The Brisbane – Gladstone transport corridor:
identification of risk and vulnerability for the bulk transport of dangerous goods

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Introduction: the hazard

With the ever-increasing variety and quantity of chemicals used by industrialised societies, communities continue to face risks of injury from *hazmat* (hazardous materials) emergencies. This is despite the implementation and continual improvement of regulatory and technological systems for the safe management of hazardous materials. Of particular concern in the context of public exposure to hazardous chemicals is their release during transportation. Along transport routes this may result from an accident involving one or more vehicles carrying dangerous goods, or from failure of containment systems due to factors such as inadequate equipment or loading procedures.

Public risk from transport-related hazmat emergencies relates to a variety of factors, including the hazardous properties of the chemicals involved and the likeli hood of potential exposure to the chemicals. The latter is significantly determined by the environmental conditions under which the transport is conducted and the geography of population and settlement. Experience shows that the great majority of such hazmat emergencies are minor, with effects limited to the immediate vicinity. In a small number of cases, however, the surrounding community has been placed at risk, or could readily have been so had circumstances (e.g. location, time, weather conditions) been slightly different.

The aim of this paper is the initial consideration of levels of risk and vulnerability relating to potential hazmat emergencies from the transport of bulk dangerous goods along the Brisbane-Gladstone transport corridor. Geographical regions at risk will later be used in a more detailed assessment of vulnerability within selected communities, building upon some initial comments made in this paper. *Community vulnerability* is defined here in accordance with Young (1998) as 'the coping capacity of those at risk'. This is a function of factors such as the demography and socio-economic status of the community which may be affected and the level of preparedness within the community for dealing with the adverse event.

The Brisbane to Gladstone transport corridor

Brisbane and Gladstone, located some 600 km apart on the east-coast of Queensland, are the two major heavy industrial centres of the state. Both have significant chemical industries. Brisbane has two oil refineries and two fertiliser works. Gladstone has two cyanide manufacturing plants (at nearby Yarwun), an alumina refinery and an aluminium smelter. In addition to these major hazard facilities, which use large quantities of hazardous chemicals, both cities host numerous other industries that use and store hazardous materials. The potential of using and transporting dangerous goods throughout the region must, however, be balanced against the many economic, employment and other benefits that accrue from the development of these facilities.

Transport of dangerous goods[1] between these two centres utilises both road (the Bruce Highway, National Route 1) and rail (the North Coast railway). For much of the corridor, the road and the rail line closely parallel each other, often within one kilometre and generally less than ten kilometres apart. In one section, however, between Maryborough and Gladstone, they follow very different routes and can be up to 40 km apart (*Map 1*).

The road link

The major chemical industries in Brisbane are located to the east of the city at the mouth of the Brisbane River with other important concentrations in southern and south-western suburbs. Transport of goods northwards from these facilities is generally through the north-eastern part of the Brisbane metropolitan area. Under a policy established by Queensland Transport, dangerous goods road transport northbound from these areas is directed to the Gateway Motorway which passes to the east of the metropolitan area to connect with the Bruce Highway at its commencement in the northern suburb of Bald Hills. From here the road passes through the populous Sunshine Coast hinterland. The current alignment of the Highway by-passes many towns and villages through which it previously passed directly, but it still comes within one or two hundred metres of residential areas at some locations, e.g. Nambour. At the small cities of Gympie and Maryborough, the Highway skirts the CBD but passes through, or adjacent to, residential areas. In several small towns, such as Childers, the Highway becomes the main street of the settlement. The Highway passes some 40 km west of Bundaberg and 20 km west of Gladstone with feeder roads providing access to those cities.

