5.0 GENERAL ENVIRONMENTAL CONSIDERATIONS – ALL ROUTES

This chapter discusses environmental issues, including electric and magnetic fields, and stray voltage; radio, television, and microwave interference; and noise as they relate to transmission line operation and construction. Each of these issues is discussed in a general sense, since all routes would have similar potential affects.

5.1 Electric and Magnetic Fields, Stray Voltage

Electric and magnetic fields (EMF) exist wherever electricity is produced or used. EMF are invisible lines of force that surround any electrical appliance or wire that is conducting electricity.

5.1.1 Existing Conditions

Electric Fields

Electric fields are related to the presence of a voltage (electric charge) on any conductor (wires, electric appliances, transmission lines etc.) and would be present even when electric current is not flowing. The voltage would produce an electric field in the area surrounding the conductor or appliance. The electric field associated with a high-voltage transmission line (HVTL) extends from the energized conductors to other nearby objects, such as the ground, towers, vegetation, buildings and vehicles. The electric field from a transmission line gets weaker with increasing distance from the line. Nearby trees and buildings also greatly reduce the strength of transmission line electric fields.

The intensity of electric fields is associated with the voltage level of the transmission line and is measured in kilovolts per meter (kV/m). Transmission line electric fields are typically measured approximately one meter above the ground. The predicted electric fields for each line design option for the Project are provided in Appendix D.

Magnetic Fields

Current passing through any conductive material, including a transmission line conductor, produces a magnetic field in the area around that material. The strength of the magnetic filed is directly related to the amount of electric current flowing through the conductors. As current flow increases, the magnetic field would likewise increase. The magnetic field associated with a HVTL surrounds the conductor and decreases rapidly with increasing distance from the conductor. The magnetic field is expressed in units of magnetic flux density, expressed in milliGauss (mG).

Graphs of the magnetic field with current flow at the conductors' maximum capacity for each structure/conductor configuration under consideration for the Project are provided in Appendix E. The peak magnetic field density for the Project's transmissions lines with current flow at the conductors' capacity ranges from 129 mG to 355 mG directly under the conductors. The magnetic field density at the edge of the right-of-way with current flow at the conductor's capacity ranges from 12 mG to 100 mG.

Table 5-1 below shows current flow at the conductor's capacity and expected normal peak current flow with ESM's load at its expected Phase III peak demand of 300 MW. The magnetic field decreases as current flow decreases. Since the graphs in Appendix E depict the expected magnetic field with current flow at the conductors maximum capacity, the graphs conservatively over-predicts the magnetic fields that would be generated under normal operation.

Table 5-1: Current Flow at Conductor's Capacity and Expected Normal Peak Current Flow

Transmission Line	Conductor Type	Current Flow (amps)	
		Conductor Capacity	Normal Peak
Shannon to Essar Steel Plant	1590 ACSR	1,445	150
Boswell to Essar Mine Substation	1590 ACSR	1,445	796
Blackberry to Essar Steel Plant	954 ACSR	1,180	554
Essar Mine Substation to Essar Steel Plant	1590 ACSR	1,445	421

For example, the Blackberry–Essar Steel Plant transmission line's normal current would be 554 amps, which is approximately 50 percent of the current flow at the conductor's capacity of 1,180 amps. This means that the magnetic field along this proposed transmission line would be approximately 50 percent of the field depicted in the graphs. Thus, the expected peak magnetic field within the right-of-way would be approximately 126 mG during normal operations and approximately 26 mG at the edge of the right-of-way. According to the Environmental Protection Agency (EPA 1992), these magnetic field densities represent smaller magnetic fields than those associated with many common household appliances (See Table 5-2).

Table 5-2: Typical 60 Hertz (Hz) Magnetic Field Levels of Common Home Appliances

Appliance	Distance from Source		
	6 inches	1 foot	2 feet
	Magnetic Field Level (mG)		
Hair Drier	300	1	--
Electric Shaver	100	20	--
Can Opener	600	150	20
Electric Stove	30	8	2
Television	N/A	7	2
Portable Heater	100	20	4
Vacuum Cleaner	300	60	10
Copy Machine	90	20	7
Computer	14	5	2

Source: EMF In Your Environment (EPA 1992).

