Transportation of Dangerous Goods Policy and Evaluation Framework

Cam Nelson, MEDes, City of Calgary
Anne Cataford, P.Eng., City of Calgary
Pansy Hwang, P.Eng., Morrison Hershfield Limited

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ABSTRACT

The City of Calgary initiated a study to develop 2 products:

- A policy outlining guidelines and principles for the selection of dangerous goods routes, and
- An evaluation tool to be used in assessing dangerous goods routes

A stakeholder group was formed for the study and included representation from:

- The City of Calgary:
- The Alberta Motor Transport Association (AMTA)
- Alberta Infrastructure and Transportation (AIT)
- The Centre for Transportation and Engineering Planning (C-TEP)
- The University of Calgary (Geography and Civil Departments)

A literature review was undertaken that included investigation of the practices of other jurisdictions and included; Ottawa, Hamilton, Saskatoon, Vancouver, and Edmonton. The salient point from this investigation was that there was no quantitative or explicit/repeatable procedure in place to conduct a review of dangerous goods routes. Nor was there policy in place to guide City Administration on how dangerous goods routes are to be reviewed and evaluated. Most jurisdictions approach dangerous goods route selection based on the expertise of City Administration and/or industry experts.

Based in part upon the literature review and the practices of the surveyed jurisdictions, the stakeholder group developed a list of evaluation criteria that considered: risk management, social implications, environmental impact, and economic considerations in determining whether routes should be designated as dangerous goods routes.

After finalizing the evaluation matrix a policy was drafted to identify the process for evaluating dangerous goods routes and included such items as how the matrix was to be used, who was to be involved, how often were reviews to be undertaken and how it was to be included in planning for new routes/communities.

The documentation was finalized and approved by City of Calgary Council in January 2006. The City is now evaluating all existing and future dangerous goods routes to ensure that all of the appropriate routes have been identified. The Bylaw will be subsequently updated in accordance with the policy and the evaluation criteria to account for any required changes.

BACKGROUND

The City of Calgary first established dangerous-goods routes in 1979. At that time a multidisciplinary committee was created to select and manage Calgary's Dangerous Goods Truck Routes (DGR). The selected routes were defined in City of Calgary Bylaw 13M2004, Transportation of Dangerous Goods (1).

The City of Calgary recognized that there was a need to re-evaluate the existing Dangerous Goods Route (DGR) network to account for recent and future expansion of the road network and changes to dangerous goods handling legislation. Additionally, the

City of Calgary needed to ensure a cohesive and integrated approach between land development and the transportation network. The review would also assist the City in responding to requests from the public and politicians to eliminate roadway designations allowing for the transport of dangerous goods and would provide a consistent, comprehensive procedure to ensure viability and integration between the land use planning, and transportation network processes. As a result, the City initiated a study to develop 2 products:

- A policy outlining guidelines and principles for the selection of dangerous goods routes, and
- An evaluation tool to be used in assessing dangerous goods routes.

STUDY PROCESS

The first step in the development of the policy was a literature review. The literature review included surveys of various jurisdictions across Canada. The jurisdictions selected were; Ottawa, Hamilton, Saskatoon, Edmonton, Vancouver, in addition to an evaluation of the current City of Calgary practices. In addition, existing literature and documents related to the transport of dangerous goods were evaluated.

One of the studies evaluated was the Alberta Transportation Urban Goods Movement Project, Phase I: Inventory of Municipal Bylaws and Urban Goods Movement Studies (2). This document focused primarily on the importance of urban goods movement, recommended uniform signage across jurisdictions, and the establishment of a provincial urban goods movement council. The report was similar to one conducted by iTrans Consulting, Goods Movement in Central Ontario: Trends and Issues (3) and the City of Hamilton Development of Policy Papers for Phase Two of the Transportation Master Plan for the City of Hamilton Goods Movement Policy Paper (4). All three of these reports however, did not specifically address the transport of dangerous goods.

The guiding documents included direction from Council and the Dangerous Goods Route Selection Criteria Report (5) that the City and the Centre for Transportation Engineering and Planning (C-TEP) partnered in. The report was prepared in 2003 by Hamilton Finn and Associates. Hamilton Finn conducted an exhaustive literature review at the time of the report preparation and developed a DGR Framework that could be used in the evaluation of routes for their acceptability as DGR's. Their primary goals were to develop evaluation criteria that included crash frequency and crash severity. Morrison Hershfield Ltd. reviewed the findings of this report and reviewed the literature referenced in the report as part of their research for this study.

In addition phone interviews were held with the cities of Hamilton, Saskatoon, Vancouver and Edmonton to determine what other tools and methods were being used across Canada for the selection of DGR's. A standard list of questions was prepared and reviewed with all interview participants. The questions focused on current 'formalized' policies, processes, and evaluation frameworks used for the designation of dangerous goods transport. Additionally, the survey looked at the effectiveness of current networks, enforcement activity and future actions, in this area, for the purposes of designating dangerous goods routes.

