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Indicators for Assessing the Quantitative Effects of External Safety Policy

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The fireworks disaster at the Dutch city of Enschede in the year 2000 has stimulated activities in the area of external safety at the national, regional and local level in the Netherlands. New legislation was developed, and adequately implementing this new legislation as well as increasing the quality of carrying out existing legislation became an important issue. This concerned in particular the provinces and municipalities, being the competent authorities for environmental regulation, and also the so-called safety regions as the competent authorities for disaster and fire brigade regulation. In order to facilitate the necessary activities at the regional and local level, the national government has provided the provinces with substantial resources since 2004, which were to be spent through provincial programs and distributed over all parties involved on the basis of well-defined projects. Over the years, indicators have been developed for assessing the effectiveness of these programs at regional and local level (IPO, 2009). The indicators in question, however, are focused primarily on the *processes* of implementing legislation, as opposed to being focused on *actual safety*.
Although there were some parallel activities which concentrated on actual safety, by the National Institute for Public Health and the Environment (RIVM) for the Ministry of the Environment and by a number of individual provinces for their own purposes, a structured and nationally agreed-upon set of indicators for assessing the quantitative effects of external safety policy was lacking. The RIVM was willing to coordinate a joint effort in order to develop such a set of indicators, but was faced with a lack of sufficient resources to actually carry it out. Subsequently, the Interprovincial working group on external safety took initiative and established a small project team for addressing this task.
The paper discusses the development process and describes its results. It starts with summarizing Dutch external safety policy (section 1). The process of developing a structured set of indicators is discussed in section 2. Next, section 3 presents a summary description of the resulting set of indicators (version 1), after which some indicative calculations, which were performed by way of example, are presented in section 4. Concluding remarks are given in section 5.

1. Dutch external safety policy

Dutch safety legislation is organized along three different perspectives: safety at work, external safety, and fire safety. Each of these areas has its own competent authority, and each of the competent authorities has its own set of tasks and responsibilities. External safety, or safety outside industrial establishments, is regulated through spatial planning and environmental legislation. It belongs to the domain of local and regional authorities (municipalities and provinces). The system is built around permission for a spatial development and the environmental license.
Specific external safety criteria are laid down in dedicated legislation: the External safety of establishments decree (Dutch abbreviation: Bevi), the External safety of transportation routes decree (Bevt), and the External safety of pipelines decree (Bevb). These criteria relate to location-based, or individual, risk and societal risk.

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1.1 Location-based risk

Bevi states as the general protection level of the public that the probability of being killed in the vicinity of an establishment by an on-site accident involving hazardous materials must be smaller than 10^{-6} per year. This so-called location-based risk must be calculated by means of a quantitative risk analysis (QRA). If the limit value is exceeded at the location of a vulnerable object (houses, schools, shopping malls, etc.), the risk must be reduced by additional safety measures (in case of a licensing procedure) or the spatial development is not permitted (in case of a spatial planning procedure). Location-based risk is presented on maps through risk contours. Generally, 10^{-7} and 10^{-8} contours are included in addition to the 10^{-6} contour (see Figure 1 for an example). The 10^{-7} and 10^{-8} contours are of interest for giving an impression of the risks outside the 10^{-6} contour – the latter may be small, whereas at the same time the 10^{-8} contour may be large. In that case, population in a large area has to be taken into account for the societal risk calculation. A similar approach as in Bevi is adopted in Bevt and Bevb.

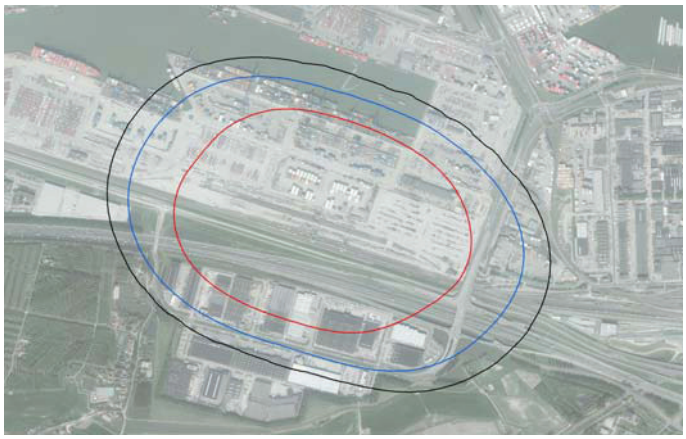

Figure 1: Location-based risk contours (10^{-6}, 10^{-7} and 10^{-8})

