Risk-based
Land Use Planning
Guidelines
The MIACC Process
The Major Industrial Accidents Council of Canada (MIACC) was established in 1987. Prior to that, there was no single organization in Canada that focused on the wide spectrum of prevention, preparedness and response (PPR) activities relating to the manufacture, storage, distribution, transportation, handling, use, and disposal of hazardous substances.

A non-profit, multi-stakeholder organization, MIACC is the national focus and leader for cooperative action to reduce the frequency and severity of major industrial accidents involving hazardous substances. MIACC also promotes uniformity in implementing PPR measures in Canada.

In carrying out its mission, MIACC brings together in one neutral forum all those with a vested interest in PPR. This alliance comprises the federal, provincial and municipal governments, industry and industry associations, emergency response organizations, labour, academia, and other interested groups. MIACC is governed by this membership.

Specialists representing the membership work together in a spirit of cooperation, consultation and consensus to develop practical, low-cost solutions for the integrated safe management of hazardous substances. While it is primarily the high-impact, low-probability major event which is addressed, MIACC’s products and services cover many other safety, health and environmental issues. Products take the form of national guidelines and standards, but may include policy positions, procedures, publications, computer software, and other processes. MIACC’s services include conferences, workshops, seminars and courses which foster the exchange of information, knowledge and experience.

The PPR measures developed in MIACC are portable through all jurisdictions in Canada. The uniform adoption of these measures can reduce the heavy and frequently conflicting requirements which stem from overlapping activities in the numerous jurisdictions. Appropriate standards and guidelines are referenced in legislation and industry codes of practice to achieve further streamlining and harmonization.

For more information on the Risk-based Land Use Planning Guidelines, on MIACC, or on the products and services available through MIACC, please contact:

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OVERVIEW OF MIACC RISK ASSESSMENT PRODUCTS

The MIACC risk assessment products comprise a group of six planned or current publications dealing with hazardous substances and urban areas: *Risk-based Land Use Planning Guidelines*, *Pipeline Corridors*, *Dangerous Goods Transportation Corridors*, *Lists of Hazardous Substances*, *Hazardous Substances Risk Assessment: A Mini-Guide for Municipalities and Industry*, and *Risk Assessment Guidelines for Municipalities and Industry*, and potentially computer software. These are intended to form a hierarchy of products capable of addressing risk assessment of sites at which hazardous substances are handled (produced, stored, re-processed or used, etc.) or through which hazardous substances pass or are transported, at various levels of sophistication depending on the requirements of the situation and the experience and qualifications of the user. The products are summarised below.

**Risk-based Land Use Planning Guidelines**

The *Risk-based Land Use Planning Guidelines* provides the reader with background material and advice on the use of risk assessment in respect to the development of land use plans.

**Pipeline Corridors**

The *Pipeline Corridors* guideline addresses the particular question of land use planning along pipeline corridors.

**Dangerous Goods Transportation Corridors**

The *Dangerous Goods Transportation Corridors* guideline addresses the particular question of land use planning along highway and railway transportation corridors through which dangerous goods are likely to be transported by highway or railway vehicles.

**Lists of Hazardous Substances**

The *Lists of Hazardous Substances* provide a simple method for identifying hazardous substances and ranking fixed sites at which hazardous substances are handled. There are three lists:

List 1 is a short list of "top priority" substances commonly found in Canada both in fixed facilities and transport situations. List 1 substances in quantities larger than the listed threshold quantity, if released, have a high probability of causing fatalities off site.

List 2 is a longer list of potentially hazardous substances which, if released, could cause fatalities off site. This includes the substances of List 1, in amounts smaller than the large quantities that merit the top priority of List 1.
List 3 comprises other hazardous substances which are frequently encountered in Canada but present smaller acute risks than those of Lists 1 and 2, and are less likely to cause or be involved in a major accident. They may present environmental or long-term risks.

The Lists give the name of the substance, the usual physical state, Chemical Abstracts Service (CAS) numbers, product identification number/United Nations number (PIN/UN), transport of dangerous goods (TDG) class and division numbers, and a threshold quantity. It is recommended that a risk assessment of a site or activity be undertaken where quantities of a hazardous substance are above the threshold quantity. Priority should be given to the assessment and management of sites holding large amounts (above the threshold quantities) of substances on List 1, followed by substances in amounts above the threshold quantities of List 2, these same substances in smaller quantities, the substances of List 3, and then all remaining sites.

**Hazardous Substances Risk Assessment: A Mini-Guide for Municipalities and Industry**

The *Mini-Guide* provides a brief self-contained introduction to the basic concepts involved in risk assessment and some calculated results that allow initial screening assessments to be made for a limited range of simple situations. The *Mini-Guide* provides results in the form of tables of separation distances equivalent to specified risk values, calculated for a limited range of conditions. Using these results a preliminary assessment of the risk can be made without having to perform the calculations. In many cases this will be sufficient to give an indication of the acceptability of the risk associated with industrial activities. The results in the *Mini-Guide* have been obtained by applying the methodology contained in the *Risk Assessment Guidelines* (see below). When the situation is not covered by the *Mini-Guide* reference should be made to the more comprehensive products described below.

**Risk Assessment Guidelines for Municipalities and Industry**

The MIACC *Risk Assessment Guidelines for Municipalities and Industry* provides procedures for evaluating the risk due to a wide range of industrial activities. As with the *Mini-Guide*, the *Guidelines* is a self-contained document providing an introduction to the relevant risk assessment concepts and outlining the procedures to obtain estimates of the risk. In the *Guidelines* the procedures provide for more detailed investigation of risk assessment problems. To apply the methodology described in the *Guidelines* the user must have information about the process being considered and must perform calculations to determine the risk.

**Computer Software**

A computer software product is proposed to implement the risk assessment procedure contained in the *Guidelines* described above. The methodology and results would be identical to the *Guidelines*; the software simply makes the application of the MIACC risk assessment procedures more convenient.
Capabilities and Limitations

It should be noted that risk assessment can be a complicated process. However, in many situations simplified methods are sufficient. The MIACC risk assessment products described above are meant to satisfy the needs of users dealing with problems for which more comprehensive methods are not justified.

It is important to review and understand both the capabilities and limitations of each of these methods as described in the relevant product. The products are organized in a manner to provide a range of approaches with increasing sophistication. If the circumstances for which the risk assessment is to be performed lie outside the scope of these screening methods, the problem should be referred to a risk analyst for more detailed treatment. The MIACC Lists, Mini-Guide and Guidelines are not intended to be used for emergency response planning as such, particularly not for the calculation of evacuation distances in the event of a chemical release.

MIACC believes that if a hazardous substance is not included in either List 1 or List 2, or is present at a site in a quantity less than the threshold quantity shown in List 2, it does not constitute a risk of a major industrial nature. This is not to say that in the fullness of time, a site assessment should not be undertaken.
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Acceptable level of risk

The determination by public authorities through a process involving industry and the public of levels of risk which are considered acceptable if all reasonably practical measures have been taken to reduce risks. Acceptability depends on the trade-offs between risks, costs, and benefits and may vary from one community to another.

Buffer or transition zones

An area of land established around an industrial activity to separate other adjacent land uses, particularly residential areas, from the potential effects of an industrial accident. Buffer or transition zones are established through the determination of minimum separation distances between various land uses and through the determination of "buffer" land uses within these areas.

Hazard

A condition with the potential for causing an undesirable consequence.

Hazardous substance

Any substance described in the MIACC lists.

Hazardous site

A location where hazardous substances are used, stored, or produced. Such sites may be "point sources" of risk (e.g. an industry) or linear sources of risk (e.g. a pipeline or transportation corridor).

Individual Risk

The annual frequency at which an individual may be expected to sustain a given level of harm (e.g., death) from the realization of specified hazards.