Electric and Magnetic Field Research

The question of whether exposure to power-frequency (60 Hertz (Hz)) magnetic fields can cause biological responses or even health effects has been the subject of considerable research for the past three decades. The most recent and exhaustive reviews of the health effects from power-frequency fields conclude that the evidence of health risk is weak. The National Institute of Environmental Health Sciences (NIEHS) issued its final report, *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields,* on June 15, 1999, following six years of intensive research. NIEHS concluded that there is little scientific evidence correlating extra low frequency EMF exposures with health risk.

The Minnesota Environmental Quality Board (EQB) and Department of Commerce (DOC) have addressed the matter of EMF with respect to new transmission lines in a number of separate dockets over the past few years. [See Docket Nos. 03-64-TR-Xcel (the Lakefield 161 kV transmission line); 03-73-TR-Xcel (the Buffalo Ridge 345 kV transmission line); 04-84-Tr-Xcel (the Buffalo to White 115 kV transmission line); and 04- 81-TR-Air Lake-Empire (a 115 kV transmission line in Dakota County).] The findings of the EQB and the discussion in the Environmental Assessments prepared on each of those projects are pertinent to this issue with respect to this Project. Documents from those matters are available on the PUC webpage.

Most recently, in June 2005, in Docket No. 03-73-TR-Xcel for the Buffalo Ridge 345 kV transmission line, the EQB made the following findings with regard to EMF:

> *118. No significant impacts on human health and safety are anticipated from the project. There is at present insufficient evidence to demonstrate a cause and effect relationship between EMF exposure and any adverse health effects. The EQB has not established limits on magnetic field exposure and there are no Federal or Minnesota health-based exposure standards for magnetic fields. There is uncertainty; however, concerning long-term health impacts, and the Minnesota Department of Health, the EQB and Xcel all recommend a "prudent avoidance" policy in which exposure is minimized.*
>
> *119. In previous routing proceedings, the EQB has imposed a permit condition on HVTL permits limiting electric field exposure to 8 kV/m at one meter above ground. This permit condition was designed to prevent serious hazard from shocks when touching large objects, such as semi trailers or large farm equipment under extra high voltage transmission lines of 500 kV or greater. Predicted electric field densities are less than half of the 8 kV/m permit condition for both the 345 kV transmission line and the 115 kV transmission line.*

While the consensus is that electric fields pose no risk to humans, the question of whether exposure to magnetic fields can cause biological responses or even health effects continues to be the subject of research and debate. This Project would minimize and/or avoid any potential health effects from magnetic fields, if they exist, by maximizing the distance between the transmission line and residences, to the extent practicable.

Stray Voltage

Distribution lines (not transmission lines) may cause stray voltage to occur on the electric service entrances to structures. More precisely, stray voltage is a voltage that exists between the neutral wire of the service entrance and grounded objects in buildings such as barns and milking parlors.

Transmission lines do not, by themselves, create stray voltage because they do not connect to businesses or residences. However, transmission lines can induce stray voltage on a distribution circuit that is parallel and immediately under the transmission line. Appropriate measures would be taken to prevent stray voltage problems when the proposed Project parallels or crosses distribution lines.

5.1.2 Direct/Indirect Effects

Induction

When an electric field reaches a nearby conductive object, such as a vehicle or a metal fence, it induces a voltage on the object. The magnitude of this voltage is dependent on many factors, including the object's

capacitance, shape, size, orientation, location, object to ground resistance, and weather conditions. If the object is insulated or semi-insulated from the ground and a person touches it, a small current would pass through the person's body to the ground. This might be accompanied by a spark discharge and mild shock, similar to what can occur when a person walks across a carpet and touches an object or another person.

