Risk Associated with Hazardous Substances in the Wellington Region

Scoping Study Report

Prepared for the Wellington Regional Council

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Summary

Opus International Consultants were engaged by the Wellington Regional Council to carry out a scoping study of the risks associated with the storage and land based transportation of hazardous substances in the Wellington Region. The study covers all hazardous substances covered by the Hazardous Substances and New Organisms Act 1996, except for petroleum substances, pesticides and biological substances. This study forms part of the Regional Council's strategy towards ensuring that the community is prepared for risks from natural and technological hazards, and where appropriate, risk management measures are in place to achieve an acceptable level of risk.

The objectives of this study were to identify the nature and distribution of hazardous substances stored in the Wellington Region, assess the vulnerability of these storage facilities to natural hazards, consider the hazard associated with the transportation of hazardous substances, and the consequential risk to the community and the environment.

The study included a literature review and collation of data on hazardous substances, discussion with authorities having responsibility for controlling and managing the risks from hazardous substances and an assessment of natural hazards and their impact on facilities storing these substances. The regional distribution of people, built and natural environments and their vulnerability to natural hazards and associated risks were also considered. An initial screening process was developed and applied to identify facilities in the region that may potentially give rise to significant hazards. For the facilities that could potentially give significant hazards, the likelihood of potential incidents involving release and the consequential risks to the population, built and natural environments were derived. These risks were integrated to get an appreciation of the combined risk associated with hazardous substance storage from natural hazards.

The risk associated with transportation of hazardous substances was also considered based on the limited information that was available for this study.

Maps showing the environments, hazards and risks have been compiled using a Geographical Information System and are presented in this report. The ArcInfo coverages of these maps are provided for installation in the Wellington Regional Council's GIS database.

The study has identified sites with very high risk from hazardous substances predominantly in the Seaview area, but also in other parts of the Hutt Valley and a few locations around the Region. These sites are identified as generally having risks from chlorine, corrosives, flammable solvents and toxic substances (e.g. lead).

The absence of large natural hazard events such as major earthquakes in the Wellington Region over the past 50 years or more means that the potential hazards may not be appreciated by the community. However, these risks are real and risk management measures are important. Possible risk management approaches are discussed in this report.

The information collection process undertaken in this study indicates that the information held by territorial authority dangerous good inspectors is variable, and limited in the breadth of type of substances. It would be useful to have this data in an accessible form held by appropriate authorities, so that the potential risks are better known and can be managed. Some improvement and rationalisation of the present data collection and management systems to encompass the range of substances covered by the Hazardous Substances and New Organisms Act is considered prudent. The Act places obligations on every person and/or organisation involved with hazardous substances to know about the controls on the substances and how to implement them.

Risk management may be carried out by reducing the likelihood of incidents through appropriate mitigation, maintenance and safety measures, or relocation of storage from hazardous sites in the long term. It is recommended that the likely performance of storage facilities associated with identified high risk sites be considered further. These would include those storing toxic gases (chlorine and ammonia), solvents and explosives.

Resource consent measures can be effectively used by the Regional Council to manage the risk. The use of risk assessment in considering resource consents would help manage the risks from new developments or upgrading existing facilities. Planning measures may be applied by District and City Councils through controlling the land use around significant storage facilities. Alternatively, where the land use is sensitive, type and quantities of storage could be restricted, for example avoiding chlorine storage where the population density is high.

The significant risks from the transportation of hazardous substances are associated with the transportation of toxic gases such as chlorine and ammonia, and to a lesser extent explosives and solvents. The main risk management initiatives could be to control or discourage transporters from using populated areas or peak traffic times to transport the higher risk hazardous substances, and emergency preparedness by industry and those with emergency response responsibilities (e.g. fire service).

Emergency management measures are an effective means of managing the risk, particularly for low frequency events. The risk of incidents that occur can be managed by having in place appropriate containment or fire fighting measures. Improvements that could help enhance effective management of incidents are suggested in this report.

A number of initiatives are presently being instigated in the emergency management area to improve response. These provide an ideal opportunity for the Regional Council to raise the issue of emergency preparedness to deal with hazardous substances incidents.

This is a regional scale scoping study to draw together information and gain an appreciation of the risks associated with hazardous substances storage. When using the results presented, the regional generic nature of the study should be remembered. While the risks are shown at the location of storage sites, the impacts will extend beyond the immediate location, and this should be considered in assessing the effects and response strategies.

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1 Introduction

The Wellington Region has a high risk from natural hazards, particularly earthquakes. There are also significant hazards from flooding, storms and wild fire. While there have been no major recent incidents associated with hazardous substance storage or transport in the Region, there is a potential hazard and risk to people as well as built and natural environments. The Wellington Regional Council has a proactive strategy to ensure that the community is prepared for potential hazards, and where appropriate, risk management measures are in place.

Studies were completed over 1998-2000 on the hazards associated with the transport and storage of petroleum substances in the Wellington Region (Opus International Consultants, 1999 and 2000).

Opus International Consultants Limited (Opus) have been commissioned to carry out a scoping study of the risk associated with the transportation of hazardous substances, and the risk associated with the storage of hazardous substances from natural hazards in the Wellington Region. The study excludes petroleum products, which have been considered during the previous studies, pesticides and biological substances.

The objective of this study is to:

- Identify the nature and distribution of hazardous substances stored in the Wellington Region.
- Assess the vulnerability of these storage facilities to natural hazard events
- Consider the risk arising from transportation of these products.
- Estimate the consequential risk to the community and the environment.

This report summarises the hazardous substances stored in the region, and presents the potential hazards and risks arising from these substances.

2 The Area of this Study

The study area is the Wellington Region, which has its northern boundary to the north of Otaki on the Kapiti Coast and to the north of Mauriceville in the Wairarapa, as shown in Figure 1. The Wellington Region also includes the Coastal Marine Area, which extends 12 nautical miles (or 22 km) out to sea, except where it adjoins the Coastal Marine Area boundary of another region (also shown in Figure 1). The study area is covered by the NZMS 260 maps (1:50,000 scale) of R26, S26, T26, R27, S27 and T27.

3 What are Hazardous Substances?

Under the Hazardous Substances and New Organisms Act 1996 (HSNO), a hazardous substance is defined as any substance that has one of the following properties:

- An explosive nature
- Flammability
- Ability to oxidise (i.e. to accelerate a fire)
- Corrosiveness
- Toxicity (including chronic toxicity)
- Eco-toxicity, with or without bio-accumulation (i.e. can kill living things either directly or by building up in the environment)
- Generates a hazardous substance on contact with air or water

Substances with these characteristics are used, transported and stored throughout the Wellington Region. Classes of Hazardous Substances, as defined in the HSNO Act, are given in Appendix 1.

4 Scope of the Study

This scoping study has been carried out to quantify the risk that natural hazards pose to the storage of non-petroleum hazardous substances and the nature and extent of the hazard associated with the transport (land-based only) of hazardous substances in the Wellington Region. It includes the substances having one or more properties that exceed the thresholds of the intrinsic properties listed in Section 3. The study also includes radioactive substances as per the Radiation Protection Regulations 1982.

This study excludes petroleum substances, pesticides and biological substances. It also does not consider hazardous substances that have been disposed of or have already entered the environment, such as in landfills and contaminated sites. These sites have been addressed by the Wellington Regional Council, who have a separate database of their location within the Region.

The scope of this study included:

(a) A review of the existing information on the storage and land based transport of hazardous substances in the Wellington Region.

(b) A preliminary screening assessment of hazardous substances in the Wellington Region to establish a database of substances that:

  (i) pose a significant risk to built, social (people) and natural environments, and

  (ii) can be effectively assessed.

(c) Identifying known substances that could not be effectively assessed due to limitations in the data available.

(d) Categorising the screened substances into respective classes as per NZS 5433 (Transport of Dangerous Goods on Land Standard) and identifying quantities of each type stored in the Wellington Region.

(e) Determining the mode of hazardous substance storage i.e. physical containment and robustness of storage.

(f) Developing an understanding of hazardous substance storage and transport operations and identifying the likely changes to these over time.

(g) Identifying the potential effect (scale, likelihood and impact) that any escape of hazardous substances poses to built, social and natural environmental values in both the short and long term.

(h) Identifying the perception of risk from the storage and transport of these hazardous substances compared with the perception of other common hazards.

(i) Presenting potential release scenarios, with different levels of impact.

(j) Assessing the adequacy of, and if necessary, recommending improvements to, existing control and response systems to assist in planning for risk management and emergency management.

5 Incidents Associated with Hazardous Substances

An event associated with hazardous substance storage or transport and natural hazards may potentially have a high impact. It can adversely affect water, soil and eco-systems, and the health, safety and social and economic well being of the community. Recent incidents involving hazardous substances have occurred in New Zealand, such as the:

- Kerosene-solvent tanker crash at Whenuakura, near Patea, on 23 January 2001, where 21,000 litres of solvent escaped and about 500 litres flowed into the Whenuakura River.
- Ongoing issues regarding dioxin from herbicide manufacture and disposal in New Plymouth.
- An effluent spill from meat processors in Ashburton on 1 February 2001, contaminating a water race.
- Caustic soda leak at the Marsden Point oil refinery in Northland on 19 May 2001, which sparked a major emergency response and affected 35 workers.
- Truck and double trailer crash on State Highway 1 south of Kaikoura on 23 May 2001, where 18 tonnes of rat poison and paint were tipped into the sea.
- Truck accident south of Nelson, spilling urea formaldehyde resin on 6 June 2001.

6 Legislation Governing Hazardous Substances

6.1 The Resource Management Act 1991

The control of the use, storage, transport and disposal of hazardous substances involves several agencies and pieces of legislation. Under the Resource Management Act 1991 (RMA), district councils have a responsibility to control the use of land in relation to managing the effects of the use, storage, transport and disposal of hazardous substances at the district level. The Wellington Regional Council has a regional function for managing the effects of hazardous substances under the RMA and describes this function in the Regional Policy Statement. Overall, provisions for hazardous substances under the RMA aim at managing the location of hazardous substances by taking into account site-specific conditions and sensitivities.

The emphasis of the Resource Management Act is on sustainable management and the avoidance, remediation and mitigation of environmental effects. Significant resource management issues that may be affected by hazardous substances are:

- Human health, safety and property can be adversely affected by the release of hazardous substances during their use, storage, transport or disposal. In extreme cases, this may result in death.
- The health and continued existence of living elements of natural eco-systems can be adversely affected by the release of hazardous substances during their use, storage, transport or disposal.
- Land, water (both surface and underground) and air can be adversely affected by the release of hazardous substances during their use, storage, transport or disposal.

6.2 The Hazardous Substances and New Organisms Act 1996

At the national level, the Hazardous Substances and New Organisms Act 1996 (HSNO) sets minimum performance requirements for managing the intrinsic hazardous characteristics and the life cycle of hazardous substances, irrespective of location. The HSNO Act 1996 repealed several historical pieces of legislation, including the Dangerous Goods Act 1974, the Explosives Act 1957, the Toxic Substances Act 1979 and the Pesticides Act 1979. ERMA (the Environmental Risk Management Authority) is responsible for the implementation of the HSNO Act and delegates enforcement to a number of agencies. The start date for hazardous substances management under the HSNO Act is 2 July 2001.

Minimum performance requirements under the HSNO Act apply across the board, including any activities involving hazardous substances managed under the RMA. Therefore, the definition of hazardous substances under the RMA is based on hazardous characteristics specified by the HSNO Act.

6.3 The Radiation Protection Act 1965

The Radiation Protection Act 1965 is administered by the Ministry of Health. It deals with the control of radioactive substances, waste and equipment and the health and safety of workers involved with radioactive substances. The National Radiation Laboratory (located in Christchurch) is the main implementing agency.

6.4 The Transport Act 1962 and the Land Transport Act 1993

The Transport Act 1962 and the Land Transport Act 1993 control the transport of hazardous substances by land. The Land Transport Rule 1999, together with NZS

5433:1999 (Transport of Dangerous Goods on Land Standard) specify requirements for the land transport of hazardous substances. The land transport legislation is administered by the Land Transport Safety Authority.

6.5 Other Legislation

Other pieces of legislation also broadly relate to the management of hazardous substances, including the Building Act 1991, the Fire Service Act 1965, the Health Act 1956 and the Health and Safety in Employment Act 1992.