Minimum separation distances

A distance to be maintained between different land uses or constructions. The separation distance determines the width of a buffer zone.
Performance zoning

Zoning based on standards to be met concerning various enumerated nuisances or levels of risk. An industry that can operate in a fashion that meets such standards can locate in an industrial zone.

Risk

A measure of the probability and severity of an adverse effect due to a hazard.

Risk assessment

The characterization of the likelihood and importance of risks.

Risk contour

A contour around a hazardous site connecting locations with equal probability of risk. The contours usually represent powers of 10, i.e., 1 chance in 1,000 per year or \(10^{-3}\) that an individual may die, 1 chance in 10,000 per year or \(10^{-4}\), 1 chance in 100,000 per year or \(10^{-5}\), etc.

Risk management

The optimization of exposure to known and assessed risks.

Societal risk

The relationship between annual frequency and the number of people suffering from a specific level of harm in a given population from the realization of a specified hazard. This is the number of people that might be harmed in the event of a release. Societal risk is estimated from all possible events.
INTRODUCTION

Risk management concerns five different objectives:

1. risk reduction at the source (modifications to facilities or processes, technical changes, training, etc.),
2. risk reduction through better land use planning around industrial sites, pipeline and dangerous goods corridors,
3. emergency preparedness,
4. emergency response, and
5. risk communication and public participation.

Many ongoing activities by MIACC concern risk reduction within industrial facilities themselves (objective 1), the preparation of emergency response plans (objective 3), and adequate emergency response should an accident take place (objective 4). These efforts involve industry, emergency responders, regulatory authorities and the public.

While efforts are required in all five areas, experts in France have also noted that most efforts to date in that country have also focussed on objectives 1 and 3 above, and that less attention has been paid to land use concerns (objective 2):

Effectively, hazard analyses completed to implement the Seveso Directive have gradually brought to light a contradiction between the important efforts to reduce risk at the source through improved safety within industrial sites and ongoing urbanization which contributes to increased exposure by the population to a major industrial accident. This contradiction limits both the security of adjacent property owners and the potential for expansion of the companies themselves. As a result, technological risk, rather than being managed on a specific basis (nuclear, chemical, hazardous goods transportation) must be managed for an entire territory. This conclusion has led to the inclusion of technological risk concerns in the planning of urban development projects...It is consequently in the realm of management of risk within the zones adjacent to industrial sites that the most considerable efforts are now required. [translation]¹

To assist in public and private efforts to better deal with objective 2, the present document focuses specifically on how the potential impacts of an accident on surrounding human activities can be anticipated and limited through adequate land use planning and control. Developments in the United States and in Canada have brought to the forefront the importance of objective 5 and the question of public participation is briefly discussed.
The document is divided into six parts:

Section 1. Fundamentals of land use planning and control;

Section 2. Risk assessment for land use planning and control (including MIACC guidelines for acceptable levels of risk);

Section 3. Economic, legal and political considerations

Section 4. Public involvement

Section 5. Risk-based planning for fixed facilities: official plans, regulations and evaluation procedures

Section 6. Conclusions and recommendations

Section 1 will be of particular interest to those less familiar with land use planning and control while Section 2 presents the MIACC risk assessment guidelines. Sections 3 and 4 discuss the broader implications of risk-based land use planning. Section 5 deals more specifically with implementation of this approach for fixed industrial or commercial facilities which use, produce or store hazardous substances. Risk-based land use planning for pipeline and dangerous goods transportation corridors are the subject of separate documents. Finally, Section 6 briefly presents certain conclusions and recommendations.

It must be mentioned that these guidelines are primarily concerned with human safety, and more specifically, with fatalities which may result from major industrial accidents. Concern also exists with immediate injuries, long term health impacts (permanent incapacity) and environmental impacts (wildlife, vegetation, contamination of watercourses or soil, etc.). Although methodologies for risk assessment are available for these other impacts of industrial accidents, little work has yet been done with respect to appropriate guidelines for risk acceptability. Risk assessment dealing with health and environmental concerns is not considered in this document although it must be recognized that particularly for land use planning and control purposes, it is difficult to separate these issues.

The document deals with the inclusion of risk assessment in land use planning rather than with appropriate methodologies for risk assessment itself. For the latter, the reader should refer to various documents which concern risk assessment, particularly those by MIACC as listed in the Overview. The Canadian Standards Association (CSA) has produced or is producing several documents dealing with risk: Risk Analysis Requirements and Guidelines, Risk Management and Environmental Risk Assessment.

Finally, while the main thrust of the document is not on risk reduction and control, a number of techniques are mentioned in the sections dealing with built-up areas. In these situations, risk reduction through land use planning and control is less effective and more direct measures for reducing risk may be required.
1. FUNDAMENTALS OF LAND USE PLANNING AND CONTROL

1.1 Planning tools

Local and regional municipalities, provinces and other authorities share responsibilities for land use planning and control. While the role of each varies from one province to another, local municipalities generally are most directly responsible for preparing and for implementing two types of land-use planning and control tools:

- official plans and by-laws which determine land uses within all parts of their territory;
- standards and regulations used in the development approval process for industrial projects and for adjacent land uses.

Increasingly, a third type of planning and control tool is used for major projects and is often a responsibility of regional, provincial or federal government:

- impact assessment procedures for major projects.

All three land-use planning and control tools should include an evaluation of risk to the public. A brief description of each of these three tools follows and in subsequent chapters, approaches for including risk assessment in land use planning will be suggested.

1.1.1 Land use choices in official plans

In land use planning and control, choices regarding the appropriate locations for various land uses take into account their compatibility with adjacent land uses. Planning choices, as exemplified by regional and local official plans, attempt to minimize the potential negative impacts of certain land uses, including industry, by favouring their separation from other urban land uses such as housing, schools and community facilities.

Historically, such choices have been based on potential "nuisance" effects. In the case of industrial uses, concern with noise, dust, heavy traffic, odour etc., have traditionally justified the separation of industry from other land uses. The development of industrial parks, in both new and redeveloping areas, represents one example of such attempts to isolate industry from other uses.

Zoning by-laws translate land use designations in official plans by identifying those uses which are permitted or prohibited in each of the zones into which the municipality is divided. By-laws also usually include standards and regulations which must be respected in requests for subdivision, building or development permits.
This conventional "Euclidean" approach has its limitations:

In time, however, many communities realized that neither distance nor the segregation of industry by category would adequately solve all the problems associated with industrial land uses. Many cities developed extensive lists of the types of industrial operations permitted in different categories of industrial districts, typically labelled "light," "heavy," and "general." These lists, based on the industries' historical characteristics, often become outdated. They fail to recognize both the changes that occur as industry evolves and the degree of flexibility that often exists in industry operations.²

1.1.2 Standards and regulations

Fixed standards for buffer or transition zones

Buffer zones around industrial sites (particularly hazardous sites) or corridors are one type of land use standard. A buffer zone is an area of land established to separate one type of land use from another with which it is incompatible. Land uses within a buffer zone are limited to ensure that certain uses such as permanent residences and slow-to-evacuate facilities (i.e., schools, hospitals, jails) are located sufficiently far away from the potential accident site so that individuals in the area are not exposed to unacceptable levels of risk. This is sometimes referred to as the principle of transitional land uses between industrial and residential areas, hence the use of the term "transition zone" as a synonym for buffer zone.

Buffer or transition zones are usually defined through "minimum separation distances" between the industrial activity and various categories of surrounding land uses. These distances which determine the dimensions of the buffer zone may be specifically defined in zoning by-laws or regulations on the basis of the anticipated consequences of an industrial accident. Such standards take the form of fixed separation distances to be maintained between industrial activities and other categories of land uses. Industries themselves may also have policies on minimum separation distances.

