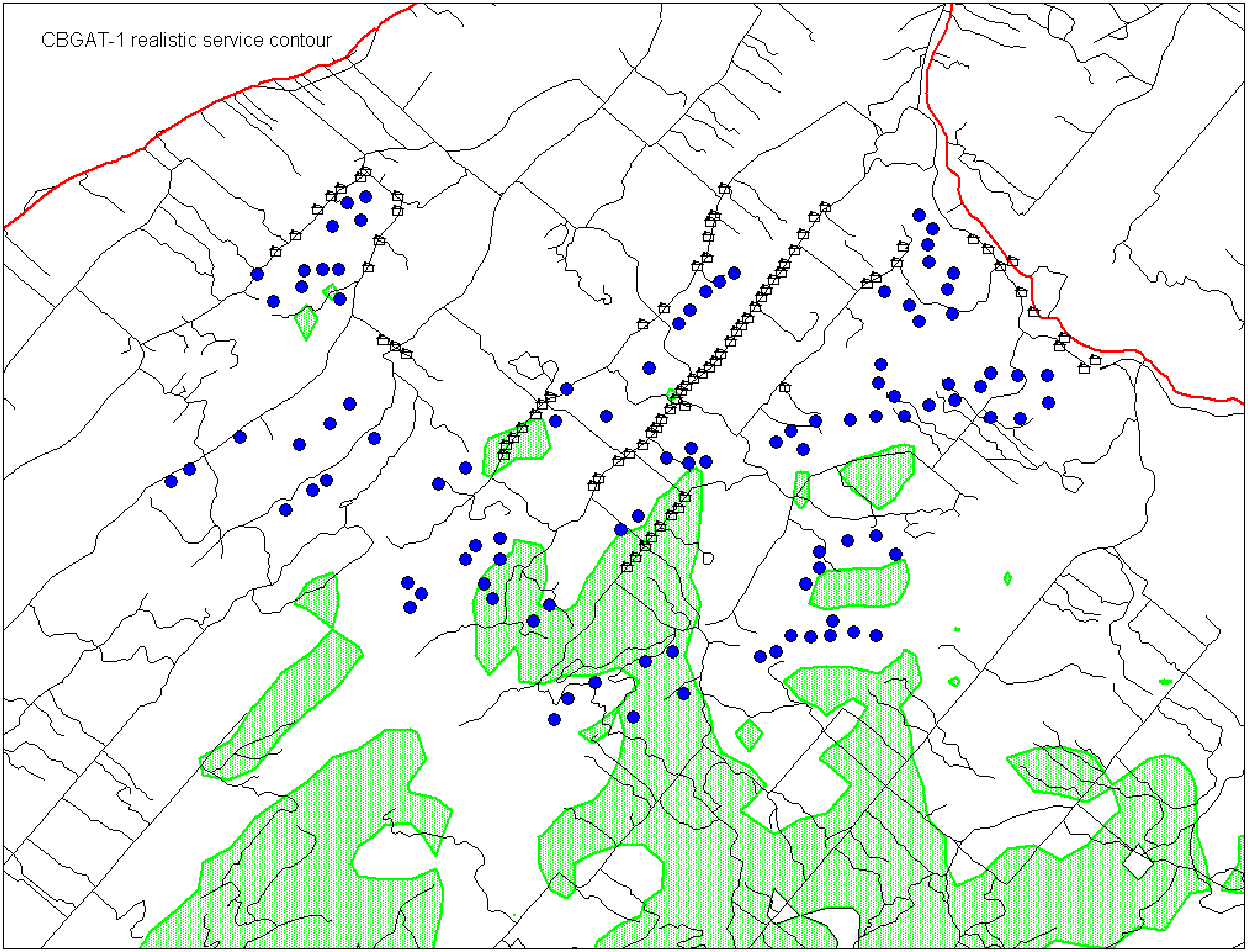
TURBINE_ID	LATITUDE	LONGITUDE
1	48.6864	-67.5776
2	48.7509	-67.5446
3	48.6865	-67.5724
4	48.7234	-67.5216
5	48.7513	-67.7083
6	48.7247	-67.7022
7	48.7236	-67.5751
8	48.7009	-67.6673
9	48.7261	-67.5142
10	48.7460	-67.7166
11	48.7195	-67.6077
12	48.7269	-67.5388
13	48.7244	-67.5593
14	48.7221	-67.5817
15	48.7461	-67.5400
16	48.7309	-67.5221
17	48.6941	-67.6603
18	48.7297	-67.5402
19	48.7539	-67.5451
20	48.7238	-67.5294
21	48.6866	-67.5828
22	48.7036	-67.5599
23	48.7486	-67.7090
24	48.7168	-67.6085
25	48.7243	-67.5518
26	48.7566	-67.5435
27	48.7261	-67.5455
28	48.7099	-67.7142
29	48.6839	-67.5866
30	48.7314	-67.5292
31	48.7153	-67.7439
32	48.7029	-67.5674
33	48.6826	-67.6208
34	48.7011	-67.5749
35	48.7589	-67.5471
36	48.7407	-67.5476
37	48.6872	-67.5662
38	48.7489	-67.5383
39	48.7188	-67.5785
40	48.7212	-67.7103
41	48.7178	-67.6143
42	48.7203	-67.5856
43	48.7515	-67.7033
44	48.7009	-67.6583
45	48.7237	-67.5662
46	48.7308	-67.5145
47	48.6730	-67.6448
48	48.7226	-67.7259
49	48.7508	-67.7205
50	48.7496	-67.5956

