CRYPTOGRAPHIC SECURITY AND THE ECONOMICS OF CYBRIC INVASION: A RATIONAL ANALYSIS

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20:1 (1.81 million ÷ 90,000). This ratio continues to rise, and is directly reflected in a continued increase in odour complaints in Ontario’s rural areas (Fraser, 2001).

**HISTORY OF MINIMUM DISTANCE SEPARATION (MDS) FORMULA**

To address nuisance odours, separation siting of Ontario livestock facilities originated in 1970 (ODAF *et al*, 1970), with the introduction of *A Suggested Code of Practice* (Figure 1). It recommended fixed minimum separation distances between livestock barns and neighbouring houses, residential zones, lot lines and roads. The Suggested Code of Practice rationalized that the effect of odours could be reduced if livestock facilities were located as far as practical from nearby dwellings. While it contained a framework for the establishment and expansion of livestock facilities, it provided little protection for farms from encroachment by other non-farm land uses.

In 1976, the *Agricultural Code of Practice* (OMAF *et al*, 1976) provided a two-way approach to separating livestock and poultry barns from non-compatible uses and vice-versa. It introduced the concept of a sliding scale for separation distances, since fixed distances were too restrictive, or too lenient, depending on the size and type of farm. The *Code* first introduced the *Minimum Distance Separation (MDS)* formulas. MDS I determined minimum separation distances between proposed new development and existing livestock facilities and/or permanent manure storages, while MDS II determined minimum separation distances between proposed new or enlarged livestock facilities and/or permanent manure storages and other existing or approved development.

Both formulas were updated in 1995 in two documents, *Minimum Distance Separation I (MDS I)* and *Minimum Distance Separation II (MDS II)* (OMAFRA, 1995). The MDS I version was presented differently than before, no longer using formulas, but instead a series of cross-referenced tables.

The latest edition is *MDS-2006*, Publication 707, *Minimum Distance Separation (MDS) Formulae, Implementation Guidelines* (OMAFRA, 2006). While developing the 2006 version of MDS, one of the key principles was to limit radical changes to the setback distances, except where warranted, recognizing that livestock operators and those proposing new development nearby would have often made business decisions and potential investments based on current rules and what had gone on around them in past.
MDS: THE BASICS MDS is a planning tool developed by the Ontario Ministry of Agriculture, Food and Rural Affairs. It determines a setback distance between livestock facilities and other land uses, and vice versa. Livestock facilities are defined as ‘one or more barns or permanent structures with livestock-occupied portions, intended for keeping or housing of livestock. A livestock facility also includes manure or material storages and anaerobic digesters.’

MDS is implemented through the land use planning system and is identified in the Provincial Policy Statement 2005 requiring new or expanding livestock facilities and new land uses to comply with MDS\(^a\). The objective is to minimize nuisance complaints due to odour and reduce land use incompatibility. MDS I determines minimum setbacks between proposed new development and existing livestock facilities or permanent manure storages. It is applied to official plan amendments, zoning by-law amendments and lot creation applications, and is incorporated into municipal planning documents. Municipalities have the option to apply it to building permits for development on existing vacant lots. MDS II determines minimum setbacks between proposed new or expanding livestock facilities and existing or approved development, lot lines and road allowances. Separation distances vary based on a combination of five factors:

- Factor A – Odour Potential Factor (how ‘odorous’ the type of livestock can be)
- Factor B – Nutrient Units Factor (how many livestock can be housed)
- Factor C – Orderly Expansion Factor (what % increase in Nutrient Units is proposed)
- Factor D – Manure or Material Form Factor (solid vs. liquid manure or material)
- Factor E – Encroaching Land Use Factor (what land use is proposed)

\(^a\) The Provincial Policy Statement 2005 is issued under Section 3 of Ontario’s Planning Act. It is intended as a basis of a policy led framework for planning, by identifying key matters of provincial interest. Municipalities and others making decisions on land use planning matters are to be consistent with PPS.
• For MDS I, Building Base Distance, \( F = \text{Factors A} \times \text{B} \times \text{D} \times \text{E} \) (Factor C is not used)

• For MDS II, Building Base Distance, \( F = \text{Factors A} \times \text{B} \times \text{C} \times \text{D} \) (Factor E is not used)

SUMMARY OF 7 KEY TECHNICAL CHANGES TO MDS-2006 VS. MDS-1995

1. MDS I and II are now presented in similar fashion and format in both the written version (Publication 707) and electronic version (MDS Minimum Distance Separation Computer Program) to demonstrate how MDS I and MDS II give similar setbacks.