7 Methodology

The methodology carried out for this project included the following steps:

- Data collection
- Initial data Screening
- Assessment of potential hazard from the substance
- Review of natural hazards and their effects
- Vulnerability assessment
- Risk assessment for storage
- Geographical Information System and mapping
- Transportation risk assessment
- Assessment of significant risks in the Wellington Region
- Presentation of hazard incident scenarios
- Review of risk perceptions
- Consideration of environmental implications
- Risk management issues
- Recommendations

8 Data Collection

Information has been derived from council databases of premises with licences for hazardous substance (dangerous goods) storage and from discussions with Dangerous Goods Inspectors, Emergency Management and Health Protection Officers and transportation bodies. Given the scoping nature of this study, the data collection carried out for this project has been primarily a desktop exercise, relying on the information provided by the following:

- Central Government
    - Environmental Risk Management Authority (ERMA)
    - Hutt Valley Health
    - Ministry of Health
    - National Radiation Laboratories
    - Occupational Safety and Health (OSH)

- Regional Government
    - Wellington Regional Council

- Territorial Authorities
    - Wellington City Council
    - Hutt City Council
    - Porirua City Council
    - Upper Hutt City Council
    - Kapiti Coast District Council
    - Masterton District Council
    - Carterton District Council
    - South Wairarapa District Council

A literature search was also carried out with the assistance of our Technical Library and Information Service (TeLIS), and information from this search has been used in the screening and classification process.

The information collection process undertaken in this study indicates that the information held by territorial authority dangerous good inspectors is variable, and limited in the breadth of type of substances. Little information was available from central government agencies.

It would greatly assist a study of this nature if data with class, quantity, type of substance, storage method and detailed location reference (preferably grid reference) were available in an accessible form held by appropriate authorities. Improvement and rationalisation of the present data collection and management systems to encompass the range of substances covered by the Hazardous Substances and New Organisms Act would also assist in further studies. The Act places obligations on every person and/or organisation involved with hazardous substances to know about the controls on the substances, and how to implement them.

9 Initial Data Screening

Data obtained from the bodies listed above has been brought together into a single database through a combination of the following:

- Utilising a uniform classification system, as the data from different sources all used different classifications.
- Assigning quantity and substance, based on knowledge of the type and size of the facility, where information on the hazardous substance and quantity was unavailable.

Preliminary Screening of the data was then carried out using a substance-based approach, similar to that used in the Hazardous Facilities Screening Procedure (HFSP) - "Land Use

Planning for Hazardous Facilities (interim draft)" (MfE, 1999). In this, the quantity of the substance stored was compared to a threshold value[1], where the threshold value was defined as the substance quantity that would normally be permitted to be used or stored on the site without consent, if the site were located in a typical heavy industrial zone. When the base threshold value was exceeded, the substance was 'screened in' for further investigation.

10 Assessment of Potential Hazard from the Substance

The potential hazard from the substance was assessed based on:

- The intrinsic properties of the class of substance, which allowed the identification and assessment of potential effects
- Quantity of the substance present, using the threshold quantities to assess the magnitude of the effects, based on the multiples of the threshold quantity stored.

Potential effects were categorised into three types, as listed below. In assessing the different effects, the practicality of exposure is also considered.

- Fire/Explosion Effects - concerned with the safety of people as well as damage to property,
- Human Health Effects - concerned with the health and safety of people, primarily toxicity; and
- Environmental Effects - concerned with the potential impact on ecosystems.

Scores were assigned for quantity based on the multiple of the threshold values from the HFSP and the material, depending on the class of substance, based on professional judgement. From the scores derived through this process, the potential hazards were ranked as shown in Table 1, using a matrix analysis with numeric values to create a semi-quantitative estimate of the potential hazard.

Table 1 – Material and Quantity Description for the Hazardousness Assessment

Level	Descriptor	Quantity Rating	Material Rating
A	Very Hazardous	100	100
B	Hazardous	10	10
C	Moderate	1	1
D	Minor	0.1	0.1

[1] The threshold values used for this estimation were derived primarily from the Hazardous Facilities Screening Procedure (HFSP). Where this information was not available, a combination of threshold values set by the Auckland Regional Council, the USEPA, the CIMAH (UK) and SEP33 (New South Wales, Australia) regulations have been used.

E	Insignificant	0.01	0.01

The "hazardousness" was then derived using the matrix analysis given in Table 2.

Table 2 – Matrix Analysis to Determine Hazardousness

Quantity Rating		**Material Hazard**				
		A 100	**B 10**	**C 1**	**D 0.1**	**E 0.01**
A	**100**	10000	1000	100	10	1
B	**10**	1000	100	10	1	0.1
C	**1**	100	10	1	0.1	0.01
D	**0.1**	10	1	0.1	0.01	0.001
E	**0.01**	1	0.1	0.01	0.001	0.001

The overall hazardousness was determined by weighting the effects of Fire & Explosion at 40%, Human Toxicity at 40% and Environmental Contamination & Toxicity at 20%. These were then described on a qualitative level of hazardousness, using Table 3 below.

Table 3 - Level of Hazardousness from Matrix Analysis

Level	**Hazardousness**
> 100	Very High
10 - 100	High
1 - 10	Moderate
0.1 – 1	Low
< 0.1	Negligible

The hazardousness of facilities assessed from the database is presented spatially on the map in Figure 2, and shows all facilities within the Wellington Region (the areas excluded have no documented facilities).

10.1 Advantages

The advantages with this approach are as follows:

- The approach makes use of the limited available information and establishes a preliminary assessment based only on the quantity and intrinsic properties of the substance.

- The approach is simple and is adaptable for carrying out the assessment on a large database.
- The methodology similar to this approach, especially the use of threshold values, is supported by a number of methodologies including the Hazardous Substances Screening Procedure (HFSP).
- The approach takes the effects into account rather than the activity or substances used, and so is in line with the requirements of the RMA and the HSNO Act.

10.2 Limitations

There were a number of limitations to the available information. These are as follows:

- The classes of substances were used rather than information relating to individual substances, as the information sources only provided the class rather than the actual substances. Therefore, the effects relate to "classes" and "sub-classes" rather than the actual substances themselves.
- In some circumstances, the data on quantity and substances was not available. It became necessary to estimate these parameters based on the assessors knowledge of the operation/process. However, in most cases, the lack of information related to smaller facilities, which pose a lower risk and would in any case be excluded after the initial screening.
- The screening assessment does not take into account the actual safety performance of the facility.

11 Review of Natural Hazards and Their Effects

11.1 Types of Natural Hazards

The range of natural hazards affecting the Wellington Region, and their potential impacts on storage facilities are summarised here.

The effects of natural hazards on transportation routes are not considered, as the likelihood of vehicles transporting hazardous substances being present at the same time and at the same location as a natural hazard induced failure is considered to be remote.

The natural hazards that may have an impact on hazardous substances in the Wellington Region are:

- Earthquakes
- Storms (including floods and wind)
- Tsunami/Seiche
- Wild fire
- Lightning
- Volcanoes

11.2 Earthquakes

11.2.1 Earthquake Effects

Earthquakes are considered the most likely natural hazard to affect hazardous substances stored in the Wellington Region. The region has a high seismicity with potential for large earthquakes. This includes the potential for a magnitude 7.5 earthquake on the Wellington Fault, which traverses the developed areas of the region, and magnitude 8 earthquakes on the Wairarapa Fault and the Indo-Australian/Pacific Plate boundary Subduction Zone. There are also a number of other sources of earthquakes in the region.

Earthquakes can result in the following effects:

- Ground shaking
- Liquefaction
- Slope failures
- Fault rupture
- Tsunami/seiche
- Land subsidence

11.2.2 Ground Shaking

Studies by the Wellington Regional Council (1992) present ground shaking hazard maps for the region. These give the potential for ground shaking in two earthquake scenarios. The ground shaking is presented for different zones numbered 1 to 5, depending on the likely level of amplification of ground motion. Ground shaking zone 1 generally represents bedrock areas with little potential for amplification of ground shaking, and 5 represents areas with deep or soft sediments that can significantly amplify ground shaking.

Earthquake ground shaking in the region under the major scenario associated with an earthquake on the Wellington Fault may have a major effect on storage facilities. Storage facilities may not be designed to withstand earthquakes or the ground accelerations associated with earthquakes. The connections to storage tanks may be vulnerable, or if substances in drums stacked on pallets or cylinders are not tied down, they may be susceptible to being thrown about by the earthquake.

11.2.3 Liquefaction

Liquefaction is where loose saturated cohesionless soils (such as sands and silts) subjected to strong ground shaking (such as from earthquakes), experience an increase in porewater pressures and hence loss of shear strength. This could lead to the soil behaving as a liquid and resulting in ground deformation.

Liquefaction may result in the following effects:

- Sand boils (water & sand is ejected from the ground), with associated flooding
- Subsidence of the ground
- Floatation of buried structures such as underground tanks
- Foundation failure of structures or bunds built on liquefied ground
- Failure of slopes in ground subject to liquefaction
- Lateral spreading of ground towards free surfaces such as rivers or the sea
- Rupture of buried pipelines due to ground deformation

Liquefaction hazards in the Wellington Region were mapped for the Wellington Regional Council in 1992-1993 (Brabhaharan et al, 1994). The results have been published as hazard maps (Wellington Regional Council, 1993), which have been used in a qualitative manner in the assessment of potentially vulnerable facilities.

In the Wellington Region, ground subject to liquefaction is generally associated with flat coastal areas and reclamations. The main types of ground damage that may affect hazardous substance facilities in the Wellington Region are:

- Above ground storage facilities
  - Ground subsidence resulting in damage to vessels, pipelines and pipe connections
  - Lateral spreading / subsidence damage to containment bunds / walls
  - Lateral spreading damage to tanks, where located close to rivers, harbours or the sea
  - Foundation failure of supports
  - Foundation damage to buildings and facilities surrounding hazardous substances, resulting in collapse and possible damage to the containment vessel
- Underground tanks
  - Floatation of buried tanks leading to damage, particularly to pipe connections
  - Lateral spreading deformation leading to possible tank damage

These forms of damage can cause varying levels of consequences to the storage facilities. The extent of damage will depend on the type, density and thickness of the liquefiable deposits, the presence and distance of free surfaces towards which lateral spreading can occur, and the construction and robustness of storage tanks, pipelines and pipeline connections.

11.2.4 Slope Failures

Earthquake induced slope failures can affect moderate to steep slopes (generally greater than 35°) in the Wellington Region. A Wellington Regional Council (1995) study of earthquake induced slope failures indicates shaking thresholds for significant earthquake induced slope failures in the Wellington Region. The hazard maps have been used in a qualitative manner in the assessment of potentially vulnerable facilities. Slope failures can have a significant effect on storage facilities, however the effect will depend on the facility and the substance being stored.

11.2.5 Fault Rupture

The rupture of major active faults in the Wellington Region could lead to severe damage to facilities located along the fault or in close proximity, say within 50 m of the fault. Damage to these facilities may include damage to services, with the potential of causing fire. The damage to the hazardous substance storage containers may result from direct damage to the storage vessel by fault movement, and indirect damage caused by building collapse.

Five facilities were found to be located within 50 m of fault lines and these contained low flash point solvents (Class 3a) and radioactive materials (Class 7).

The main fault that crosses developed areas in the region is the Wellington Fault (Wellington Regional Council, 1990), which has a return period of 600 years. The Ohariu Fault has a relatively large return period of 1000 years to 3000 years, and has not been considered further.

11.2.6 Land Subsidence

An earthquake with surface fault rupture may be associated with a rise or subsidence of land. For example, the land in parts of Wellington was raised by up to 1.5 m during the 1855 Wairarapa Earthquake. Potential subsidence of land may occur during fault rupture. This may cause parts of the land in the lower areas to become subject to tidal influence. In the Seaview area, which is the coastal area with significant hazardous substances, the hazardous substances storage facilities are located on land more than 1 m higher than the sea level. Therefore, any possible subsidence of the land by up to 1 m in a Wellington Fault earthquake event is still not likely to bring it below sea level.

Underground storage vessels may become more vulnerable to floatation in subsequent flood events.

11.3 Storms

Storms are periods of strong winds and intense rainfall. The dominant effects of storms that may have an impact on facilities are:

- Storm induced slope failures
- Flooding
- Wind

11.3.1 Storm Induced Slope Failures

Intense or prolonged rainfall associated with storms can increase the groundwater pressures within slopes, saturate the soil and lead to slope failures. Large slope failures can cause damage to facilities.

Locations that are susceptible to slope failure have been taken into consideration in the assessment.

11.3.2 Flooding

Storms with heavy rainfall can lead to flooding. Flooding can affect facilities in a number of ways, such as:

- Damage to facilities located along waterways and in flood plains from erosion and flood debris
- Inundation leading to floatation of buried storage vessels

Flooding can occur from major rivers and streams in the region located near storage facilities. These major watercourses are the Hutt River, Waikanae River, Otaki River, Waiohine River, Waingawa River, Waipoua River, Whareama River, Mangatarere River and Ruamahanga River. The hazard has been taken into consideration in the assessment of facilities that could be affected.