The next step was to establish a group of stakeholders to assist in the development of the framework and policy. They included representation from:

- City of Calgary:
    - Roads Business Unit;
    - Transportation Planning Business Unit;
    - Land Use Planning Business Unit
    - Animal and By-Law Services Business Unit
    - Calgary Police Service;
    - Calgary Fire Department
- Alberta Motor Transport Association (AMTA)
- Alberta Infrastructure and Transportation (AIT)
- Centre for Transportation and Engineering Planning (C-TEP)
- University of Calgary (Geography and Civil Departments)

The stakeholder group developed a list of evaluation criteria that considered: risk management, social implications, environmental impact, and economic considerations in determining whether routes should be designated as dangerous goods routes.

The proposed evaluation matrix was tested using a sample of road segments to determine its sensitivity and to ensure that repeatable, accurate results could be achieved. The roadways were reviewed and evaluated and a risk matrix was employed to determine whether a roadway was suitable for inclusion as a dangerous goods route. The City's GIS database was used as a tool to summarize data for the evaluation criteria for population density, employment density and land use.

After finalizing the evaluation matrix a policy was drafted to identify the process for evaluating dangerous goods routes and included such items as how the matrix was to be used, who was to be involved, how often were reviews to be undertaken and how it was to be included in planning for new routes/communities.

The documentation was finalized and approved by City of Calgary Council in January 2006. The City is now evaluating all existing and future dangerous goods routes to ensure that all of the appropriate routes have been identified. The Bylaw will be subsequently updated in accordance with the policy and the evaluation criteria to account for any required changes.

LAND USE PLANNING AND TRANSPORTATION PLANNING INTEGRATION

Planning is an important step in developing a cost-effective network for dangerous goods. The design of future routes and the upgrading of the existing roadways to allow safe transportation of dangerous goods is a valuable step in ensuring the network meets current and future safety expectations. Use of the policy in the initial planning would determine if a new roadway should be considered for inclusion in the dangerous goods network and, if so, what design features should be incorporated to ensure an acceptable risk level.

The Transportation Department is responsible for incorporating dangerous goods policy into the planning of new routes. The Department monitors the planned infrastructure projects and notifies the Dangerous Goods committee if there needs to be a review of existing routes before the five year timeframe as a result of anticipated projects (i.e. completion of new freeway links).

The Planning, Development and Assessment Department, is responsible for considering the guiding principles that resulted from the Truck Route Policy Framework when drafting transportation related sections for the new Municipal Development Plan (MDP). The implementation would then occur through the detailed local area planning processes. For example, the skeletal road network and truck routing would be considered in the preparation of Regional Policy Plans.

At this planning level, consideration of broader truck route and related network planning issues (truck route contiguity, employment and residential area connections etc.) would be evaluated. At the more detailed planning policy levels (i.e. area structure plans, community plans, area redevelopment plans and then subdivision/outline plan) more localized impacts of truck route planning and abutting land use issues (i.e. appropriate land uses, separation distances and buffers) would be considered.

MANAGING RISKS

Given that the transportation of dangerous goods is a federally and provincially regulated activity, and generally, the movement of these goods is facilitated through a Bylaw process, the determination of new routes becomes one of 'risk management'. At the City of Calgary, risk management has recently been incorporated as a Council-approved policy, and as such has been incorporated into the TDG policy and evaluation protocols.

Risk management is an essential component of good traffic engineering and planning process. The use of risk management tools provides the following benefits:

- Better decisions are made when supported by a systematic approach to risk management.
- Risk management becomes integrated into existing long term strategic and business planning as well as informed decision-making in the day to-day management of activities.
- Risk management is applied to the development and implementation of policy, programs, plans and future directions
- The integration of risk management provides a corporate philosophy and culture that encourages everyone to manage risks proactively and to communicate openly about risk.

The City of Calgary has an approved Integrated Risk Management (IRM) Policy (6). The Policy notes that the City of Calgary will strive to manage risks in compliance with:

- Legislated requirements;
- City of Calgary values;
- the IRM policy;

- Tools, techniques and processes approved by senior management (i.e. technical requirements and/or standards imposed upon practitioners by their regulatory bodies; and
- That risks be assigned to the person best able to manage the risk.

Under Integrated Risk Management Policy (6), all employees are required to actively attempt to identify and manage risks under their control so as to reduce the likelihood of risks occurring. If an employee does not have control over the occurrence of a risk, the employee will implement strategies to reduce the impact of the risk if it does occur.

All risks are to be managed using the Integrated Risk Management Framework approved by Council. The steps in this Framework include:

- Assessing internal and external factors affecting risk,
- Assessing and clarifying corporate objectives,
- Identifying risks,
- Analyzing and evaluating risks,
- Accepting or mitigating risks,
- Monitoring and reporting on risks,
- Communicating risks and mitigation strategies to Council, Committee and senior management

The Integrated Risk Management Procedures provide details on these steps and these have been implicitly incorporated into the DGR evaluation process. Risk management, as a strategy, is an ongoing, iterative process and the risk mitigation strategies should be re-assessed at regular intervals. The legislated requirement of a TDG review at least every five years serves as a step in the IR Framework. The TDG evaluation criteria provides the tool to fulfill that requirement. This follows the City of Calgary process for managing risk, and provides a consistent methodology, for identifying, analyzing, monitoring, communicating and reporting on risks.