The main concern with induced voltage of an object is not the level of the induced voltage, but the current that flows through a person to the ground should the person touch the object. To ensure the safety of persons in the proximity of HVTLs, the NESC requires that any discharge be less than 5 milliAmperes (mA). The Applicants used computer modeling to estimate the spark discharge from a typical school bus (40 feet long by 8.5 feet wide by 10.75 feet high) stopped at mid-span under a 230 kV line. The modeling showed that the spark discharge current would be less than 2 mA. This is significantly less than the 5 mA NESC limit, and unlikely to register as an annoyance. The Applicants would also ensure that any fixed conductive object proximate or parallel to the transmission line, such as a fence or other permanent conductive fixture, would be grounded so any discharge would be less than the 5 mA NESC limit.

Electromagnetic Compatibility of Active Implantable Medical Devices

High intensity electric fields can have adverse impacts on the operation of pacemakers and implantable cardioverter defibrillators (ICD). Interference with implanted cardiac devices can occur if the electric field intensity is high enough to induce sufficient body currents to cause interaction. Magnetic fields from transmission lines do not reach levels where they would have adverse impacts on the operation of pacemakers or ICD's.

Modern "bipolar" cardiac devices are much less susceptible to interactions with electric fields. Medtronic and Guidant, manufacturers of pacemakers and ICDs, have indicated that electric fields below 6 kV/m are unlikely to cause interactions affecting operation of most of their devices. The older "unipolar" designs of cardiac devices are more susceptible to interference from electric fields. Research from the early 1990s indicates that the earliest evidence of interference was in electric fields ranging from 1.2 to 1.7 kV/m.

Electric fields for all structure alternatives are well below levels at which modern bipolar devices are susceptible to interaction with the fields (See Appendix E). For older style unipolar designs, the electric fields do exceed levels that research from the 1990s has indicated may produce interference. However, recent research conducted in 2005 concluded that the risk of interference inhibition of unipolar cardiac pacemakers from high voltage power lines in everyday life is small. In 2007, Minnesota Power and Xcel Energy conducted studies with Medtronic under 115kV, 230 kV, 345 kV, and 500 kV transmissions lines to confirm the 2005 findings. The analysis was based on real life public exposure levels under actual transmission lines in Minnesota; no adverse interaction with pacemakers or ICDs occurred (University of Minnesota Power Systems Conference Proceedings 2007). The analysis concluded that although interaction may be possible in unique situations, device interaction due to typical public exposure would be rare.

In the unlikely event a pacemaker is impacted, the effect is typically a temporary asynchronous pacing (commonly referred to as reversion mode or fixed rate pacing). The pacemaker would return to its normal operation when the person moves away from the source of the interference.

Electric Fields

The Project's four transmissions lines would have a peak magnitude of electric field density of approximately 3.1 kV/m beneath the conductors, one meter above ground level. The predicted levels are

significantly less than the maximum limit of 8.0 kV/m that has been a permit condition required by the Office of Energy Security (OES) for other transmission line projects. The standard was designed to prevent serious hazard from shocks when touching large objects, such as tractors, parked under HVTLs of 500 kV or greater. Research has also shown that it is unlikely that implantable medical device interaction would result from typical public exposure to transmission line electric fields. Therefore, the Project would not have direct or indirect effects associated with electric fields.

Magnetic Fields

With current flow at the conductor's maximum capacity, the Project would have a peak magnitude of magnetic field density of approximately 355 mG beneath the conductors and drop to less than 42 mG within 100 feet of the centerline of the transmission structure. The magnetic field density would be significantly less than this during normal operations and, according to the EPA, would be less than the magnetic fields associated with many household appliances. Therefore, the Project would not have direct or indirect effects associated with magnetic fields.

Stray Voltage

No stray voltage issues are anticipated with this Project.

5.1.3 Mitigation

No direct or indirect effects attributed to EMF from the Project are anticipated; therefore, mitigation would not be necessary.

