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REPORT NO. WA07-116-3

PREDICTION OF BLASTING NOISE/VIBRATION LEVELS AT THE EXISTING AND PROPOSED HOSPITAL AND COLLEGE SITES IN LABRADOR CITY, NL

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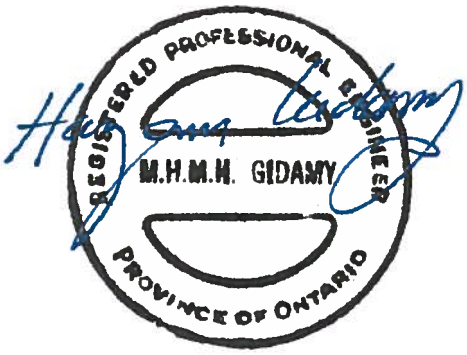

APRIL 4, 2008

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1.0 BACKGROUND

SS Wilson Associates (SSWA) has been retained by Environmental Resources Management Canada (ERM), on behalf of Iron Ore Company of Canada (IOC), to predict the noise and vibration levels of IOC's long-term mine plan (i.e., 'Wabush 3') on the proposed new hospital and educational institute (college) sites in Labrador City. SSWA has also been requested to predict noise and vibration levels at the existing hospital and college sites.

The primary objective of this report is to provide all concerned parties with the results, findings and conclusions of our preliminary predictions to facilitate discussion of all aspects related to IOC's blasting noise/vibration based on the use of noise/vibration modeling.

In the course of our examination we conducted the following activities:

i) Visited the locations of the proposed hospital and college sites along the north side of Fermont Highway, as well as the location of the existing hospital in Labrador City.
ii) Visited the areas of current and future phases of IOC's mining operations, and reviewed the ground conditions for noise/vibration propagation conditions/factors.
iii) Obtained the necessary information from IOC on a range of blasting techniques as well as the relevant technical parameters needed for noise/vibration predictions.
iv) Constructed a comprehensive noise/vibration prediction model that has been especially developed for the subject area to estimate the potential for air blast and vibration impacts on the proposed and existing hospital and college sites.

Figures 1.a and 1.b illustrate the general area of Labrador City and its surroundings, including the approximate locations of the existing and proposed hospital and college sites and IOC's existing Luce Pit and future Wabush 3 facilities. Figure 2 illustrates the general topography of the subject area.

2.0 RELEVANT DATA AND BLASTING PARAMETERS

The following summarizes the data used for predicting sound and vibration levels for this assignment:

2.1 IOC Blast Parameters for Sound/Vibration

In the course of our preliminary investigation, IOC provided the following blast parameters for the purpose of noise and vibration prediction:[1]

[1] Bench height: 13.7m, hole depth: 15.2m, sub-drill: 1.5m, hole diameter 381mm, 8 rows paced at approximately 7m (variable delay as noted), each row contains 60 holes spaced at approximately 8m (variable delay as noted) and emulsion as the explosive type.

- Blasting Design 1.1: 1,600 kg/hole of explosives and up to 8 holes firing simultaneously (72 ms row-to-row delay)
- Blasting Design 1.2: 1,600 kg/hole of explosives and up to 16 holes firing simultaneously (72 ms row-to-row delay)
- Blasting Design 2.1: 1,600 kg/hole of explosives and up to 60 holes firing simultaneously (72 ms row-to-row delay)

For the purposes of this report, we selected blasting designs 1.1 and 1.2 to represent the current blasting practices within the Luce Pit, while design 2.1 was selected for the future Wabush 3 mine as it represents the largest theoretical blast, and therefore provides a relatively conservative prediction for potential noise and vibration impacts.

2.2 Effects of Natural Ground Features for Sound/Vibration Propagation

Interrupting the line-of-sight from a source of noise to a receptor by a more-or-less continuous structure or a barrier can reduce the sound level at the receptor by varying amounts depending on the geometric relationship of the source, receiver and barrier as well as the frequency (pitch) of the noise signal. This process is known as 'sound diffraction'. Sound diffraction may take place across the top of the barrier (vertical diffraction) and/or around the edge(s) of a limited extent barrier (horizontal diffraction).

Based on our knowledge of the intervening lands between the Wabush 3 pit and the proposed hospital/college site north of Fermont Highway, the 800+m land contour formation is capable of providing noticeable acoustic shielding from the majority of blasting activities within Wabush 3 (see Figure 3). The only exception to this acoustic shielding is the eastern part of Wabush 3 (almost 1/3 of the total area) where acoustic shielding will be marginal or non-existent.

Two additional, but smaller, land contours are located east and south east of the 800+ m feature. Although these hills have elevations of up to 750m they are not expected to provide any noticeable sound barrier effect due to the large area of noise propagation and the types of very low frequency sound produced by blasting.

The degree of acoustic shielding provided by the dominant land features has been incorporated into this noise prediction model.

With regards to impeding ground-borne vibration levels due to blasting, the existing natural features (specifically local water bodies) are not likely to be

of any significance for the so-called "surface" Raleigh vibration waves.