1.2 Societal risk

Societal risk is important for taking into account the degree of societal disruption as a result of an on-site or transportation accident involving hazardous materials. In contrast with location-based risk, a guide value has been defined instead of a strict standard. Societal risk in a given situation (licensing procedure, spatial planning development) has to be justified always, but particularly in two cases: when it increases or when the guide value is exceeded. This justification has to deal with the magnitude of the societal risk, the possibilities for emergency preparedness and response by the safety region, and other relevant aspects, such as economic interests and the availability of alternatives. A typical societal risk curve and the guide value are presented in Figure 2.

2. Developing a structured set of indicators

The project team which was established by the Interprovincial working group on external safety consisted of representatives from DCMR Environmental Protection Agency and the provinces of Noord-Brabant and Zuid-Holland. Beforehand, no formal project plan was prepared – it was expected that a limited number of meetings would suffice, particularly given the fact that various indicators had been developed already and were used in practice. This turned out to be too optimistic after distributing an intermediate result for comments and discussion. In hindsight, three phases can be distinguished: initial development, further development, and completion.

2.1 Initial development

The project started with collecting indicators that were already being applied by the RIVM for the Ministry of the Environment and by a number of individual provinces for their own purposes (RIVM, 2010; province of Zeeland, 2010; province of Zuid-Holland, 2010). These were divided into two categories: establishments and transportation. Within each category, a distinction was made between mandatory indicators from a legal point of view and indicators that were additional to those derived from legal obligations and could be considered to be policy-oriented. Thus, two tables were constructed: one for establishments and one for transportation, with “mandatory” and “policy-oriented” as additional distinction.

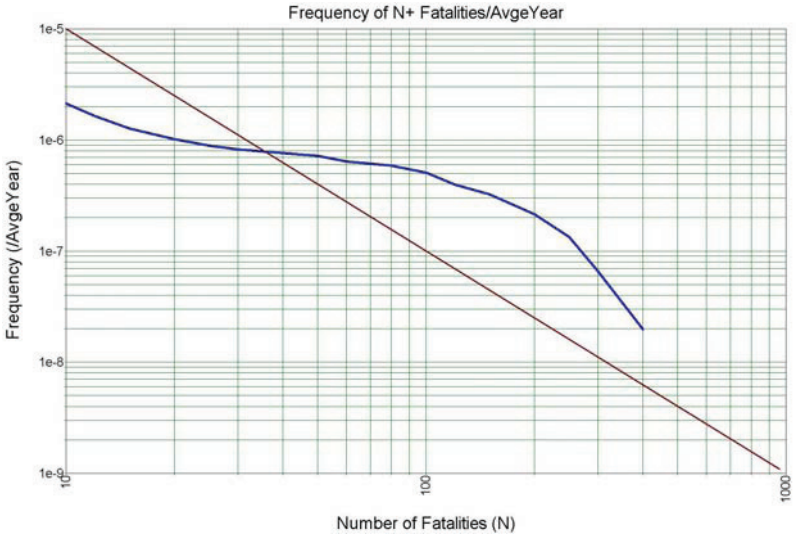

Figure 2: Societal risk curve (typical result and guide value)

A careful look at these two tables showed that a lot of similarities existed, although with differences in formulation. Insofar as the indicators in question were considered to fall within the scope of the project, a best formulation was chosen for each of these. Some indicators were considered not to be relevant and were deleted from the tables: outside the scope, for example when dealing with implementation processes, or not useful in terms of policy making, such as the number of Seveso establishments in a province. Additional indicators were derived from a brainstorm session by the project team, for which some preliminary ideas of DCMR served as input. As a result, there were still two tables with indicators. These contained for each indicator: its meaning, the policy objective which could be associated with it, the information required for it to be determined, and any relevant notes. This intermediate result was discussed with the interprovincial working group and with the RIVM. Key comments were:

- Why limit to Bevi establishments? Other risky establishments exist and should be incorporated, such as those which are regulated through fixed distances and airports.
- For transportation, a distinction should be made between pipelines and road-rail-water transportation. Also, these indicators should be discussed with external safety transportation experts because of some specific aspects in forthcoming transportation legislation (despite similarities in approach as regards risk criteria).
- For each indicator: add the governmental level for which it may be of interest (municipality, province, ministry).