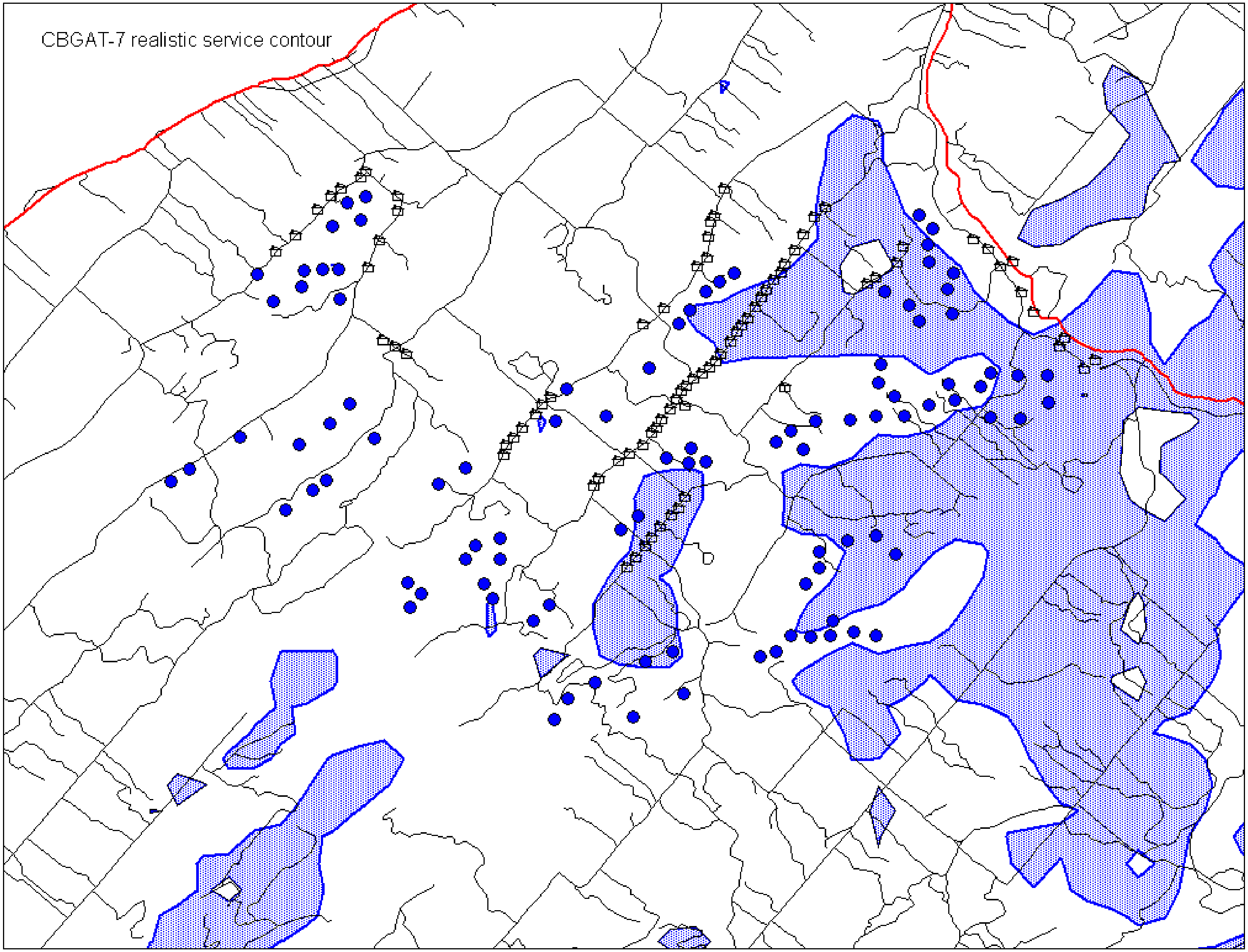
TURBINE_ID	LATITUDE	LONGITUDE
51	48.6863	-67.5603
52	48.7220	-67.6905
53	48.7418	-67.5388
54	48.7045	-67.6582
55	48.7513	-67.6991
56	48.6765	-67.6411
57	48.6731	-67.6244
58	48.7333	-67.5579
59	48.7433	-67.6074
60	48.7277	-67.5544
61	48.7334	-67.6185
62	48.7434	-67.5502
63	48.6927	-67.6822
64	48.6769	-67.6111
65	48.7167	-67.6670
66	48.6950	-67.6792
67	48.6842	-67.6138
68	48.7291	-67.5319
69	48.7409	-67.6104
70	48.7032	-67.6646
71	48.7150	-67.7033
72	48.7639	-67.6917
73	48.7282	-67.6968
74	48.7459	-67.5565
75	48.6791	-67.6340
76	48.7253	-67.6300
77	48.7246	-67.6433
78	48.6901	-67.6498
79	48.7172	-67.7390
80	48.6892	-67.5715
81	48.7170	-67.6041
82	48.7004	-67.5550
83	48.7300	-67.6401
84	48.7134	-67.7071
85	48.6927	-67.6456
86	48.6956	-67.5785
87	48.7464	-67.6032
88	48.7300	-67.5585
89	48.6971	-67.6827
90	48.7056	-67.6265
91	48.6983	-67.5749
92	48.7630	-67.6968
93	48.7139	-67.6740
94	48.7463	-67.6989
95	48.7078	-67.6222
96	48.7598	-67.6931
97	48.7482	-67.5995
98	48.6965	-67.6627
99	48.7589	-67.7006
100	48.6832	-67.5908