5.2 Radio, Television, and Cellular Interference

5.2.1 Existing Conditions

Communications technologies identified within the Study Areas can be divided into two broad categories: omnidirectional and unidirectional signals. Omnidirectional refers to those antennae that are able to transmit or receive signals in any direction, whereas unidirectional refers to those antennae that are able to transmit or receive signals in one direction. Microwave signals are unidirectional and all others (radio, TV, communications, and cellular phone) are omnidirectional. See Appendix A for the locations of towers in the Project vicinity.

Radio and Television (Omnidirectional) Signals

Generally, transmission lines do not cause interference with omnidirectional radio, television, or other communication antenna reception. However, four potential interference sources do exist, including: gap discharges, corona discharges, and shadowing and reflection effects.

Gap discharge interference is the most commonly noticed form of power line interference with omnidirectional signals. Gap discharges may occur on transmission lines and distribution lines where small gaps develop between mechanically connected metal parts. As sparks discharge across a gap, they create the potential for electrical noise, which can occur at any electrical line voltage. The degree of interference depends on the quality and strength of the transmitted communication signal, the quality of the antenna system, and the distance between the receiver and the electrical line. Gap discharges are typically a maintenance issue, since they tend to occur at areas where gaps have formed due to broken or ill fitted hardware (clamps, insulators, brackets). Because gap discharges are a hardware issue, they can be repaired when they occur. While gap discharges and their effects can happen on any electrical line, they typically occur on lower voltage distribution lines. The gap discharge potential of larger transmission lines (like the Project) tends to be minimized because there are fewer structures and a higher mechanical load on hardware.

Corona discharges can also generate radio frequency electrical interference. Corona discharges are a potential issue with all transmission lines. They are caused when localized electric fields near an energized conductor produce small electric discharges ionizing nearby air. Most often, the reasons for corona discharge are related to irregularities on conductors, including scratches or nicks, dust buildup, or water drops. The air ionization caused by corona results in energy loss and generates audible noise, radio noise, light, heat, and small amounts of ozone. The energy loss from corona is minimized largely through the design process by selecting conductors properly sized for the operating voltage of the line. The potential for radio and television signal interference relates to the magnitude of the transmission line-induced radio frequency noise compared to the strength of the broadcast signals. Very few interference problems occur with existing 230 kV transmission lines because the strength of the radio and/or television broadcast signal within a broadcaster's primary coverage area is great enough to prevent interference.

Shadowing and reflection effects are typically associated with large structures, such as high buildings, that may cause reception problems by disturbing broadcast signals and leading to poor radio and television reception. Although the occurrence is rare, a transmission structure or the conductor can create a "shadow" on adjoining properties that obstructs or reduces the transmitted signal. Structures may also case a "reflection" or scattering of the signal. Reflected signals from a structure result in the original signal "breaking" into two or more signals. Multipath reflection or "scattering" interference can be caused by the combination of a signal that travels directly to the receiver, and a signal reflected from the structure that travels a slightly longer distance, and thus may be received slightly later by the receiver. If one signal arrives with a significant delay relative to the other it can affect picture quality of both analog and digital broadcasts. With analog broadcasts, a second image can appear on the receiver's screen and displace the other. This type of interference reception is known as "ghosting" or "delayed image." With digital broadcasts, the picture can become pixilated or freeze and become unusable. The most significant factors affecting the potential for signal shadow and multipath reflection are structure height above the surrounding landscape and the presence of large flat metallic facades (including metallic coated glazing). Potential shadow and reflection effects from the Project tend to be minimized because there are spaces (about 19.5 feet) between the poles of each H-Frame, about 800 feet between each structure, and the structures are about the same height as the trees in the surrounding landscape. Due to the spaces between poles, the structures do not create one large obstacle; and signals travel through the structures and therefore shadowing and reflection are seldom an issue.

Microwave (Unidirectional) Signals

Microwave antennas are operated as high-frequency, directional, point-to-point systems and depend on line-of-sight between antenna receivers. These systems are unlikely to be affected negatively by electrical noise, but could potentially be affected by infrastructure located directly between two microwave signal points.

