Submission
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INQUIRY INTO HEALTH IMPACTS OF AIR POLLUTION IN THE SYDNEY BASIN

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Summary

ENVIRONMENTAL CONTAMINANTS AND THEIR HEALTH IMPACTS

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A submission to the NSW Legislative Council Inquiry into
Health Impacts of Air Pollution in the Sydney Basin, 16 August 2006

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STATEMENT

My name is Christopher Winder. I have a PhD in toxicology and pathology and a Graduate Certificate in OHS Management. I am Associate Professor in Applied Toxicology in the School of Safety Science at the University of New South Wales. I have received a summons to appear here today. I have been invited to appear at this hearing in my capacity as a toxicologist.

An inquiry into the health impacts of air pollution in the Sydney basin is a laudable proposition. Environmental contamination is a known source of health problems.

However, an inquiry that only considers health problems from air pollution will miss health problems from other environmental media, such as water, soils and sediments. Of necessity, these should also be considered in the process of identifying environmental health problems.

In looking at the problem of environment and health, it is necessary to consider at least four main interlocked topics: hazard, exposure, risk and risk control.

First, to hazard.

Air pollution exposure may be to individual and complex exposures of gases, vapours, fumes, dusts, mists, aerosols and mixtures of these.

Primary anthropogenic sources of atmospheric pollution include road transport; industrial processes such as mining, construction, and manufacturing; domestic combustion sources (mainly home heating and cooking); and natural sources, such as bushfires.

Exposure to occupational and environmental airborne contaminants is a major contributor to human health problems. Inhalation of gases, vapours, solid and liquid aerosols and also mixtures of these can cause a wide range of adverse health effects, ranging from simple irritation to systemic diseases.

Second, to exposure.

Exposure is the link between hazard and effect. Where exposures to hazardous contaminants are low or properly contained, it is possible that no adverse consequence will arise. However, there are a number of shameful cases in the Sydney basin where environmental problems are now well recognised. These include, but are not limited to:

- o sediment contamination in Cockle Creek from lead containing effluents discharged by the Sulphide Pasminco Lead Smelter in Newcastle;
- o contamination of fish with dioxins in the Parramatta River from industrial waste landfilling on the Rhodes Peninsula by Union Carbide,
- o soil contamination from on site burying of chlorinated wastes at the ICI site at Botany and contaminated groundwater spreading off site.

While it may be argued that these examples are from past activities before community expectations and regulatory regimes were not of the standards expected today, a cursory evaluation of these activities indicates industrial practices of a dubious nature even at the time they were being practiced.

Further, in many of these cases, common factors emerge, that contribute significantly to the magnitude of environmental impacts, including: lack of information, misinformation, overconfidence in part of the benefits of the original proposal, narrowly focused risk assessments, poor or inappropriate design, inadequate consideration of suitable controls, inadequate consideration of systems for failure or loss, reluctance in admitting error, and overbearing arrogance. Of all the factors in identifying safety, health or environmental problems, the ability of organisations to resist change is impressive and in some cases, odious. Indeed, there is a tried and tested hierarchy of approach by industry for dealing with new threats to its business: denial, misinformation, bluster, threat, and slow, grudging acquiescence only if public or political pressure is strong enough to force change.

These practices have not necessarily ceased even with introduction of stricter regulatory regimes or increased community expectations. The acquisition of the Royal Agricultural Show by News Corporation in 1995 was presaged by the demand to the NSW Government from them that "an unfettered production environment must be provided."

The activity of the NSW Roads and Traffic Authority (RTA) in the late 1990s to approve construction of the M5 East road tunnel was especially determined to ignore or otherwise minimise community concerns about a poorly designed tunnel ventilation system which collected vehicle emissions from the 80,000 or so vehicles using a 4 km tunnel and discharging them unfiltered and uncleaned from one stack, to the great chagrin of the community the stack was pointed at. The RTA has not changed its stance with other road tunnels built since then, even though evidence of health problems from tunnels continues to increase. Only in 2006 did they bow to Government pressure to begin dealing with the matter properly.