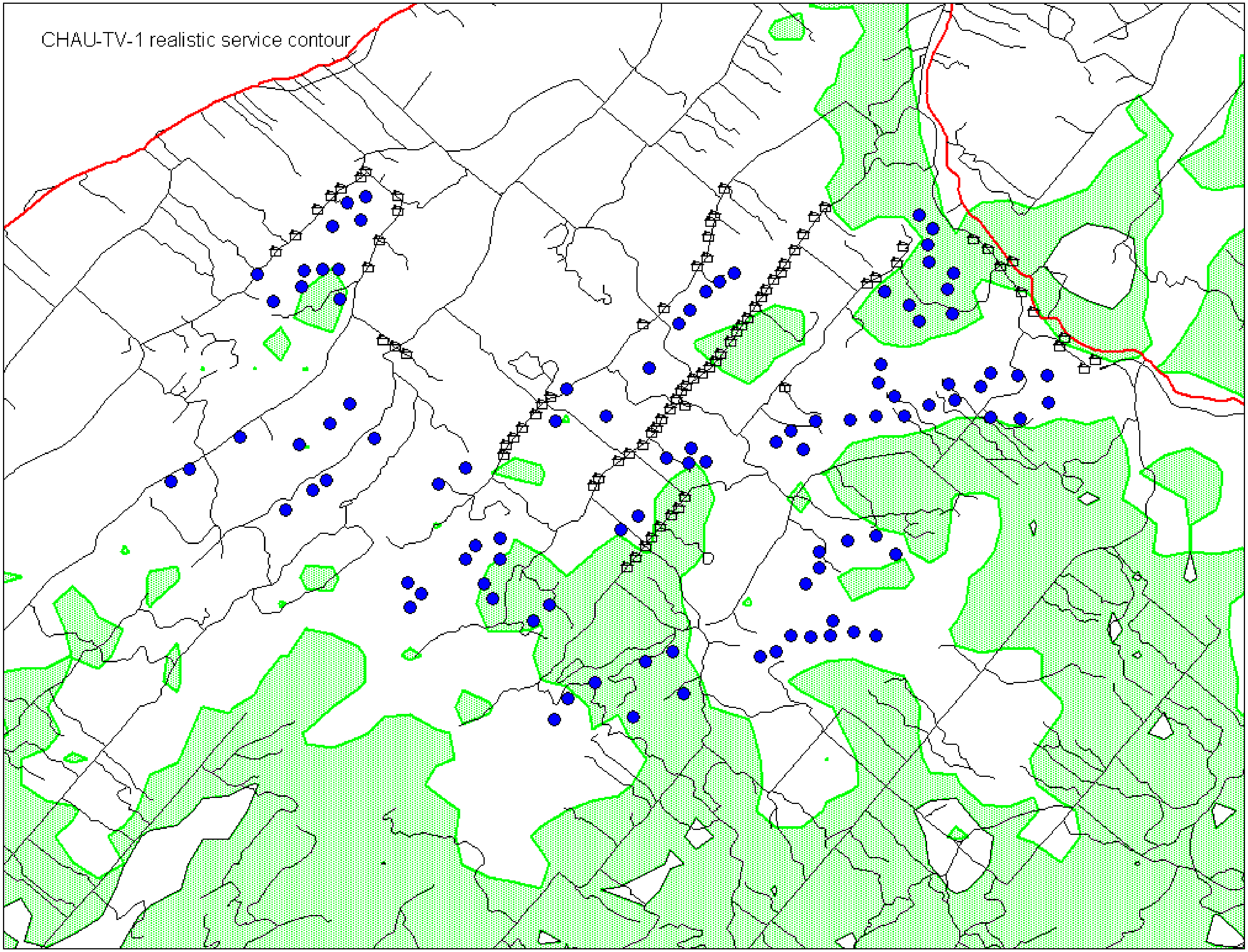
Appendix 2

Realistic contour of service of

CBGAT-1, CBGAT-7 and CHAU-TV-1


CBGAT-1 realistic service contour

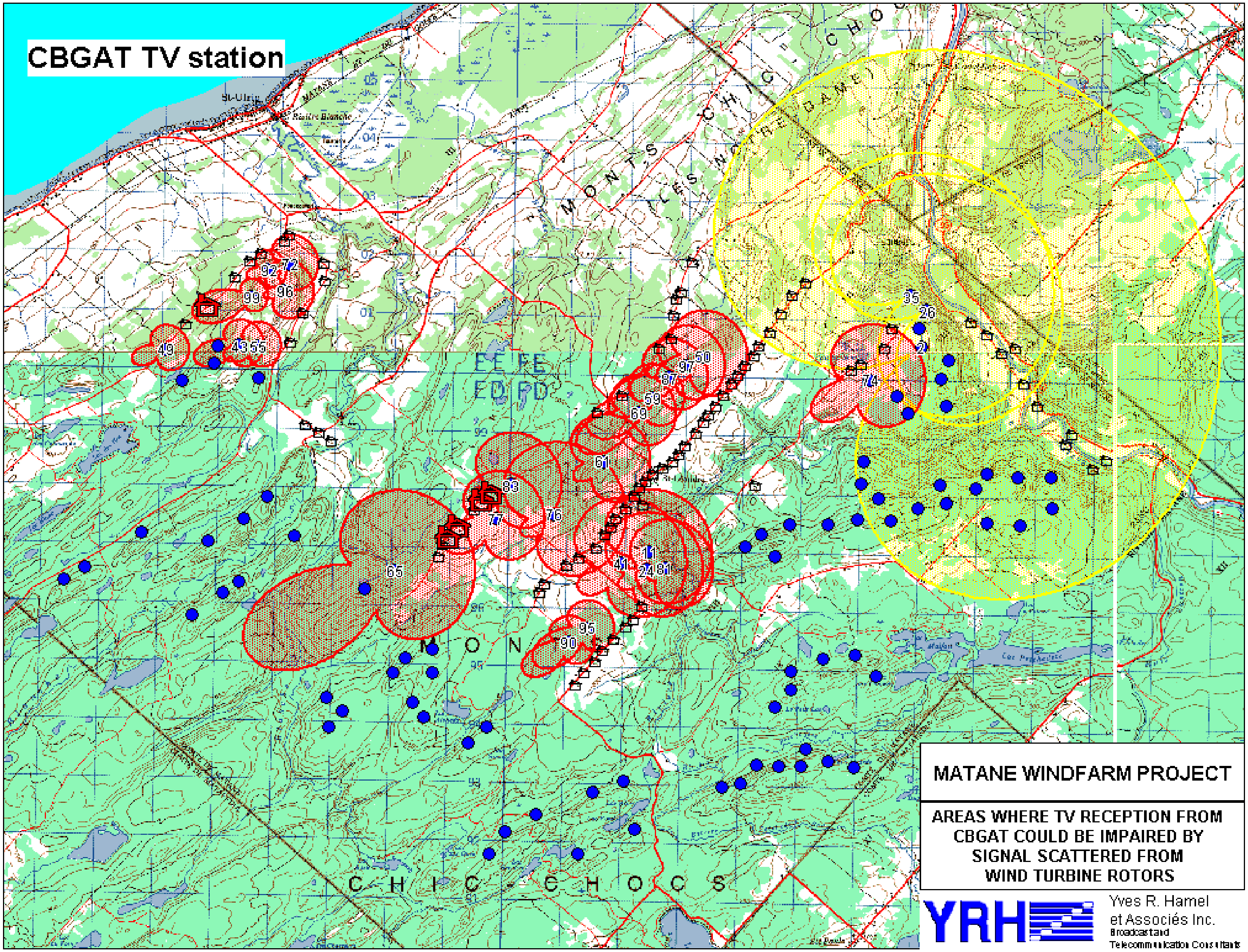

CBGAT-7 realistic service contour

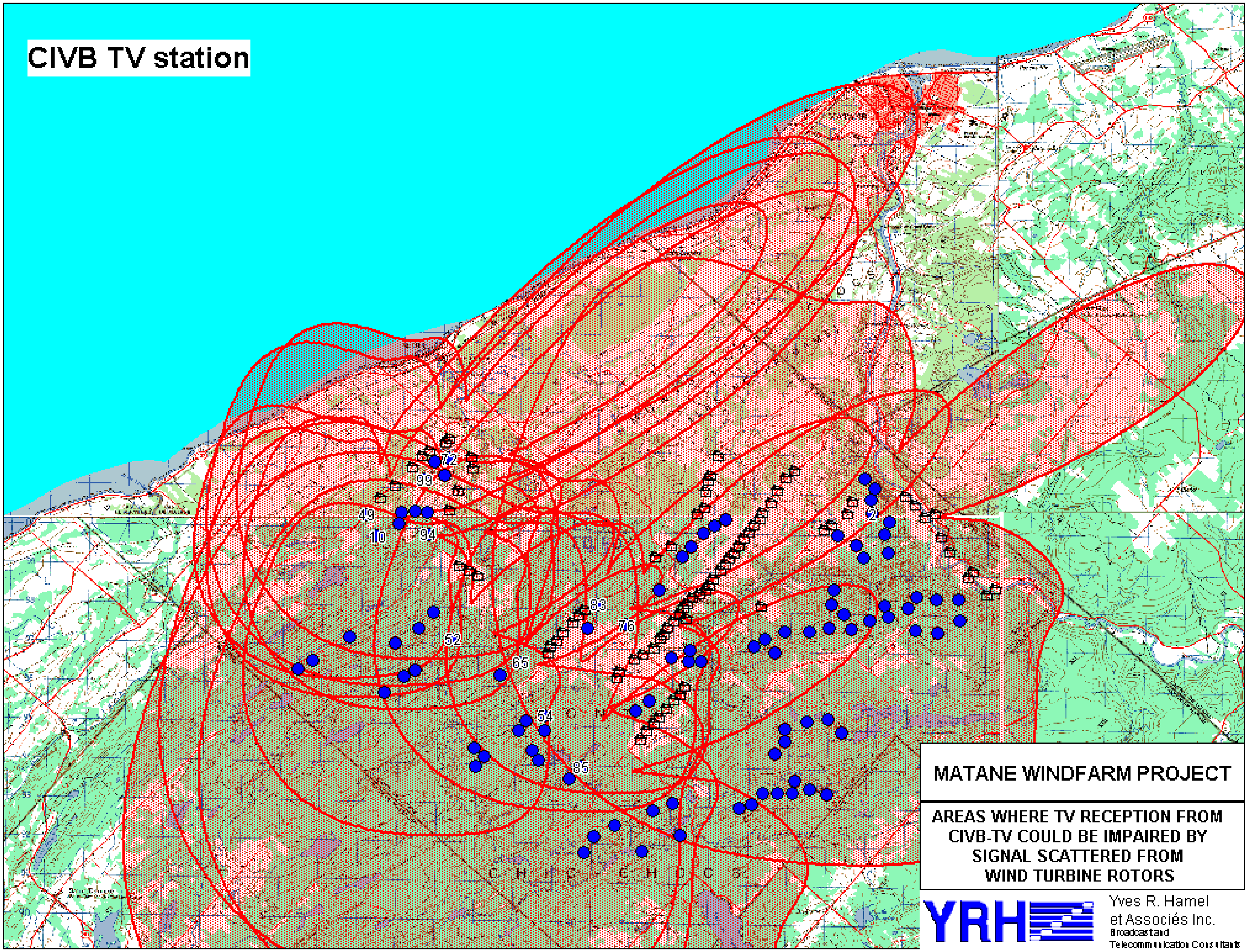