DANGEROUS GOODS ROUTE EVALUATION PROCESS

Selection and maintenance of a dangerous goods route (DGR) is an exercise in risk management. The process of evaluating a DGR was used to manage the inherent risk of transporting dangerous goods (DG). The Definition of various dangerous goods is defined in **Table 1**. The following steps were identified and used to evaluate existing and alternative DGR's in the City of Calgary.

Dangerous goods are defined by the Federal Transportation of Dangerous Goods Act, 2002 (TDGA) (7). There are 9 classes of dangerous goods that are regulated by this act based on the Canutec Emergency Response Guide (8). **Table 1** identifies examples of materials in each class and the required evacuation range.

Step 1: Choosing a Route

The first step in identifying which routes to evaluate is to determine the necessity of that route. A subjective evaluation, set up in a Go/No Go format, was used to accomplish this. **Table 2** lists the criteria for choosing a route in order of priority. If there is a firm "No Go" to a majority of the first set of criteria, there is no need to continue the evaluation of that particular route. If, however, there is a "Go" or "Evaluate" for the majority of the criteria, then the route should be evaluated further as a DG candidate route.

There are six criteria that the evaluation is based on.

1. Route purpose;
2. Part of truck route network;
3. Available alternative routes;
4. Network completion;
5. Route length; and
6. Coverage.

The Route Purpose identifies whether the route serves dangerous goods focal points. DG focal points can be defined as areas that concentrate the shipments of dangerous goods and include truck route entrances into the City of Calgary, industrial parks that deal with large DG quantities, and major DG distribution points. The Provincial Highway system into the City limits provides a starting point and the first focal points to be considered. These include Highway 1 East and West, Highway 2 (Queen Elizabeth 2) North and South, Highway 22X Southeast and Southwest, and Highway 8 West. Only areas that service vehicles that are regulated by the TDGA requiring placards are considered in this process. Small quantities of DG, such as delivery vehicles to small stores are not considered.

If a route is not part of the existing or proposed Truck Route System, it is not evaluated. It is recognized that roadways that are part of the truck route system meet certain standards for roadway classification, geometry and access control, which are also a requirement for DG vehicles.

If there are more favorable Alternative Routes to choose from, there is no need to provide additional routes. This criterion eliminates the possibility of having routes that serve the same purpose and focal points, eliminating redundancy in the DGR network.

The proposed route must serve to connect the DGR network. Network Completion negates the possibility of having dead end routes that do not serve to connect the DG network grid. Evaluating Route Length optimizes the travel time for DG shippers, and is essential to reducing costs for transport, as well as the exposure to risk for surrounding communities. Sufficient Coverage of the focal points within the City must be provided to reduce the need for DG shippers to travel off the DG network.

This process enables the evaluator to quickly assess the route for acceptance as a candidate route and determine how it fits within the DGR network.

Step 2: Evaluating a Route

As stated earlier, an evaluation of dangerous goods routes is an exercise in risk management. The management of such risks is accomplished through a risk analysis that is as objective as possible. In order to assure that the risk analysis is objective, criteria must be selected that are quantitative, ensuring that the results are repeatable if performed in a similar manner.

The selection of the risk analysis criteria were also based on the availability of data. Criteria were chosen where the data could be readily attained with no labor-intensive process. In the future, when Information Technology Systems (ITS) advance and the collection and processing of large amounts of data are available, the criteria could be changed to more accurately assess and reflect these new advances.

This process for evaluating dangerous goods routes is a tool that is provided to experts and stakeholders of dangerous goods who are knowledgeable in the area of their field and appropriately chosen in order to objectively evaluate the criteria.

Risk analysis is comprised of mainly two components: probability or likelihood of a risk occurring, and the consequences or impact of that incident if it occurs.

The Likelihood criteria are as follows:

- Road Classification
- Road Geometry
- Access Control
- At-Grade Railway Crossings
- Road Surface Condition
- Traffic Volumes
- V/C Ratio
- Truck Frequency
- Collision Statistics

The Impact criteria are as follows:

- Population Density
- Land Use
- Population Responsiveness
- Environmental Impact
- Drainage
- Emergency Response
- Speed Limits

Although the various criteria may be interdependent, they have been separated for rating purposes to simplify the rating process. Each of the Likelihood and Impact criteria are given a risk rating between the ranges of 0 to 100. A score of ‘0’ reflects a negligible risk and a score of ‘100’ translates to an extreme risk.

The rating is based on a Bell Curve formula as shown in **Table 3**.

The Bell Curve Mean Score is used within a particular risk ranking unless there is sufficient information to warrant a deviation from the mean. This system allows the rating to be mostly similar, except when there is a specific condition where the evaluator may use his/her judgment to provide another risk rating within the range provided.

The Route Risk Rating for Likelihood and Impact factors are presented in **Tables 4** and **5**, respectively, and are briefly summarized below.

Likelihood

The Likelihood of a route to provide safe passageway for dangerous goods movements is generally based on the overall design and maintenance of the roadway. In addition, the likelihood of collisions with other vehicles and rail sharing the route is taken into consideration.