Unfortunately, the justifications for such standards are often unclear and many standards are simply repeated from one zoning by-law to another. The present guidelines based on risk assessment are intended to provide a sounder basis for establishing fixed standards.

Fixed standards have the advantage of administrative simplicity since it is relatively easy to verify conformity with the prescribed minimum separation distances between land uses.
Performance zoning

Although fixed standards for buffer zones or minimum separation distances may be included in zoning by-laws or regulations, it is increasingly frequent for municipalities to use more flexible "performance zoning". Performance zoning, when permitted by planning legislation, applies performance standards to each application and evaluates the acceptability of a project on the basis of its anticipated impacts on surrounding land uses, not on the basis of conformity with predetermined detailed specifications of an ordinance.

For example, a performance standard dealing with noise would determine the maximum noise levels permitted in proximity to various land uses around an industrial site rather than prescribing specific separation distances. The developer of a residential project close to such a site could choose to construct a sound barrier, build houses at distances sufficient to respect the noise levels, or locate another land use in proximity to the industrial site (e.g. a neighbourhood commercial centre). Thus, the performance zoning approach, while directly addressing the community impacts which zoning would control, gives the developer the benefit of more design flexibility.

Few communities, however, have developed performance standards which deal with the possibility of major industrial accidents:

Most communities, of course, do not have huge chemical plants producing such deadly chemicals as methyl isocyanate [the chemical involved in the Bhopal accident]. The number of communities called upon to review plans for siting new facilities of this sort is even smaller. That does not obviate the question, however, because most communities contain industries that deal with hazardous chemicals on some scale, and even small accidents, spills, and leaks can have consequences worthy of local regulatory attention. Unfortunately, many outdated industrial performance codes are inadequate for dealing effectively with this problem. It is probably the area in which the greatest amount of rethinking is needed to equip our industrial performance standards so that they can match the technological realities of the next century.3

The guidelines for acceptable levels of risk presented in Chapter 3 are based on the performance standards approach. As opposed to the application of fixed standards, this approach requires specific analyses of each project in order to determine whether the performance standards are met. Consequently, this approach can require greater human and financial resources.
Reciprocity

Whether fixed or performance standards are used, these tools are most useful for controlling new industrial installations or new land uses around industrial sites. Buffer zones which are already in place when such projects are first proposed and which are carefully enforced during project implementation can substantially reduce risk. Once land use controls have been established, pressures to relax these standards and permit the encroachment of unacceptable land uses within the buffer zone or zones must be resisted.

Consequently, buffer zones or minimum separation requirements must apply both to industry and to surrounding land uses. Reciprocity has often been a problem since many actual regulations concern separation distances for a new or expanded industry in relation with existing residential areas but not for new residential areas in relation to an existing industries or planned industrial areas. This problem is accentuated when the authority which regulates one activity (e.g. provincial regulations for major new industrial activities) is different from that responsible for other activities (e.g. municipal zoning by-laws dealing with other land uses).

Requests to modify land use controls may result from pressures from citizen groups, from requests by industry for industrial expansion or changes in industrial processes, or from developers seeking approval for projects adjacent to industrial sites.

In some cases land use choices are controlled through the issuance of business licenses. Risk assessment associated with the licensing process can ensure that risk is sufficiently taken into consideration when permits associated with these activities are issued.

1.1.3 Impact assessment procedures for major projects

Most provinces have specific legislation dealing with impact assessments for major projects. Such environmental impact assessment procedures deal with a wide variety of issues including risk and may complement, or in some cases, may replace municipal land use planning and controls. Generally, a provincially appointed board is responsible for evaluating such projects.

Major industrial projects are generally submitted to assessment procedures based on threshold criteria dealing with project size or potential impacts. In some cases, other land uses in proximity to an industrial site may also be submitted to impact assessment procedures (e.g. regional shopping centres).

It is typical for legislation to require the initiator of a major project to prepare various documents which describe the proposed project, evaluate its direct and indirect impacts, describe the alternatives considered, and, where necessary, propose mitigation measures which are considered necessary. After analysis of these documents and some form of public participation, the authority
responsible for approving such projects hands down its decision. In some cases it is possible to appeal such a decision.

Increasingly, the assessment of impacts on human safety is becoming a part of such procedures and risk assessment should consequently be an integral part of the process. However, the absence of consensus on acceptable levels of risk or on appropriate methodologies for the inclusion of risk assessment in impact assessment procedures has posed problems in Canada.

1.2 Including risk assessment in land use planning legislation

As the above discussion of various planning tools suggests, risk assessment is not generally an integral part of land use planning and control in Canada. The opportunity does exist for including risk assessment without major changes in either planning legislation or practice.

In Europe, the inclusion of risk assessment has been an integral part of land use planning and control for several decades, as described below. In 1992, the Organization for Economic Co-operation and Development (OECD) prepared guidelines principles for chemical accident prevention, preparedness and response which included the following guidelines for land use planning:

C.1 Public authorities should establish land-use planning arrangements to ensure that new hazardous installations are appropriately sited with respect to protection of health and environment, including property, in the event of an accident involving hazardous substances. These arrangements should also prevent the placing of inappropriate developments near hazardous installations and should control inappropriate changes to existing installations.

- Land-use planning should consist of two elements: general zoning for hazardous industrial activities, taking into account all aspects of protecting health and the environment, including property; and case-by-case decision-making concerning the siting of a new installation or proposed development near an existing installation.

C.5 Public authorities should ensure that the risks of an accident posed by a specific proposed development, including adverse effects in the event of an accident, are assessed taking into account the full range of implications, advantages and disadvantages of the particular location. This should be done both for proposed hazardous installations and proposed developments of other kinds in the vicinity of hazardous installations.
1.2.1 Legislation in Europe

Specific legislation concerning risk assessment and land use planning and control has been in existence in Europe for some years, even before the adoption of the OECD guiding principles:

*In the 1970's many countries modified their legislation dealing with hazardous facilities (the United Kingdom and Germany in 1974, France in 1976, the Netherlands in 1977). These new laws included the notion of "hazardous installations" and proposed appropriate classifications. They described the analyses of safety and of risk that should be undertaken, although the specific methodologies vary with the regulatory approaches used in each country. They also prescribe conditions for development approvals.*

*The European Economic Community Directive on Major Hazards of June 1982, often referred to as the "Seveso Directive", unified and often strengthened these practices. It required the identification of installations on the basis of a list of hazardous substances and required manufacturers to produce a description of the causes of risk, of the conditions under which a major accident could occur and a description of preventative measures envisaged. It defined the principles of risk assessment to be integrated in the regulations of the various countries. Its implementation in the EEC has led to the identification and evaluation of some 1800 hazardous installations.* [translation]

In France, a modification introduced in July 1987 to the Planning Code introduced a specific reference to the notion of technological risk in several articles dealing with land use planning and control.

1.2.2 Legislation in Canada

Few provinces have specific legislation concerning the inclusion of risk assessment in land use planning and control. In general, most planning laws enable municipalities to specify land uses throughout their territory, although such plans are not obligatory in all provinces. As well, many planning laws allow municipalities, through their zoning by-laws, to ensure minimum separation distances between conflicting land uses.

A modification in 1993 to Quebec's planning act specifically provides for the identification in regional plans of activities which may generate "special restrictions for reasons of public safety, public health or general welfare" and for the establishment of standards for municipal zoning by-laws in proximity to these activities. This new power allows the municipalities to regulate adjacent land uses on the basis of "the extent of harmful or undesirable effects caused by the source". These effects may include not only nuisances, such as noise or odour, but also risk.
Risk-Based Land Use Planning Guidelines

In those provinces where provincial approval of municipal official plans or zoning by-laws is necessary, inclusion in these documents of any provincial guidelines concerning industrial activities can be required. However, few such guidelines dealing specifically with technological risks have been produced.