CHAU-TV-1 realistic service contour

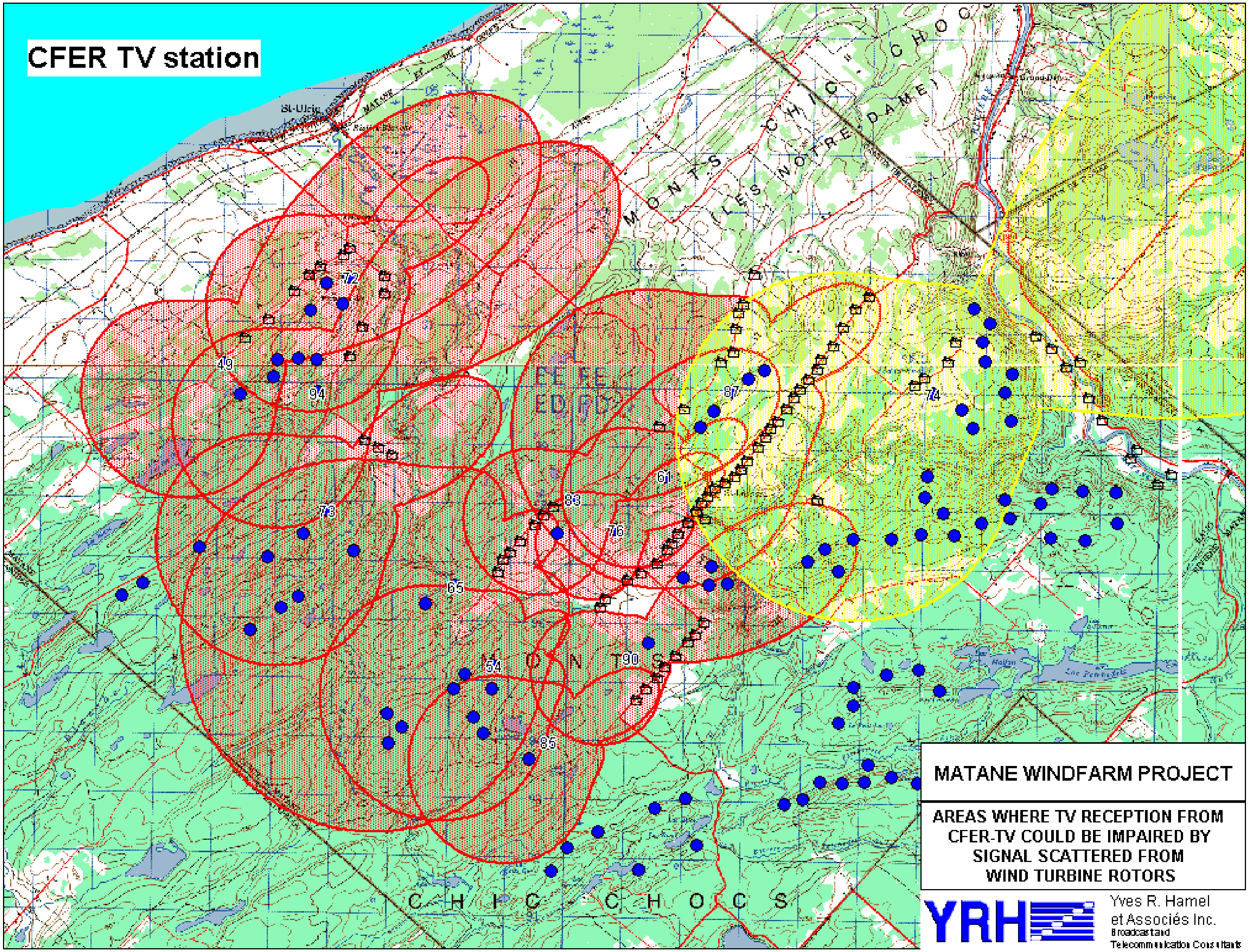
Appendix 3

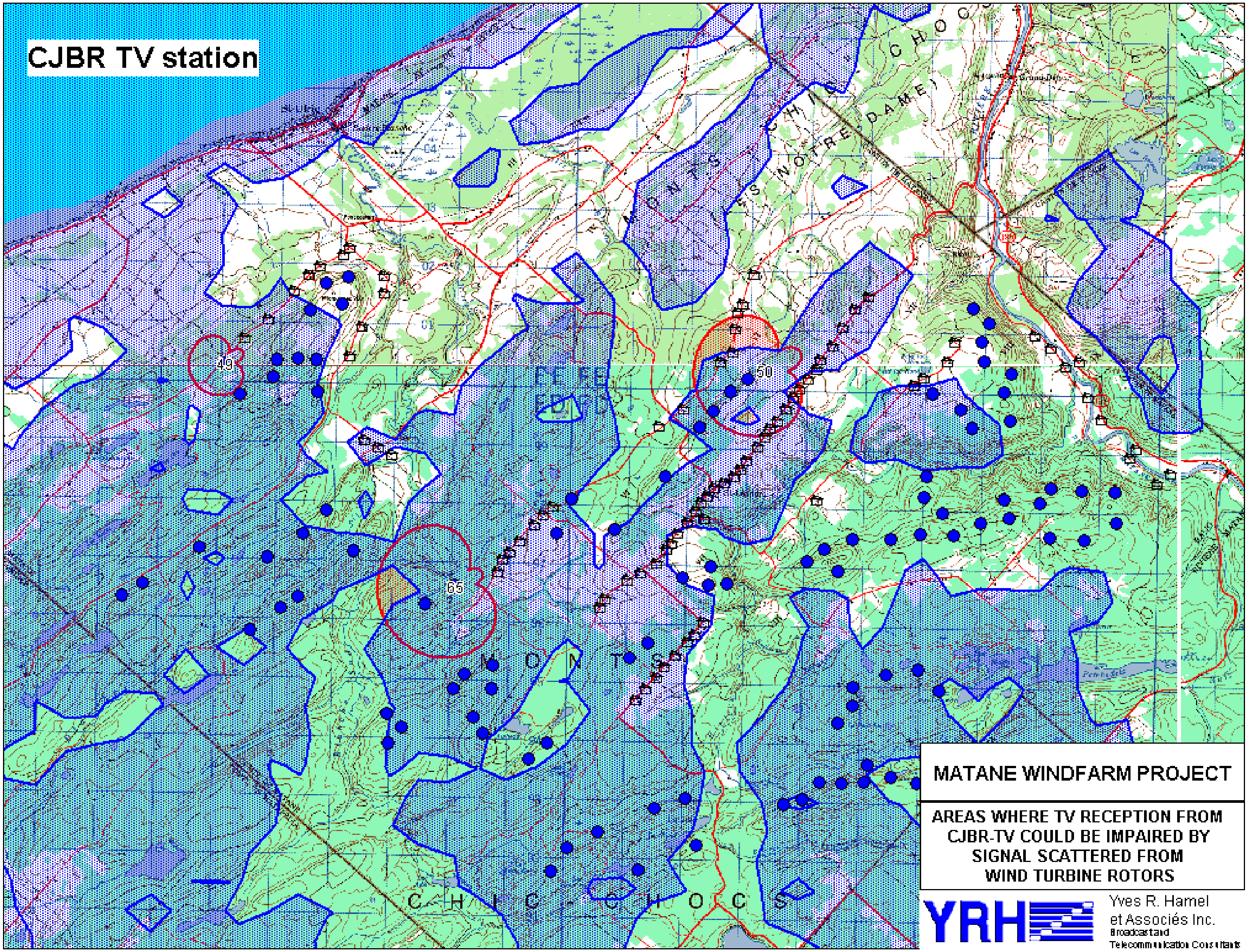
Zone of potential TV reception impairment for

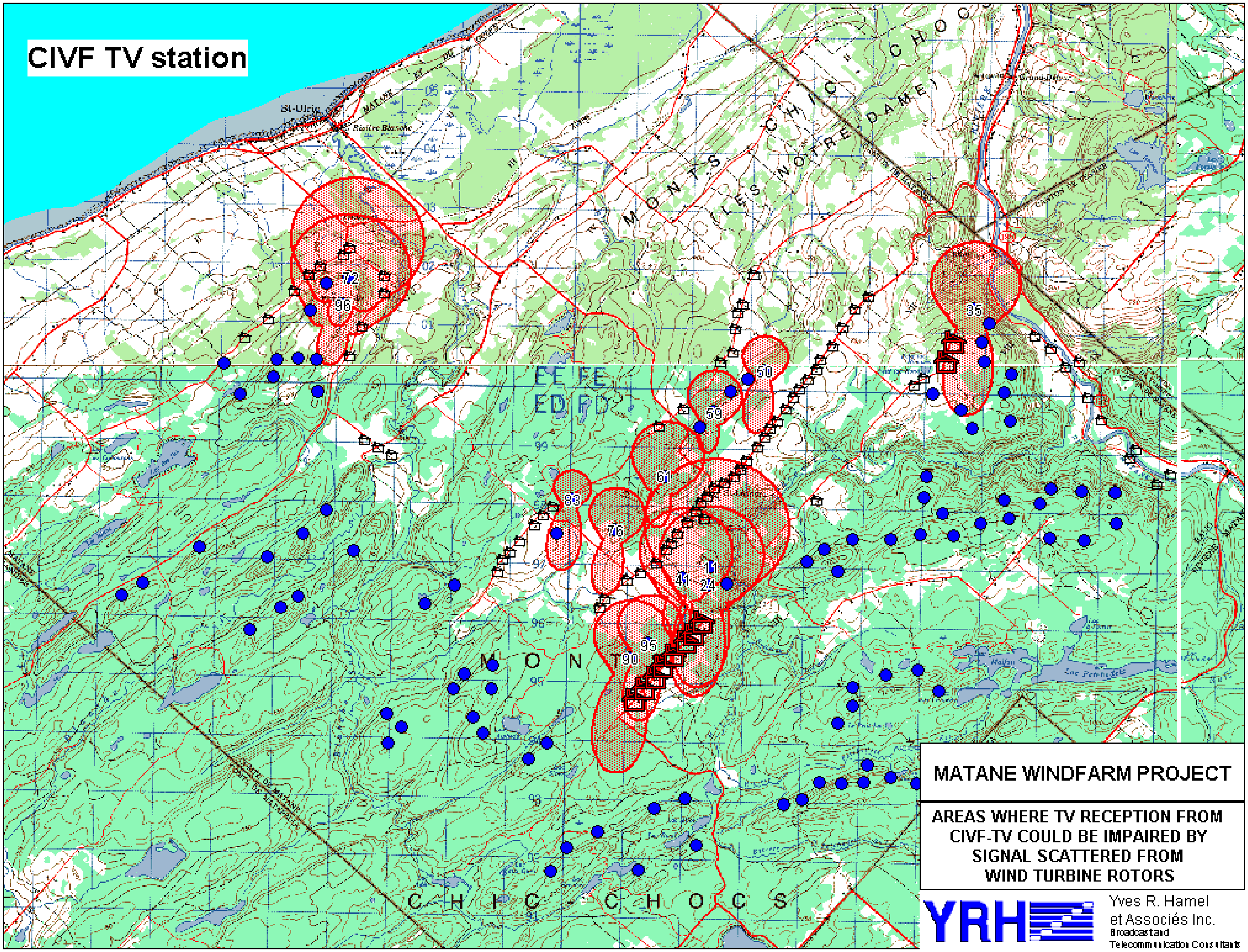
CBGAT, CIVB-TV, CFER-TV, CJBR-TV and CIVF-TV


CBGAT TV station
MATANE WINDFARM PROJECT
AREAS WHERE TV RECEPTION FROM
CBGAT COULD BE IMPAIRED BY
SIGNAL SCATTERED FROM
WIND TURBINE ROTORS
YRH
Yves R. Hamel
et Associés Inc.
Broadcast and
Telecommunication Consultants