2.3 Location/Distance Factors

One of the important factors for noise/vibration propagation is the distance from the blasted mine face to the point(s) of reception. The following is a summary of the approximate distances from the existing Luce Pit and the future Wabush 3 mining areas to the 'existing' and 'proposed' hospital and college sites, as well as the 'alternative' hospital site in the sports field east of Bartlett Drive (refer to Figures 1.a, 1.b and 3):

From the Luce Pit (The most southern tip of the pit) to:

- Existing hospital: 5,800 m
- Proposed hospital site: 5,000 m
- Alternative hospital site: 5,750 m

- Existing college: 6,650 m
- Proposed college site: 5,000 m

From the Wabush 3 Mining Area to:

- Existing hospital: 4,100 m
- Proposed hospital site: 3,500m
- Alternative hospital site: 4,000 m

- Existing college: 4,900 m
- Proposed college site: 3,500 m

A second important factor for noise propagation is the ground elevation as measured above/below IOC's mining area and the major intervening hills as they are capable of providing additional acoustic shielding to sound waves. IOC's Wabush 3 area is located primarily in the high 700m contours with a few locations in the 800+m zone. The proposed hospital/college site is located around the 600±m contour areas, while the existing hospital is also located below the 600m contour line.

The following observations were made during our field visit and examination of the area, and were also included in the prediction model:

- The existing hospital is not shielded by the 800+m feature; however, it is partially shielded by local land formations on its immediate north and west boundaries.

- The existing college is shielded by many residential and commercial structures within Labrador City and partially shielded by the 800+m feature.
- The proposed hospital and college sites along the north side of Fermont Highway will not be shielded by the 800+m feature when blasting takes place near the east side of Wabush 3.
- The alternative hospital location on the sports field will not be shielded from blasting on the east and north sides of Wabush 3. Additionally, this location will have more prolonged years of exposure to Wabush 3.

A third factor, which was unknown at the time of this report, is the number of stories within the proposed hospital and college (the existing hospital is a two to three storey low rise structure). Taller buildings increase the potential for increased noise levels and building seismic movements at higher stories.

2.4 Wind Direction

At distances greater than 100m, wind direction becomes an important factor for noise propagation in general. For blasting noise involving significant distance setbacks, wind direction becomes a significant factor especially when coupled with other factors such as ground cover, temperature, sky cover, etc. The magnitude of the change relative to calm wind is significant as sound levels can vary up to +/- 9 dB.

We relied on available annual wind data compiled from 1998 to 2002 at the Wabush Airport for predicting blasting noise under different wind directions. These wind data are the basis for the "wind rose" in Table 4, which indicates the wind directions and wind speeds. The data for wind direction were reported as the percentage of time the wind blew from each of 36 directions.

The predominant winds in Labrador City come from the south and west with 5.66% and 5.14%, respectively, of the total observations. The least frequent winds come from the northeast through southeast quadrants where none of the directions has over 1.14% of the readings. January has the highest percentage of south winds, 7.12%, while 9.38% of the winds recorded in December were from the west.

For the purposes of blasting noise prediction, the wind rose data have been regrouped into three primary directional classifications; downwind (N and N-W winds), upwind (S, S-E and S-W winds) and crosswind (E, N-E, S-E, W, N-W and SW winds) in reference to the Wabush 3 site and the areas of concern. The approximate cumulative averages of the noted wind classifications are as follows:

- Downwind: 15%
- Upwind : 20%

- Crosswind: 65%

3.0 RECOMMENDED SOUND AND VIBRATION LEVELS CRITERIA FOR BLASTING OPERATIONS

Surface mine blasting produces a wide range of effects that span across the largest possible scale, and may impact humans as a result of producing sound and vibration waves. On the upper end of the scale, blasting is known to cause physical damage to structures at shorter distances. At the lower end of the scale it may cause annoyance and public dissatisfaction. Structural damage ranges from the development of superficial or serious cracks and gaps in foundations and drywall to ultimately breakage of windows and rattling of objects.

A reasonable approach in predicting potential noise and vibration impacts on the proposed hospital and college sites in Labrador City is to rely on blasting sound and vibration criteria used successfully in Ontario since 1976. These criteria are summarized as follows:

- **Blasting vibration (cautionary limit): Peak Particle Velocity: 10 mm/s** (up to 12.5 mm/s if routine monitoring is conducted); **and,**
- **Blasting noise (cautionary limit): Peak Sound Level (L_{pk}): 120 dBL** (up to 128 dBL if routine monitoring is conducted).

Our primary concern in this situation is the impact on the hospital and, in particular, on facilities that would demand the application of more stringent criteria such as in operating rooms, emergency room wards, some laboratory equipment and intensive care units. Equally important in some educational facilities are laboratories dedicated to metrology, electron microscopes/scales and microchip testing.

4.0 PREDICTED MINE BLASTING SOUND/VIBRATION LEVELS DUE TO IOC EXISTING AND FUTURE OPERATIONS

For the purposes of this study, we have restricted our investigation to the sound/vibration due to IOC blasting as other sources of noise/vibration (e.g., truck movements, crushing plant, various modes of extraction and haulage within the pit area) are located at considerable distance setbacks with significant acoustic shielding by the land form.

The results presented here are based on a comprehensive blasting noise/vibration prediction model developed by SSWA to take into account numerous important factors such as:

- Possible blasting locations within the mined area;
- Blasting direction (face direction: opposite face, behind face or perpendicular to the face);

- Number of blast holes, rows, their extent within the mine and firing sequence;
- Weight of charges/delay;
- Acoustic propagation and shielding by the intervening topography and/or buildings;
- Wind direction based on historic data from 1998 to 2002 in the area; and,
- Other acoustic shielding factors as noted.