11.3.3 Wind

The Wellington Region commonly experiences strong winds and occasionally extreme winds. However, hazardous substance storage facilities are generally not considered to be particularly prone to damage from winds. Roof structures may be damaged in high winds, but this will only lead to substance release if the storage vessel or connections are damaged.

11.4 Tsunami / Seiche

A tsunami is a wave with a long period that is generated near shore or offshore due to a sub sea earthquake associated with sea floor displacement or a sub sea landslide, which may be triggered by an earthquake. It could also be associated with a sub sea or near shore volcanic eruption. Tsunami can be several meters in height and arrive at the shore with significant speed, causing widespread destruction to coastal areas.

Several facilities may be potentially affected by tsunami along the coast in the Wellington Region, if the tsunami were significant in size. Tsunami hazard has been taken into account in a qualitative manner in this analysis, where appropriate.

Seiche is an associated phenomenon where a body of water in a basin or harbour resonates in response to a strong local earthquake. The effect is more likely to be inundation of coastal areas and flooding, rather than a tsunami and associated destruction. Seiche is a possibility in the Wellington and Porirua Harbours. A study by Gilmour and Stanton (1990) indicates the area around Wellington Harbour that may be affected by seiche. The height of inundation is indicated to be less than 1 m, so therefore the impact of seiche on hazardous substance facilities is not considered significant, as these are more than 1 m above the Mean High Water Spring Level.

11.5 Wild Fire

Wild fires originating in the vegetated hillsides can spread and affect adjacent facilities. Underground storage vessels are generally not vulnerable as they are protected by the ground cover. Vessels that may explode when subjected to intense heat, or with contents that can ignite if an existing leak is present, may be vulnerable.

A Wellington Regional Council study carried out in 1997 mapped areas vulnerable to wild fire hazard. The information on these maps has been used in a qualitative manner to assess sites that are likely to be affected by wild fire.

Should a fire occur near any hazardous substance storage sites, the risk to the installation will depend on:

(a) The wind direction and strength at the time of the fire.

(b) The vegetation conditions (dryness, fuel load).

(c) The propensity of the vegetation on fire to produce flying brands (pieces of vegetation on fire, which get dispersed by convection and any wind).

(d) The separation of the fire from the hazardous substance storage vessel.

(e) The fire control efforts in place.

(f) The storage vessel fire protection measures in place.

Of these risk factors:

(a) is uncontrollable and unpredictable

(b) and (c) can be controlled by changing the vegetation from scrub to managed grassland or less vulnerable vegetation (such as indigenous forest).

(d) can also be improved by clearing the perimeters of the scrubland and replacing it with managed grassland or by encouraging scrub to regenerate into indigenous forest.

Sites within metropolitan areas will have adequate Fire Service response and water supplies, including access to helicopters with monsoon buckets. However, the risk is extended by the longer time scale involved with extended vegetation fires. Fire control activities may last several hours or even longer. Information on fire control methods (e.g. sprinklers etc) is not presently available and is outside the scope of this report. Discussions with the Fire Service indicate that the risk to storage facilities from wild fires is likely to be low in urban areas.

11.6 Exposure Fires

Any fire that occurs near a hazardous substance location or storage (including temporary storage) vessel could well be construed as a natural hazard. Such fires are particularly likely in the aftermath of earthquakes when gas mains and electrical supplies are damaged. The ignition means may be either human intervention or a natural cause but the progress of the subsequent fire is a natural process. Apart from the risk of a fire spreading between vessels, the next risk mechanism is for an external fire to spread by radiation or flying brands into an area with available fuel, including timber buildings.

Typically, this potential is taken into account by the storage vessel being buried or the separated from the exposure risk by incombustible screen walls or separation distance.

11.7 Lightning

Lightning can affect combustible hazardous substance storage sites by the electric energy raising the products to their flash point, setting it on fire and possibly leading to explosion. However, lightning has an extremely low probability of striking any storage site. Underground storage vessels are unlikely to be affected.

11.8 Volcanic Eruption

Volcanic eruptions from the Central North Island can potentially affect the Wellington Region. Ash eruptions, which are more common, may get blown towards Wellington depending on the prevailing wind at the time. However, ash falls are unlikely to have a major effect on hazardous sites or transportation as the quantity of ash is likely to be limited at this distance. Larger, very infrequent eruptions such as that of Taupo can have potential effects, but have not been considered given the very low frequency of the event occurring.

11.9 Natural Hazards Impact on Storage Facilities

Assessment of natural hazards impact on hazardous substance storage facilities in the region was carried out in a two-stage, qualitative manner. This evaluation was carried out only on the sites considered worthy of further evaluation by having greater than a negligible potential of hazardousness (i.e. low through to very high hazardousness).

The first stage was to assess the likelihood of the facility being vulnerable to damage resulting in release of a substance during a natural hazard event. Based on in-house knowledge, the sites were qualitatively ranked using the measures of likelihood from Appendix E of AS/NZS 4360:1999 Risk Management (Standards Australia, 1999). The ranking was based on an overview assessment of possible design, maintenance and operation of the facility, based on the type of industry.

The second stage used the assessment carried out in the first stage and relied on previous knowledge gained during other studies carried out by Opus, of the susceptibility of sites to natural hazards. The assessment was based on the type of substance present and how it is or is likely to be stored, the type of facility at the site, the natural hazards likely at the site and the site location. The previous petroleum risk studies and hazardous substance studies in specific areas of Seaview, provided the basis used for this assessment.

12 Vulnerability Assessment

Hazardous substance incidents are likely to have a wide effect on the community. Such effects are likely to impact:

- People
- Buildings
- Residential properties
- Commercial and industrial facilities
- Water supply
- Natural habitats
- Ecologically sensitive areas
- Groundwater
- Businesses, causing disruption
- Traffic, causing disruption

For the purpose of this assessment, these impacts can be classified into the following major types of environments that are vulnerable to incidents involving hazardous substances:

1) Population

2) Built Environment

3) Natural Environment

The vulnerabilities of these three environments have been mapped and used for the risk assessment. The parameters used for representing these environments and the method of compilation are discussed below.

12.1 Population

The population 'environment' figures used in this report are based on population data figures held by the Wellington Regional Council, dated 1996. The data is based on census mesh blocks and represents the resident population. As such, it does not adequately represent the much larger population present in the urban / suburban centres during working hours. The population during the day time (working hours) was derived by the Wellington Regional Council using commuter travel data and the resident population. This was based on larger area blocks.

Given that the hazardous substances will have an effect during both the day and night, the population 'environment' was derived as the weighted average population density. Population densities (population per square kilometre) were derived as the basis for the population environment for the resident population as well as the population over the working hours. The average population was then derived based on the proportion of the working hours (assumed as 44 hours multiplied by the number of working weeks) to the total hours. A 44-hour week was assumed to allow for commuting as well as weekend shopping in the urban centres. The population was represented by the weighted Average Population Density, calculated as:

Average Population Density = [(Resident population density x 6672) + (Working hours population density x 2088)]/8760

However, even the weighted population density will not adequately represent localised population densities such as at shopping centres, schools or travel along transport corridors. Such specific variations are difficult to represent in a regional study, particularly since the variation is also dependent of concentrations at specific times of the day or week.

The population density was grouped into the classes shown in Table 4, and vulnerability ratings are assigned as shown. The population vulnerability distribution developed is shown on the map in Figure 3.

Table 4 - Population Vulnerability Classes

Population Vulnerability	Average Population Density (persons / km^2)	Population Vulnerability Rating
Low	< 250	2
Medium	250 – 2,500	20
High	2,500 – 10,000	70
Very High	> 10,000	100

12.2 Built Environment

The built environment represents community assets, such as the infrastructure and buildings. This includes commercial and industrial development as well as residential properties. The Built Environment is represented by data from the Wellington Regional Council land cover database, which also shows land use

The built environment distribution in the region is presented on the map in Figure 4. The vulnerability of the built environment has been classified into the classes given in Table 5, which also presents the built environment vulnerability ratings assigned for each class of land use.

Table 5 - Built Environment Vulnerability Classes

Built Environment Vulnerability	Land Use	Built Environment Vulnerability Rating
Very Low	Rural	1
Medium	Residential	20
High	Commercial / industrial	100

12.3 Natural Environment

The natural environment comprises waterways, lakes, sea, rivers, groundwater, flora, fauna and associated ecological/ conservation values, including those from the perspective of tangata whenua.

This was compiled from:

- The Wellington Region Land cover database
- Waterways, rivers and lakes
- Groundwater contamination vulnerability map
- Areas of important and significant conservation values (AICV, ASCV)
- Coastal Marine Environment
- Recreation areas and areas of shellfish gathering
- Department of Conservation (DoC) listed areas of ecological significance

The information representing the natural environment was assessed and used to compile the three broad classes of vulnerability of the natural environment given in Table 6, and the spatial distribution of the natural environment vulnerability is presented on the map in Figure 5.

The areas assessed to be of *high* vulnerability include the DoC listed areas, islands, the areas of important and significant conservation values, recreation / shell fish gathering areas of the coastal environment, waterways and lakes, and areas of high groundwater contamination vulnerability in the Hutt Valley.

The *medium* vulnerability areas are the remaining coastal marine environment, remaining areas of high groundwater contamination vulnerability, swamps and native forests.

The areas other than the above areas judged to be of most significance are classified as having *low* significance in terms of the natural environment for the purposes of this study. This includes farmland and urban areas.

The groundwater contamination vulnerability areas are based on information supplied by the Wellington Regional Council. It is understood to be based on a report by the Resource Investigation Department of the Wellington Regional Council (1997).

Table 6 - Natural Environment Vulnerability Classes

Natural Environment Vulnerability	Land Type	Natural Environment Vulnerability Rating
Low	Areas other than those below that are judged to be of most significance	10
Medium	Coastal marine environment (other than recreation and shell fish gathering areas), areas of high groundwater contamination vulnerability (other than Hutt Valley), and swamps and natural forests	40
High	DoC list areas, the areas of important and significant conservation values, islands, recreation / shell fish gathering areas of the coastal environment, waterways and lakes, and areas of high groundwater contamination vulnerability in the Hutt Valley	100

The natural environment vulnerability ratings presented in Table 6 are assigned subjectively to the three classes of natural environment mapped for the Wellington Region. This is the same as those used in the previous petroleum hazard studies carried out for the Wellington Regional Council.

13 Risk Assessment for Storage

13.1 Risk to Population, Built and Natural Environments

Risk assessment for the project is based on the conventional approach as outlined in AS / NZS 4360:1999 Risk Management (Standards Australia, 1999). Using this approach

Risk = Likelihood x Consequences.

In the present study, consequences are a product of hazardousness and vulnerability, and the equation above becomes:

Risk = Hazard Likelihood x Hazardousness x Vulnerability

The hazard likelihood is a function of the probability and size of the natural hazard event and the adjudged capacity of the facility to withstand the event (dependent on design, operation and maintenance). Therefore, for this semi-qualitative assessment, risk can be evaluated as:

Risk = Hazard Rating x Vulnerability Rating

Note that the hazard rating is calculated for Fire / Explosion Effects, Human Health Effects and Environmental Effects. Hazard rating is calculated as a combination of Hazard Likelihood and Hazardousness, i.e.

Hazard Rating = Hazard Likelihood x Hazardousness

This may be calculated separately for the different environments, as follows:

Population Risk = Max (Hazard Rating for Fire/Explosion Effects and Human Health Effects) x Population Vulnerability Rating

Built Environment Risk = Hazard Rating for Fire/Explosion Effects x the Built Environment Vulnerability Rating

Natural Environment Risk = Hazard Rating for Environmental Effects x Natural Environment Vulnerability Rating

High vulnerability natural environments, such as the harbour or rivers, are not at the immediate storage sites, but are generally close to storage sites. Any spills may potentially escape into these nearby vulnerable natural environments. This has been taken into consideration in the risk assessment by assuming spills within 150 m of high vulnerability natural environments will affect the environment.

In fact, liquid spills even further away may find their way into sensitive natural environments such as rivers and harbours, through drains, groundwater flow or subsidiary water courses and landforms. However, much of the spill may be dissipated or trapped prior to reaching the water body. In comparison, spills close to sensitive environments will receive the pollutants directly and in significant quantities. Gaseous spills may potentially have even wider reaching effects resulting from the greater spread of gas (e.g. 200 m – 1500 m), although this is not taken into account in the analysis at this stage.

The present analysis recognises that spills from major storage facilities, further than 150 m away from the receiving environments could lead to substantial pollution of the sensitive environments. The consequence associated with facilities within the immediate "catchment" of sensitive water bodies has been assigned the higher natural environment vulnerability rating.