CIVB TV station
72
99
49
10
94
2
83
76
52
65
54
85
MATANE WINDFARM PROJECT
AREAS WHERE TV RECEPTION FROM
CIVB-TV COULD BE IMPAIRED BY
SIGNAL SCATTERED FROM
WIND TURBINE ROTORS
Yves R. Hamel
et Associés Inc.
Broadcast and
Telecommunication Consultants

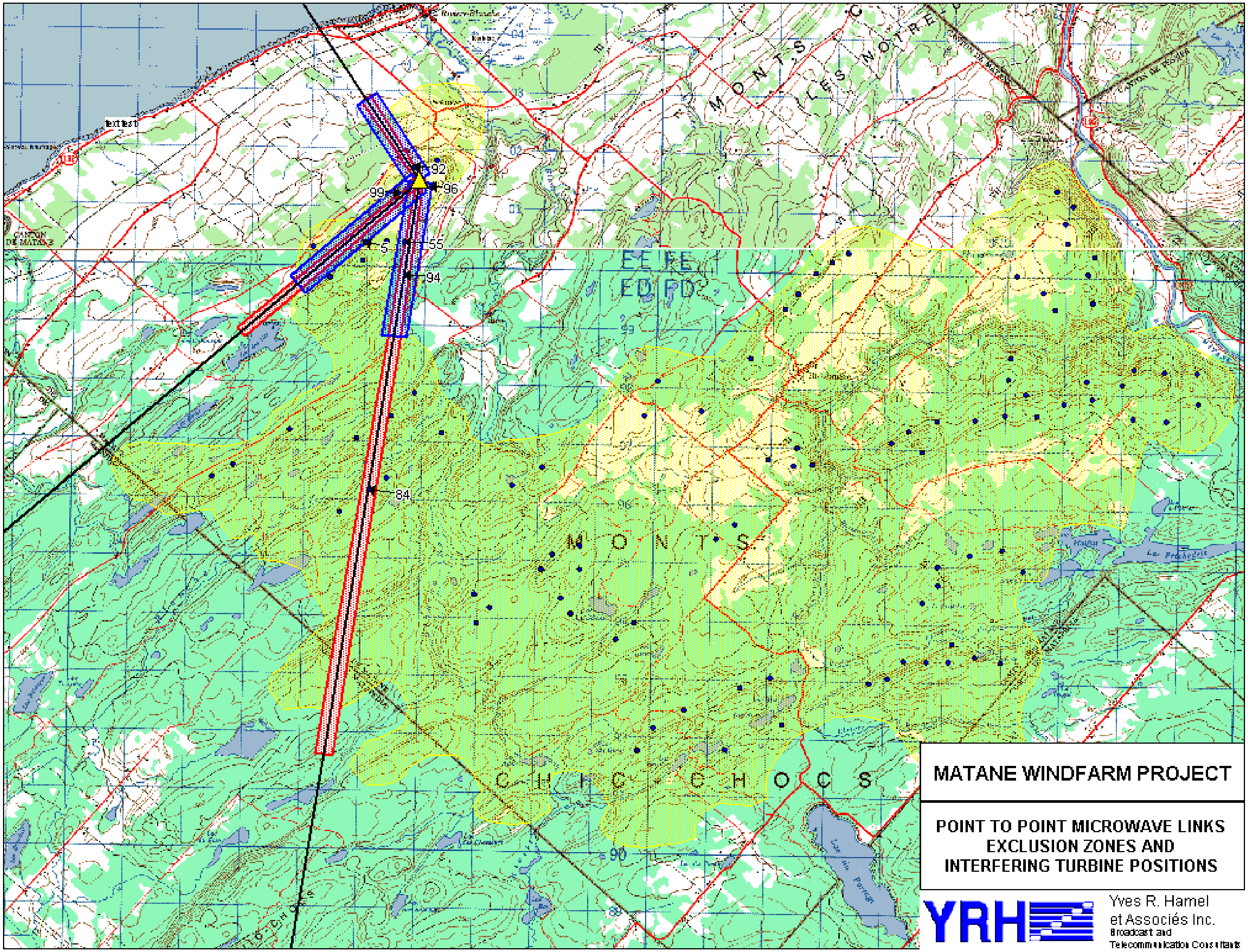

CFER TV station
St-Ulric
MONTS (LES NOTRE-DAME)
CHIC-CHOCS
MATANE WINDFARM PROJECT
AREAS WHERE TV RECEPTION FROM CFER-TV COULD BE IMPAIRED BY SIGNAL SCATTERED FROM WIND TURBINE ROTORS
Yves R. Hamel et Associés Inc.
Broadcast and Telecommunication Consultants


CJBR TV station
49
50
65
M O N T S
C H I C - C H O C S
MATANE WINDFARM PROJECT
AREAS WHERE TV RECEPTION FROM CJBR-TV COULD BE IMPAIRED BY SIGNAL SCATTERED FROM WIND TURBINE ROTORS
YRH
Yves R. Hamel et Associés Inc.


CIVF TV station
MATANE WINDFARM PROJECT
AREAS WHERE TV RECEPTION FROM CIVF-TV COULD BE IMPAIRED BY SIGNAL SCATTERED FROM WIND TURBINE ROTORS
Yves R. Hamel et Associés Inc.
St-Ulric
MONTS CHIC-CHOCS
MONTS NOTRE-DAME
CHIC-CHOCS