5.2.2 Direct/Indirect Effects

Radio Signals

If interference from transmission line corona does occur for an AM radio station within a station's primary coverage area with good reception before the Project was built, satisfactory reception can be obtained by appropriate modification of the receiving antenna system. Interference with FM broadcast reception is generally not a problem for two reasons. First, corona-generated radio frequency (RF) noise decreases in magnitude with increasing frequency and is quite small in the FM broadcast band (88-108 Megahertz [MHz]). Second, the excellent interference rejection properties inherent in FM broadcast systems make them virtually immune to amplitude type disturbances.

A two-way mobile radio located immediately adjacent to and behind a large metallic structure (such as a steel transmission line structure) may experience interference because of the signal blocking effects of the structure. Moving either mobile unit by less than 50 feet so that the metallic structure is no longer immediately between the two units should restore communications. RF noise is not an issue for cellular phones because it is almost nonexistent in the frequency range for cellular type phones, and the technology used by cell phones is superior to that used in two-way mobile radio units.

Television Signals

Corona-generated RF noise and transmission line structure placement could cause interference with TV broadcast signals. The national transition to digital TV broadcasts would be complete by the time the Project is constructed. However, this transition to digital did not apply to low power translators or Class A TV stations which may continue transmitting in analog. The federal government has not yet set a timeline for these stations to switch to digital; because of this, over the air TV reception in the Project area may be received via digital and analog signals now and in the immediate future.

Digital reception is in most cases considerably more tolerant of noise and somewhat less resistant to multipath reflections (i.e., reflections from structures) than analog broadcasts. However, if the noise level or reflections are great enough, they can also affect digital television reception. Due to the higher frequencies of television broadcast signals (54 MHz and above), a 230 kV transmission line seldom causes reception problems within a station's primary coverage area. In the rare situation where the construction of the Project may cause interference within a television station's primary coverage area, the Applicants would work with the affected viewers to correct the problem. Usually any reception problem can be corrected with the addition of an outside antenna.

Loose and/or damaged transmission line hardware may also cause television or radio interference. If interference were caused by the operation of the Project, the Applicants would inspect and repair any loose or damaged hardware in the transmission line or take other necessary action to restore reception to the present level.

Microwave (Unidirectional) Signals

Minnesota Power owns and operates two microwave towers in the Project area. These existing towers are used for utility communications and are located at the 230 kV Blackberry Substation and at the 115 kV Nashwauk Substation. Two additional microwave towers are located within the Project area along CSAH 58 near the Essar Steel Plant site.

No direct or indirect impacts to omnidirectional communication towers are anticipated as the transmission line hardware would be designed and maintained to reduce gap and corona discharges. Typically, microwave towers are taller than the proposed pole structures for the project; therefore, no direct or indirect impacts are anticipated.

5.2.3 Mitigation

Radio and Television (Omnidirectional) Signals

The Applicants are not aware of any complaints related to radio or television interference resulting from the operation of existing 230 kV and 115 kV transmission lines located near the Project area, and do not expect that such interference would be an issue along the Project routes. The following discusses potential mitigation measures that could be applied if interference occurs.

Microwave (Unidirectional) Signals

The Applicants would work with tower operators to resolve any issues directly related to the Project. Mitigation may include shorter structures near the signal direction.

5.3 Noise

The Applicants modeled conductor audible noise with both H-frame, single-pole and single pole 230/115 kV double circuit structures. Single-circuit configurations were modeled as stand-alone structures and alongside existing 115kV transmission lines where appropriate.

Appendix F displays the model assumptions for single-circuit and double circuit configurations.

5.3.1 Existing Conditions

Noise is defined as unwanted sound. It may be comprised of a variety of sounds of different intensities across the entire frequency spectrum. Noise is measured in units of decibels (dB) on a logarithmic scale. Because human hearing is not equally sensitive to all frequencies of sound, certain frequencies are given more "weight." The A-weighted decibel (dBA) scale corresponds to the sensitivity range for human hearing. A noise level change of 3 dBA is barely perceptible to average human hearing. A 5 dBA change in noise level is clearly noticeable. A 10 dBA change in noise levels is perceived as a doubling or halving of noise loudness. For reference, Table 5-3 shows noise levels associated with common, everyday sources and places the magnitude of noise levels discussed here in context.