2.2 Further development

All comments were listed in a document, to serve as input for discussion by the project team. This discussion resulted in a subsequent document which contained the reaction of the project team on every single comment and which was distributed as feedback to all those who had submitted comments. Next, it took various sessions to discuss and address all comments which had been accepted by the project team. Particularly, adding more types of establishments turned out to be a time-consuming activity – originally, there was one table for establishments, but three tables had to be added: one for establishments which are regulated through safety distances, one for wind turbines, and one for airports. All this led to the second intermediate result which was once again discussed with the interprovincial working group and with the RIVM. Remaining comments were in particular focused on the importance of explaining the rationale behind certain choices, and also emphasized the value of adding some example calculations for a number of selected indicators.

2.3 Completion

Eventually, a final draft was prepared and presented, although mainly as a formal step to adequately finish the process. This led to minor comments which were mostly concerned with the introduction to the set of tables. Moreover, the need was emphasized for a follow-up project which would result in a user manual, including a more extensive set of illustrative examples, and which would also deliver a communication plan in order to stimulate implementation. Next, version 1 was prepared and distributed (Interprovincial working group on external safety, 2013).

3. Results

The resulting set of indicators for assessing the quantitative effects of external safety policy consists of six tables, four for establishments and two for transportation, with a distinction between mandatory and policy-oriented indicators within each table:

- Establishments
  - Bevi establishments.
  - Establishments which are regulated through safety distances.
  - Wind turbines.
  - Airports.
- Transportation
  - Road, rail and water transportation.
  - Transportation by pipeline.

For each indicator, the tables contain: its meaning, the associated policy objective, the information required for it to be determined, and any relevant notes (see Table 1). In total, around 40 indicators have been defined. By way of illustration, some typical indicators are as follows:

- Total area of 10^{-6} contours minus integrated area of 10^{-6} contours, for a region with an intended concentration of establishments. A large value of this indicator means that the various establishments are located closely to each other. The associated policy objective is: to minimize the area which is taken by risky establishments and to minimize transportation distances.
- Population within 10^{-6} to 10^{-7} contours and within 10^{-7} to 10^{-8} contours. This indicator is a degree for external zoning. The associated policy objective is: to stimulate external zoning.
- Population in very vulnerable objects, such as hospitals, within 10^{-7} contours. This indicator is a degree for undesirable situations which are legally allowed to exist but which one would rather get rid of. The associated policy objective is: to provide more protection to people that are more vulnerable.

Table 1: Layout of the indicator tables

Indicator	Meaning	Associated policy objective	Required information; how to determine?	Notes
E.B-1	…	…	…	…
E.B-2	…	…	…	…
…	…	…	…	…

4. Some indicative calculations

Results of applying the indicators in real monitoring cannot be presented yet, since they have just been developed. Thus, in order to illustrate their meaningfulness, some indicative calculations were performed for the Rotterdam-Rijnmond region. This is the region between Rotterdam and the North Sea, which is not only the most densely populated region in the Netherlands, with more than 1 million people living within an area of less than 800 km^2, but also heavily industrialized. Many chemical and petrochemical plants, power plants, and storage and transshipment companies are located in this region, and among these there are a substantial number of Seveso sites. Despite the tendency to concentrate industrial activities in designated subregions, large distances between these subregions and populated areas are not always possible.