In some cases, provincial governments have themselves established specific regulations. For example, in Alberta, setback regulations for sour gas operations were established by the Energy Resources Conservation Board in 1976 and by Provincial Planning Authorities in 1979.

While general planning and zoning powers thus exist, the absence of risk assessment in official plans, zoning by-laws and environmental assessment procedures can be explained by the lack of generally accepted guidelines for acceptable levels of risk and of methodologies for risk assessment. The following section addresses these issues.
2. RISK ASSESSMENT FOR LAND USE PLANNING AND CONTROL

As mentioned in the introduction, the present guide deals with the inclusion of risk assessment in land use planning rather than with methodologies for risk assessment itself. As described in the Overview, MIACC has published three documents dealing with the methodology for risk assessment. These three documents deal with fixed facilities risk assessment in a sequential manner from very simple to less simple. Complex problems are not dealt with and require individual analysis by competent risk analysts.

These three documents should be used in conjunction with the present guide for land use planning and control and the reader should consult them for a more detailed description of the methodological aspects of risk assessment. Nevertheless, it is important to briefly describe the basic concepts associated with risk assessment, particularly in relation to land use planning and control.

2.1 Defining risk

Risk can be defined as the combination of the probability of occurrence of an undesired event and the possible extent of that event's consequences. Thus defined, risk can be calculated. Risk assessments involve estimating:

- the likelihood or expected frequencies of undesirable events
- consequences to people of these undesirable events
- the associated risk in quantitative terms.

The risk to the public of a potential hazard becoming real is determined by the following expression:

\[
\text{Risk} = \text{Frequency of occurrence} \times \text{Estimated consequences}
\]

where the frequency of occurrence is the frequency of occurrence of a hazardous release (sometimes called event frequency) and the estimated consequences are the estimated consequences of that hazardous release (often expressed in terms of human fatality, but sometimes in terms of injury, health effects, property damage, etc.).

The preceding expression defines the event risk for a particular hazardous event. If many different types of hazardous events are possible at a given industrial facility, then the overall facility risk is obtained by summing up all the event risks.
The MIACC guidelines for risk assessment are based on a series of lists which identify the more commonly occurring hazardous substances (including the minimum quantities which generate cause for concern). These lists are presented in the following form:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Usual State</th>
<th>CAS Number</th>
<th>PIN/UN Number</th>
<th>TDG Class &amp; Division</th>
<th>Threshold Quantity in tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquefied petroleum gases</td>
<td>Liquefied gas</td>
<td>68476-85-7</td>
<td>1075</td>
<td>2.1</td>
<td>100</td>
</tr>
</tbody>
</table>

The presence of sufficient quantities of such substances associated with an industrial activity or other land use justifies an analysis of the risk of accident involving the release of a hazardous substance, an explosion, a fire or other event. The frequency of occurrence of a hazardous release event can be estimated on the basis of process safety data using fault and event tree techniques.

The estimated consequences of a release can be defined as "the chances of an exposed individual suffering a particular effect" (a fatality, an injury, etc.). Individual consequences will vary depending on the location of the receptor (the exposed individual) with respect to the emission or risk source. Factors such as the type and quantity of substance released, the concentration level at particular locations, the duration of exposure, and the type of contact (for example, inhalation, dermal contact, ingestion), determine the severity of the effect that the exposed individual suffers. Substances released into the environment can reach a receptor through a variety of transport media, such as the atmosphere, contaminated soil (dust particles), water, and ground water.

In public safety risk assessments, one must differentiate between individual and societal consequences. The individual consequences concern the chances that an individual exposed to a given hazardous event may suffer a particular effect (a fatality, an injury, etc.). The societal consequences can be estimated by adding up all the individuals suffering that given effect.

MIACC risk assessment guidelines are primarily based on the evaluation of individual risk of fatality only, since the objective is to avoid the death of even a single person in the affected area. Individual risk is the annual frequency at which an individual may be expected to sustain a given level of harm (i.e. death) from the realization of specified hazards.

In the present guidelines, societal risk concerns are also addressed through the specification of allowable population densities in the form of proposed land uses in proximity to industrial activities. The evaluation of societal risk is also appropriate for assessing risk associated with existing facilities or land uses, as discussed in Section 5.4. Such evaluations take into account existing populations at risk and enable the identification of the most critical situations requiring immediate intervention.
Figure 1: Risk contours around a fixed facility

Risk contour (1 in 1,000,000)

Risk contour (1 in 10,000)
The usual form in which individual risk is calculated is the chance of death per year. For example, statistics show that the chance of dying from being hit by lightning are one in 10 million.

Since level of individual risk is closely related to the distance from the potential accident source, the evaluation of a specific situation (whether a planned industrial site, an existing or a proposed plant) consequently generates a series of "risk contours" associated with various levels of individual risk. The distance separating the risk source and each risk contour will evidently vary depending on the characteristics of the source and on any mitigating measures (see Figure 1).

Land use planning can take these risk contours into account by determining what land uses are (or not) appropriate in areas subject to various levels of risk (e.g. a higher level of risk may be acceptable for land uses involving the presence of fewer people than land uses which imply higher population densities). However, in order to propose such land uses, it is first necessary to determine what levels of risk are acceptable.

2.2 Guidelines for acceptable levels of risk

There generally exists a level of risk that is clearly unacceptable, no matter what the level of benefits and costs. On the other hand, certain "de minimis" risks are so insignificant as to not justify concern:

This high, "unacceptable" level of risk together with the "de minimis" level of risk define the "grey area" of safety criteria, where risks may or may not be acceptable depending on the individual situations. In this grey area, risks are "acceptable only if all reasonably practical measures have been taken to reduce risks". "Reasonable" and "practical" depend on the trade-offs between risk and costs and risk and benefits.7

The definition of acceptable levels of risk is difficult and requires considerable efforts to achieve consensus. Like other sensitive land use questions, public information and participation are essential aspects of the process, as discussed subsequently in this document.

The definition of acceptable levels of risk is consequently a political rather than a purely technical exercise. Decision-makers responsible for land use planning must balance the concerns of both the proponents of projects and of those affected by them. The acceptable levels of risk proposed in the present guidelines are intended to serve as a basis for such choices. They apply equally to risk from hazardous substances from all sources: fixed facilities, pipelines or transportation corridors. Before presenting the proposed levels, it is useful to review briefly the European experience in defining acceptable levels of risk.
2.2.1 The European experience

Land Use Controls in the U.K.

In the United Kingdom, the Health and Safety Executive (HSE)\textsuperscript{8} has developed guidelines based on societal risk for evaluating the acceptability of various types of land use near major hazards. For these purposes, HSE developed a classification of land uses based on a number of factors including:

- inherent vulnerability of the exposed population (compare: healthy adults, children, elderly, disabled, etc.);
- proportion of time spent by any individual in the development (compare: home, workplace, shopping, hospital, leisure centre, etc.);
- size, i.e., number of people who might be present;
- whether people are likely to be indoors or out of doors, and, if out of doors, how easily could seek shelter (compare: home, garden centre, football stadium, cinema, office block, etc.);
- ease of evacuation or other emergency measures; and
- construction of buildings (height, materials, ventilation, etc.).

Four categories of land use are defined in the United Kingdom, based on these factors:

- **Category A:** Housing, hotel, or holiday accommodation
- **Category B:** Some workplaces, parking areas, etc. (includes: factories, warehouses, offices, farm buildings, non-retail plants, nurseries, all for less than 100 occupants; and car parks for less than 200 vehicles, etc.)
- **Category C:** Retail, community leisure, etc.
- **Category D:** Highly vulnerable or very large facilities (hospitals, homes for the elderly, schools, etc.)