Appendix 4

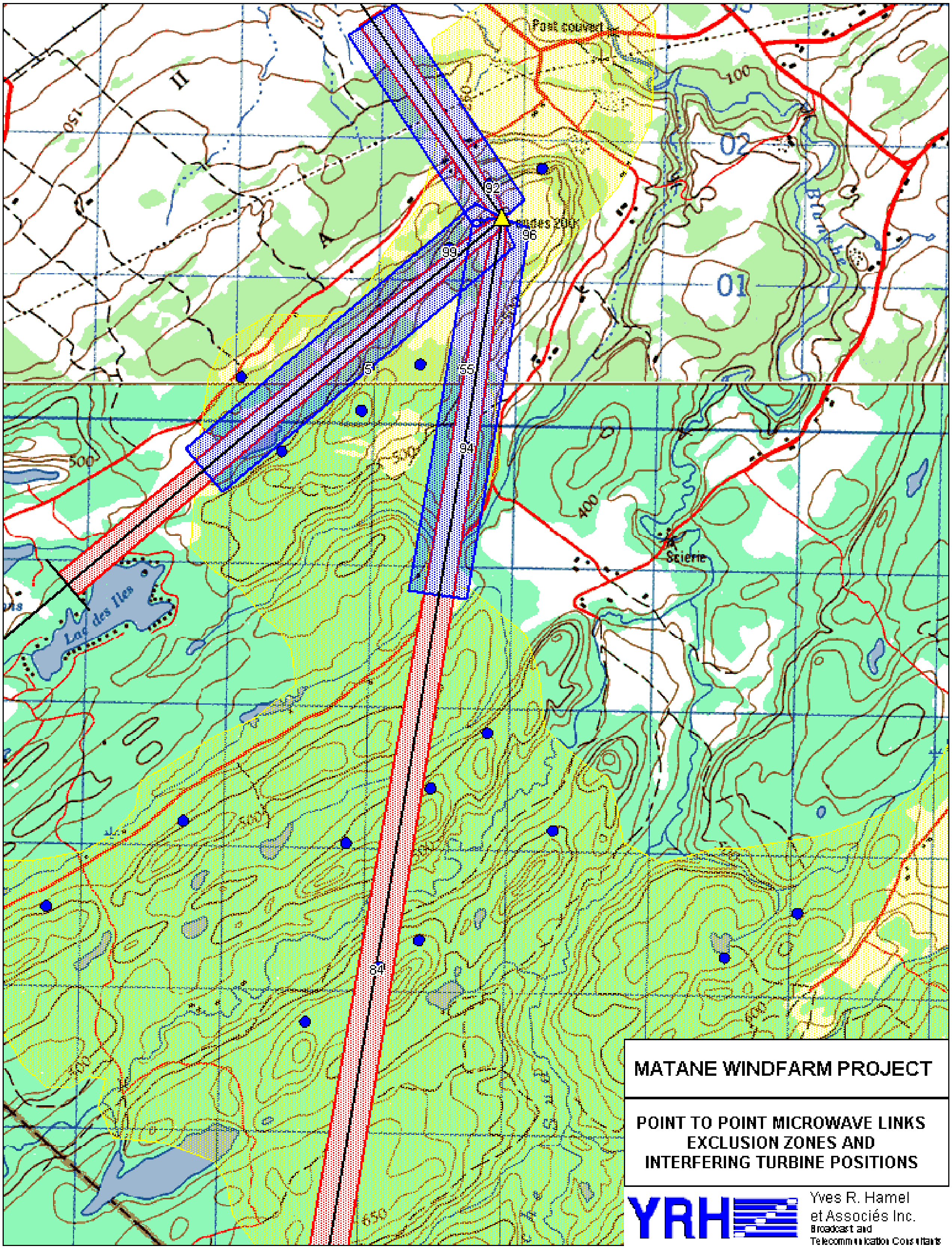
Point to Point systems exclusion zone



MATANE WINDFARM PROJECT

POINT TO POINT MICROWAVE LINKS
EXCLUSION ZONES AND
INTERFERING TURBINE POSITIONS

YRH Yves R. Hamel et Associés Inc.
Broadcast and Telecommunication Consultants


Post couvert
100
150
II
02
01
92
96
99
55
94
84
500
400
Scierie
Lac des Iles
650
MATANE WINDFARM PROJECT
POINT TO POINT MICROWAVE LINKS
EXCLUSION ZONES AND
INTERFERING TURBINE POSITIONS
YRH
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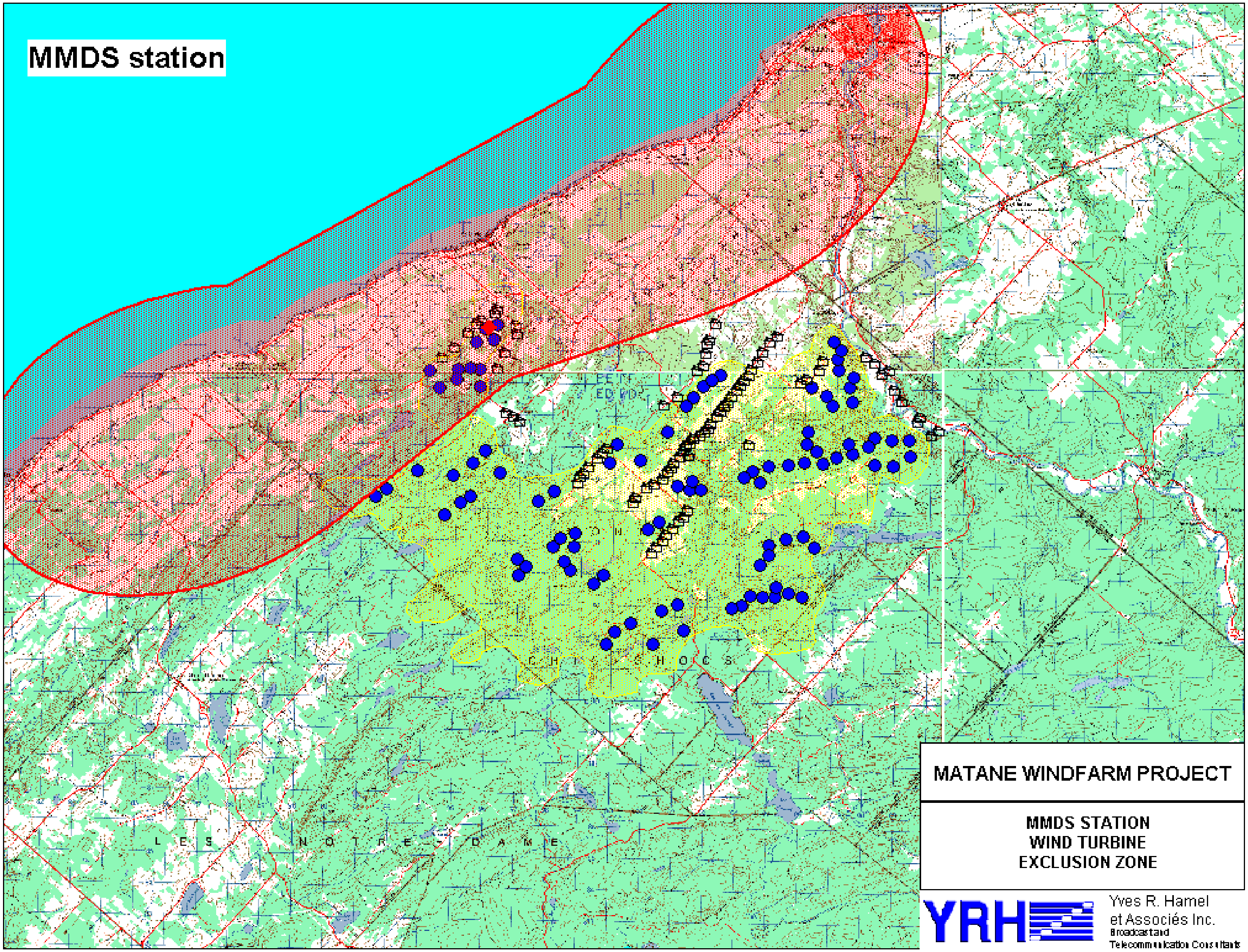
Telecommunication Consultants