2. Factor A now has a longer list of livestock types and wider range of values to better reflect livestock specialization and reduced/increased odours associated with systems.

3. Factor B is higher now in the range under 20 NU, because setbacks had been too short for very small livestock operations.

4. Factor C is smaller now for NU increases under 33% to encourage orderly expansion, but higher between 33% and 200%; it specifies three years between successive building permits before getting the benefit of the expansion factor; and Factor C was altered to ensure a 2nd barn of equal capacity to a 1st barn sited by MDS (i.e. 100% expansion) will yield a setback 2.5% shorter to a neighbour’s home than the 1st barn.

5. Factor D did not change, but more types of permanent manure storages are described now and adjustments made to setbacks for earthen storages on smaller operations.

6. Factor E has now been set so that when MDS I is applied in encroachment situations next door to a livestock facility, it leaves room for that facility to expand from 150 to 300 NU (i.e. 100% expansion), assuming the first barn was sited according to MDS.

7. In MDS I, the potential NU housing capacity is now based on the product of tillable hectares on that lot multiplied by 7.5 NU/tillable ha, to a maximum of 300 NU. This is an increase from 5.0 LU/tillable ha in MDS-1995 giving greater protection for small and medium size livestock operations by requiring larger setbacks.

MDS I and II are more similar MDS-1995 didn’t tell users how the MDS I formula worked. It relied on cross-referenced tables in an attempt to simplify calculations. This created confusion and led many users to conclude the formulas were different or based on different factors. This led to accusations that MDS I and II were too lenient on livestock facilities or on neighbouring land use changes, or both. Steps were taken to reduce confusion. First, MDS I and II look similar with similar setbacks. Second, definitions and implementation guidelines are presented together to demonstrate consistent interpretation. Third, the computer software helps users understand how similar MDS I and II are in selecting animal types, systems and manure storages. Many municipal planners and building officials have limited experience with livestock operations so they need simple MDS formulas and interpretative materials. The user-friendly software is Windows© based; has drop down menus; the ability to save and print files in PDF version; can be run metric or imperial; the ability to put comments on file; produce several scenarios all on
one file; automatically calculates Factor C based on how long it has been between successive building permits for livestock facilities; and has an optional mapping function utilizing Google maps. The software has more interpretative material and users can clearly see that MDS I and MDS II are ‘the same’.

**Factor A: odour potential factor** Factor A is based on the type of livestock and its relative potential for offensive odours. The higher the Factor A, the higher the odour potential and higher resulting setback distances, all other things being equal. Factor A = 1.2 for feeder hogs but Factor A = 0.7 for horses since most people would agree feeder hogs have a higher odour potential.

Factor A in MDS-2006 now has a longer list of livestock types (80) than MDS-1995 (34), reflecting the much wider range and specialization of livestock operations in Ontario today. For instance, dairy sheep, quail, and operations that import manure onto operations that do not generate their own manure are now included in the list.

The range of values for Factor A has also widened, and varies from 0.5 to 1.2 to better reflect anticipated reduced or increased odours associated with different livestock types and systems. For instance, Factor A = 0.5 for storages of digestate from anaerobic digesters, but which do not produce as many odours as a typical manure storage. Factor A = 1.2 for storages for manure imported to a lot not generating manure. The higher Factor A value reflects how a manure storage not associated with any pre-existing livestock facility can affect a locality not accustomed to manure storage odours.