The risk maps for the population, built and natural environments, for the part of the Wellington Region with documented significant hazardous substances storage facilities, are shown on Figures 3, 4 and 5.

The risk assessment provides a risk at the storage site. The complex site specific (e.g. topography) and temporal characteristics will determine the area of impact of a risk event, particularly given the variable nature of the terrain and weather/wind conditions in the Wellington Region. For a more detailed analysis, the actual area of impact of an incident at any particular site of interest would need to be assessed on a site-specific basis.

13.2 Combined Risk

The combined risk is derived by integrating the risks to the population, built and natural environments, with appropriate weightings for the individual risks as given in Table 7. The relative weightings are subjective and rely on the relative values placed on the people, their built assets and the natural environment.

The weightings used in the assessment are the same as those used in the previous petroleum hazard studies (Opus International Consultants, 1999 and 2000). Those weightings were chosen in consultation with Wellington Regional Council staff.

Table 7 - Risk Weightings

Environment	Risk Weighting
Population	10
Built Environment	6
Natural Environment	5

The combined risk ratings, calculated using these weightings, have been classified into four classes. These are presented in Table 8.

Table 8 - Combined Risk Classification

Combined Risk Rating	Combined Risk Class
Low	0.1 - 1
Medium	1 - 10
High	10 - 100
Very High	> 100

The Combined Risk for the Wellington Region is shown in Figure 6. The part of the region excluded has no documented significant hazardous substances storage facilities.

14 Geographical Information System and Mapping

The Hazardousness and Vulnerability maps have all been developed as Geographical Information System (GIS) coverages. These are then used to derive the risk maps using GIS technology.

The risks have been calculated as described in Section 11.2 using the GIS, and the risk component maps integrated to derive the Combined Risk map.

The maps are prepared using the ArcCAD and ArcView programs and output as ArcINFO coverages for installation in the Wellington Regional Council's GIS database.

15 Transportation Risk Assessment

15.1 Modes of Transport

The modes of transport of hazardous substances in the Wellington Region are:

- Road
- Rail
- Pipelines
- Sea

Sea transport is not considered further in this study.

15.2 Road

Transportation risk is difficult to determine. Quantities of substances and the transportation routes taken by carriers of these substances proved extremely difficult to define, as most of the substances were transported in relatively small quantities. Furthermore, the routes taken were highly dependent on traffic and route conditions at the time of travel. Road works, and the road configuration, may control local routes chosen by the truck driver. For example, the comment was made by the Dangerous Goods Inspector in the area that the roundabouts constructed in Lower Hutt are very difficult to negotiate with a large truck.

It was established that most of the hazardous substances travel through the Wellington Region on State Highway 1. Other the significant routes for hazardous substance transport around are the following:

- Hutt Road from Ngauranga to Petone
- The Esplanade and Waione Street to Seaview
- State Highway 2 and link roads to sites in the Hutt Valley (the data identifying exact routes is not presently available)
- Roads through Wellington City (data identifying exact routes is not presently available).

Apparently little transportation occurs along State Highway 2 between Manor Park and the Wairarapa, with hazardous substances generally entering the Wairarapa from the north.

15.3 Rail

Detail regarding the quantities and types of hazardous substances moved through the Wellington Region by rail is presently unavailable. It is understood that hazardous substances are moved through the region from the North to the South Island, and also back from the South Island to the North Island by ferry. The quantities shipped by rail from Wellington to the Wairarapa are understood to be negligible.

Hazardous substance incidents in tunnels can have a high impact due to the confined space leading to concentration of the energy, and limited access for emergency response. The fire (March 1999) in the tunnel through the French Alps between France and Italy highlights the consequences of such an event. This applies to both road and rail tunnels. While there are a number of rail tunnels in the region, the low quantity of hazardous substances transported by rail and the unlikely presence of many people in such freight trains means the risk is lower than that for road tunnels, which could have many other road users. Specific road tunnels in the region are the Mt Victoria Tunnel and Terrace Tunnels. The risk would be particularly pronounced during peak traffic hours.

15.4 Pipelines

A range of Class 3 flammables and caustic soda are unloaded by pipelines from Point Howard Wharf to storage tanks in the area.

Vulnerability models were developed for petroleum spills from pipelines at Point Howard to Seaview by Opus (2000). These models took into consideration a number of factors, including the ductility of the material, the pipe diameter, the pipe jointing and the construction methods, in evaluating the vulnerability. In the risk assessment, it was assumed that the petroleum pipeline from Point Howard to Seaview was “rested” in petroleum, as this was then proposed as a more suitable arrangement by the petroleum companies. That is, after discharge, petroleum remains in the pipe until the next round of discharge through the pipeline.

It is understood that the pipeline for caustic soda between Point Howard and Seaview is flushed with water following use. For a spill assessment, the natural hazards taken into account are earthquakes including slope failures and storms including flooding and slope failures. Earthquakes were considered for the fire/explosion assessment. The likelihood of release of caustic soda will be lower than that previously calculated (in Opus 2000), because the pipeline is “rested” in water and the frequency of use will be much lower.

16 Assessment of Significant Risks in the Wellington Region

The sites identified as having significant risk from hazardous substances in the Wellington Region are mainly in the Seaview area and other areas of the Hutt Valley. These sites are identified as generally having risks from chlorine, explosives and flammable solvents. Other sites in the Wellington Region are identified as having significant risk from these substances and also corrosives and toxic substances (e.g. lead).

Explosives in large quantities are used by the quarries and stored by the military. It proved extremely difficult to identify all locations where explosives were stored, as the information was not readily available. Sites that were identifiable, such as quarries, are usually away from population centres. Further analysis should be carried out to locate the sites of presently unknown locations that store explosives, to better quantify the risks.

Chlorine is used in water treatment plants, swimming pools and some industry. Ammonia is used in industry. The high risk from these substances generally results from the high consequences of an incident (refer to example in Appendix 2). The details of individual storage facilities and the specific risk factors involved with these are beyond the scope of this study. However, given the high risks associated with these toxic gases, the risks from these facilities are considered worthy of further investigation.

Solvents, toxic substances (e.g. lead) and corrosives are used in industry at varying locations around the Wellington Region.

The primary issues influencing the riskiness of facilities and sites are considered to be the design and maintenance of storage facilities and the emergency preparedness of the owner to be able to cope with a release arising from a natural hazard event.

The absence of large natural hazard events such as major earthquakes in the Wellington Region, over the past 50 years or more means that the potential hazards may not be appreciated by the community. However, these risks are real and risk management measures are important.

Substances were left out of the analysis if they lacked adequate data for inclusion. The most significant of these were facilities with relatively large quantities of substances, especially explosives, where the locations of the storage sites were unable to be determined.

17 Hazard Incident Scenarios

17.1 Toxic Gas Exposure

The release of toxic gases/vapours, such as chlorine and ammonia is a very high consequence, low probability hazard. Accidental release of large quantities of toxic substance in a worst-case scenario could cause multiple fatalities in addition to long-term health effects and permanent injuries.

An assessment for chlorine gas has been carried out. The results of this scenario are presented in Appendix 2. The consequences of the low probability event of chlorine gas release are assessed to be severe and the consequences could extend to downwind distances as far as 200 m to 2000 m.

17.2 Explosives

The hazard scenario for an explosives incident is not available from earlier studies. Considering that explosives are considered to be a high risk hazardous substance, carrying out a fault tree analysis for an explosive event could prove useful in establishing the consequences from such an event.

However, if the explosives are in quarries, the consequences of an explosive event are likely to be low and no further study will be required. If the explosives are for military use and stored close to a residential area, further studies will be useful. At this stage, the locations of military storage sites are not known and these may need further discussions with the Ministry of Defence to establish if this is likely to be of concern.

17.3 Solvents

The fire scenario resulting from release of solvents is likely to be a pool fire. In a semi-confined environment, volatile substances may cause a potentially explosive situation, forming an Unconfined Vapour Cloud Explosion (VCE) or Fire Ball. Given a spill, the likelihood of a pool fire was estimated as 1 in 50 and that of a VCE as 1 in 10,000 (refer to Appendix 3). A large spill would be required to create adequate vapour for a VCE to occur.

Depending on wind conditions, a small spill event may affect people up to 150 m from the event, and a large spill event may have lethal effect for people more than 200 m from the spill site.

18 Review of Risk Perceptions

It is important to consider the relative risk associated with hazardous substances, and compare it to the other common risks to which the community is exposed. This will enable a realistic perception of the risk posed by hazardous substances.

The annual probability of many common risks and that associated with individual risk from chlorine gas (derived from the scenario described in Appendix 2) as an example, has been compared in Table 10, to place the severe risks associated with hazardous substance storage in context.

It can be seen that the risk of fatality to people from storage incidents from natural hazards is quite low compared to other risks faced by the community. However, it should be noted that the consequential impact of the above risk events generally increase down the table. For example, a few people may die in a motor vehicle accident, whereas a large number of people may be killed by a meteorite impact.

Table 10 - Comparison of Annual Probabilities of Various Risks (per million people)

Hazard	Combined Risk Class
Motor Vehicle Travel	145
Swimming	50
Playing rugby football	30
Aeroplane Flight	10
Electrocution (non-industrial)	3
Chlorine gas (within range of facility)	3
Cataclysmic Storms and Floods	0.2
Lightning Strike	0.1
Meteorite Impact	0.001

Figures other than hazardous substance storage from Higson (1989) for Australia.

It should be noted that risks associated with hazardous substances are involuntary risks to a member of the public, that is, a risk imposed on them , rather than something which they voluntarily take on. The community generally perceives an involuntary risk more in terms of its perceived consequences rather than in terms of its low likelihood. On the other hand people are more prepared to accept voluntary risks because they make a choice to take them on and they receive direct benefit from it.

In addition, there is a tendency to consider the risk from industrial / technological hazards as being less acceptable, compared to a natural hazard such as an earthquake. This is probably because the benefits from such industries, in terms of profit, is seen to be reaped by others and the risks are borne by the local community.

The perceptions of risk from hazardous substances and facilities has been considered in further detail as part of this study, based on a review of relevant literature (Gough, 2001). This considers the various factors that influence the perception of risk by the public. Excerpts from this report, relevant to the present study, are presented in Appendix 4. This report also includes recommendations for risk communication for issues associated with hazardous substances.

19 Environmental Implications

19.1 Factors Influencing Impact on the Environment

The conditions existing at the time of and immediately following an incident at a hazardous substance storage facility can vary considerably, namely:

- Weather conditions during and following a spill;
- Condition of the sea during and following a spill;
- Season in which the spill occurred;
- Nature and mix of the substances involved;
- Rate of discharge of the substances (i.e. a slow seepage or a single spillage action);
- Whether the facility was bunded, enclosed, had internal containment systems, internal fire fighting capacity etc.
- Location of the facility;
- Whether more than one facility has suffered spillage because of the natural hazard event.

The geographical extent and the impact of a hazardous substance incident caused by a natural hazard to a large degree, will depend on:

- The substance released and state of the substance (i.e. solid, liquid or gas)
- The preparedness of the response units, including the availability of trained personnel and appropriate recovery and containment materials, if recovery or containment is possible;

- The scale of the natural hazard - if it is of a sufficient scale, then priorities may necessitate resources being channelled into rescuing people, fighting fires, etc ; and
- The prevailing weather conditions - a storm scenario for instance may make it difficult to contain or control a spill event.
- The environmental conditions and uses of the area affected by the spill
- Ecological values of the area and species present

19.2 Impact in the Wellington Region

Several high and very high-risk storage facilities are located adjacent to or in very close proximity to the Wellington Harbour. The harbour is very much an aesthetic focus for Wellington and is held in extremely high regard by its residents and visitors. It has high ecological value and is a well-utilised recreational resource, especially during weekends.

The presence of rivers, estuaries, the sea and underground water systems are also important in evaluating the potential effects of a spill event. Tidal flows may assist the spread of substances 'upstream' while fresh water flows assist with flushing. Artesian water is used for supplying potable water to the local population such as in the Hutt Valley. Groundwater is used by farmers in much of the Wairarapa and some areas of the Kapiti Coast. A leakage from any underground storage vessel could have consequences for groundwater. The implications of such a leak will depend on:

- The depth of the water table below the vessel;
- The permeability of the ground separating the source of the leak from the water table;
- The ground in which the vessel is set;
- The direction of the groundwater flow;
- The spatial location of the leak; and
- The rate, volume and type of substance released.

The characteristics of the substances are highly significant for the nature and extent of ecological impacts of an incident. From a strictly ecological stance, those areas at most risk from a spill are the watercourses, islands and those parts of the coastline that have basically remained in their natural state, including the wildlife that inhabit them. Depending on the event, from the stance of the general populace, most of these could become temporarily 'out of bounds', while parts would remain polluted for some time after the initial event. In the worst-case scenario, the potential exists for animal and plant life in the affected area to be largely exterminated.