The model developed by SSWA is based on numerous, well-founded empirical data and procedures including US Bureau of Mines data, Ontario Ministry of the Environment data, ISO standards and other well developed data in the literature.

Three blasting locations in Wabush 3 were selected for predicting noise/vibration levels in this study. These are denoted as Ls, Ln and Le on Figure 3. Figure 3 also shows the location of the sampling locations relative to the existing and proposed hospital/college sites as well as the intervening topography. Due to the considerable acoustic shielding provided by the 750 to 800+m land contours, it is expected that the north, west, central and south parts of Wabush 3 would result in noticeably lower noise levels on all land developments south of the Wabush 3 site. The eastern portion of Wabush 3 (represented by Location Le) is, more-or-less, directly exposed to most areas of concern to this study as little or no acoustic shielding is provided by local land forms. As such, location Le represents the greatest potential for noise and vibration impact on the existing and proposed hospital/college sites. In order to provide the most conservative prediction of potential noise/vibration impacts from Wabush 3, location Le was used in the modeling exercise.

Results – Existing Luce Pit Mining Area

The Luce Pit is located in an area lying between 5 km and 14 km from the proposed hospital/college site. This represents a considerable distance from the proposed facilities.

The results of the preliminary modeling exercise for blasting in the Luce Pit are summarized in Tables 1 (blast design 1.1) and 2 (blast design 1.2). A range of average sound levels resulting from IOC's *current blasting practices* indicates the variability of the emitted sound levels depending on the wind direction. The possible "upper limits" due to unusual or unforeseen conditions are also presented.

With regards to the potential impact of blasting in Luce Pit on the existing hospital, the existing college and the proposed hospital/college location, the predicted average sound/vibration levels are below the recommended criteria under all possible environmental conditions related to wind direction. The predicted upper limits also show sound levels that are within the acceptable criteria with noticeable excesses only under downwind conditions. No vibration impacts are predicted in all cases.

Results – Wabush 3 Mining Area

This section summarizes predicted sound and vibration levels at the "worst case" blasting location within the future Wabush 3 mining area: Le (an area to the far east of Wabush 3 where there is very little attenuation by the land topography).

The results of the preliminary modeling exercise for blasting in Wabush 3 are summarized in Table 3 (blast design 2.1). A range of average sound levels resulting from IOC's *largest potential blast* indicates the variability of the emitted sound levels depending on the wind direction. The possible "upper limits" due to unusual or unforeseen conditions are also presented.

Sound levels from Wabush 3 are predicted to vary considerably depending on the wind direction with minor to significant changes depending on the location of the building of concern. This is the result of several factors, as discussed below.

- Due to the location of the existing and the proposed hospital sites relative to the east side of Wabush 3, our results show small differences between the two locations for blasting noise and vibration under all environmental conditions.

- During up-wind conditions, we predict the blasting noise impact on the existing hospital, the existing college and the proposed location for both facilities to be within the acceptable sound level criteria. The impact due to ground-borne vibration is also considered acceptable at the existing hospital and the existing college and only marginal at the proposed hospital/college location. It is only under unforeseen and unusual ground conditions that the predicted upper limit of the vibration criteria would be significant.

- Most importantly, during periods of down-wind and cross-wind conditions, it is predicted that the existing and the proposed hospital/college locations will be exposed to considerably high sound levels due to blasting. However, it is only under unforeseen and unusual ground conditions that the predicted upper limit of the vibration criteria would be significant.

TABLE 1: PREDICTED EXISTING BLASTING SOUND/VIBRATION LEVELS AT THE LUCE PIT (BLAST DESIGN 1.1)

Existing Hospital	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	97 to 99 dBL	1.0mm/s
Downwind (N & N-W) @15% of time:	115 to 117 dBL	1.0mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	110 to 113 dBL	1.0mm/s

[levels upper limits; Lpk: 89 to 125 dBL & PPV: 2.1mm/s]

Existing College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	92 to 94 dBL	0.8mm/s
Downwind (N & N-W) @15% of time:	110 to 112 dBL	0.8mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	106 to 107 dBL	0.8mm/s

[levels upper limits; Lpk: 80 to 116 dBL & PPV: 1.7mm/s]

Proposed Hospital/College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	98 to 100 dBL	1.3mm/s
Downwind (N & N-W) @15% of time:	116 to 118 dBL	1.3mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	111 to 114 dBL	1.3mm/s

The levels reported in this table represent the "**average**" predicted levels in front and behind the mine face based on the average levels forming the base of this empirical model.

The possible "**upper limits**" noted below represent the upper limits of the model data that corresponds to unusual or unforeseen conditions.

[Levels upper limits; Lpk: 90 to 126 dBL & PPV: 2.7mm/s]

Acceptable Limits
Blasting vibration (cautionary limit)
Peak Particle Velocity: 10 mm/s (up to 12.5 mm/s if routine monitoring is conducted)

Blasting noise (cautionary limit)
Peak Sound Level (L_{pk}): 120 dBL (up to 128 dBL if routine monitoring is conducted).