**Factor B: nutrient units factor** Factor B is based on the number of Nutrient Units (NU) in housing capacity at a livestock facility. The higher the NU, the higher the Factor B and the higher resulting MDS separation distances, all other things being equal. Nutrient Units (NU) are used in MDS-2006 instead of Livestock Units (LU) in MDS-1995. In part, this change was prompted by the introduction of the Nutrient Management Act, 2002, and a desire to reduce confusion for building officials and municipal planners by relying on one ‘system’ for describing the relative size of livestock operations. This change obliged amending MDS formulas so setbacks would not be substantially increased or decreased. For example, in MDS-1995, there were 4 feeder hogs per LU; in MDS-2006 there are 6 feeders per NU.

Factor B was established in MDS-1976 using the science-based observation that as point source odours increased, so did setbacks required for minimizing the possibility of people complaining about those odours. MDS-2006 uses this same relationship. While attempts were made to create one exponential formula for its values in MDS-2006, this proved impossible given the criterion that setbacks could not be altered dramatically over MDS-1995 and because MDS-1995 and its predecessor MDS-1976 had not used one formula. Instead, MDS-2006 uses a series of six linked exponential formulas to describe Factor B.

The most significant change to Factor B was for values under 20 NU (Figure 2). In MDS-2006, the minimum value for Factor B is 150, compared to the minimum value of Factor B of 107 in MDS-1995. The higher value in MDS-2006 was set to create greater setbacks for small size operations, especially in the under 5 NU size. Also, Factor B is now higher in the range from 5 to 20 NU than in MDS-1995. This change was made due to the disproportionate number of odour complaints received for small operations compared to larger operations because setbacks in MDS-1995 were too short. For instance, in MDS-
1995 the setback for a new hobby horse operation housing 5 horses was 56 m (184 ft) from the new barn to a neighbour’s dwelling. In MDS-2006, this setback is now 84 m (275 ft), a more realistic setback that should reduce odour complaints.

Even if the operation is less than 5 NU, Factor B is still 150 in MDS-2006. In other words, the minimum livestock operation size is given as 5 NU. This is not unlike the way MDS-1995 worked for operations under 5 LU.

Figure 2. Factor B is based on the number of Nutrient Units a farm will have after construction (MDS II), or could have based on barn capacity or tillable hectares (MDS I). Note that in 1995, Livestock Units were used. Figure 2 shows only a portion of the Factor B graph for small livestock operations less than 20 NU, or 20 LU.

**Factor C: orderly expansion factor** Factor C only applies for MDS II, and is based on the percentage increase in NU for the proposed construction or expansion. The higher the percentage increase, the higher Factor C, and the higher the resulting MDS II setback, all things being equal. Factor C allows for future expansion of the livestock operation.

Factor C is highest for the first livestock building (or first permanent manure storage where no livestock are housed) on a lot, resulting in a building location allowing most subsequent livestock buildings to be built within a reasonable building envelope. In part, this higher value for Factor C is based on the premise that the first livestock facility can be more of a change for the neighbourhood than if there is a history of a livestock facility on the property, and it sometimes takes time to get best management practices in place to minimize odours. It is also easier to build a first livestock facility further from neighbours to begin with before the farm operator has invested in significant infrastructure.

Factor C = 0.5 is the smallest it can be for 0% increase in NU. This may happen when an operator is reconfiguring a barn layout for efficiency reasons, or simply adding manure storage to do a better job environmentally. Since in both these cases there really should be no increase in odours expected, it made little sense to penalize an operator for doing the right thing. In other words, Factor C encourages small increases in livestock and more...
orderly expansion or investments that lead to good environmental practices. Factor C is now smaller than it was in MDS-1995 for expansions under about 33%.

Expansion of a livestock facility is a necessary and typical process for the economic development of most farm operations, and can reasonably be expected over time, but there had been some abuse of this factor because successive, rapid expansions would result in reduced setbacks compared to one ‘large’ expansion.