Table 5-3: Decibel Levels of Common Noise Sources

Sound pressure level (dBA)	Noise source
140	Jet Engine (at 25 meters)
130	Jet Aircraft (at 100 meters)
120	Rock Concert
110	Pneumatic Chipper
100	Jackhammer (at 1 meter)
90	Chainsaw, Lawn Mower (at 1 meter)
80	Heavy Truck Traffic
70	Business Office, Vacuum Cleaner
60	Conversational Speech, Typical TV Volume
50	Library
40	Bedroom
30	Secluded Woods
20	Whisper

Data from "A Guide to Noise Control in Minnesota," Minnesota Pollution Control Agency, 2008

Typical noise sensitive receptors along the transmission line routes include residences, churches, schools, and parks where either sleep or outdoor activities occur. Current average noise levels in these areas are typically in the 30 to 50 dBA range and are considered acceptable for residential land use activities. Ambient noise in rural areas is commonly made up of rustling vegetation and infrequent vehicle pass-bys. Higher ambient noise levels, typically 50 to 60 dBA, would be expected near roadways, urban areas, and commercial and industrial properties in the Study Area.

The Minnesota Pollution Control Agency (MPCA) has established standards for the regulation of noise levels. The land use activities associated with residential, commercial, and industrial land have been grouped together into Noise Area Classifications (NAC) (See Minn. R. 7030.0050). Each NAC is then assigned both daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.) limits for land use activities within the NAC (See Minn. R. 7030.0040). Table 5-4 shows the MPCA daytime and nighttime limits in dBA for each NAC. The limits are expressed as a range of permissible dBA within a one hour period; L50 is the dBA that may be exceeded 50 percent of the time within an hour. L10 is defined as the dBA that may be exceeded 10 percent of the time within an hour. Residences, which are typically considered sensitive to noise, are classified as NAC 1. Note that the utility industry typically reports audible noise emissions at L5 and L50, rather than those at L10. L5 is the noise level exceeded five percent of the time, or for three minutes in an hour.

Table 5-4: MPCA Noise Limits by Noise Area Classification (dBA)

Noise Area Classification	Daytime		Nighttime	
	L10	L50	L10	L50
1	60	65	50	55
2	65	70	65	70
3	75	80	75	80

5.3.2 Direct/Indirect Effects

High Voltage Transmission Lines

The level of noise generated by the conductors depends on conductor conditions, voltage level, and weather conditions. Noise emission from a transmission line is greatest during heavy rain and wet conductor conditions. In foggy, damp, or rainy weather conditions, transmission lines can create a subtle crackling sound due to the small amount of electricity ionizing the moist air near the wires. During heavy rain, the general background noise level is usually greater than the noise from a transmission line.

Modeling was completed to determine the level of audible noise from operation of the Projects high voltage transmission lines. The transmission line is anticipated to be essentially inaudible, less than 20 dBA, at the edge of the right-of-way during fair weather conditions. Under wet conditions, the maximum L5 noise level directly under the transmission line is less than 50 dBA, which is below the most restrictive permissible noise level for NAC (1) (See Table 5-4). Anticipated noise levels for the route in fair weather conditions and at the L5 and L50 levels for wet conditions are shown in graphs in Appendix F.

Substations

Audible noise may also be generated by substation equipment, with the main source of noise due to the operation of the transformers. Noise from a transformer is present whenever it is energized and is nearly constant with only a slight variation associated with the operation of the cooling fans or pumps. The transformers installed as part of this Project would be within the Essar Mine and the Essar Steel Plant Substations that are located on ESM Property.

The primary land uses in the area around the substations are forested and industrial. ESM operations would consist of mining and operation of the taconite and steel plants. Because this is not a populated area, noise associated with substation operations would not be an issue.

5.3.3 Mitigation

Transmission line and substation equipment would be maintained in good working order. Noise associated with the operation of the Project would not require mitigation.