TABLE 2: PREDICTED EXISTING BLASTING SOUND/VIBRATION LEVELS AT THE LUCE PIT (BLAST DESIGN 1.2)

Existing Hospital	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	98 to 101 dBL	1.8mm/s
Downwind (N & N-W) @15% of time:	116 to 119 dBL	1.8mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	111 to 115 dBL	1.8mm/s

[levels upper limits; Lpk: 91 to 127 dBL & PPV: 3.7mm/s]

Existing College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	93 to 96 dBL	1.5mm/s
Downwind (N & N-W) @15% of time:	111 to 114 dBL	1.5mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	107 to 109 dBL	1.5mm/s

[levels upper limits; Lpk: 82 to 118 dBL & PPV: 2.9mm/s]

Proposed Hospital/College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	99 to 102 dBL	2.3mm/s
Downwind (N & N-W) @15% of time:	117 to 120 dBL	2.3mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	112 to 116 dBL	2.3mm/s

The levels reported in this table represent the "**average**" predicted levels in front and behind the mine face based on the average levels forming the base of this empirical model.

The possible "**upper limits**" noted below represent the upper limits of the model data that corresponds to unusual or unforeseen conditions.

[levels upper limits; Lpk: 92 to 128 dBL & PPV: 4.6mm/s]

Acceptable Limits
Blasting vibration (cautionary limit)
Peak Particle Velocity: 10 mm/s (up to 12.5 mm/s if routine monitoring is conducted)

Blasting noise (cautionary limit)
Peak Sound Level (L_{pk}): 120 dBL (up to 128 dBL if routine monitoring is conducted).

TABLE 3: PREDICTED BLASTING SOUND/VIBRATION LEVELS NEAR THE EAST SIDE OF WABUSH 3 (BLAST DESIGN 2.1)

Existing Hospital	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	112 to 119 dBL	9.2mm/s (0)
Downwind (N & N-W) @15% of time:	130 to 137 dBL	9.2mm/s (0)
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	126 to 132 dBL	9.2mm/s (0)

[levels upper limits; Lpk: 120 to 156 dBL & PPV: 18.3mm/s]

Existing College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	102 to 107 dBL	6.9mm/s
Downwind (N & N-W) @15% of time:	120 to 125 dBL	6.9mm/s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	115 to 121 dBL	6.9mm/s

[levels upper limits; Lpk: 98 to 134 dBL & PPV: 13.8mm/s]

Proposed Hospital/College	**Noise, L_{pk}**	**Vibration, PPV**
Upwind (S, S-E & S-W) @ 20% of time:	113 to 120 dBL	11.8mm/s
Downwind (N & N-W) @15% of time:	131 to 138 dBL	11.8mm /s
Crosswind (E, N-E, S-E, W, N-W & S-W) @65% of time:	127 to 133 dBL	11.8mm /s

The levels reported in this table represent the "**average**" predicted levels in front and behind the mine face based on the average levels forming the base of this empirical model.

The possible "**upper limits**" noted below represent the upper limits of the model data that corresponds to unusual or unforeseen conditions.

[levels upper limits; Lpk: 121 to 157 dBL & PPV: 23.6mm/s]

Acceptable Limits
Blasting vibration (cautionary limit)
Peak Particle Velocity: 10 mm/s (up to 12.5 mm/s if routine monitoring is conducted)

Blasting noise (cautionary limit)
Peak Sound Level (L_{pk}): 120 dBL (up to 128 dBL if routine monitoring is conducted).

5.0 CONCLUSIONS

The following is a summary of our findings and conclusions with regards to present and future blasting locations and conditions, and how they may affect the existing, alternative and proposed locations for the hospital and college:

1. The predicted average blasting sound and vibration levels from the current Luce Pit operations at the existing hospital and the college locations are expected to be significantly below the recommended criteria for sound and vibration under all environmental conditions. This conclusion is expected due to the significant distance setback from Luce Pit to both locations, and the blasting design parameters utilized by IOC to suit current conditions and demands for ore.

2. The average blasting sound and vibration levels from the current Luce Pit operations at the proposed hospital and college locations are also predicted to be significantly below the recommended criteria under adverse environmental conditions.

3. IOC's proposed Wabush 3 mining area presents an interesting acoustic relationship to all the considered noise sensitive locations. Predicted sound levels are likely to change by a significant margin depending on the relative location of the area to be blasted to the specific site/building locations. This will be brought about by the significantly higher land contours (800m+) between Wabush 3 and the receptors. The acoustic shielding effect of the two small peaks to the south of Wabush 3 will be insignificant due to horizontal sound diffraction around their sides. The following is a qualitative summary of the results of the noise prediction model:

    a. The east area of Wabush 3 will be the most exposed extraction area to the existing hospital, the existing college and the alternative hospital locations.
    b. The proposed hospital location north of Fermont Highway will have less exposure to Wabush 3 than the existing hospital and alternative hospital locations.
    c. The existing college is acoustically shielded by numerous buildings and dwellings. In comparison, the proposed location north of Fermont Highway is likely to be more exposed to the eastern portion of Wabush 3.

4. Using the 'worst case' scenario for Wabush 3, there is potential for greater noise and vibration impacts as a result of the significant reduction in distance setbacks and potential blasting parameters that may be required to develop the pit. Such changes may impact both the existing and the proposed hospital/college locations as follows:

    a. Under all conditions, the existing college will be exposed to sound and vibration levels that remain below the recommended sound and vibration

criteria even under adverse weather conditions.

b. Average vibration levels for the proposed hospital and college locations are predicted to be below the upper limit of the recommended vibration criteria. Under adverse weather conditions, vibration levels may be slightly higher than the recommended 'cautionary' level.
c. The proposed hospital location may be exposed to marginally higher average sound levels than the existing hospital location. However, under unfavorable weather conditions (downwind and crosswind and possibly due to temperature inversions) sound levels are predicted to significantly exceed the recommended criteria.