19.3 Impacts on People and their Activities

The effects resulting from natural hazards may be relatively local in extent, such as resulting from wildfire. However, an event such as an earthquake is likely to be widely felt. The immediate impact of such events on the population will be equally varied to the extent that even a major spillage and/or fire at one or more of the hazardous substance sites may be the least of their immediate concerns, depending on the substance released and the likely spread of the substance.

Many of the sites have relatively small volumes of substance being stored, and some have underground storage vessels. The larger-use facilities are generally sited remote from residential areas. However, these facilities are typically surrounded by other industrial complexes (which are populated during working hours) and transport corridors. The proximity and density of people residing or working in the vicinity is a significant consideration in an event.

In the event of fire or gas leak in high wind conditions, the resulting plume may be quickly dispersed but could cause local problems and major disruption to traffic flows, especially if the wind direction is 'unfavourable'. If the wind strength is weak or it is calm, the plume is likely to be slow to disperse. If such an event occurred in the vicinity near a major traffic corridor for instance, delays of up to several hours could be experienced until the effects were neutralised.

In the event of a hazardous substances release incident near business centres or residential areas, people may have to be evacuated for health, safety or convenience reasons, thus resulting in lost productivity and the possibility of production problems due to the unscheduled closure. The inhalation of toxic vapours and smoke, and the effects due to burns and heat from fires can be injurious, if not fatal, to people, especially fire crews. In some situations, the explosive force of substances can be catastrophic, not only to people, but also to the built environment. Such an explosion could be devastating to the re-establishment of plant and equipment following any leakage episode.

The impacts of a large-scale incident could result in the affected area or the region suffering a down turn in the tourism trade with a resultant decline in secondary, semi-dependent industries, such as transportation, the restaurant trade and event facilities. The time span over which such a detrimental effect could last is likely to exceed the duration of the spill itself. Its influence may be experienced over several years as it could damage Wellington's growing reputation and external perception as a visitor destination.

20 Risk Management Issues

20.1 Approach to Risk Management

Risks can be managed using a number of approaches, such as:

1) Reducing the likelihood of an incident

2) Reducing the consequences from an incident

3) Land Use Planning and Consents

4) Emergency management

Emergency management aims to reduce risks, raise individual and organisational preparedness, respond to events and aid recovery.

20.2 Reducing the Likelihood of an Incident

Measures can be taken to reduce the likelihood of a severe incident. These measures will generally have to be taken by those organisations involved in the storage of hazardous substances. In most cases, they probably already have measures in place to limit the likelihood of an incident. However, such measures may not always be adequate. Some measures may be implemented by others, such as local authorities.

Some measures that may be considered under this category are:

- Safety or emergency shut-down valves to reduce the loss of substances from the storage facilities or pipelines in the event of natural hazards
- Re-routing, securing or burying transfer and connector pipelines (where practicable) to protect from damage due to natural hazards, or from external fires.
- Carrying out regular maintenance of storage facilities, connections and pipelines.
- Ensuring that new facilities meet appropriate standards for natural hazard events including earthquakes (NZS:4203 1992 - Code of Practice for the General Structural Design and Design Loadings for Buildings and other industry specific standards), and upgrading facilities that do not presently meet these standards.
- Relocate sites and storage facilities or plan storage facilities in lower hazard areas in the long term.

20.3 Reducing the Consequences of an Incident

These are measures taken to reduce the impact of an incident on people, the built environment or the natural environment. These are measures that storage companies can be encouraged to take, by persuasion or regulation, or other authorities or agencies can implement.

Examples of such measures are:

- Providing bunding, where appropriate, to prevent escape of liquid spills. Bunding is generally provided for the major facilities in the Region, but may be substandard, particularly for some of the smaller facilities.
- Incorporating fire-fighting features, where these are absent.
- Having in place emergency response procedures and ensuring personnel know what to do i.e. preparedness planning.
- Public information/notification of what to do in incidents involving hazardous substances.

20.4 Land Use Planning and Consents

Management by land use planning and consents may assist with avoiding incidents occurring in the first place, and reducing the potential impact of an incident in the future.

Planning measures could be used to reduce the risk by maintaining a separation between the hazardous facility and the environment (say people). The recent fireworks warehouse explosion in Holland (May 2000) and the consequent destruction of surrounding residential properties highlights the severe adverse effects that can arise from the proximity of hazardous facilities and other land uses, such as residential areas. District Plan land use zoning is one of the means of achieving the required separation.

Land Use Planning for Hazardous Facilities (Ministry for the Environment, 1995) provides guidance on land use planning for hazardous facilities. This provides a screening procedure for considering hazardous facilities. The report on “Implementation of Hazardous Facilities Screening Procedure into Lower Hutt District Plan” (Wood, 1995) considers the implementation of such procedures for Hutt City. Alternatively, a quantitative risk assessment may be considered for specific facilities.

Resource and building consents are important means to ensure that the risk to the community and the environment is acceptable; when new facilities are planned or upgrading of existing facilities is proposed. Both the Regional Council and Territorial Authorities have a role to play in managing the risk through :

- Resource and discharge consents (Regional Councils)
- Building and land use consents (Territorial authorities)
- District Plans land zonation (Territorial authorities).

20.5 Emergency Management

20.5.1 Emergency Response

Should a major natural hazard event occur which subsequently results in the release of hazardous substances or ignition of stored hazardous substances, the Fire Service and the company involved would attempt to control the release. The ability to control the release or a fire will depend on the substance and quantity involved and the damage caused by the natural hazard.

Discussions with the Fire Service suggest that they are well prepared to react to emergencies arising from a hazardous substances event and any associated fires. However, the capability of the local Fire Services would be overwhelmed in the event of a moderate or more severe natural hazard event. In such cases, the immediate priority of the Fire Service and other response agencies would likely be concentrated on saving people, and hazardous substances events that don’t pose an immediate threat may well not be able to be attended to.

Emergency services organisations are well aware of their limited capability in a larger event such as a significant earthquakes, and initiatives are being taken to co-ordinate with emergency services from other regions, and also establish national emergency response centres.

Features relating to fire protection and fire fighting that should be incorporated in any future storage site development or refurbishment are the provision of fixed fire protection in the form of appropriate foam pourers and spray rings to all large facilities used for storage. It should be ensured that the fire controlling method will not react adversely with the substance, causing a worse problem.

Access for fire fighting is also an important issue, and it should be ensured that in all cases fire fighting from safe positions should be possible. The distance from vegetation and boundary fences should also be controlled to protect the storage facility from the effects of a fully developed vegetation fire occurring immediately outside the fence. The heat energy radiated from such a fire may exceed the ignition trigger point for some hazardous substances such as solvents.

20.5.2 Risks Arising From Emergency Response

The risk of contamination of the environment from run-off following a fire event needs to be considered. While the Fire Service has a responsibility, and will make every effort to prevent contamination, for many sites it is unlikely that effective measures will be in place to protect the environment from run-off during and after a fire incident. For small incidents, this may not be a major concern, as foam and other run-off will normally be contained within the site bunded area.

Specific on-site containment measures may need to be adopted where excessive quantities of liquid contaminants are present. This may involve isolating the bund and storm water drainage system and then physically removing the contained run-off to a safe disposal site after the event. For large events, this may involve discharge into a separate water retention basin from where treatment, disposal or evaporation and sludge disposal can be effected.

Material resources to control spills and spill fires may not be readily available in sufficient quantities for the emergency measures to be effective, in some instances. The normal immediate response party is the local Fire Service, who may have limited containment capabilities for spills, but they would act to control or remove the spill utilising whatever equipment they could adapt to the task.

20.6 Future Changes to Risk from Hazardous Substances

A number of factors may influence the risk from hazardous substances in the future, such as:

- Population increase – This may put more people at risk in the event of incidents involving hazardous substances, particularly if extensive residential development occurs close to large storage facilities.
- With the decline in some heavy industries in some areas, there is growing pressure to site non-industrial activities in close proximity to hazardous facilities. This has the potential to increase the risk from hazardous substances.
- Increased congestion along highways and arterial routes may increase the risk associated with hazardous substances transport.
- Technological improvements – In the longer term, improvements in technology of storage facilities, connections and safety features may reduce the hazards.
- The introduction of regulations for hazardous substances associated with the HSNO Act (1996).

21 Limitations

The following limitations of the study should be noted:

- This is a regional scale scoping study and the hazards shown are indicative of the spatial distribution of the hazards and risks.
- Given the limited information, many parameters have been subjectively assumed.
- The focus has been on sites with significant storage volumes. However, there are numerous other sites with smaller storage and these do pose a risk, although the risk is relatively small.
- The study was based on known information held and made available by local authorities. Due to lack of information, the study may not be completely inclusive of all facilities.
- The risks are indicated at the storage sites only. However, the impacts would extend outside the immediate storage sites and can cause effects far from the incident location. For any particular site of interest, such consequences would need to be considered specifically.
- The hazards associated with a particular type of storage or site are indicative only, and site specific studies may be required for particular issues.
- Users should make their own interpretations as to the effect on a specific facility or issue of interest, from the hazards indicated.
- Wellington Regional Council and Opus International Consultants assume no liability for a loss or claim arising from the publication of this report and associated maps.

22 Recommendations

(1) The highest risk facilities have been identified as having explosives, toxic gases and flammable liquids. Further assessment of these facilities will confirm the risk appraised in this scoping study and enable site-specific measures for risk mitigation to be suggested. The requirements for each class of substance are as follows:

- **Explosive Storage/ Handling Facilities**: Further assessment should confirm the sub-classes of these explosives, location of the facilities (where these were not able to be established), and storage details. Assessment of risk for explosive storage should also be carried out.
- **Toxic Gases Facilities:** Further assessment is required to confirm storage details, confirm risk from specific sites, and develop site-specific risk mitigation measures where appropriate.
- **Flammable Liquid Storage Facilities:** The flammables of interest are solvents, but the information available appears to have facilities with petroleum storage listed. During the screening stage, the petroleum storage facilities have been eliminated as far as possible, but further work should be carried out to confirm the assumptions made regarding facilities storing non-petroleum solvents.

(2) A detailed assessment is recommended for the high and very high-risk facilities, including that of the quality and standard of storage facilities and other related issues. This should be carried out by a suitably qualified Engineer.

(3) It is recommended that the Regional Council discuss the co-ordination of the emergency response with territorial authorities and other emergency service organisations. The discussions should include readiness to deal with incidents involving a variety of substances. The future Civil Defence Emergency Management Group for the Wellington Region may provide an appropriate vehicle to pursue this issue.

(4) Further data collection activities may be required, in addition to those presently required by the Dangerous Goods Act. The Regional Council should keep itself informed and up to date on storage and movement of hazardous substances in the Wellington Region that pose a significant risk to the community. There is lack of information now being held. Changes associated with the phased introduction of the HSNO Act may be an opportunity for territorial authorities to implement improvements.

(5) The risks from hazardous substances should be taken into consideration in the issue of resource, discharge, land use and building consents and district planning. e.g. hazardous substance storage facilities in high hazard areas.

(6) Carry out a detailed study of how management of the risks arising from hazardous substances could be improved.

(7) Review risks associated with the transport of toxic gases and explosives through populated areas and along key transport corridors and agree risk management actions with the industry.

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Figures

Appendices

Appendix 1: Classification of Substances Based on the Hazardous Substances and New Organisms Act 1996 (formerly from the Dangerous Goods Act, 1974)

Class 1	Explosives
Class 2	Gases, being--
	(a) Gases (other than those included under any other paragraph of this Class) when compressed, liquefied, or dissolved under pressure.
	(b) Ethane, ethylene, hydrogen, methane, and any other flammable gas (other than that included under any succeeding paragraph of this Class).
	(c) Acetylene, compressed or dissolved, and contained within a porous substance.
	(d) Liquefied petroleum gas, and any other liquefied flammable gas.
	(e) Chlorine.
	(f) Anhydrous ammonia.
	(g) Liquid oxygen.
Class 3	Flammable liquids, being-
	(a) Liquids, mixtures of liquids, and liquids containing solids in solution or suspension, which in each case has a flash point lower than 23 degrees, and nitrocellulose with, by mass, a nitrogen content not exceeding 12.6 percent wetted with, by mass not less than 45 percent flammable liquids with a flashpoint less than 23 degrees Celsius:
	(b) Liquids, mixtures of liquids, and liquids containing solids in solution or suspension, which in each case has a flash point of 61 degrees Celsius or lower, but not lower than 23 degrees Celsius, and nitrocellulose with, by mass, a nitrogen content not exceeding 12.6 percent wetted with, by mass, not less than 45 percent flammable liquids with a flashpoint of 61 degrees Celsius or lower but not less than 23 degrees Celsius:
	(c) Fuel oil.
Class 4	Flammable solids Flammable solids, being substances liable to spontaneous combustion or substances which, on contact with water, emit flammable gases, and which consist of the following divisions and categories:
Division 4.1	Flammable solids, being solids, other than those classed as explosives, possessing the common property of being easily ignited by external sources.
Division 4.2	Substances liable to spontaneous combustion, being solids or liquids possessing the common property of being liable spontaneously to heat and to ignite.