Appendix 5

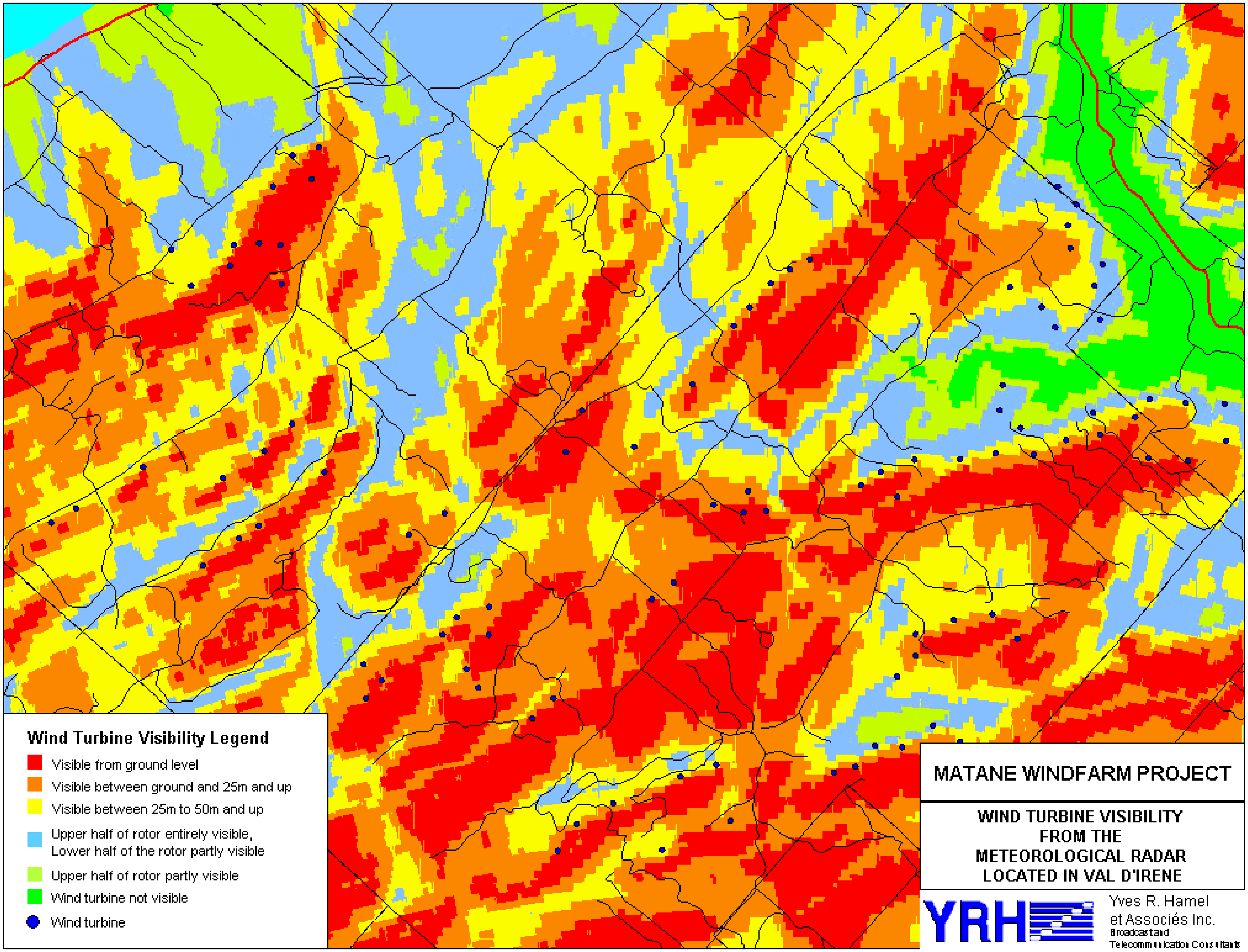
MMDS station exclusion zone


MMDS station
MATANE WINDFARM PROJECT
MMDS STATION
WIND TURBINE
EXCLUSION ZONE
Yves R. Hamel
et Associés Inc.
Broadcast and
Telecommunication Consultants

Appendix 6

Wind turbine visibility from

Val d'Irène radar station


Wind Turbine Visibility Legend
Visible from ground level
Visible between ground and 25m and up
Visible between 25m to 50m and up
Upper half of rotor entirely visible,
Lower half of the rotor partly visible
Upper half of rotor partly visible
Wind turbine not visible
Wind turbine
MATANE WINDFARM PROJECT
WIND TURBINE VISIBILITY
FROM THE
METEOROLOGICAL RADAR
LOCATED IN VAL D'IRENE
YRH
Yves R. Hamel
et Associés Inc.
Broadcast and
Telecommunication Consultants

Appendix 7

E-mail from the manager of
the National Radar Program
of Environment Canada

-----Original Message-----
From: Best,Christine [Ontario] [mailto:Christine.Best@ec.gc.ca]
Sent: Friday, November 26, 2004 4:35 PM
To: rdastous@yrh.com
Cc: Best,Christine [Ontario]; Joe,Paul [Ontario]; Bergeron,Sylvain [Montreal]
Subject: Potential Impact of Matane Wind Farm on Weather Radar Data

M. d'Astous,

My colleague, Paul Joe, has informed me that you are interested in Environment Canada issuing an impact statement with regards to the possible construction of a large wind farm at Matane.

Any formal impact statement will require significant lead time to prepare as it would have to be reviewed thoroughly before approval. However, we are able to provide some qualified opinions at this time.

Mr. Joe has performed a quick analysis based on:

- the information you provided to him on the proposed wind farm;
- our limited experience with existing wind farms and similar structures; and,
- information and advice from research colleagues in the UK Met Office and the US NEXRAD program.

Mr. Joe's work could be summarized as follows:

- Insufficient time was allowed for full consultation within the radar community, so these findings have not been reviewed for general acceptance.
- Simulations of the expected radar return using the proposed turbine locations, shapes and characteristics were NOT done, as they would require more time.
- Based on US data, wind farms are visible in low clutter environments out to at least 40 km.
- It appears that the wind farms effects cannot easily be mitigated by using Doppler filtering techniques - ground clutter masks seem to be the only successful way of removing the wind farm's effects, which creates holes in the radar data.
- In general, wind farms degrade the radar data. It will impact the ground clutter and may create false severe weather velocity signatures.

For the Matane site in particular:

- The proposed turbines are too far from the radar at Val d'Irene and too far below its horizon to block the radar's view of weather.
- The radar data from the Val d'Irene site is already characterized by substantial ground clutter due to local topography.

Therefore, it is our preliminary conclusion that while the proposed wind turbines at Matane will add to the current ground clutter, it should be sufficiently similar in character to not have a significant impact on the radar data being produced from our Val d'Irene site.

If you require further information for this or any other project, please feel free to contact me.

Christine Best
Manager, National Radar Program
Meteorological Service of Canada, Environment Canada
4905 Dufferin Street
Downsview ON M3H 5T4
416-739-4292
416-739-4261 (fax)