Factors used to determine the Likelihood risks are as follows:

Road Classification is used in most jurisdictions to provide an overall grouping of the type of roadways on the network, and their suitability to handle large truck traffic. The City of Calgary Design Guidelines for Subdivision Servicing (9) outlines lane widths, shoulder widths, raised medians, unimpeded traffic flow, minimum intersection spacing, etc. for certain classifications of roadways, and was used to determine the acceptable roadway types for DG trucks. Freeways, expressways, major roadways, and industrial streets were considered acceptable road classifications because of their acceptable design for use as truck routes.

Road Geometry considers vertical and horizontal alignment elements of the roadway to determine the ability of the driver to safely maneuver along the roadway. Horizontal elements include stopping sight distance and radius of curvature. Vertical elements include road grade, K-values, and percentage of super-elevation. City of Calgary Guidelines (9), Alberta Infrastructure and Transportation Highway Geometric Design Guide (10), and Transportation Association of Canada (TAC) manual (11) can be used.

Access Control is based on the number and type of intersection controls located along the route. There are usually four types of intersection control: free flow, signalized, stop/yield and uncontrolled. The safest access controls include interchanges where there are no conflict of vehicles movements, and signalized intersections, where movements are regulated by traffic signals. Stop/yield and uncontrolled conditions pose a greater risk of collisions because judgment is left to the driver.

At-Grade Railway Crossings pose a high collision risk due to the nature of the stopping distance required by a locomotive. In order to control this risk factor, the sight distance of a DG truck must be optimized. For example, a high-speed at-grade crossing with passive crossbuck rail signage would be considered an extremely high risk. A slow-speed crossing with active flashing rail signals and gates would be considered a low risk.

Road Surface Condition is measured using the pavement quality index (PQI), which is a combination of a visual inspection number (VIN) and pavement structure. PQI is a rating between 0 and 10, with 10 indicating a newly finished surface, and 1 indicating a surface overdue for upgrades. The PQI provides a quantitative number to assess the risk posed by the road surface condition.

Traffic Volumes is defined by the Annual Average Daily Traffic (AADT) of the roadway. AADT provides a quantitative measure of the daily traffic movements along a roadway, which can indicate the amount of congestion on a route or the inherent risk of incidents on a route.

Truck Frequency describes the total number of trucks on the road segment compared to the total traffic.

V/C Ratio or volume to capacity ratio gives a good indication of congestion or capacity of an intersection. Increased congestion can directly increase the number of vehicles that can safely use the roadway, and therefore increase the risk to DG vehicles becoming involved in a collision or incident.

Collision Statistics provide a quantitative and historical measure of the risks of a particular route or intersection, and validates the actual conditions of the roadway. Collision statistics are presented as the average number of collisions of a given sector per year divided by the total length in kilometers of that sector.

Impact

In order to measure and compare the impact of a DG incident on various routes, a definition of an area of influence is required. Evacuation distances are recommended in the Canutec Emergency Response Guide (5) for risks presented by different chemicals. They generally fall within the ranges of 800m or 1600m. An initial evaluation distance of 800m was decided upon by the stakeholder group as a reasonable area of influence. This area realistically covers the majority of the dangerous goods that are transported, while maintaining an area of influence that is not so large that the routes become homogeneous in criteria characteristics. For example, if an area of influence of 1600m was used to define land use criterion, there would be an over-exaggerated risk rating because there would be very few areas with no residential land uses.

Factors used to define the Impact risk factors are as follows:

Population Density was determined by using employment population and residential population data. Data was obtained from the City of Calgary Land Information and Mapping Business Unit, which manage the City's geographic data and infrastructure information. Using shape files, the data was manipulated and presented in graphs with Geographic Information Systems (GIS). An example of the mapping produced for this analysis is presented in **Figure 1** for residential population density. Since it is impossible to determine when a DG incident may occur during the day or night, it was determined that the worst-case scenario should be evaluated for any subject area.

Land Use files defined by transportation zones were obtained from the City of Calgary. Land use plays a major part in defining the impact of a DG incident. Areas of high residential land uses score high in the risk matrix, while areas with industrial land uses score low. The predominant land use within the 800m area of influence was used to rate the route, with consideration given to other identified uses in the area.

Population Responsiveness indicates the ability of persons to evacuate an area quickly and efficiently. Files were obtained with locations of schools and hospitals, and the location of large-scale periodic gatherings such as stadium sporting events were identified. If an area of influence of 800m along a route required the evacuation of five or more such facilities it was considered an extreme risk while less than one was negligible.

Environmental Impact rating was based on whether or not a route was adjacent to nearby waterways, parks or sensitive habitats that could be overly affected by a DG spill.

Drainage criterion provides the ability to confine or control the spread or release of dangerous goods as defined by the type of storm drainage or ditch control.

Emergency Response data was provided by the Calgary Fire Department on the response times of fire stations to calls throughout the City. Since the fire department is usually the first on the scene to assess the severity of a DG incident, their ability to provide suitable intervention based on response times was used in the risk rating.

Speed Limit was used to define the impact of a DG incident because increased speed will govern the severity of an incident and increase the amount of dangerous goods that could be released.

Once the rating is completed for each of the criteria, the scores are totaled for Likelihood and Impact and the final scores are graphed in a Risk Matrix. The risk matrix is marked with a maximum risk tolerance line. Any score that falls above this line must undergo some form of mitigation before being accepted as a DG route. Any routes that fall below this risk matrix line can be considered as a suitable candidate to be included in the DGR network.