To prevent this from happening, MDS-2006 specifies three years between successive building permits before getting the benefit of the expansion factor. Where a livestock facility is to be expanded, and one or more building permits to establish or expand that facility were already issued within the previous three years, the % increase is calculated using: the total additional NU established or added by building permit issued during the previous three year period, plus the proposed expansion, as the numerator; and the total existing NU prior to the previous three year period as the denominator. See Table 1.

Table 1: Four examples of how % increase is calculated, all ending up with 500 NU after construction. This change greatly clarified things and been welcomed by Municipal staff.

<table>
<thead>
<tr>
<th>New Livestock Facility</th>
<th>Existing Livestock Facility (Constructed more than 3 years ago)</th>
<th>Have Expanded In Last 3 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>New with Expansions</td>
<td>Existing with Expansions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Operation Size 4 Years Ago</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>300 NU</td>
<td>N/A 200 NU</td>
</tr>
<tr>
<td><strong>Operation Size 2 Years Ago</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/A</td>
<td>Same as above (no expansions)</td>
<td>300 NU (NEW) Expansions of 150 NU</td>
</tr>
<tr>
<td><strong>Proposed increase in NU</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500 NU (NEW)</td>
<td>Expansion of 200 NU</td>
<td>Expansion of 200 NU</td>
</tr>
<tr>
<td><strong>Total NU Capacity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td><strong>Calculation of % increase in # of NU</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All first livestock facilities C = 1.14</td>
<td>(200/300) x 100 = 67% Since first facility built &lt; 3 years ago Factor C = 1.14</td>
<td>[(150+150)/200] x 100 = 150%</td>
</tr>
</tbody>
</table>

Factor C formulas were slightly altered into three linked straight-line relationships (Figure 3). The key points were at 0% and 100%. At 0% increase, Factor C was set to 0.5 for reasons described above. At 100% increase, Factor C was set to 0.8737 to make sure a second barn of equal capacity to a first barn sited with Factor C = 1.14 would yield an MDS setback to a neighbouring home of about 2.5% less distance. This was to recognize that operators usually want to locate subsequent livestock facilities close to the first one. An example will illustrate this point.

Suppose a feeder swine barn with liquid manure is built with capacity 300 NU. For MDS II, Building Base Distance, 

\[ F = \text{Factors A x B x C x D}, \]

with Factor A = 1.2 (feeder swine); Factor B = 464 (300 NU); Factor C = 1.14 (new); Factor D = 0.8 (liquid manure). So, Building Base Distance = 508 m. If a second barn of equal capacity for feeder swine is built with liquid manure, Factor A = 1.2; Factor B = 591 (for 600 NU); \textbf{Factor C =}
0.8737 (for 100% increase); Factor D = 0.8, and Building Base Distance = 496 m. This setback is within 2.5% of the first building’s required setback of 508 m, and facilitates the construction of the second barn within the same building envelope as the first barn.

For MDS-2006, this relationship between a first and second livestock barn on the same property, where the operation is doubling in size will work in all circumstances and livestock types, but only for the second barn. All subsequent additions of equal size, (i.e. for a third or fourth barn) will gradually require greater and greater setbacks to neighbours, as compared to the first barn. In MDS-1995 the setbacks generated in these circumstances were much smaller and inappropriate.

At 50% increase, Factor C was set to 0.81, higher than in MDS-1995 (0.7) because it would have resulted in inappropriately short setbacks. At 200% increase, Factor C was set to 1.0 so it would closely ‘fit’ the value for Factor C in MDS-1995 (0.97).

Figure 3: Factor C is smaller now for NU increases under 33%; higher from 33% - 200%

**Factor D: manure or material form in permanent storage** Factor D is based on the type of manure, or material, and its relative potential for emitting offensive odours. The higher the Factor D, the higher the odour potential, and the higher the resulting MDS separation distance, all other things being equal.

There were few changes made in MDS-2006 to Factor D, although liquid manure is now better defined as less than 18% dry matter, with solid manure 18-100% dry matter. MDS 2006 provides much better descriptions and a longer list of the various solid and liquid manure storage types that are used on Ontario farms. Twelve storage types are described compared to only four in MDS-1995. Of these, seven are very low odour storages, two low odour storages, two medium odour storages, and one high odour storage.