Third, to effects.

Exposure to contaminated air, water, food or soil can cause a range of short term or long term health problems. These include conventional medical conditions such as effects in respiratory, nervous, reproductive and endocrine systems, and emerging health conditions such as chronic fatigue syndrome, immune system effects and chemical sensitivity.

Some of these occur after exposures to single contaminants. But other health problems induced by environmental factors are characterised by multi-causality with different strengths of association.

Further, while the links between exposures and their health consequences depend on consideration of the physico-chemical, toxic and environmental properties of environmental pollutants; they are also influenced by factors such as genetic constitution, age, nutrition and lifestyle, and socioeconomic factors such as level of education, unemployment and poverty.

Lastly, to controls.

It is a commonly held belief - at least among business people - that business's only function is to make profits and create wealth for its shareholders. Such a viewpoint does acknowledge the principle that an organisation in business draws its licence to operate from the community, and, therefore, has an obligation to that community.

It is important for organisations to understand that under both statute and common law, there is no higher duty than duty of care. Before identification, assessment and control of risks can be properly considered, the person or organisation must acknowledge, whether publicly or privately, that they will keep a duty of care for those activities for which they are responsible.

Duty of care of directors, designers, employers, suppliers and employees is specifically outlined in OHS legislation. Environmental legislation should also include and impose this duty explicitly. This includes a duty of care not to cause harm to the environment sufficient to impact on human health.

In New South Wales, legislation that provides a legislative basis for duty of care is explicit in the Occupational Health and Safety Act 2000, and implicit in other legislation. There is a need to make the duty of care explicit in all legislation.

Further, discharge of duty of care must be demonstrated by evidence of systems for due diligence. Failure to make this effort is negligence.

In addressing organisational impacts from their activities, organisations should use the contemporary approach of risk management. This requires identification of impacts, assessment of their impacts, and where risks are adjudged to be unacceptable, control of such impacts. Because the possibility of impacts having long term consequences, programs for dealing with organisational impacts on the environment should adopt the Precautionary Principle and take a precautionary approach.

There is an extensive body of legislation that impacts on the control of chemicals in NSW. It takes a piecemeal approach to chemical legislation and has, to a large measure, failed. The chemical or contaminant is presently controlled under various environment, OHS, health, transport, waste management or other regulatory arrangements. What is need now, is a *chemicals based approach* to the control of chemicals, involving the whole of government.

INTRODUCTION

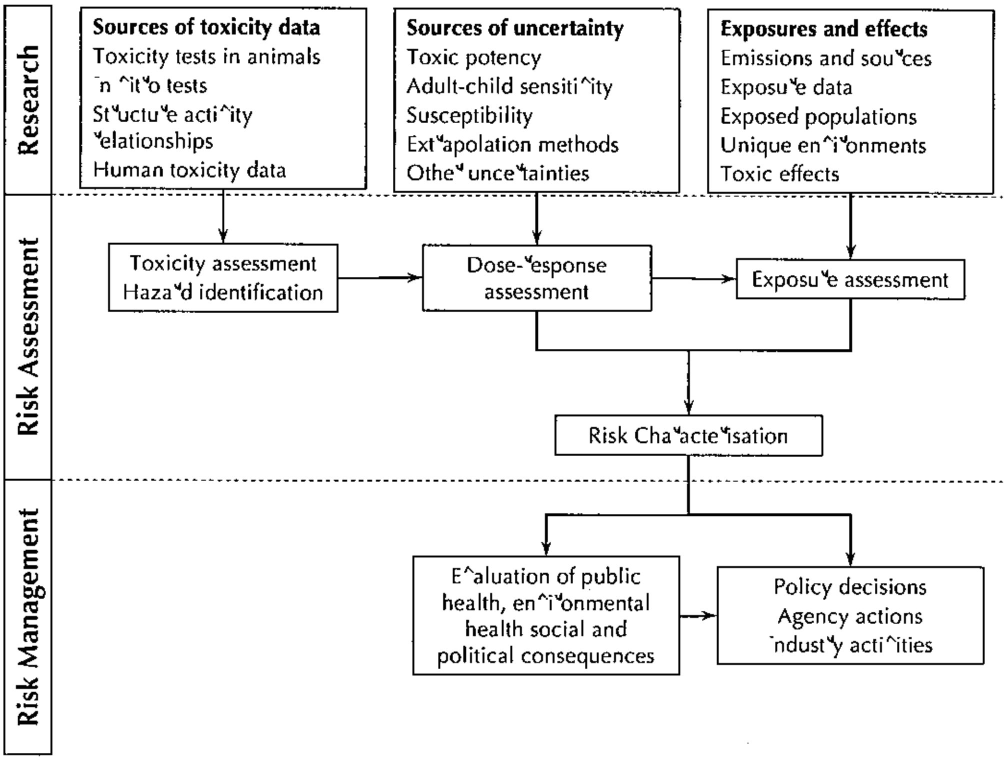
The effect of the environment on health remains a major public concern: in a recent survey in the European Union, some 89% are worried about the potential impact of the environment on their health. Furthermore, new technologies, changing lifestyles, work and life patterns, present new and sometimes unexpected impacts on the environment and its influence on health.