Using these categories, HSE suggests that development is inadvisable where risk exceeds $10^{-5}$ for categories A and B and $10^{-6}$ for categories C and D.
Risk-Based Land Use Planning Guidelines

Risk Levels in the Netherlands

For the licensing of new activities that fall under the scope of article 5 (major hazard installations) of the Seveso Directive of the European Community and for licensing and siting of LPG installations, the Netherlands government has set acceptable levels of risk which were, in fact, approved by that country's Parliament.

For new major hazard installations the maximum acceptable level for individual risk has been taken as the risk level which increases the risk of death by all other causes with a maximum of one percent. The individual "natural death" risk run by the population group of 10 to 14 year olds, which is $10^{-4}$ per year, has been taken as the basic risk.

The maximum acceptable individual risk has thus been established as 1% of $10^{-4}$, or $10^{-6}$ per year. In other words, the risk of a fatal accident to which an individual is exposed because of his continuous presence (365 days per year) in the neighbourhood of a hazardous activity shall be less than one in a million years. Risk exposure levels of less than $10^{-8}$ per year, or less than one in 100 million years, are considered to be negligible.

2.2.2 MIACC guidelines for acceptable levels of risk in Canada

On the basis of these European standards, and discussions with experts in both Canada and abroad, MIACC has proposed the guidelines for acceptable levels of risk described below. At the outset, it is important to mention four important characteristics of these guidelines.

Firstly, the guidelines are formulated in terms of acceptable land uses in relation to specified levels of individual risk. This approach implicitly provides a guideline for acceptable levels of societal risk without having to resort to the use of complex FN curves (frequency of events vs. number of fatalities) as are used in the Netherlands, or the use of specific numerical values as in the United Kingdom. Furthermore, the present guidelines are universally applicable to both point and linear sources of risk, whereas the Netherlands and United Kingdom guidelines are directly applicable only to point sources and require modification for linear sources.

Secondly, no acceptable levels of societal risk are proposed. Evaluation of societal risk can, however, be useful to establish priorities for intervention, particularly in built-up areas and this approach is described in the MIACC Risk Assessment Guidelines for Municipalities and Industry.

Thirdly, it is recognized that the acceptability of risk can vary from one community to another. Consequently, the proposed levels of acceptable risk are guidelines rather than standards to be respected uniformly across Canada. Communities must adopt their own guidelines which reflect their values. This can best be accomplished through public participation process which includes a discussion of the acceptability of risk, as discussed in section 4.
Figure 2: MIACC Guidelines for Acceptable Levels of Risk

**Annual Individual Risk**
- 100 in a million \((10^{-4})\)
- 10 in a million \((10^{-5})\)
- 1 in a million \((10^{-6})\)

**Risk source**
- No other land use
- Manufacturing, warehouses, open space (parkland, golf courses, etc.)
- Commercial, offices, low-density residential
- All other uses including institutions, high-density residential, etc.

**Allowable Land Uses**
Fourthly, the levels are recommended for use in respect to hazardous substances risk from all sources, i.e., there is no need to distinguish between risk from a fixed facility at which hazardous substances may be found, or a pipeline or a transportation corridor. The acceptability levels are equally applicable.

With these considerations in mind, the guidelines for acceptable levels of risk are as follows (see Figure 2 in which levels associated with a fixed facility are illustrated):

From risk source to 1 in 10,000 \((10^{-4})\) risk contour:
no other land uses except the source facility, pipeline or corridor

1 in 10,000 to 1 in 100,000 \((10^{-4} \text{ to } 10^{-5})\) risk contours:
uses involving continuous access and the presence of limited numbers of people but easy evacuation, e.g., open space (parks, golf courses, conservation areas, trails, excluding recreation facilities such as arenas), warehouses, manufacturing plants

1 in 100,000 to 1 in 1,000,000 \((10^{-5} \text{ to } 10^{-6})\) risk contours:
uses involving continuous access but easy evacuation, e.g., commercial uses, low-density residential areas, offices

Beyond the 1 in 1,000,000 \((10^{-6})\) risk contour:
all other land uses without restriction including institutional uses, high-density residential areas, etc.

It is important to emphasize that these guidelines do not prohibit all activities or structures within the various risk contours, but rather restrict land use within each zone. As is the case for many other land use questions (e.g., flood plains), the contours are used to define special restrictions on land uses. This aspect of the guidelines is particularly important since, as discussed in a subsequent section, land use controls around industrial sites have important legal and economic implications.

The guidelines are thought to be realistic in terms of existing practices of risk management and levels of risk. They are also compatible with criteria that have been selected and implemented in other industries and other countries. In a practical sense, these criteria can only achieve authority if they represent a consensus view of Canadian society. They must not impose unrealistic requirements on industry and should reflect the contemporary standards of the society to which they are applied.
Risk-Based Land Use Planning Guidelines

The inclusion of acceptable levels of public risk in planning decisions is not yet common and it is interesting to note that the 1992 Draft Official Plan for Metropolitan Toronto included a policy on risk but that the final version eliminated such a reference because of anticipated difficulties with implementation. The initial policy read as follows:

\[
\text{to establish 1 per 100,000 (probability of death per year for an exposed population of more than 25 persons) as an acceptable level of public risk upon which appropriate risk reduction measures in land use planning can be developed.}^{10}
\]

Also, in 1991, the City of Toronto decided that "an individual level of risk of 10 in a million (1 per 100,000) is an upper bound of acceptable level of risk while risk levels approaching 100 in a million (1 per 10,000) are totally unacceptable."^{11} This standard applies only to residential development and public facilities in proximity to the main freight line through Toronto. The railways themselves are directly involved in the negotiations concerning use of adjacent land and play an active role in assuring respect of this standard.

These two examples demonstrate the difficulties municipalities can experience with the implementation of guidelines for acceptable levels of risk, particularly in built-up areas.
3. ECONOMIC, LEGAL AND POLITICAL CONSIDERATIONS

Economic considerations

While the European experience demonstrates that the total area of land around industrial sites where land use has been restricted as a result of risk-based land use planning is not considerable, the location and the value of such land does have important economic consequences.

It is generally thought that restrictions on land use around industrial sites are likely to diminish the value of such land. However, a recent study in France concluded that the loss in value is nevertheless less than the costs of improved emergency planning imposed upon industry if development on such lands were permitted. As well, the impact of the land use controls on the value of the land seemed to be less important than the impact of other factors, particularly the low attractiveness of such land for other forms of development (e.g., housing).\(^2\)

A related question concerns the ownership of land within buffer zones. It is reasonable to require that the industry which is the source of a risk acquire and conserve ownership of land within the 1 in 10,000 \((10^{-4})\) risk contour where no other land uses other than the source of risk should be permitted. Such ownership, in combination with the restrictions on land use proposed here, can help to reduce the responsibilities and liabilities of such industries should a major industrial accident occur. Land use regulations with respect to minimum lot sizes, setbacks from property lines and site plan controls can ensure that industrial sites are sufficiently large to include the 1 in 10,000 \((10^{-4})\) risk contour.

On the other hand, industry ownership of lands within the 1 in 10,000 to 1 in 100,000 \((10^{-4} \text{ to } 10^{-5})\) and the 1 in 100,000 to 1 in 1,000,000 \((10^{-5} \text{ to } 10^{-6})\) risk contours may not be necessary or desirable since other land uses can be permitted in these zones. Evidently, property owners in these areas are subject to certain restrictions but, as outlined above, this does not mean that their properties have no value and cannot be used for other purposes.

Legal considerations

As previously mentioned, restriction of land uses around certain industrial activities should not preclude use of such lands. Where such restrictions are based on the public interest, in this case, reduction of the level of risk, the courts have generally upheld the validity of such planning controls and have not required compensation of owners for any reduction in land values subsequent to the adoption of new land use controls.
Risk-Based Land Use Planning Guidelines

A complete prohibition of use of land in proximity to an industrial site without compensation for the owner and in the absence of an adequate assessment of risk could, however, be considered to be illegal by the courts since it is the equivalent of an expropriation without adequate compensation.