The calculations concerned a couple of indicators which are related with the 10^{-6} and 10^{-8} contours, for two different industrial subregions in the Rotterdam-Rijnmond region. The focus was on total and integrated area of contours, with also some attention for population and very vulnerable objects. There are around 30 establishments in subregion 1, located relatively close to each other, and seven establishments in subregion 2, more spread out. Results are presented in Figures 3 to 6. The following observations can be made from Figures 3 and 4:

- For subregion 1, the differences between total and integrated area of 10^{-6} as well as 10^{-8} contours are large. This means much overlap of contours, as can also be seen in Figure 3, and a high degree of concentration of establishments.
- For subregion 2, the difference between total and integrated area of 10^{-6} contours is small. This means little overlap of contours, as can also be seen in Figure 4. The difference between the two 10^{-8} areas is significantly smaller in comparison with subregion 1 (relatively spoken). There is room for adding new establishments, whereby the objective should be to keep the integrated area the same.

(a) Total area 10^{-6} contours: 2020 ha

(b) Integrated area 10^{-6} contours: 1390 ha

(c) Total area 10^{-8} contours: 11420 ha

(d) Integrated area 10^{-8} contours: 3570 ha

Figure 3: Separate and integrated 10^{-6} and 10^{-8} contours (industrial subregion 1)

(a) Total area 10^{-6} contours: 560 ha

(b) Integrated area 10^{-6} contours: 500 ha

(c) Total area 10^{-8} contours: 3130 ha

(d) Integrated area 10^{-8} contours: 2260 ha

Figure 4: Separate and integrated 10^{-6} and 10^{-8} contours (industrial subregion 2)

The indicators which are related with the 10^{-6} and 10^{-8} contours may be applied for establishing new industrial activities within existing subregions. First of all, integrated areas should be as small as possible. This is the primary criterion, intended to minimize the area which is taken by risky establishments (10^{-6}) and to minimize the number of people exposed to risky industrial activities (10^{-8}). Next, the differences between total and integrated areas are a measure for the degree to which the primary criterion is realized. If these differences are large, then the objectives are achieved. When they are small, then internal zoning is not ideal and room exists for further development: new risky establishments may be added while still complying with the primary criterion.

Figure 5: Integrated 10^{-6} & 10^{-8} contours, and residential areas (industrial subregion 1)

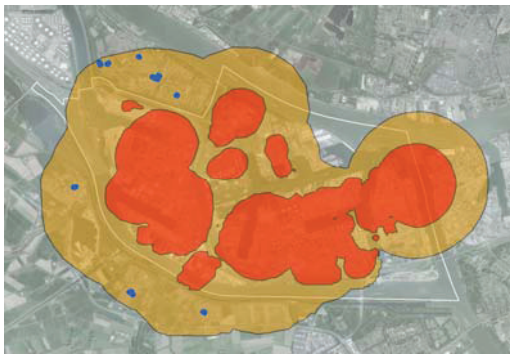

Figure 6: Integrated 10^{-6} & 10^{-8} contours, and very vulnerable objects (industrial subregion 1)

Figures 5 and 6 show residential areas and very vulnerable objects (dark areas and spots respectively, inside 10^{-8} but outside 10^{-6} contours), for subregion 1. Population is around 14,000 inhabitants, whereas the number of very vulnerable objects is 10, with around 300 inhabitants. The 10^{-7} contours are not yet available, and these are required in order to monitor external zoning as well as the undesirable, albeit legally allowed presence of very vulnerable objects. In this particular case, they will be available in the not too distant future (although it is certainly clear from Figure 6 that a number of the very vulnerable objects are located far away from the 10^{-6} contours). More generally, it is anticipated that defining policy objectives and assessing the degree to which these are realized by monitoring the associated indicators may stimulate initiatives to gather the necessary information.

5. Conclusion

Evidently, the set of indicators which resulted from the exercise carried out by the project team is highly influenced by the various elements of Dutch external safety policy. Since the result is also written in Dutch, it may seem to be of limited value outside the Netherlands. However, the description of the process to achieve this result is hoped to be of wider value, and also the perspective adopted by the project team. Whereas the traditional approach to monitoring is: monitoring follows policy, and as a consequence indicators are derived from existing policy, the approach taken here has not only been received as ambitious but also as new and innovative in comparison with the traditional approach: from safety to indicators to policy objectives. This paper is hoped to stimulate the development of quantitative external safety indicators in other countries, using the particular national external safety policy and associated safety criteria as starting point to develop indicators which may be applied in practice in order to support government initiatives towards higher levels of safety.

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