The rail link

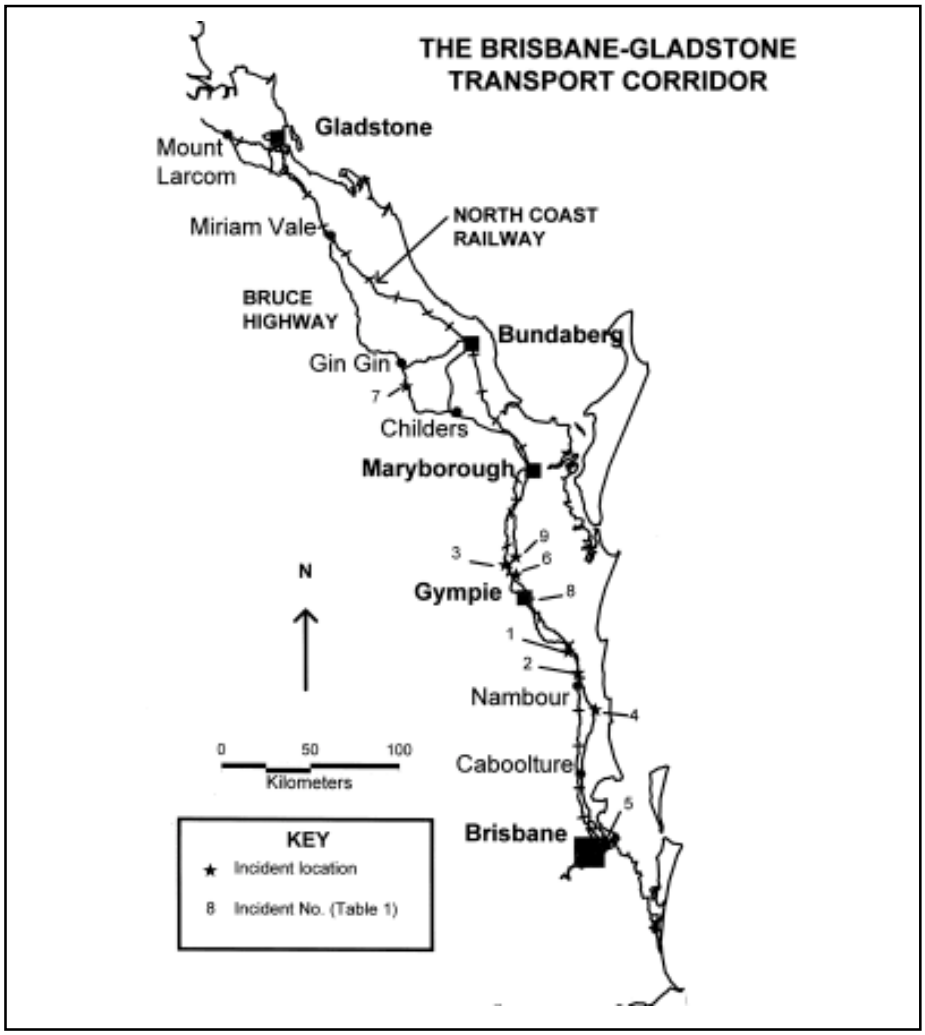
From the Brisbane CBD, the North Coast railway extends through northern suburbs and near-northern townships, before proceeding through the Sunshine Coast hinterland and passing through the major towns and cities en route to Gladstone (*Map 1*). Because it was a historical focus for growth, the North Coast rail line passes through the heart of most cities, towns and villages which lie on its route.

Dangerous Goods transport along the corridor

There is considerable movement of dangerous goods along the Brisbane-Gladstone corridor, either for use in those centres or for destinations beyond. Much of this transportation is in bulk loads. For example, travelling northwards are petrol (flammable liquid), liquefied petroleum gas (flammable gas), liquefied ammonia

Notes

1. The term 'dangerous goods' is used in relation to chemicals considered to be sufficiently hazardous to require regulation of their transportation under the *Australian Dangerous Goods Code* (the ADG Code).



Map 1 : The Brisbane-Gladstone transport corridor.