Risk management is an approach that covers both the identification of hazards and risks, and the control of risks that are considered unacceptable.[1] This begins with the toxicity risk assessment process, which looks at hazards, exposures, risk and uncertainties (see Figure 1).

This process requires:

- A research phase, including creation of new knowledge, gathering of information, identification of information gaps.
- A technical process of assessment of hazards, risks and exposures.
- Characterisation of risks and, where appropriate, management of the risks in a process that may evaluate and control the risks at the sociopolitical level, where technical, economic and equity issues can be evaluated, and suitable toxics elimination or risk minimisation strategies policies, programs, controls and actions can be determined.

Figure 1: Basic Chemical Risk Assessment Process



This process will be discussed below in four phases selected from Figure 1:

- Hazard (Sources of toxicity data/Sources of uncertainty);
- Exposure (Exposures and effects);
- Effects (Risk Characterisation); and
- Risk control

HAZARD

Types of Chemical Contaminants

Exposure to occupational and environmental airborne contaminants is a major contributor to human health problems. Inhalation of gases, vapours, solid and liquid aerosols and also mixtures of these can cause a wide range of adverse health effects, ranging from simple irritation to systemic diseases.[2,3,4,5] Despite significant achievements in the risk assessment of chemicals, the toxicological database, particularly for airborne contaminants, remains limited.

Air contaminants are exogenous substances in indoor or outdoor air including both particulates and gaseous contaminants that may cause adverse health effects in human or animals, affect plant life and impact the global environment by changing the atmosphere of the earth.[6] Various physical, chemical and dynamic processes may generate air pollution leading to emission of gases, vapours, particulates or mixtures of these into the atmosphere.[7] While great attempts have been made to reduce emissions from both stationary and mobile sources, millions of people today face excessive air pollution in both occupational and urban environments.[8,9] Many industrial and commercial activities release toxic contaminants in gas, vapour or particulate forms. Occupational and environmental health problems can potentially arise where such releases are not controlled properly. Moreover, today air contaminants are not limited to the urban environment or to the industrial workplaces but may be common indoor air contaminants present in office workplaces, schools and hospitals.

Based on their physical properties airborne contaminants can be classified into two main types:

- Gases and vapours or dissolved air contaminants;
- Aerosols or suspended air contaminants.

The term aerosol refers to both liquid droplets and solid particles suspended in the air such as dust, fiber, smoke, mist and fog.

This classification is critical as it defines how atmospheric contaminants arise, where they disperse, and how they can be controlled.

These terms can be defined as shown in Table 1 (from:[4,10,11]).