Division 4.3	Substances which, in contact with water, emit flammable gases, being substances which, by interaction with water, are liable to become spontaneously flammable or to emit flammable gases in dangerous quantities.
Class 5	Oxidising substances
	Oxidising substances being,--- (a) Bromates, chromates and dichromates, chlorates, chlorites, chromium trioxide (anhydrous), hypochlorites (with more than 39 percent available chlorine), inorganic peroxides, nitrates, perborates, perchlorates, permanganates, persulphates, potassium nitrite, sodium nitrite, tetranitromethane, urea hydrogen peroxide, hydrogen peroxide, zirconium picramate wetted with not less than 20 percent water:
	b) Organic peroxides.
Class 6	Toxic and Infectious Substances
Division 6.1	Toxic substances
	These are substances liable either to cause death or serious injury or to harm human health swallowed or inhaled or by skin contact;
Division 6.2	Infectious substances
	These are substances known or reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsia, parasites, fungi) or recombinant micro-organisms (hybrid or mutant), that are known or reasonably expected to occur
Class 7	Radioactive Materials
Class 8	Corrosives
	"Corrosives, being hydrofluosilicic acid, hydrofluoric acid, nitric acid, sulphuric acid, chlorosulphonic acid, potassium hydroxide in solution, phosphoric acid, sodium hyperchlorite in solution, sodium hydroxide in solution, and aqueous ammonia."

Appendix 2: Toxic Gas Risk Assessment for a Release Scenario

A2.1 Hazards from Chlorine Release

The release of toxic gas, such as chlorine, is a very high consequence, low probability hazard. Accidental release of large quantities of toxic substance in an incident could cause multiple fatalities in addition to long-term health effects and permanent injuries. The risk of exposure from toxic clouds of gas has been assessed for scenarios involving chlorine gas release and the results of these studies are presented here.

Calculations carried out using computer models show that the predicted worst-case chlorine concentrations subsequent to a release event can be high even at a distance of 2 km from the event. For a scenario of chlorine release from a point source, e.g. chlorine tank with a hole, results show that there is a delay of 33 minutes between arrival of the gas cloud between 200 m and 2000 m, but the cloud appears to be gaining speed. As the distances are increased, the cloud gets lighter and is carried along more easily by the wind. If the local meteorology and topography channel the wind into a narrow path, e.g. as in the Hutt Valley, the movement of the cloud would be largely one-dimensional. These factors indicate that the consequence of gas cloud exposure would remain significant as the downwind distance increases.

A2.2 Likelihood of Release of Chlorine

A2.2.1 Large Scale, Catastrophic, Instantaneous Release

Large scale, catastrophic releases of chlorine occur due to rupture of a cylinder (tank), which could be caused by one of the following events:

- Heating of the tank resulting in the boiling over of chlorine resulting in a Boiling Liquid Expanding Vapour Explosion (BLEVE) caused by adjacent fire and failure to put out the fire or keep the tank cool;
- The tank damage from natural hazard events such as a large earthquake
- Under-design of the tank strength for normal operation has been ignored here, as tanks are assumed to be subject to chlorine tank standards.

These causative events give the theoretical tank rupture rate of 1 chance in 200,000 per tank per year. The theoretical probability of chlorine gas reaching a site 400 m from the source is estimated to be 1 chance in 500,000 per year. Although for slowly developing events such as heating and subsequent BLEVE, there is likely to be adequate time to evacuate, some catastrophic releases are unlikely to provide adequate warning. Unless there is an automatic alarm system accompanied by an efficient evacuation plan, successful evacuation is unlikely to occur. Therefore, high probabilities of failure of evacuation or manual warning system have been assumed.

A2.2.2 Medium Scale, Continuous Release

Medium scale releases would be caused by small holes in the chlorine tank, operator errors during transfer operations, failure of instrument/ connection/ valve, from natural hazards.

Small/medium releases have been assessed to have a likelihood of 3 in 100,000 per plant per year. However, for leaks of this nature to reach a site 400 m from the source, the wind and weather conditions should be favourable. The early warning system must fail and evacuation be delayed before this is a risk to humans. The likelihood of small/medium scale release travelling 400 m and posing risks to humans has been calculated to be 1 in a million per year.

A2.3 Individual Risk for Chlorine

At the concentrations predicted by heavy gas dispersion modelling at the medium continuous and instantaneous release rates, the number of fatalities will be near 100% within 400 m. Therefore, the individual risk level is 3 in a million per year. This is below the individual risk criteria of 5 in a million deaths per year recommended by New South Wales Department of Planning for commercial development.

Based on instantaneous release dispersion modelling results, the maximum concentration in the cloud takes approximately 7 minutes to travel 200 m. This estimate is expected to be conservative and offers just enough time to evacuate or seek shelter.

The effects of shelter based on 3 air changes/ hour (being a largely open building), reduces the indoor concentration to about 45% of the outdoors concentration, when exposed for a duration of 12 minutes. When exposure is continued for an hour, the reduction is negligible. The moderate continuous releases are likely to last for longer, so that concentrations indoors will gradually rise. Therefore, shelter will not reduce the risk of exposure significantly, unless measures are in place to reduce the air changes. In this study, we have assumed that shelter does not contribute to reduction in risk levels.

A2.4 Assessment in Context

The likely occurrence of a release of chlorine is low, assuming adequacy of in-house safety measures taken by the facility. There are likely to be effective safety systems in place to maximise public safety in line with legislation and industry standards, and the relevant authorities, including the Regional Council, have the ability to inspect and monitor these to ensure compliance with all standards.

A2.5 References

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Appendix 3: Solvents Assessment for a Release Scenario

A3.1 Solvents

These are likely to be similar to that for release of petroleum, for a small or medium release (Opus International Consultants, 2000). That study indicated that the likely fire scenario for is a likely to be a pool fire. In a semi-confined environment, volatile substances (e.g. petrol and other low flash point solvents) may cause a potentially explosive situation, forming an Unconfined Vapour Cloud Explosion (VCE) or Fire Ball.

Given a spill, the likelihood of a pool fire was estimated as 1 in 50 and that of a VCE was estimated as 1 in 10,000 (Lees, 1980). A large spill would be required to create adequate vapour for a VCE to occur.

The area of impact from a spill depends largely on the geographic and climatic factors. A typical zone of impact particularly to the people and built environments can be estimated from the size of pools formed and which can be ignited in the presence of an ignition source. Computation of pool sizes in water is complex and was not considered as part of this scenario.

An indicative radius of lethal impact for different sizes of spill is given in Table A3.1. This expected to be very similar to the case for solvents.

Table A3.1 - Radius of Impact from Petrol Spill (Assumed Similar for Solvents)

Release Size	Volume of Spill (l)	Pool Diameter (m)	Radius of Impact for No Lethality* (m)		
			Wind speed zero	Wind speed 5 m /s	Wind Speed 15 m/s
Small	10,000	30	90	135	150
Medium	100,000	80	140	210	230

* It is assumed that there will be no lethality beyond radius of impact.

Appendix 4: Perceptions of Risk from Hazardous Substances and Facilities

Extracts from a report of risk perception (Gough, 2001).

A4.1 Introduction

The Australian and New Zealand risk management standard (AS/NZS, 1999) defines risk as “the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood”. This definition is consistent with the common understanding of risk as a combination of the likelihood of a particular event occurring and a measure of the magnitude of the consequence is that event did occur. Where quantitative information is available (or can be imputed), risks analysts estimate levels of risk by multiplying probabilities and magnitudes. In other circumstances, qualitative estimates of levels of risk can be determined and used as a means of ranking risks.

Typically, risk estimates use past statistical information to predict what might happen in the future. Risk analysis is therefore a predictive tool. Estimates of risk made by analysts using technical approaches are often very different to perceived risk estimates made by individuals and communities. Thus, there has been considerable research into understanding the difference between expert predictions and lay perceptions of risk as a means of finding ways of reconciling them.

A4.2 Review of Literature on the Perception of Risk (With Particular Reference To Hazardous Substances)

Risk perceptions are closely linked to the concept of acceptable risk, which is itself an integral part of modern society. In any particular situation, determining what is an ‘acceptable risk’ requires asking questions such as `to whom is the risk acceptable?' and `where are the likely costs (risks) and benefits likely to fall?' Perceptions of risk are an important factor when determining an acceptable level of risk, which must itself be specific to a particular issue or context.

A4.3 Factors that Affect Perceptions of Risk

Through the 1980s, a number of authors used different techniques to develop and analyse the heuristics that people use to make estimates of risk. The most important authors in this area Tversky and Kahneman (1982), developed concepts relating to availability, representativeness and anchoring that were used by other researchers as explanatory tools.

Other researchers concentrated on identifying the major factors that apparently affected people’s perceptions of risk. The following list of factors (unordered) derives from the psychometric studies of Fischhoff and Slovic, and other authors (Slovic et al., 1979; Griffiths, 1981; Covello et al., 1981; Slovic, 1987).

They are, whether:

- The risk is voluntary or involuntary.
- The risk is known to science or not.
- The consequences are likely to be immediate or delayed, reversible, common or dread.
- The subject is familiar or unfamiliar with the risk.
- The hazard is encountered occupationally.
- The risk affects 'average' people.
- The risk is new – or has it been previously experienced (not necessarily directly).
- There is likely to be misuse (relevant to hazardous substances).
- The effects are chronic, cumulative or catastrophic in nature.
- Whether there is seen to be any easy way of reducing the risk.

Other factors are:

- What measure of control over the risk the subject has.
- The severity of the consequences.
- The distribution of the risk - is exposure equitable and the size of the group exposed to the risk.
- The degree of personal exposure.
- The effect on future generations.
- The global catastrophic nature of the risk.
- The changing character of the risk.
- The availability of alternatives.
- The necessity of exposure.

Following on from this and applying principle component analysis techniques, Krewski et al. (1987) concluded that three main factors seem to affect risk perception; whether a risk is common or has dread features (e.g. nuclear power accidents, hazardous waste issues), personal and scientific understanding of the risk, and the number of people involved should the risk be realised.

A4.4 Characteristics of Different Types of Risk

Early work on risk perceptions concentrated on the public's response to technological risk, and in particular, the risks related to energy technologies. However, the psychometric approach pioneered by Fischhoff and Slovic required participants to rate or rank a large number of hazards according to a set of attributes. Typically, the set of hazards used was over 25, and covered a range from short-term chronic effect hazards to long-term, cumulative and highly uncertain hazards. Thus, both technological (man-made) hazards and natural hazards were included. The results, however, did not directly compare responses to these different types of hazards, and Covello (1983) noted that few attempts had been made to relate technological risk perceptions to natural hazard risk perceptions. It is notable that there has been little comparative work since this time, possibly due to the techniques used to estimate and evaluate perceived risk, which do not lend themselves to valid comparisons being made. The USEPA applied work on comparative risk in the early 1990s (following from the methods developed in USEPA, 1990), compared different types of environmental risk using criteria based on perceptions of risk and professional judgement.

A4.5 Hazardous Substances

There is little specific reference to public perceptions about hazardous substances in the literature, with the main reference coming through from areas such as facility siting. International work on risk perceptions associated with facility siting has concentrated on issues such as LPG storage, nuclear power plants, and hazardous waste (Kunreuther and Linnerooth, 1983; Weigman et al, 1995; Arabie and Maschmeyer, 1988; Slovic et al, 1991; Easterling, 1997).

Early New Zealand experience in these matters centred on the proposed LPG storage facilities in Lyttelon and Seaview. Experience from the Seaview example, where there was considerable public opposition, was that the community did not believe that the quantitative risk assessments that had been conducted addressed the full scope of the issues. This was because they did not consider the complete transport system associated with the storage of LPG for use in the Wellington and Hutt area (Jenny Boshier, pers comm.). Local residents, including those in the Petone area, were very concerned that this aspect had been omitted and felt that the whole question of storage and transportation should have been addressed together.

Equity is a major issue with respect to siting of facilities that relates to hazardous facilities as well as non-hazardous facilities that are regarded as undesirable by a community, such as prisons. In 1996, the journal RISK: Health, Safety and Environment devoted an issue to the IIASA symposium on fairness and siting which refers perceived risk work[2]. This leads to the NIMBY (not in my backyard) and NIABY (not in anyone's backyard) attitudes that have been reported in the literature. In the case of hazardous facilities, communities are concerned that the organisation operating the facility gains the benefit (often including profits) while the community bears the risks.