Date	Location (No. on map)	Incident	Result	Deaths/ Injuries
Sept 1992	Nambour (1)	Collision between LPG tanker and ethanol tanker (road)	no loss of containment	nil
Nov 1992	Yandina (2)	Rollover of semi-trailer with large load of compressed gas cylinders (road)	fire; explosions resulting in gas cylinders being projected large distances	driver killed and incinerated
June 1994	Gunalda (3)	Derailment of petrol tanker (rail)	spill of petrol; fire	
July 1995	Caloundra turnoff (4)	Rollover of petrol tanker (road)	spill of petrol; fire	driver killed and incinerated
Oct 1996	Murarrie (5)	Rollover of anhydrous ammonia tanker en route to Gladstone (road)	release of ammonia; toxic gas plume	2 minor injuries from ammonia exposure
July 1998	North of Gympie (6)	Collision between petrol tanker and car (road)	spill of petrol; possibility of fire	2 killed by impact
Jan 1999	Near Wallaville (7)	Collision resulting in rollover of anhydrous ammonia tanker (road)	no release of ammonia	Injuries from impact
Feb 1999	Gympie (8)	Semi-trailer carrying paint rolled over on banks of Mary River (road)	Major spill of paint into river	Nil
Mar 1999	Glenwood (9)	Fire in truck carrying calcium nitrate fertilizer	Fire	Nil

Table 1 : Selected hazmat transportation incidents involving bulk or large loads of dangerous goods along the Brisbane-Gladstone corridor, 1992-1999.

(toxic gas) and molten sulfur (flammable) in bulk tankers (often 20,000 litres capacity) as well as liquefied chlorine (toxic gas), concentrated hydrochloric acid (corrosive) and compressed hydrogen (flammable gas) in smaller containers. In the southward direction, sodium cyanide (toxic solid) is carried in briquette form in IBCs (Intermediate Bulk Containers of 1 cu.m. capacity) and bulk tankers. Liquid fuels are also distributed southward from Gladstone.

Many aspects of the transport of dangerous goods by road are already regulated, but there is no centralised recording of individual loads to provide a comprehensive picture of this activity. Information on the types, quantities and frequencies of dangerous goods loads is held by individual transport operators on a commercial basis. By contrast, comprehensive information on dangerous goods transported by rail is available through Q-Rail's centralised computer system.

Recent hazmat emergencies along the Brisbane-Gladstone corridor

Since 1992 a number of accidents, involving vehicles carrying dangerous goods, has occurred along the Brisbane-Gladstone corridor. A selection of these incidents is shown in *Table 1* and their locations are shown on *Map 1*. The outcomes of these accidents ranged from no loss of containment of the dangerous goods through to loss of the major part of the load leading to a fire or the generation of a toxic gas plume. Four drivers and/or passengers have been killed as a result of these accidents over the seven year period. No significant injury or death to the public has occurred, but outcomes could have been more serious in at least two cases had circumstances been slightly different, as the following examples show.

Yandina, 1992

A truck accident occurred less than a hundred metres from houses and a caravan park. The resultant fire caused numerous compressed gas cylinders in the truck's load to explode and debris was projected in excess of a hundred metres away. Minor differences in the trajectories of projectiles could have caused casualties. Had the truck been carrying bulk LPG, there could have been the potential for a major BLEVE (boiling liquid expanding vapour explosion) to have occurred.

Murrarie, 1996

A Gladstone-bound ammonia tanker travelling through Murrarie, an eastern suburb of Brisbane, overturned and ruptured resulting in the release of some

12 tonnes of liquid ammonia which rapidly boiled away to form a toxic gas plume. Fortunately, the atmospheric conditions prevailing at the time allowed the plume to rise quickly into the atmosphere and disperse. The nearest residential area was about one kilometre away from the accident scene and there was no significant public exposure. Had the accident occurred closer to a built-up area and had stable atmospheric conditions (e.g. a cold, still night) held the ammonia plume at ground level, numerous casualties from exposure to ammonia gas might have resulted.

Risk factors and vulnerability

With the resultant expected increase in the quantity of chemicals passing along the corridor commensurate with projected population[2] and industrial growth[3] in Southern and Central Queensland, there is a need to assess risks and community vulnerability associated with the bulk transport of dangerous goods along the Brisbane-Gladstone corridor. While the probability of a catastrophic accident is very low, the consequences of such an accident, should it occur in a built-up area, could be very severe.