It must also be mentioned that, as is the case for other planning questions, the introduction of new regulations cannot generally limit the rights of an owner to continue an activity which was permitted by a previous land use plan or regulatory standards. Such vested rights, sometimes referred to as "grandfathering", exist for any existing land uses and for approved projects which have not yet been completed. As a result, it is unrealistic to attempt to use new land use controls in order to close an existing industrial activity or to prohibit existing land uses on adjacent properties.

New land use restrictions do apply to all vacant lands for which no development projects have yet been approved. Consequently, the owner of undeveloped lands around an industrial site cannot claim to have vested rights allowing, for example, the construction of a residential project if the new land use controls no longer permit such a project. Similarly, new provisions in a land use by-law can limit any increase in the density or intensity of an existing development as well as expansion of building area.

Political considerations

The implementation of land use decisions based on risk assessment has important political considerations for the elected officials responsible for such choices. Where regional or provincial governments have such authority, conflicts with local officials and elected officials may arise since the latter are often faced with direct pressures from citizens, industry and private developers.

In France where the state plays a major role in determining land use within buffer zones around hazardous industries, the consequences for local elected officials are important. Where such decisions are made at the local level, regional or provincial governments may be solicited by citizens or developers unhappy with the decision of their local elected officials:

*It is easy to understand the strong reactions of local elected officials who must balance the catastrophic consequences of events which may or may not occur with the more concrete limitations to their own efforts to develop their municipality. It is a difficult choice, particularly where they have the impression that the decision is not ultimately in their hands.*

[translation].

13
4. PUBLIC INVOLVEMENT

Most planning laws require public participation in land use decisions and this aspect is particularly important when such decisions concern public safety and health. In many cases, the debate can become highly emotional since the perception of the level of risk may be disproportionate to the assessed risk:

*To achieve consensus and to inform the public, the question of language used is particularly difficult but crucial. The concepts associated with technological risk and safety are difficult even for the experts and are difficult to translate in easily understood terms for public debate. The notions of objectives and criteria for risk management are particularly difficult to communicate.*

*Explanations of accident probabilities and determination of acceptable levels of risk are crucial. However, a major effort is required to make such concepts understandable to most decision-makers. Implementation is a costly and time-consuming process which justifies a national effort to establish guidelines.*

*In any event, such risk assessments must be the basis for discussions rather than the sole criteria for choices: any purely technical transformation of risk evaluations into regulatory standards neglects consideration of less quantifiable and more political factors which are nevertheless important. [translation]*

Acceptance by the public, particularly of any new industrial facility, cannot be expected on the basis of risk assessment alone. Public confidence is not gained through the assurances of industry, their consultants, or government that the level of risk is acceptable because the mathematical models prove it conclusively. On the contrary, public acceptance and confidence can only be achieved through public involvement in which risk assessment is just one of the ways the community can assess the overall impact of the project.

In land use decisions related to industries using hazardous substances or development projects in proximity to industrial sites, public involvement programs which go beyond the basic public participation requirements of planning laws may be required. It is not the purpose of this document to propose specific approaches for such programs but it is particularly important that adequate measures are taken to ensure public involvement in the early stages of the decision-making process. Such guidelines for public consultation have however been produced by certain industrial associations, such as the Canadian Petroleum Industry. Where possible, a public discussion of guidelines for acceptable levels of risk should take place prior to any discussion of modifications to land use plans or controls or approval of specific projects.
Associated with the question of public involvement is that of the public's "right to know", that is, the right to have sufficient information concerning projects which may have impacts on safety, health and the environment. In the United States, the 1986 Superfund Amendment and Reauthorization Act included the Emergency Planning and Community Right-to-Know Act (EPCRA):

There are three essential layers of information created under the law, and each serves a different purpose. The most specific and voluminous layer is information generated from material safety data sheets (MSDS), which industrial employers were first required to complete under the 1970 Occupational Safety and Health Act. EPCRA expanded the use of MSDSs to require their submission to local emergency planning committees and state emergency response commissions. An MSDS lists a specific hazardous substance that a facility is handling and details its known health impacts, physical properties, and appropriate protective measures...

Firms must also file toxic chemical release forms, the basis for the EPA's Toxic Release Inventory (TRI), a categorization of each firm's estimated release of regulated toxic substances into the air, land, and water. The TRI, despite flaws in its accuracy and limits to its usefulness for comparing data, has become a popular informational tool among grass-roots and national environmental groups. It has afforded them access to information about the operations of specific companies in a way that never existed prior to the passage of Community Right-to-Know.16

Experience has shown that the positions of the various actors can rapidly become polarized in a debate concerning a specific project. In some cases, opposition to an industrial project or to the development of lands close to an industrial site may be focused on the objective of "zero risk" and on the "cost of saving a life". Other actors may insist on job creation and on economic development:

Opposition between the creation of wealth and risk, safety and risk, vulnerability and adaptation are consequently permanent characteristics which determine the structure of urban areas. In the face of economic imperatives, concern with risk constitutes another force which shapes urbanization. Thus a hazardous industry is both a source of wealth and of risk for the city. It is not surprising that employment and the safety of persons and property are the major issues of debate within the community.17
5. RISK-BASED PLANNING FOR FIXED FACILITIES: OFFICIAL PLANS, REGULATIONS AND EVALUATION PROCEDURES

5.1 Fixed standards vs. ad hoc risk assessment

Ideally, quantitative risk assessment for fixed facilities (industries, warehouses, commercial uses etc.) as proposed in the MIACC guidelines for municipalities and industry should be used for all three types of planning and control instruments (official plans, standards and regulations, impact assessments). However, this approach can require separate evaluations for each situation, rather than pre-established standards.

In France and in the Netherlands, where case by case risk assessments are required to determine the perimeter of irreversible impacts and the perimeter of 1% fatalities, it is interesting to compare in Table 1 the average and median minimum separation distances which result. These results are based on a sample of 54 installations in France and all 54 installations in the Netherlands and cover a range of hazardous substances. This comparison is also interesting since similar results were obtained using different methodologies for risk evaluation.\textsuperscript{18}

<table>
<thead>
<tr>
<th></th>
<th>Perimeter of irreversible impacts</th>
<th>Perimeter of 1% fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>France:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average</td>
<td>781 m</td>
<td>464 m</td>
</tr>
<tr>
<td>median</td>
<td>700-750 m</td>
<td>300-350 m</td>
</tr>
<tr>
<td><strong>Netherlands:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>average</td>
<td>987 m</td>
<td>498 m</td>
</tr>
<tr>
<td>median</td>
<td>750-800 m</td>
<td>350-400 m</td>
</tr>
</tbody>
</table>

An illustration of the MIACC method for risk calculation for a fixed facility which uses, produces or stores anhydrous ammonia in quantities equivalent to the MIACC List 1 threshold quantities provided the results described in Table 2.\textsuperscript{19}
While such specific risk assessments are inevitable for major projects, it may be possible to define in advance standards, including minimum separation distances for buffer zones, for certain categories of industrial uses. The MIACC *Hazardous Substances Risk Assessment: A Mini-Guide for Municipalities and Industry* uses such an approach to define recommended minimum separation distances for 200 common chemicals in quantities typically found in industrial or commercial sites.

Such fixed standards must nevertheless be based on risk assessments for typical industrial facilities in order to assure a sound basis for their determination. As for other examples of land use conflicts (e.g. aggregate extraction quarries vs. residential uses), standards are often criticized and planners may have difficulty in explaining and justifying them.