Alternate Routes

Using the same risk evaluation methodology as for permanent routes, alternate routes can be chosen for emergency or construction situations where it may be necessary to close dangerous goods routes for a period of time. Given the duration for use of the alternate route a higher risk tolerance may be acceptable. Alternate routes may have been identified as acceptable as part of the route evaluation but, because of the risk rating, not included in the primary network. These routes would be primary considerations for emergency bypass. If routes through a neighbourhood are rated as having too great a risk for transportation of dangerous goods under normal conditions, the risk may be reduced by the addition of restrictions such as time restraints or types of chemicals transported. If the risk remains high it may be necessary for the operators to take a longer route for delivery, but this option must be weighed against the risk that the additional length of route generates.

Step 3: Mitigation of Risk

Mitigation of risk must involve a balance between the safety of citizens and the environment with the financial implications of providing that safety. After a route has been evaluated using the Risk Matrix in Step 2, and it has been found to be above the risk tolerance line, it must undergo some kind of mitigation to be accepted as a dangerous goods route. The decision to mitigate a route and the extent to which improvements will be made upon the route in order to bring the risk matrix score below the risk tolerance line will depend upon the necessity of the route, as determined in Step 1 of the evaluation.

In general, mitigation should start in the Likelihood category because the criteria are much less complicated to manipulate and improve. For example, the criteria of road geometry, access control, road surface condition and v/c ratio can be improved with proper maintenance, addition of traffic signals or widening of a roadway. Conversely, changing the land use, population density or responsiveness by moving a hospital along a route, for example, is much less attainable.

Additional mitigation measures can be taken by using time and material restrictions. However, enforcement of such restrictions is costly to both governing authorities and individual carriers by reducing their efficiency, so their use should be minimized. Another possible method of temporary mitigation may include notification of the appropriate DG authority within the City to set up an escort for a dangerous goods shipment.

An example of mitigation measures used in the evaluation a DG route in Calgary is presented in **Tables 6** and **7**. The subject segment is 16th Avenue Central between Sarcee Trail and Deerfoot Trail. Prior to mitigation, the route risk evaluation resulted in a risk matrix score that was above the risk tolerance line (Likelihood score of 43.3 and an Impact score of 63.6). Portions of this route are under construction between 2006 - 2008 to widen the existing 4-lane undivided roadway to a 6-lane divided major roadway. These improvements were accounted for in the mitigation scores presented in the following table. The Likelihood scores for Road Geometry and Road Surface Conditions dropped because of the impending improvements, resulting in an overall Likelihood score of 35.0. Without changing any of the Impact criteria, these improvements were sufficient to bring the overall risk matrix score below the risk tolerance line, and therefore, present 16th Avenue Central as an acceptable DG route.

Step 4: Reviewing Routes

In accordance with the Dangerous Goods Transportation and Handling Act (9), (10), municipalities must conduct a full review of their Dangerous Goods Truck Routes every five years. At this 5-year review, the stakeholder group should conduct a full review of the route criteria and risk levels to determine the validity of the existing DGR network, conduct a comprehensive risk rating based on this policy, and review additional routes that have been added to the road network since the last formal review.

Construction of a major route or significant changes to existing City Dangerous Goods routes should trigger a review of the dangerous goods network. Determining the need for an interim review will be the responsibility of the Roads Business Unit.

SUMMARY

The City of Calgary recognized that as the transportation network expanded, as land development proceeded, and as stakeholder involvement increased, a mechanism was required to ensure continued TDG viability. Further, legislation changes mandated reviews of the TDG network regularly. The combination of these factors therefore necessitated the development of a consistent, technically robust protocol, in addition to a policy that could ensure long-term sustainability of a TDG network. The policy developed at the City of Calgary creates an administrative framework, ensuring the departments responsible for decision-making affecting the TDG network, consider impacts. Further, the framework establishes a stakeholder advisory committee to ensure the needs of industry, emergency services, community aesthetics, and the viability of a transportation network are maintained. Finally, the framework has created the technical criteria that provide for a transparent, repeatable, and defendable analysis to ensure the needs of the community at large are provided for.