In a community risk and vulnerability analysis of this hazard, factors which would need to be considered include: the nature of goods being transported; frequency and amounts of transport; population potentially exposed; socio-economic characteristics of communities; impact radius of potential *hazmat* emergencies; local geographic characteristics; highway conditions and levels of emergency resources and community preparedness. An evaluation of potential levels of risk and vulnerability along the Highway has been attempted as a first step in the process of selecting locations for more detailed analysis. Initial consideration of some of these factors are outlined below in the context of the study area.

Impact radius of potential hazmat emergencies

The impact radius of a hazmat emergency represents the distance over which there may be effects on people or the environment. Events that are likely to have the largest impact radius are fires/explosions and toxic gas releases. For such events, the emergency services are advised to consider evacuation of people for distances of up to 1500 metres in all directions (Standards Association of Australia 1997). For the present analysis, built-up areas within 1500 metres of the road are considered to be within the impact radius. Quantitative modelling of relevant hypothetical emergency scenarios supports the conclusion that an impact radius of hundreds of metres can be expected[4].

Population potentially exposed

Large sections of the Bruce Highway traverse open country with no permanent settlements and therefore risk to public safety is limited to isolated homesteads and passing traffic, and to the environment (creeks, soils, etc.).

Larger population centres may be at greater risk from a hazmat emergency because of (i) the longer distances traversed by the dangerous goods within their built-up areas and (ii) the greater population density within the impact radius. While, by this logic, smaller centres may be at lesser risk, they may be less able to cope with a hazmat emergency because of the lower levels of emergency response resources available locally and the need to rely on resources from further afield. For this reason, attention must be given both to sections of the highway that pass through, or adjacent to residential zones in the larger population centres, and also to smaller, more remote and less well-resourced settlements along the corridor.

Local geography and highway conditions

Geographic characteristics and the condition of roads can increase the likelihood of a traffic accident occurring at any particular location or time, which could lead to a hazmat event and the potential flow of hazardous materials into the atmosphere. These can include the following:

- terrain and drainage characteristics
- prevailing weather conditions
- higher speed limits
- single carriageway (as opposed to dual carriageway)
- intersections or entrance ramps
- highway alignment/sharp bends[5]

In the event of a hazmat incident, these same factors can also affect emergency response and levels of community disruption.

Level of emergency response resources

A major hazmat emergency requires appropriate responses by Police, Fire, Ambulance, Local Government and probably medical and hospital personnel. In the Brisbane metropolitan area these resources are readily available. In larger urban centres along the route they may be all available, but to a relatively limited extent. In small centres not all these resources may be available, and what is available may be very restricted in capability.

Risk and vulnerability along the Brisbane-Gladstone corridor

Qualitative consideration of the combination of these factors along the Brisbane-Gladstone corridor suggests several levels of potential risk and vulnerability for the hazards associated with the bulk transport of dangerous goods for given geographical regions.

Brisbane metropolitan area

The Gateway Motorway is a dual-carriageway, high-speed (100 km/h), limited access road which passes through or adjacent to built-up areas including residential suburbs such as Bracken Ridge. The consequences of a major hazmat emergency along the Motorway would be severe because of the levels of population potentially exposed within the identified risk zone. The severity of an emergency could be moderated, however, by the high level of emergency response resources available in the Brisbane area.

Near-northern corridor

From Bald Hills to Nambour-Yandina, the Bruce Highway is a dual carriageway, high speed road which passes adjacent to a series of rapidly growing residential areas such as Burpengary and Caboolture. While the overall populations potentially exposed within the risk zones in these localities may be less than for the metropolitan area, the levels of emergency response resources are commensurately less, thus tending to increase community vulnerability.

Notes

2. *Monitoring Brisbane and the South East Queensland Region,* (1998) Australian Housing and Urban Research Institute (AHURI).

3. Planned developments include a new alumina refinery at Gladstone and a magnesium production facility at Rockhampton, about one hour's drive north of Gladstone.

4. Computer modelling indicates that a BLEVE (boiling liquid expanding vapour explosion) of a 14 tonne LPG tanker would have injurious thermal effects within a radius of 240 metres. A leak rate of 0.25 tonne per minute from an anhydrous ammonia concentration in the air sufficient to cause injury by inhalation up to a radius of 900m. in stable atmospheric conditions.