Another approach combines both fixed standards and ad hoc risk assessment. Thus a general standard can be established for minimum separation distances between various land uses but a reduction of this distance may be accepted on the basis of an ad hoc risk assessment. This approach has been used in Strathcona County in Alberta where the General Municipal Plan and Land Use By-law established a separation distance of 3 km between existing heavy industry and future residential development unless otherwise it is determined through an environmental impact assessment that a lesser distance is warranted, in no case less than 1.5 km.20

5.2 Land use planning and control for new industrial activities

5.2.1 Land use classifications for industry

Land use choices for new industrial activities should take into account the different levels of risk associated with various categories of industrial uses. Where municipalities use conventional planning and zoning techniques to identify land uses permitted or prohibited by zone, it may be useful to separate higher risk industries from both other industries and other land uses1. The

1 The reader should note the distinction between high risk and high hazard - high risk indicating that a hazardous site has a significant likelihood of a hazardous event occurring, a high hazard site such as one storing toxic gases may in fact be a low risk site due to very significant risk management procedures being in place, thus representing a very low event frequency.
creation of industrial parks for these uses may contribute to adequate site planning and more effective emergency planning.

Care must be taken, however, to avoid creating potentially more hazardous situations as a result of the domino effect of "knock-on" events involving multiple high-risk industries within the same area. The use of adequate buffer zones within such industrial parks is particularly important and the use of site specific risk assessments is desirable.

To assist planning authorities in improving their industrial land use classification within plans and zoning by-laws, the following typology of industry is suggested, based on examples using MIACC risk assessment guidelines:

- **Type 1:** industries presenting no major risks;
- **Type 2:** industries presenting some risk (e.g. producers or users of benzene, ammonia, vinyl chloride);
- **Type 3:** industries presenting moderate risk (e.g. producers or users of hydrogen chloride, liquefied petroleum gas, or gasoline);
- **Type 4:** industries presenting high risk (e.g. producers or users of chlorine or ethylene oxide).

For planning purposes, this typology based on risk should be included in the definition of industry classes in zoning by-laws. This classification must be based not only on safety considerations but also on concerns with environmental impacts and nuisances (noise, glare, odour, traffic and visual impact).

For example, the Strathcona County Land Use bylaw previously referred to defines three classes of industry:

**General Industrial Type I** means those developments where activities and uses are primarily carried on within an enclosed building and no significant nuisance factor is created or apparent outside an enclosed building. Any development, even though fully enclosed, where, in the opinion of a Development Officer, there is significant risk of interfering with the safety and amenity of adjacent sites because of the nature of the site, materials or processes, shall not be considered a General Industrial Type I.

**General Industrial Type II** means those developments in which all or a portion of the activities and uses are carried on outdoors, without any significant nuisance factor such as noise, appearance, or odour, extending beyond the boundaries of the site. Any development where the risk of interfering with the safety and amenity...
of adjacent or nearby sites, because of the nature of the site, materials or processes, shall not be considered a General Industrial Type II.

**General Industrial Type III** means those developments which may have a significant detrimental effect on the safety, use, amenity, or enjoyment of adjacent or nearby sites due to appearance, noise, odour, emission of contaminants, fire or explosive hazards, or hazardous goods.

As far as new industrial uses are concerned, the Strathcona County General Municipal Plan establishes the following "heavy industrial buffer":

*Future petroleum refineries, major petro-chemical plants, and other heavy industrial uses, which have or could have a significant detrimental effect on the safety, use, amenity, or enjoyment of adjacent or nearby sites due to appearance, noise, odour, emission of contaminants, fire or explosive hazards, or dangerous goods, shall be a minimum distance of three (3) kilometres from existing and future residential sites unless an environment impact study demonstrates to the County's satisfaction that a lesser separation is warranted. The separation distance shall be measured from the nearest boundary of the residential area to the nearest building or structure which is part of such industrial use. When designating land, the distance shall be measured to the boundary of the property on which such industrial uses may be permitted.*

*No future heavy industrial use shall be located less than one and one-half (1.5) kilometres from any lands designated for residential use.*

**5.2.2 Performance zoning for industry**

Where a performance zoning approach is used, it is not necessary to specify which industries are permitted in various parts of a municipality:

*The central concept behind industrial performance standards is that, so long as industrial enterprises can operate in a fashion that avoids the creation of various enumerated nuisances, they should be free to locate anywhere within an industrial zone. Common sense, of course, tells us that this will always be more difficult for some businesses than for others. But the idea behind performance standards is to offer firms the flexibility of achieving compliance with those standards in the best way they see fit, thus allowing even the "dirtiest" industries to demonstrate their creativity in redesigning their operations to meet the standards.*

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The implementation of this approach requires the inclusion in land use controls of performance standards dealing with those aspects of plant design and site planning which may influence the level of risk associated with a new or expanded industrial activity. In the United States, performance standards with respect to fire and explosive hazards and toxic and hazardous substances have been developed in some municipalities.

These performance standards generally concern:

- fire equipment required on site
- types of structures and containers within which hazardous substances are stored;
- location within the site of such structures and containers;
- nature and quantity of permitted substances.

Since the emphasis of the present document is on land use planning and control in proximity to hazardous industry, the guidelines do not deal specifically with performance standards for industry. For more information on this subject, the reader should consult the previously cited American Planning Association Planning Advisory Service Report Number 444 entitled Industrial Performance Standards for a New Century. As well, it may be useful to refer to the lists of hazardous substances in the MIACC guidelines on hazardous substances risk assessment.

In addition to planning and zoning tools, site selection studies or impact assessments for new industries or plant expansions should also include a risk assessment based on MIACC guidelines. Similarly, analyses of modifications to official plans or zoning by-laws necessary in order to permit such projects should include an assessment of risk. The screening approach based on the presence of listed hazardous substances described in Risk Assessment Guidelines for Municipalities and Industry can assist municipalities in identifying potential land use conflicts.

5.2.3 Information requirements

Use of this approach does however require adequate information concerning the substances used or present within an industrial site or other land use. In more simple cases, use of the Mini-Guide by staff of the approving authority (e.g. municipal planners) may be sufficient. However, in more complex situations, the risk assessment should be carried out by specialists.

In the case of impact assessment procedures, the initiator of the project may be required to complete such analyses. Nevertheless, to appreciate the value of such analyses, the approving authority must have its own expertise. Municipalities which use performance standards in their land use controls can also require industrial developers to produce risk assessments. Alternatively, the municipality may itself complete the risk analyses based on the information provided by the industry.
Figure 3: Fixed Standards for Transition Zones in Strathcona County, Alberta
5.3 Land use planning and control for land uses in proximity to industrial activities

As has repeatedly been stated, concern with land use planning and control must not be limited to the industrial site but must extend to the surrounding area. This concern is, in fact, the "mirror image" of the approach for new industrial activities described above.

Consequently, official plans and zoning by-laws should use risk assessment to identify areas around existing high-risk industries (or sites where such industries are permitted) where certain restrictions on land use may be appropriate. It may be useful to identify specifically in official plans the location of such industries. As previously mentioned, this approach is used in Quebec where a recent modification to the planning law provides for the identification in regional plans of such activities, including high-risk industries.

On the basis of the MIACC guidelines for acceptable levels of risk described in section 2.2.2, appropriate land uses within each contour can be defined (see Figure 2). This definition may take the form of a list of permitted or prohibited uses or, where legislation permits discretionary uses, of those uses which may be permitted subject to evaluation and approval. Identification of restrictions on land use may also take the form of "overlay zoning" which adds more restrictive provisions to existing zoning by-laws.

As discussed previously, either fixed or performance standards may be used. Where fixed standards have been adopted, a developer who wishes to build a residential project adjacent to a high-risk industrial site must respect the minimum separation distances determined by the municipality or other approving authority.