5. The alternative hospital location within the sports field east of Bartlett Drive is less acoustically favored in comparison to the existing location and the proposed location north of Fermont Highway.

6. While the foregoing results demonstrate the concerns for noise due to blasting, and to a lesser impact the concern for ground-borne vibration, two factors should always be observed throughout:

   a. The modeling results represent the 'average' expected levels. For large operations involving occasional or unforeseen parameters, the predicted levels may still reach worst case predictable levels (or simply upper limits) that are noticeably to significantly higher than those predicted here.
   b. When dealing with very sensitive land uses such as hospitals and special laboratories involving delicate operations and sensitive equipment, it is important that safety factors and fail safe mechanisms are also given due consideration during the planning stages.

FIGURES

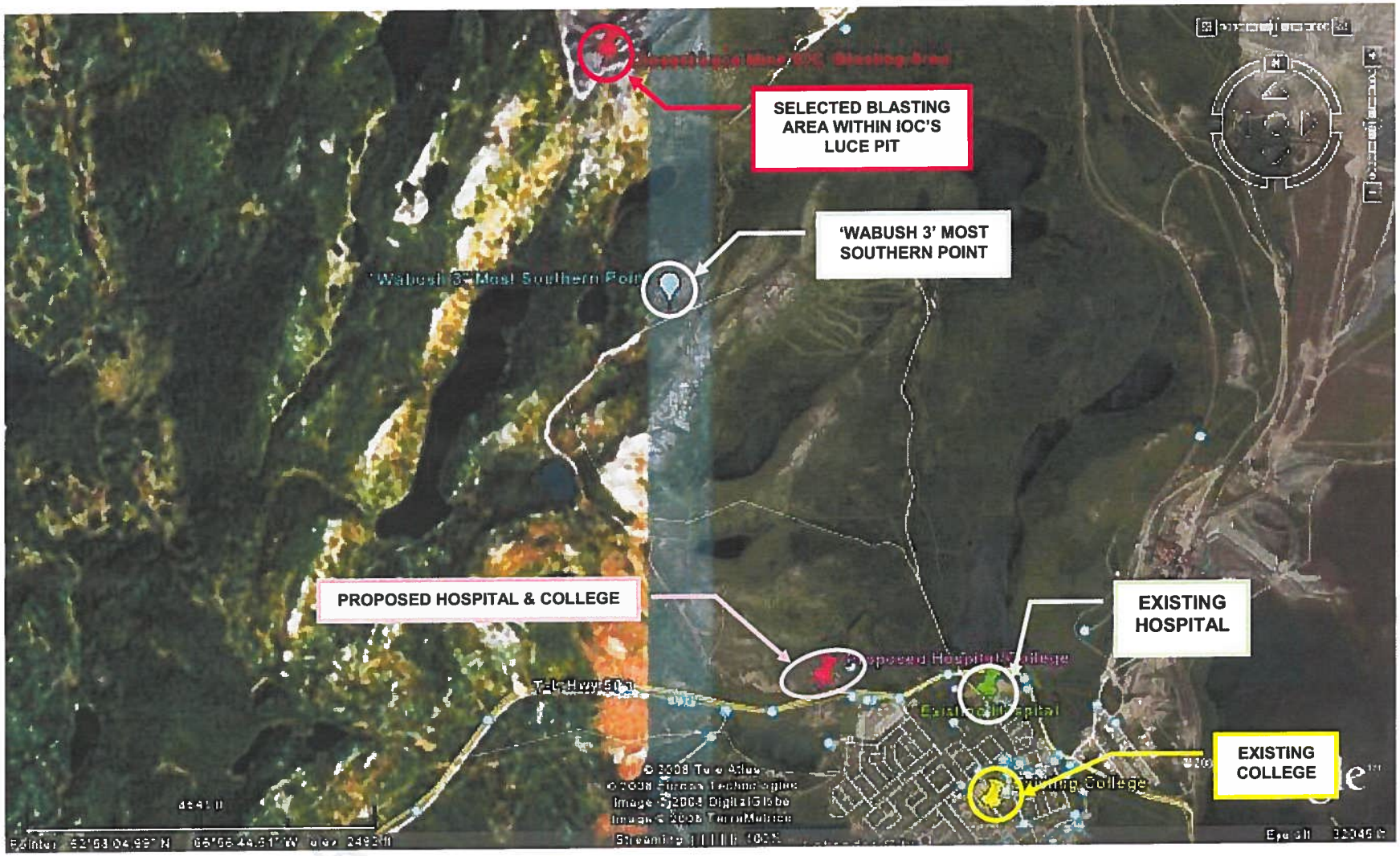

FIGURE 1.a: RELATIVE LOCATIONS OF IOC MINE TO THE EXISTING AND PROPOSED HOSPITAL AND COLLEGE

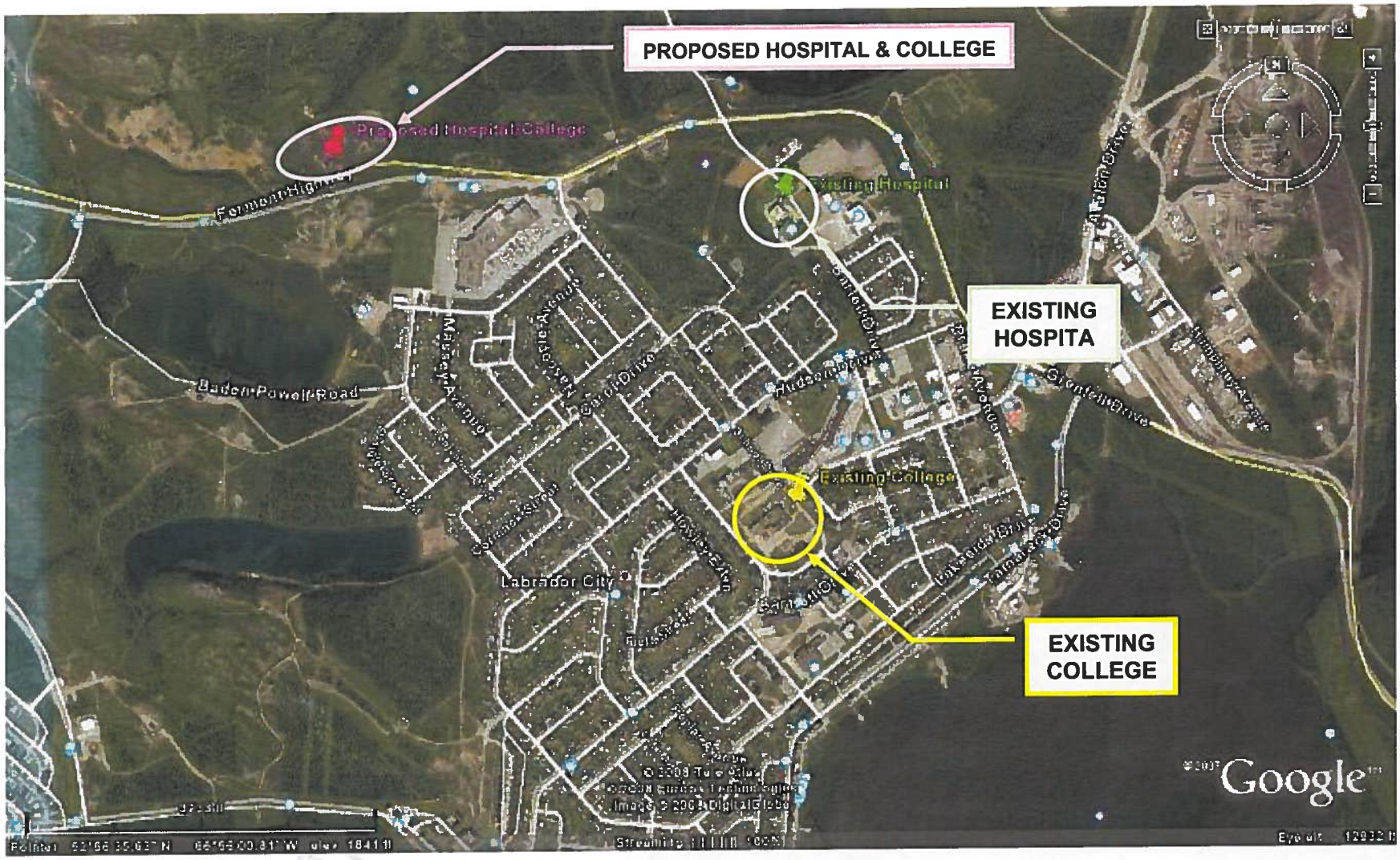

FIGURE 1.b: RELATIVE LOCATIONS OF IOC MINE TO THE EXISTING AND PROPOSED HOSPITAL AND COLLEGE