5. Apart from some minor road options, there is little scope for reducing risks to communities from dangerous goods transport along the corridor by using alternative routes. Where alternatives do exist, they usually entail a lower grade of road and/or pass through additional settlements. Their use could arguably increase the overall risk. Continuation of the strategy of building by-pass roads around population centres would generally be effective in reducing the risk to communities.

6. For disaster planning purposes Queensland is divided into Disaster Districts which usually consist of several

Regional cities and major towns

At the regional centres of Gympie and Maryborough the Bruce Highway bypasses the CBD but still passes through residential suburbs for a considerable distance. For example, in Gympie, this distance is 10 kilometres, largely of single carriageway at speeds of 60 or 80 km/h with numerous intersections adjacent to suburban shopping centres and commercial strip development. The consequences of a major hazmat emergency at any of these intersections could be severe and the availability of resources in such smaller centres may be limited.

Small towns and settlements

From Yandina north the Bruce Highway is largely single carriageway with small towns and settlements dotted along it between the major centres. In some cases the road passes through the centre of the settlement with a reduction in the speed limit (e.g. Childers), while in others it passes near residential areas at the edge of town without a reduction in speed limit (e.g. Cooroy). In such locations the smaller population may reduce the potential severity of a major hazmat emergency but local resources to deal with it would probably be inadequate. Such smaller centres have lower levels of emergency response resources and would have to rely on resources from the nearest larger centre some distance away, resulting in delayed response time and increasing vulnerability.

Towards assessing community vulnerability

The above analysis is a first step in the assessment of community vulnerability to the transport of dangerous goods from Brisbane-Gladstone. The relative vulnerability of different communities is not adequately measured simply by parameters such as location of route or population size, but must also take into account community preparedness and resilience in the recovery phase.

In the case of chemical disasters, the speed of onset of the hazard is usually rapid and, consequently, warning time for evacuations is most likely to be minimal or non-existent. Public warning systems, such as may be implemented within coastal communities aimed at reducing vulnerability to flood or cyclone damage, are of little assistance in the case of potential chemical hazards. Thus, in terms of community vulnerability, one is dealing basically with questions of the capacity of the community, in particular the resources of the emergency services, to evacuate *post-event* and to cope with potential casualties and injuries resulting primarily from the effects of fire, blast or toxic gas release.

While the availability of physical resources is an important factor, the effectiveness of such resources can largely be determined by the quality of emergency preparedness and planning at the local level. Preparedness and counter-disaster planning begins from the point of perception of risk. Current research is examining these issues and other relevant local parameters in a selection of centres representing localities at varying levels of risk and vulnerability. Focus group discussions with key personnel in Disaster District Control Groups[6] are yielding valuable data on perception of risk and local resources and conditions. The community vulnerability assessment includes activities related to the five-stage methodology outlined by Hunter (1996) which is set within an emergency risk management framework in the Australian context[7]. Description of the hazard and analysis of its interaction with the community is being achieved through the use of scenario setting and application to the particular environmental conditions of geographical regions identified above. Assessment of risk perception focuses on emergency service operatives, as those who would have primary responsibility for dealing with local emergencies and disasters.

Local Government Areas. The Disaster District Control Group is usually chaired by a district Police Officer, and includes representatives from Fire, Ambulance, local medical services, SES and local government.

7. Hunter's (1996) model includes several stages of risk evaluation and assessment: (i) description of the hazard, the community, the environment and the emergency services; (ii) analysis of interaction between the hazard, the community, the environment and the emergency services; (iii) assessment of community risk perception; (iv) ranking of vulnerabilities; and (v) comparison of risk to existing risk criteria.

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Acknowledgments

The support of the following in conducting this research is gratefully acknowledged:

- the Queensland Department of Emergency Services, the Queensland Fire and Rescue Authority, the Queensland Ambulance Service and the Chemical Hazards and Emergency Management (CHEM) Unit for support in principle and access to information;
- Ms Janelle Quelch, formerly Scientific Advisor, CHEM Unit for conducting computer modelling of scenarios.
- Rod McGee for review comments on the manuscript.