Where performance standards are used, the developer must demonstrate that his project will respect the guidelines of acceptable levels of risk adopted by the approving authority (e.g. the MIACC guidelines in the present document). This demonstration may require a quantitative risk assessment for which it will be necessary to obtain sufficient information on the nature of the existing industrial activity.

An example of such restrictions on land use around an industrial area can be found in the Strathcona County Land Use By-law. This planning tool uses overlay zoning around hazardous sites to restrict land uses within two "transition zones", the first (TZ-1) within a distance of 1.5 km of a hazardous industry, and the second (TZ-2) in the area located between 1.5 km and 3 km. of such a site (see Figure 3).
In Transition Zone 1, among the uses which are prohibited are the following: all residential, schools, recreation, child care, health services, hotels, eating and drinking establishments, etc. As well, certain restrictions are placed on height, maximum floor area ratio, and maximum size of permitted uses. Finally, discretionary uses must be evaluated taking into account ease of evacuation and protection to occupants in case of a major industrial accident.

In Transition Zone 2, all residential and medical facilities are prohibited but other land uses may be allowed through the discretionary land use development permit application procedure.

This approach consequently combines a fixed standard for minimum separation distances (1.5 and 3 km) with a performance standard approach for determining the acceptability of various land discretionary land uses. Such an evaluation could be based on the MIACC guidelines for acceptable risk.

5.4 Land use planning and control in built-up areas

Municipalities or other public authorities may also choose to complete risk assessments around existing industrial activities in order to identify priorities for intervention to reduce risk. Such an assessment can be part of a "hazard analysis" for emergency planning purposes to determine the vulnerability of a geographical area to a hazardous substances release (see for example, the original MIACC document on industry emergency planning now published by the CSA as a national standard Emergency Planning for Industry, CAN/CSA - Z731 - M94.

As previously mentioned, changes are frequent in industrial processes, types of production and substances used. As a result, levels of risk may change over time and a continuous monitoring process is important. Changes in land uses in proximity to industry may also occur, and do not necessarily require zoning amendments. Modification of these land uses must also be monitored since they may influence the number of people within the risk contours around an existing industry.

Where risk assessment associated with existing industries reveals unacceptable levels of risk, it may be possible to reduce the risk at the source through modification of production techniques, improved emergency planning and public information. Risk reduction may also include actions within the area surrounding the industry (e.g. improved access and evacuation procedures). In certain situations, relocation of either the source of risk or of the affected populations may be justified but the costs associated with such interventions are usually prohibitive.

The OECD Guiding Principles cited previously include the following guideline concerning existing hazardous installations:
C.9 Where a specific area with existing hazardous installations may not be able to meet current guidelines for land-use planning in the short-term, measures should be taken to alleviate the risks in the longer term, for example, by modifying the installations or by phasing out older installations and/or residential buildings near the site. Such a phase-out may involve the need for compensation to property owners.\textsuperscript{23}

With respect to land use around existing industrial activities, it is interesting to describe briefly the implementation of the "Seveso Directive" in the European Community. The directive requires certain industries to provide competent local authorities with a quantitative risk analysis indicating both individual and societal risk caused by the plant.

In the Netherlands, such evaluations have been completed and facilities which do not meet acceptable risk levels have been identified. Certain facilities which do not meet the maximum acceptable level of risk have been closed. Evidently, the Dutch government justifies this approach due to the extreme restrictions on available space in the Netherlands as well as the high density of population and the concentration of the chemical industry in that country.

The evaluations completed indicate that the total area inside the $10^{-5}$ contour represents 10 km$^2$, inside the $10^{-6}$ contour 60 km$^2$, inside the $10^{-7}$ contour 140 km$^2$ and inside the $10^{-8}$ contour 270 km$^2$, out of a total land area of the Netherlands of 40,000 km$^2$. Houses are situated inside the $10^{-5}$ contour around two facilities and therefore constitute an immediate problem. For eight other facilities residential areas are situated inside the $10^{-6}$ contour and therefore constitute a problem for further new development.\textsuperscript{24}

In France, the implementation of the Seveso Directive led to the identification of some 300 hazardous installations, mostly in major industrial regions:

\textit{A detailed classification of these installations reveals that the dimensions of buffer zones around these facilities where land use is restricted range from 100 to 1,000 m and that the total area concerned is some 90 km$^2$. It is important to underline that all activities are not prohibited on these lands. While housing is not allowed, limited industrial activities as well as agriculture are permitted. [translation]\textsuperscript{25}
6. CONCLUSIONS AND RECOMMENDATIONS

The present document has attempted to demonstrate that risk assessment can and should be an integral part of land use planning and control in Canada. While there is an increasing awareness of the usefulness of this approach as part of a more general effort in risk management, the manner in which risk assessment can be included in official plans, standards and regulations and impact assessment procedures has not always been clear.

It is hoped that the description of risk assessment will provide planning officials with a better understanding of the technical aspects of risk assessment and with a sound basis for including risk assessment in land use planning and control. As well, the description of the fundamentals of land use planning and control should provide industry and public authorities in other sectors with a better understanding of these two tools and their relevance to risk minimization.

The guidelines for acceptable risk are particularly important in this respect and should serve as a starting point for discussions in each province and each community. Defining acceptable levels of risk and standards for industrial development and land use in proximity to industrial sites and pipelines must be done locally on the basis of consensus between industry, government and citizens. In this respect, the inclusion of risk assessment in land use planning and control has important social and political dimensions and is not simply a technical exercise:

Too many conflicts are based on the search for a "magic number" separating the zones around a hazardous industry where no new construction should be permitted and that where no restrictions on development are necessary.

However, the question is not so much as to determine whether development should be limited within 200 or 1,000 m of an existing plant but rather how this zone can be developed...

As a result, it is quite reasonable to discover that for situations of comparable risk, the approach to land use planning and control may vary from one municipality to another. [translation]²⁶

Industry must also recognize that considerations of "what happens beyond the fence line" are as important as efforts to reduce risk within the plant or to prepare for adequate emergency response. For industries whose activities touch more than one municipality it is important to recognize that acceptable levels of risk may vary from one jurisdiction to another.

The European experience in this respect is encouraging. In France, for example, in the three years following the adoption of specific dispositions concerning risk in the planning act, considerable
progress has been accomplished:

Control of development around hazardous industries is no longer in the experimental stage. The majority of the analyses have been completed. Specific measures to evaluate risk have been defined and discussions between the various actors involved are well underway...Perhaps most important is the change which has occurred within industry itself. It is now unusual to find companies who are willing to make major investments in a plant without the assurance that development around the site is adequately planned. Today, to accept new housing, or other activities open to the public in close proximity to an existing hazardous installation is to condemn any future industrial development within the site and to pave the road to an eventual relocation or closure of the industry itself. 

[translation]27

On the basis of these conclusions, it is felt that the approach described in the present document for risk-based land use planning can contribute to reducing exposure to unacceptable levels of risk. However, to attain this objective, risk assessment must become an integral part of land use planning and control, and this requires a co-ordinated effort of industry and all levels of government. Consequently, it is recommended that:

- the provincial governments review existing planning legislation, regulations and guidelines with a view to including more specific powers concerning risk assessment;

- provincial and municipal governments require risk assessments as part of their land use planning and control tools;

- the proposed guidelines for acceptable levels of risk be used as a starting point for public discussion of such levels with a view to their inclusion by provincial and local governments in official plans, standards and regulations and impact assessment procedures; and

- industry representatives work with provincial and local governments to favour the inclusion of risk assessment in land use planning and control at all levels.
REFERENCES


3. Ibid.


5. P. Hubert et P. Blancher, op.cit., p. 7.

6. This section is based on a presentation on August 17, 1992 to MIACC Working Group 5 by Dr. Ertugrul Alp, BOVAR-CONCORD Environmental Corporation.


14. Ibid., p. 32.


23. OECD, *op.cit.*, p. 49.