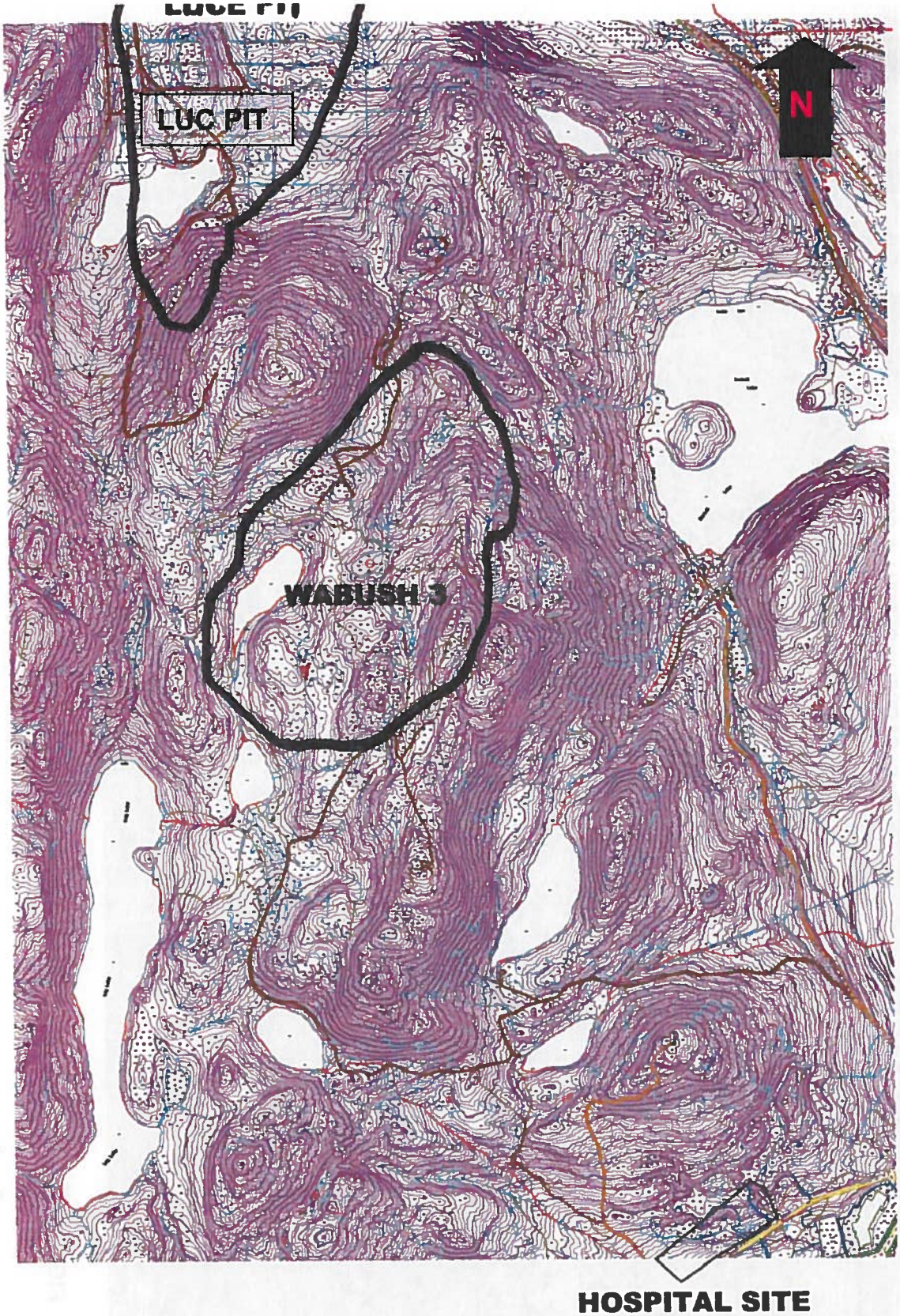

FIGURE 2: GENERAL TOPOGRAPHIC FEATURES OF THE SUBJECT AREA

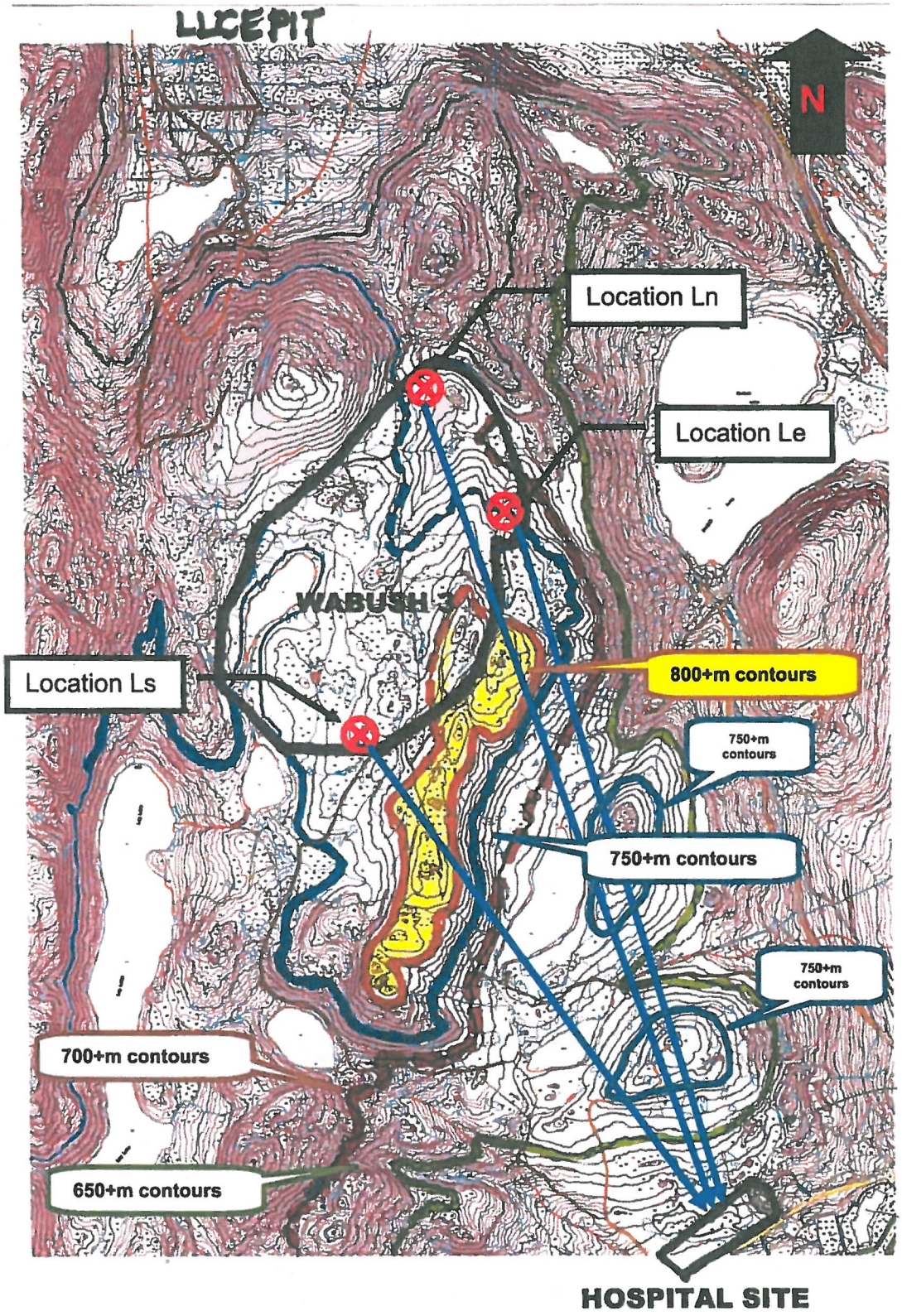

FIGURE 3: THE SELECTED BLASTING LOCATIONS (Ln, Ls and Le) AND THE MOST IMPORTANT TOPOGRAPHIC FEATURES FOR NOISE PROPAGATION PURPOSES

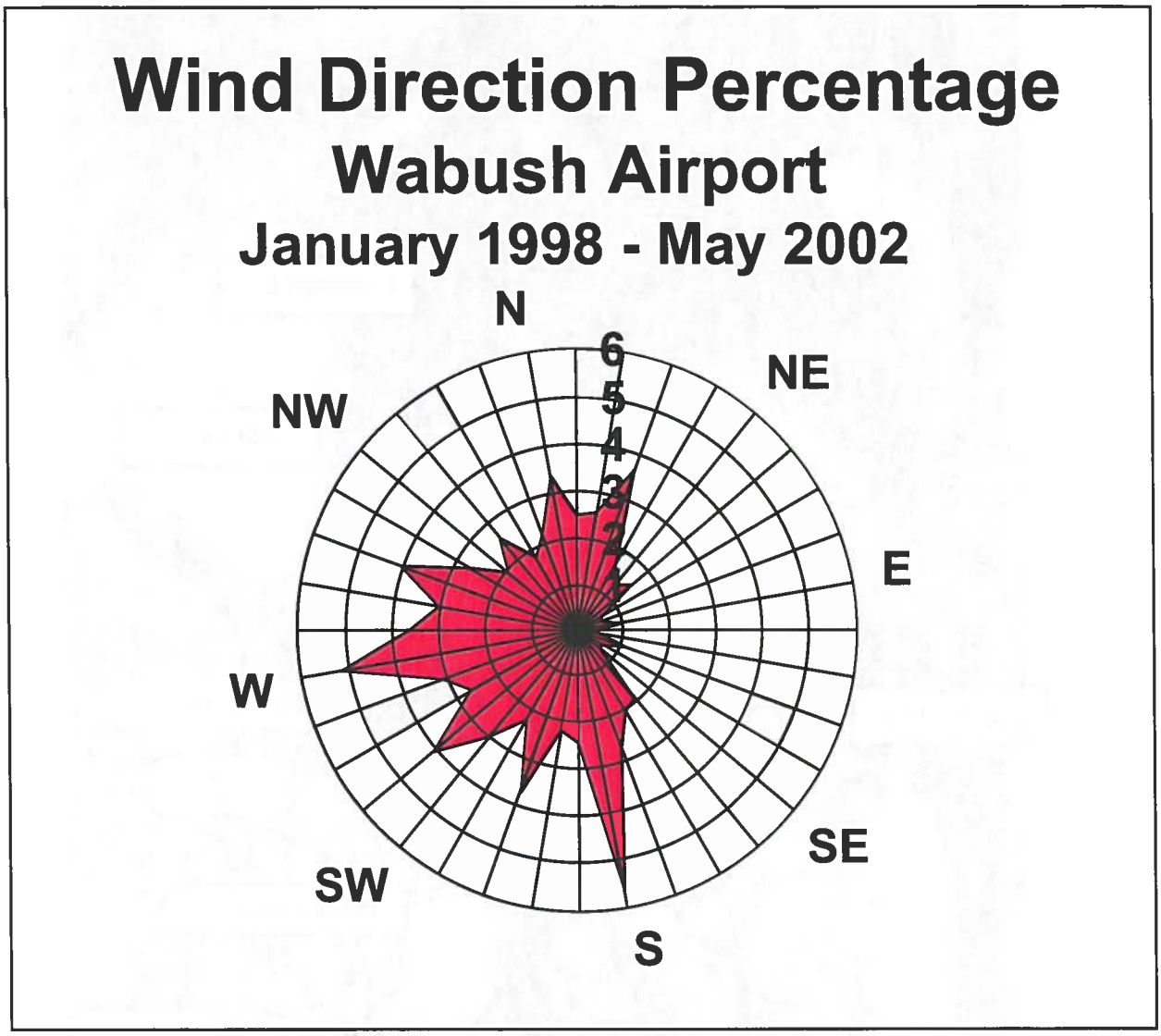

FIGURE 4: LABRADOR CITY AND WABUSH WIND ROSE