Since 1998, the OECD Environment, Health and Safety group has been undertaking a major programme in chemical risk management. Two aspects of this programme are relevant: the development of tools for integrating of socio-economic analysis into chemical risk management decision-making, and the improvement of the management of risks by better risk communication.

The status of this project is that an OECD Background paper (Renn and Kastenholz, 2000) has been prepared as a basis for a guidance document on methods for risk communication with respect to chemicals and chemical plants that is expected to be published later this year.

A4.6 The Likely Perception of Risk Arising from the Storage and Transport of Hazardous Substances (Non-Petroleum) In the Wellington Region, Compared with the Perception of Other Common Hazards

It can be said that as far as the public is concerned, risks from hazardous substances storage and transport tend to be involuntary, uncontrollable, and unequally distributed (geographically and socially). These factors will all increase a perception of (adverse) risk or effect. All of these factors will reduce the risk tolerance of the public, and those communities most immediately affected.

A4.7 Risk Communication

A general definition of risk communication is: "any purposeful exchange of information about health or environmental risks between interested parties. More specifically, risk communication is the act of conveying or transmitting information between interested parties about levels of health or environmental risks; the significance or meanings of such risks; or decisions, actions, or policies aimed at managing or controlling such risks" (Davies et al., 1986).

A4.8 Techniques for Risk Communication

Typical methods that are used for risk communication between an organisation and its 'community' are:

- Distribution of printed and electronic material.
- Face-to-face meetings with selected community groups.
- Focus groups.
- News publications.
- Public meetings.
- Tours and inspections of facilities.
- Inclusion of members of the community on advisory boards or expert committees.

Renn and Kastenholz (2000) refer to risk communication in terms of 'discourse' and note that the most influential factors on the success of discourse are:

- A clear mandate for the discourse participants.
- Openness of results.
- A clear (common) understanding of the options and permissible outcomes of such a process.
- A predefined timetable.
- Equal position of all parties.
- A neutral facilitator.

[2] Risk: Health Safety and Environment Volume 7, Number 2, Spring 1996.

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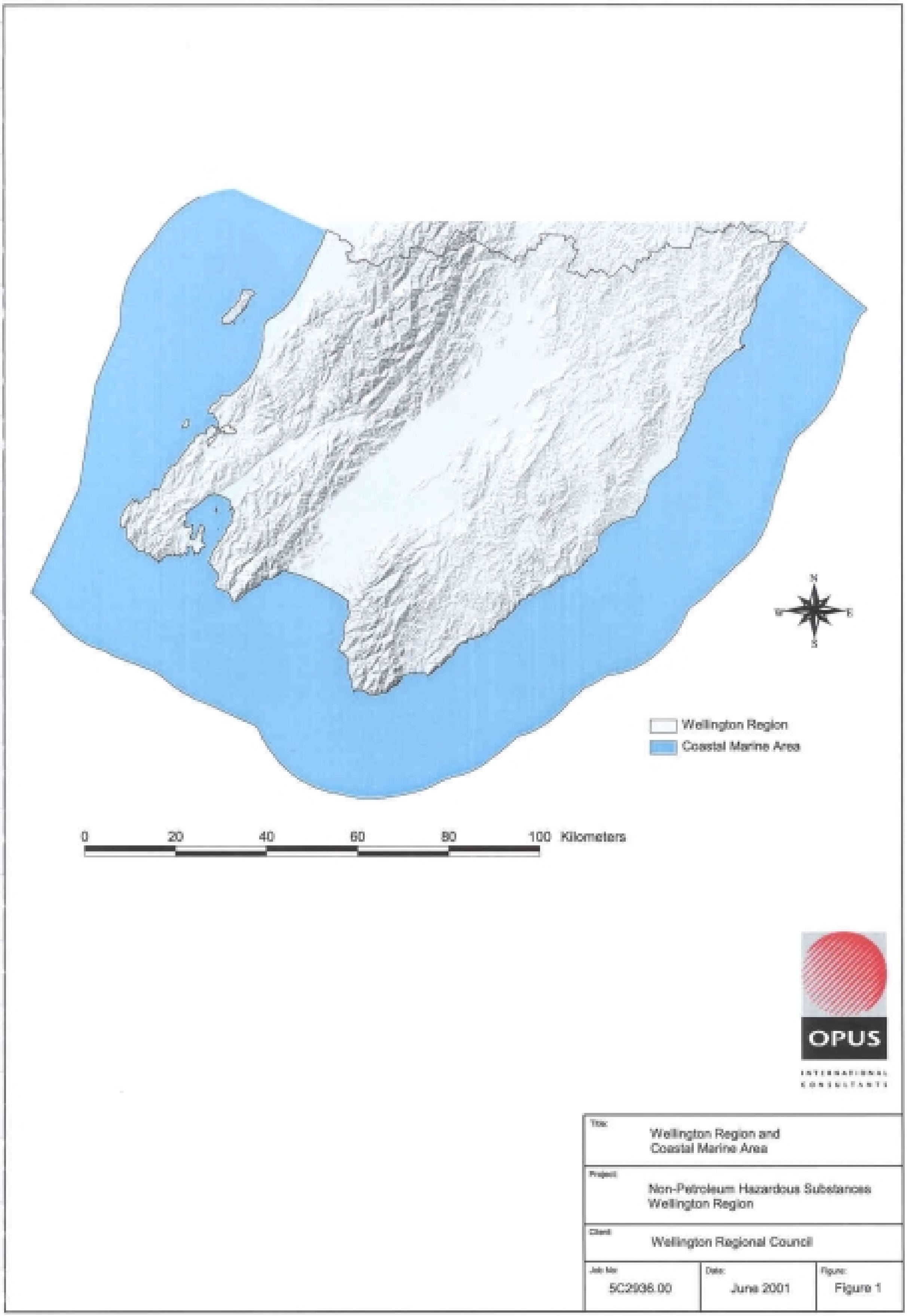
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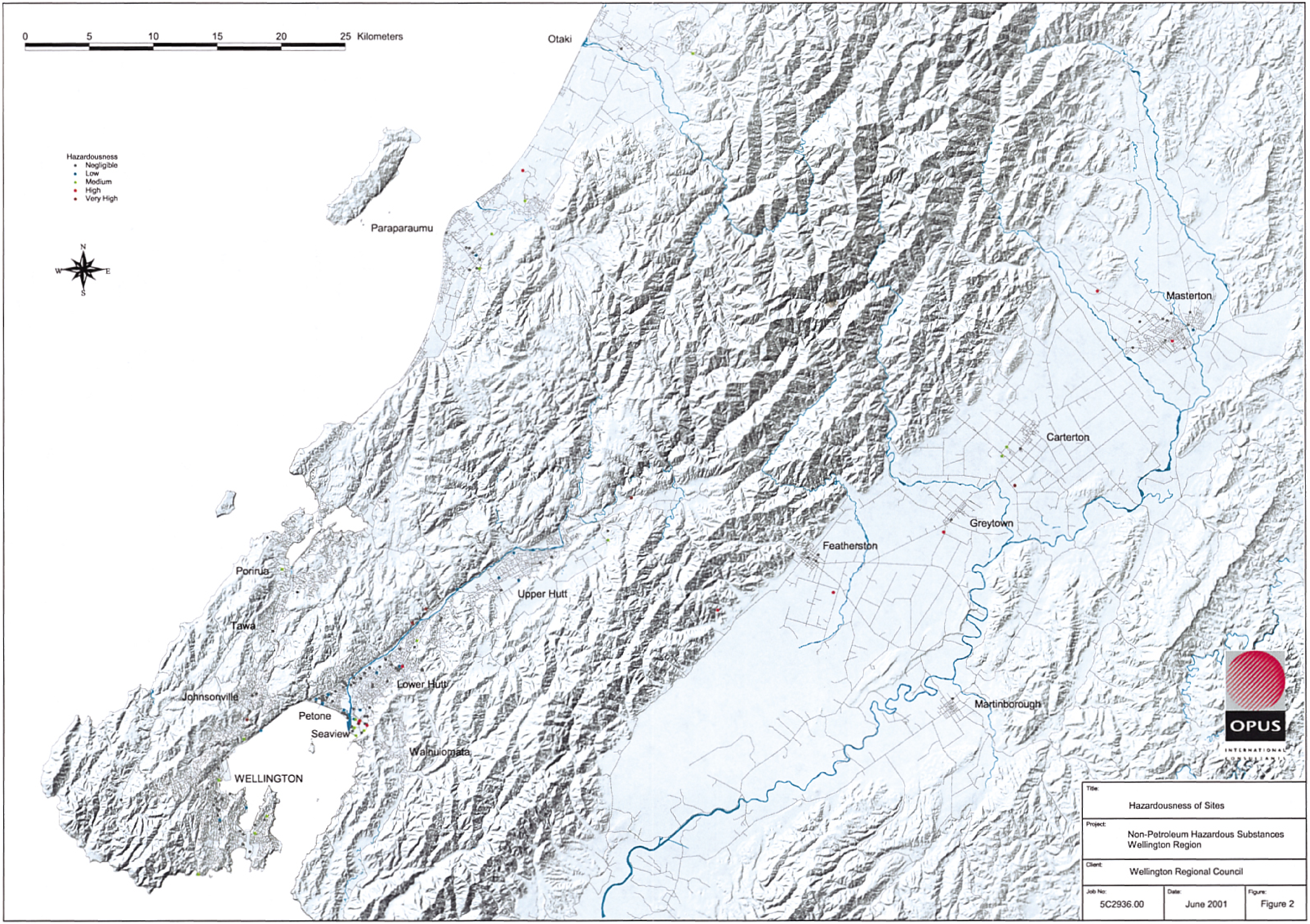

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Project: Non-Petroleum Hazardous Substances Wellington Region

Client: Wellington Regional Council

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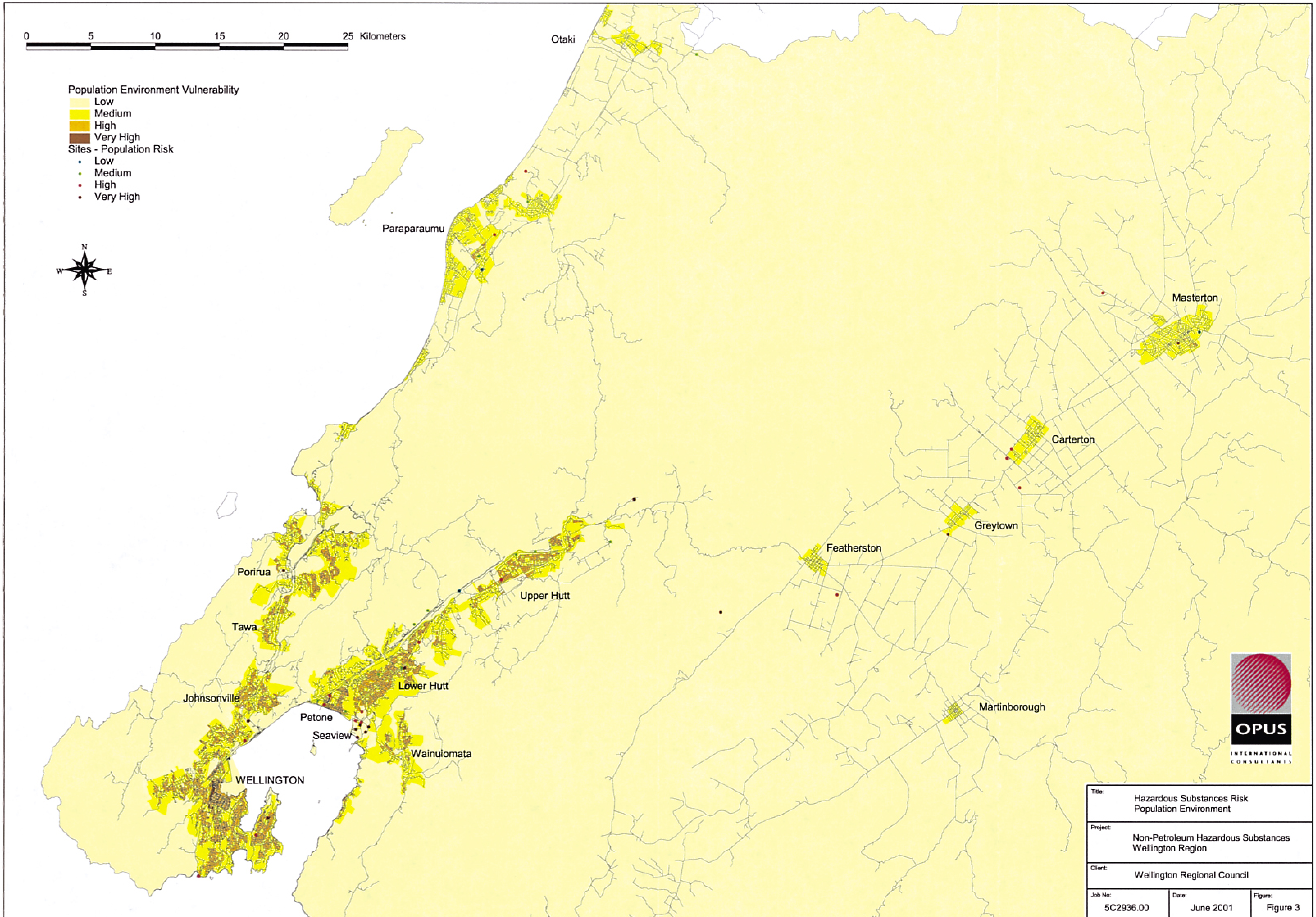