Setbacks for earthen liquid manure storages were deemed inappropriately high for relatively ‘small’ farm operations in MDS-1995. For instance, if a new 50 cow milking
herd dairy operation was built, the barn would have a minimum setback of 184 m to a neighbour’s home, while the minimum setback for its earthen liquid storage was far greater at 388 m. If that storage was an open-top concrete one instead, the minimum setback was only 240 m. This discrepancy was changed in MDS-2006, so that in this particular case the setback would still be greater, but more appropriate at 348 m.

**Factor E: encroaching land use factor** Factor E only applies for MDS I and is based on the effect encroaching land uses might have on existing neighbouring livestock facilities. The higher the Factor E, the higher the potential effect and the higher the resulting MDS I separation distance. MDS-1995 did not give as much protection against encroachment as Ontario livestock farms needed.

In MDS-1995, a new 900 head feeder hog swine barn had to be a minimum 385 m from a neighbour’s house (using MDS II). If a house was then proposed on a severed lot next door, it only had to be 270 m away from that barn (using MDS I). If the farmer then proposed a 100% increase to 1800 feeder hogs, his second barn would have to be a minimum of 372 m from any house, including the new dwelling on the severed lot (using MDS II). Clearly, MDS I did not protect the farmer adequately for future expansion and was unsustainable.

This changed in MDS-2006. Factor E was set so it now permits that livestock farmer next door to do a 100% expansion from 150 NU to 300 NU, assuming the first barn was sited according to MDS. So, Factor E for a Type A land use (uses with a lower density of human occupancy) is based on the increase in the ratio of Factor B for 300 NU (464) vs. 150 NU (364) times Factor C for a 100% increase (0.8737); 464/364 x 0.8737 = 1.1.

For example, in MDS-2006, a new 150 NU feeder swine barn has to be a minimum 398 m from a neighbour’s house (using MDS II). If a house is then proposed on a severed lot next door, it would now have to be 384 m away from barn (using MDS I). If the farmer then proposed a 100% increase to 300 NU, his second barn would have to be a minimum 389 m from any house, including the new one on the severed lot (using MDS II). Clearly, MDS I does a better job of protecting nearby livestock farmers from encroachment and this is due to the changes in Factor E.

**Tillable hectares: greater protection against encroachment** In MDS I, Factor B is based on the greater of the existing NU housing capacity of the livestock facility, or the potential NU housing capacity based on tillable hectares. Calculating NU capacity based on tillable hectares is done by taking the number of tillable hectares on a subject lot and multiplying by 7.5 NU/tillable ha. A calculation of NU capacity based on tillable hectares is capped at 300 NU.

Using tillable hectares to calculate NU housing capacity, helps give greater protection to small and medium sized livestock operations on larger properties, from non-farm encroachment. This is important because, there are fewer and fewer places in Ontario where farmers can find locations to expand their livestock operations and meet MDS requirements. Protecting larger properties from non-farm encroachment is important for the future of livestock agriculture.
Under MDS-1995, small and medium sized livestock operations received less protection as the calculation of housing capacity was based on 5 LU/tillable ha (note MDS-1995 used Livestock Units). The figure of 7.5 is based on the cutoff of 300 NU for those livestock operations in Ontario requiring a Nutrient Management Plan divided by a typical lot size of 40 ha (100 ac).

CONCLUSION MDS-2006 was a significant improvement over MDS-1995 with several major technical changes made based on input from many sources and stakeholders. Other minor technical changes, additional guidance materials and clarification of existing guidelines and policies provided for a much improved, easier to understand land use tool. The accompanying computer software was welcomed by users. A commitment by the Ontario Ministry of Agriculture, Food and Rural Affairs to review this document every five years will ensure that it continues to play an important role in shaping rural Ontario’s landscape and supporting its livestock agriculture industry.

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