Figure 1 – Dangerous Goods Route Evaluation Process

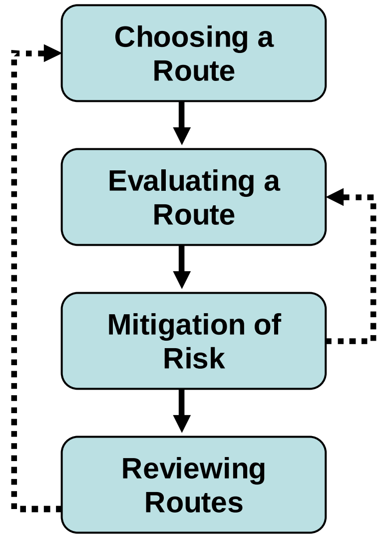


Table 1 – Dangerous Goods Classes

CLASS #	CLASS NAME	EVACUATION RANGE	MATERIAL EXAMPLES
1	Explosives 1.1 Mass explosion 1.2 Projectile explosion 1.3 Fire hazard explosion 1.4 Blast explosion 1.5 Limited blast hazard 1.6 Insensitive detonating	800 – 1600 m	Bombs ammunition Incendiaries Mercaptotetrazol
2	Gases 2.1 Flammable Gases 2.2 Compressed gases 2.3 Inhalation toxic gases	800 – 1600 m 100 – 800 m 800 – 1600 m	Acetylene, trifluoroethane Argon, nitrogen Ammonia
3	Flammable Liquids	300 – 800 m	Dichloroethane Bromobutane
4.	Flammable Solids 4.1 Flammable solids 4.2 Spontaneous combustible 4.3 Dangerous when wet	100 – 800 m	Butyl Trinitroxylene Phosphorus Barium
5.	Oxidizers 5.1 Oxidizers 5.2 Organic Peroxides	100 – 800 m 250 – 800 m	Permanganate Organic Peroxide
6	Toxic/Infectious 6.1 Toxic materials 6.2 Infectious substances	100 – 800 m	Barium Cyanide 2814, 2900
7.	Radioactive	100 – 300 m	Uranium, Thorium
8.	Corrosive	900 – 1600 m	Acetyl iodide, Sulphuric acid
9	Miscellaneous	25 – 500 m	Asbestos

Table 2 – Choosing a Route

CRITERIA	No Go	Evaluate	Go
Route Purpose	Route serves no focal points	Route serves some focal points	Route serves many focal points
Part of Truck Route	No	Could be	Yes
Alternatives	Better routes to choose from	Limited alternate routes	No alternative routes available
Network completion	Dead end route	Limited value in grid completion	Improves the network grid by joining one or more existing routes
Route Length	No distance reduction over existing routes	Limited improvement to travel distance	Significantly shortens normal travel distance
Coverage	No reduction in trips off the DG network	Marginally decreases trips off the DG network	Significantly reduces trips off the DG network
Decision	Reject	Evaluate	Rate

Table 3 – Risk Rating Scores

Risk Ranking	Bell Curve Mean Score	Range
Negligible	**5** (±5)	0 – 10
Low	**20** (±10)	11 – 30
Moderate	**50** (±20)	31 – 70
High	**80** (±10)	71 – 90
Extreme	**95** (±5)	91 – 100

Table 4 – Route Risk Rating

CRITERIA	**Negligible** 0 – **5** - 10	**Low** 11 – **20** - 30	**Moderate** 31 – **50** - 70	**High** 71 – **80** - 90	**Extreme** 91 – **95** - 100
Likelihood or Frequency Factors					
Road Classification	Freeways or Expressways	Major Street (Divided) or Industrial Major Street (Undivided)	Industrial Street	(Primary) Collector or Local Major Street	Residential Streets
Road Geometry	Desirable alignment elements	> Specified minimum or maximum alignment elements	Specified minimum or maximum alignment elements	Substandard alignment elements	Seriously substandard alignment elements
Access Control	Intersection control devices for all	Intersection control devices for most	Mixture of controlled/ uncontrolled access	Limited access control	Uncontrolled intersections
At-Grade Rail Crossing	Low speed crossing with flashing signals	Moderate speed crossing with	Moderate speed crossing with	Moderate speed crossing with	High speed crossing with passive

	and active gates	flashing signals and active gates	flashing signals or active gates	passive crossbuck	crossbuck
Road Surface Condition PQI	> 8	7 – 8	4 - 6	2 – 3	< 2
Traffic Volumes (Daily)	Less than 10,000	10,000 – 30,000	30,000 – 45,000	45,000 – 90,000	Over 90,000
Truck Frequency (% of traffic)	<5%	5 – 9%	10 – 15%	16 – 20%	> 20%
V/C Ratio	< 0.5	0.5 – 0.7	0.7 - 0.9	0.9 - 1.2	> 1.20
Collision Statistics (Collisions/kilometre/year)	< 2	2 – 7.4	7.5 - 35	36 – 75	> 75

Table 5 – Route Risk Rating

CRITERIA	**Negligible** 0 – **5** - 10	**Low** 11 – **20** - 30	**Moderate** 31 – **50** - 70	**High** 71 – **80** - 90	**Extreme** 91 – **95** - 100
Impact / Severity					
Population density (sq km)	< 500	500 – 1,250	1,250 – 2,600	2,600 – 4,500	> 4,500
Land Usage	Wide corridor of undeveloped lands	Narrow corridor of undeveloped lands	Industrial	Commercial	Residential
Population Responsiveness	No assembly/institutional within impact area	Very limited (1) assembly/institutional within an impact area	Limited (2-3) Assembly/institutional within impact area	Multiple (3-4) Assembly/institutional within impact area	Numerous (>4) Assembly/institutional within impact area
Environmental Impact	Topography prevents migration of spill from site	Route not adjacent to waterways	Route with slopes to nearby waterways	Route adjacent to waterways, parks	Route crossing sensitive habitats
Drainage	Curbs with no open drainage	Curbs with storm sewers having controlled outfall	Curbs with storm sewers	Open ditches with minimum slope	Open ditches on steep slopes
Emergency response	Fire Station response < 3 min	Fire Station response 3 - 4 min	Fire Station response 4 - 7 min	Fire Station response 7 - 8 min	Fire Station response > 8 min
Speed Limits	Under 30 kph	30 - 50 kph	50 - 80 kph	80 - 100 kph	Over 100 kph