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Client:	Wellington Regional Council

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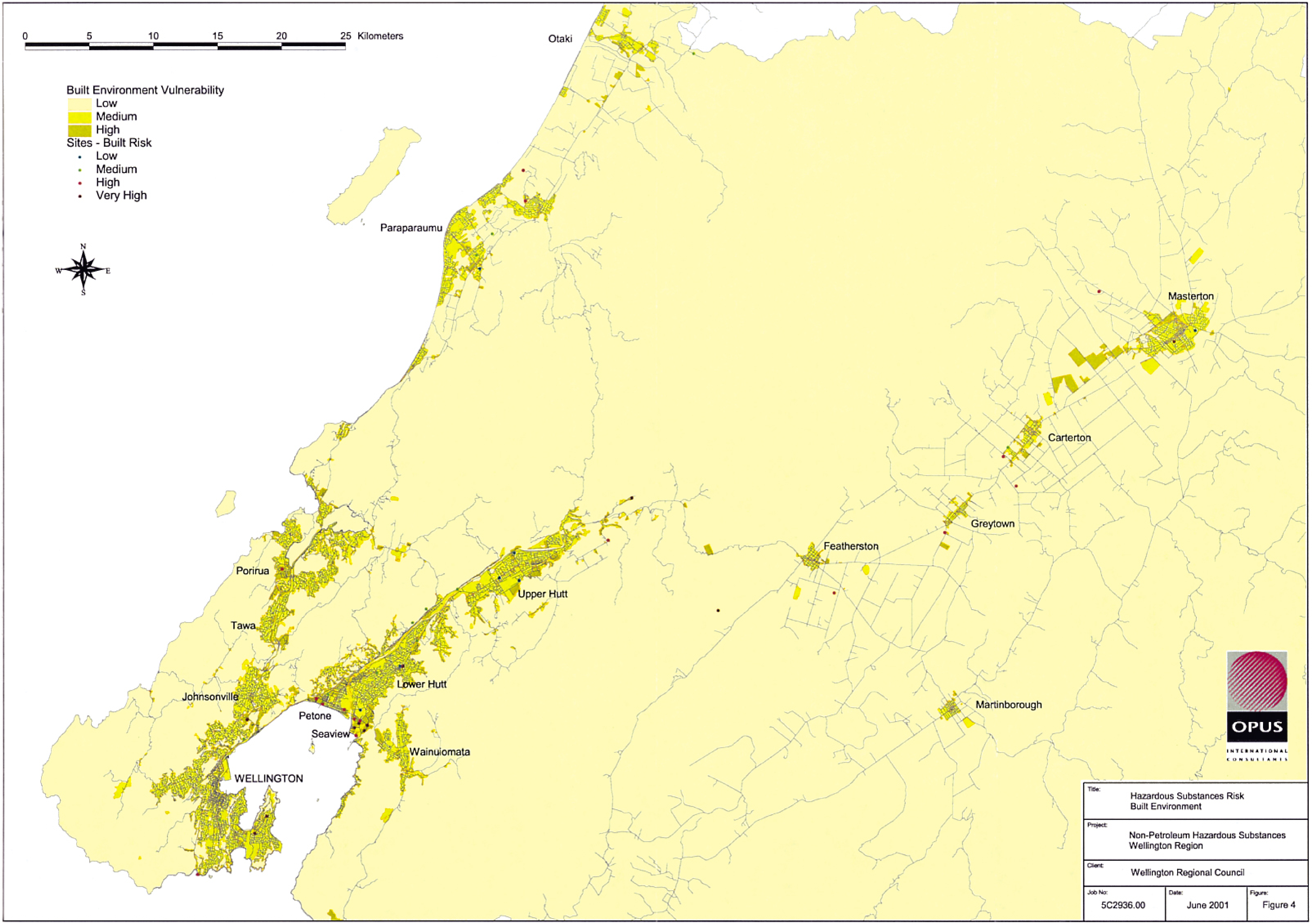

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Title:
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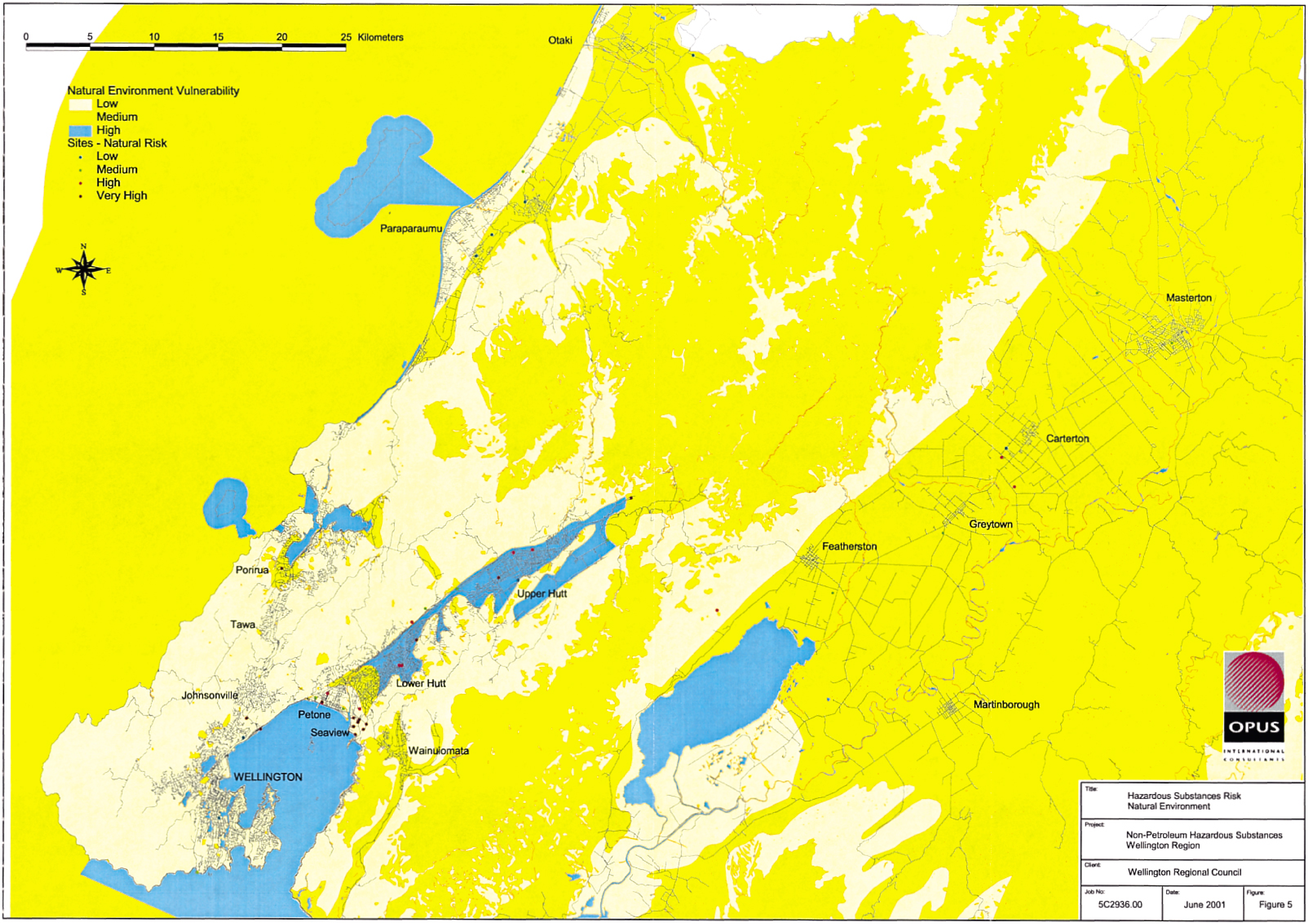
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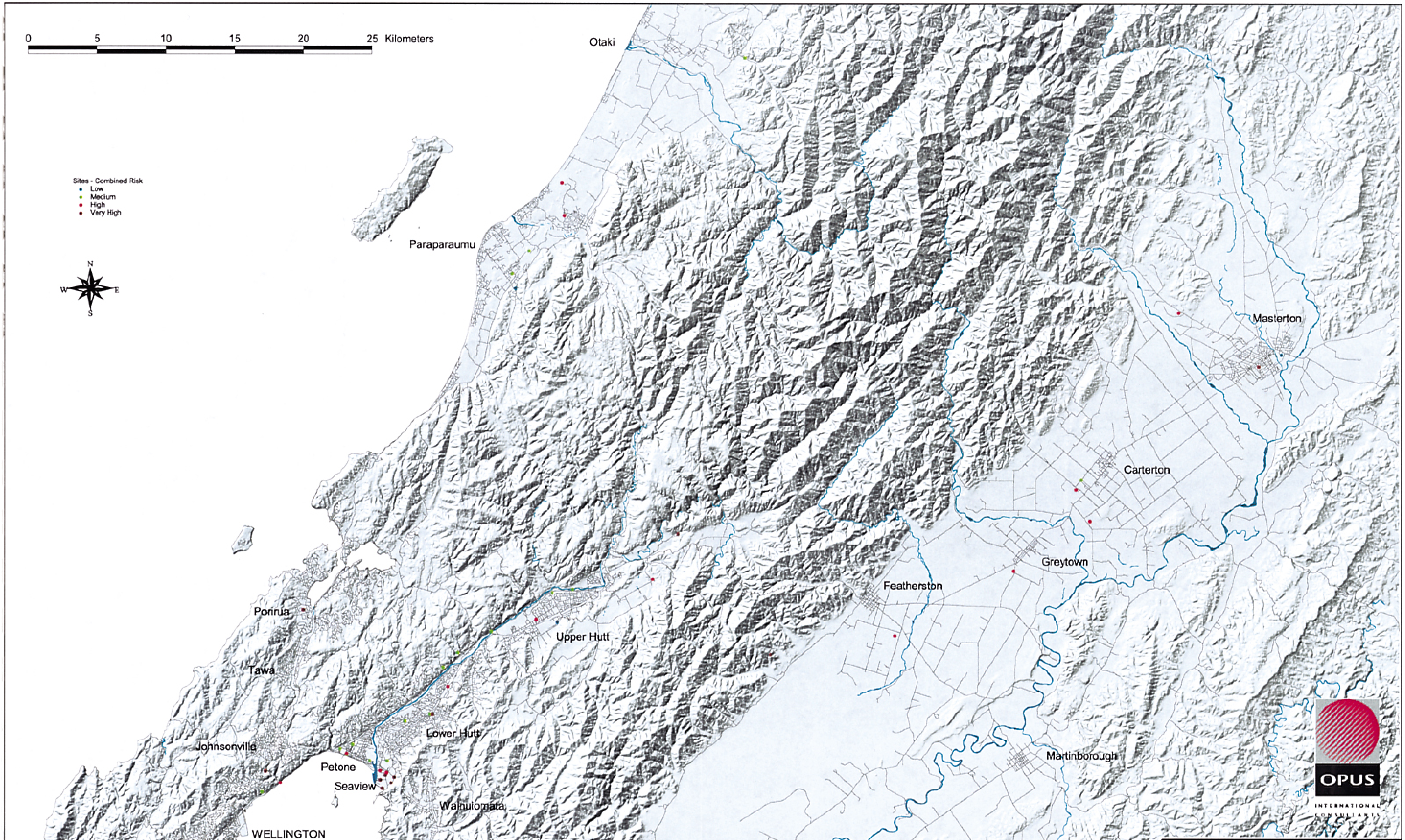

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Project:	Non-Petroleum Hazardous Substances Wellington Region
Client:	Wellington Regional Council

Job No:	Date:	Figure:
5C2936.00	June 2001	Figure 6