Figure 2 – Sample GIS output for Population Density

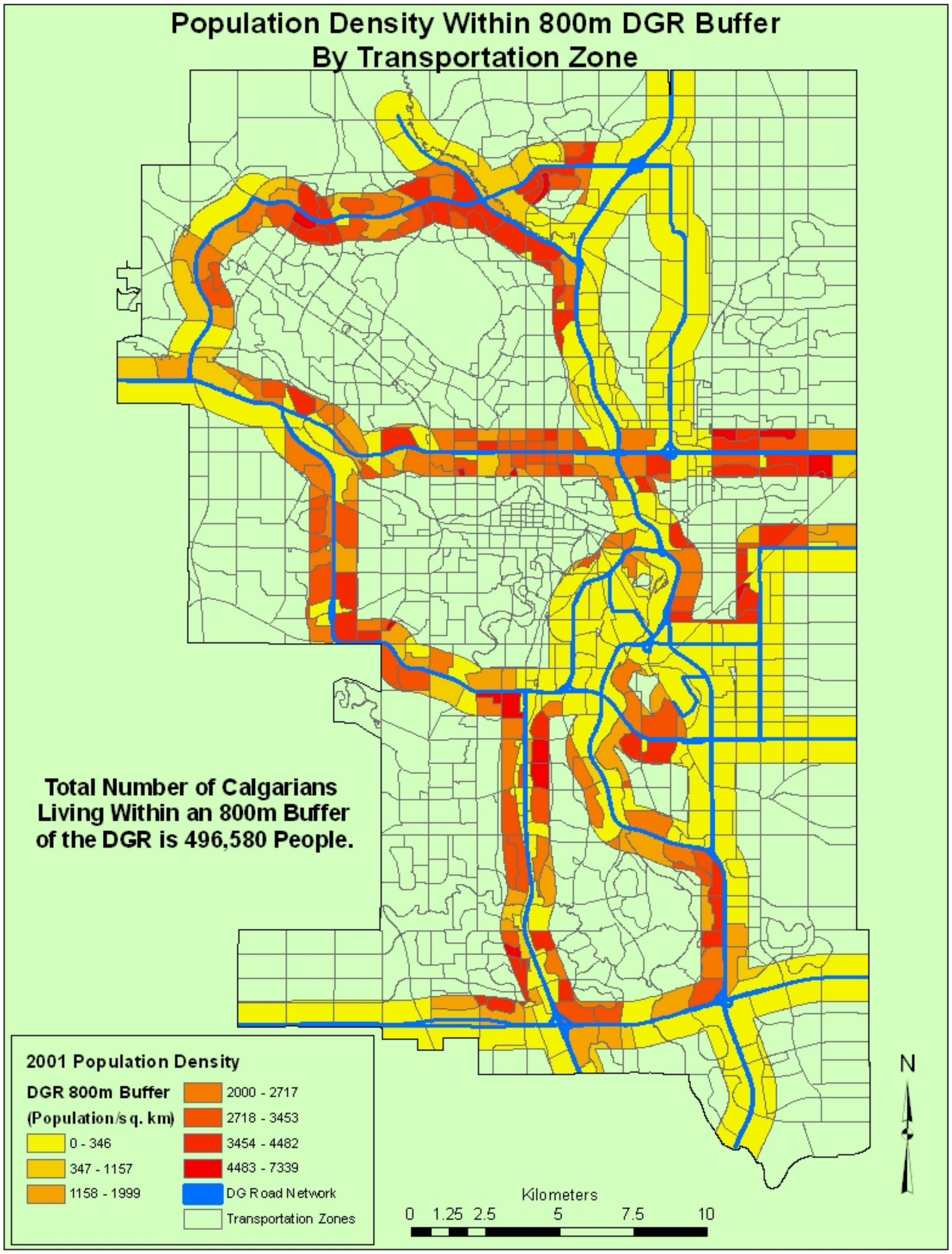


Table 6 – Risk Matrix example (before mitigation)

	Length: 6.4 kilometres	16th Avenue Central	(Sarcee to Deerfoot)			
	CRITERIA	RATING	RANKING	WEIGHT	SCORE	COMMENT
	Likelihood					
1	Road Classification	20	Low	1	20	
2	Road Geometry	50	Moderate	1	50	
3	Access Control	20	Low	1	20	
4	At-grade rail crossing	0	Negligible	1	0	No crossings
5	Road surface conditions	55	Moderate	1	55	4,5 (2004)
6	Traffic Volumes	75	High	1	75	53000
7	V/C Ratio	60	Moderate	1	60	0.85
8	Truck Frequency	15	Low	1	15	6%
9	Collision statistics	95	Extreme	1	95	102.7
	Total	43.3		1.000	43.3	
	Impact					
1	Population Density	90	High	1	90	
2	Land Use	95	Extreme	1	95	
3	Population Responsiveness	95	Extreme	1	95	
4	Environmental Impact	20	Low	1	20	
5	Drainage	50	Moderate	1	50	
6	Emergency Response	45	Moderate	1	45	6.3
9	Speed Limits	50	Moderate	1	50	Speed Limit 50
10						
	Total	63.6		1.0	63.6	

Figure 3 – Risk Matrix Before Mitigation

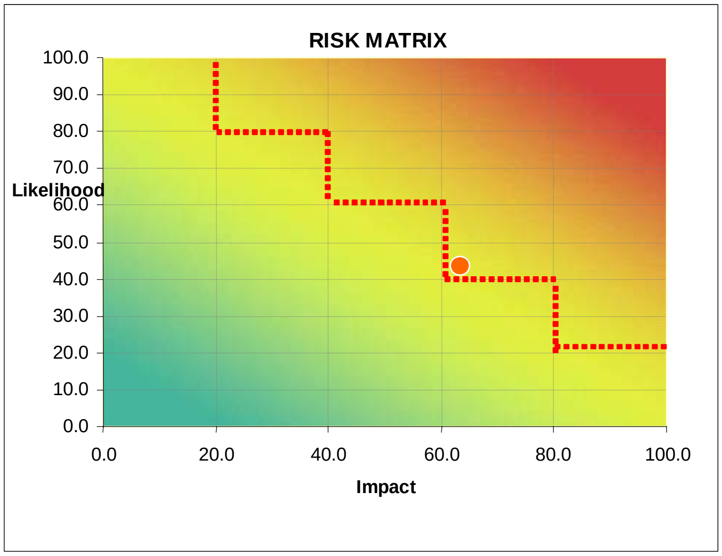
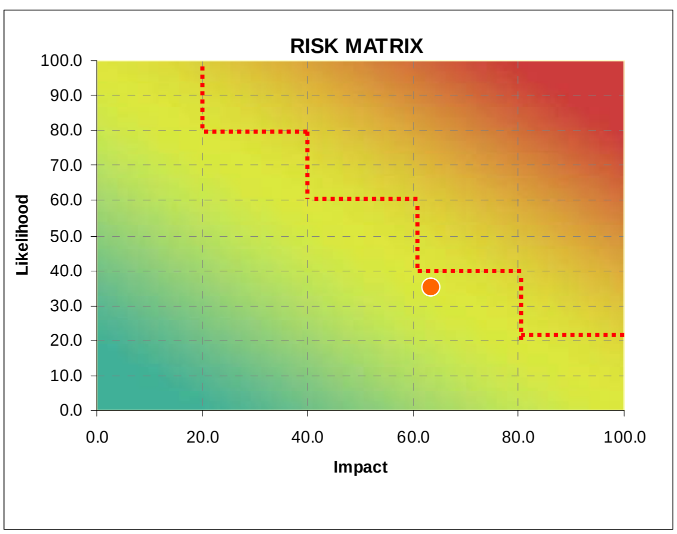


Table 7 – Risk Matrix Example (after mitigation)

	Length: 6.4 kilometres	16th Avenue Central (Sarcee to Deerfoot)				
	CRITERIA	RATING	RANKING	WEIGHT	SCORE	COMMENT
	Likelihood					
1	Road Classification	20	Low	1	20	
2	Road Geometry	**20**	Low	1	20	**Reduced lane widths**
3	Access Control	20	Low	1	20	
4	At-grade rail crossing	0	Negligible	1	0	No crossings
5	Road surface conditions	**5**	Negligible	1	5	**New pavement**
6	Traffic Volumes	**80**	High	1	80	**65000**
7	V/C Ratio	60	Moderate	1	60	0.85
8	Truck Frequency	15	Low	1	15	6%
9	Collision statistics	95	Extreme	1	95	102.7
	Total	35.0		1.000	35.0	
	Impact					
1	Population Density	90	High	1	90	
2	Land Use	95	Extreme	1	95	
3	Population Responsiveness	95	Extreme	1	95	
4	Environmental Impact	20	Low	1	20	
5	Drainage	50	Moderate	1	50	
6	Emergency Response	45	Moderate	1	45	6.3
9	Speed Limits	50	Moderate	1	50	Speed Limit 50
10						
	Total	63.6		1.0	63.6	

Figure 4 – Risk Matrix After Mitigation



REFERENCES

1. City of Calgary Bylaw 13M2004, Transportation of Dangerous Goods
2. Alberta Transportation Urban Goods Movement Project, Phase I: Inventory of Municipal Bylaws and Urban Goods Movement Studies
3. iTrans Consulting, Goods Movement in Central Ontario: Trends and Issues
4. Dangerous Goods Route Selection Criteria, Hamilton-Finn Consultants, December 2003
5. City of Calgary Integrated Risk Management Policy – CM001, July 2004
6. Transportation of Dangerous Goods Act, 2002
7. Canutec Emergency Response Guidebook
8. City of Calgary Design Guidelines for Subdivision Servicing, August 2004.
9. Alberta Infrastructure and Transportation Highway Geometric Design Guide, 1995, Updated 1999
10. Transportation Association of Canada Geometric Design Guide for Canadian Roads, 1999
11. Dangerous Goods Transportation and Handling Act, D-4 RSA 2000
12. Dangerous Goods Transportation and Handling Act – Dangerous Goods Transportation and Handling Regulation AR 157/97

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