Table 1: Types of Airborne Contaminants

Type	Properties
Gas	These are substances that exist in gaseous state at room temperature and pressure. Only by the combined effects of increased pressure and decreased temperature; gas can be changed to liquid or perhaps solid state. Processes that involve high temperature, such as welding operations and exhaust from engines, potentially can generate toxic gases such as oxides of carbon, nitrogen or sulphur.
Vapour	This is the gaseous phase of a substance that ordinarily is in liquid or solid state at room temperature and pressure. Vapour can convert to liquid state either by increasing pressure and/or reducing temperature. Several occupational practices may produce toxic vapours such as charging and mixing liquids, painting, spraying and dry cleaning or any other activities which involve volatile solvents or chemicals.
Dust	This is a small solid particle, usually produced by different mechanical processes such as grinding, cutting, sawing, crushing, screening or sieving. Dust particles may originate from organic materials. Dust particles have nonspherical shape with a wide range of size from a few nanometres, called nanoparticles, to larger particles over 100 μm.
Fiber	This is an elongated or long solid particle with an aspect ratio (length/ width) more than 3/1. There are two types of fibers including natural like asbestos and synthetic or man-made like glass fiber. Asbestos is the most important natural fiber that can induce asbestosis and lung

Type	Properties
	cancer in workers who have had heavy exposure to asbestos.
Fume	This is a solid aerosol, produced by combustion, sublimation or condensation of vapourised materials. Metallic fumes usually form in air due to oxidation of metallic vapours. Fume particles are spherical and extremely fine, usually less than 0.1 μm, through the size can increase by aggregation or flocculation as the fume ages. High temperature operations such as arc welding, torch cutting and metal smelting can generate extremely fine metal oxide fumes.
Smoke	This is a complex compound that involves solid and liquid aerosols, gases and vapours that usually result from incomplete combustion of organic materials. For example, tobacco smoke contains thousands of chemical substances, most of which are toxic or carcinogenic. Although primary smoke particles are between 0.01-1 μm, they can aggregate and produce extremely larger particles which are called soot.
Mist	This is a suspended spherical liquid droplet formed by mechanical dispersing of a bulk liquid such as spraying and atomizing. Mist droplets have their parent liquid properties with a wide range of sizes, ranging from a few to more than 100 μm. All processes involving high pressure liquids which can potentially generate mists such as paint spraying and need to be controlled adequately. Other examples of mists include oil mists in cutting and grinding operations, acid mists in electroplating and acid or alkali mists from pickling operations.
Fog	This is a suspended spherical liquid droplet aerosol like mist but, formed by condensation of vapour phase on particle nuclei of the air. The size of fog droplets is less than mists (1-10 μm).

Types of Exposure

Three main routes of exposure to chemicals are inhalation, dermal absorption and ingestion.[12] Inhalation is considered the most important means by which humans are exposed to airborne chemicals.

The major physiological function of the respiratory tract is the transfer of oxygen to the blood and removal of carbon dioxide as a metabolic waste. The human respiratory tract has a very large surface area of approximately 140 m^2 and high daily exchange volume of more than 10 m^3.[13,14,15,16] In addition, the membrane between air and blood in the gas exchange region is extremely thin, approximately 0.4-2.5 μm.[17,18] As well as olfactory, gas exchange and blood oxygenation functions, the respiratory system has evolved to deal with chemicals and airborne materials such as those usually occurring in the air environment.[17] However, this system can not always deal adequately with the wide range of airborne contaminants that may occur in urban and particularly occupational environments.[11] As a result, the respiratory system is both a site of toxicity for pulmonary toxicants, and a pathway for inhaled chemicals to reach other organs distant from the lungs and elicit their toxic effects at these extrapulmonary sites. Responses to inhaled toxicants range from immediate reactions to long term chronic effects, from specific impacts on single tissue to generalised systemic effects.[9,19]

The severity of toxic effects of inhaled chemicals is influenced by several factors such as type of air contaminant, airborne concentration, size of airborne chemical (for particles), solubility in tissue fluids, reactivity with tissue compounds, blood-gas partition coefficient (for gases and vapours), frequency and duration of exposure, interactions with other air toxicants and individual immunological status.[10,11,12,19] The site of deposition/action of inhaled toxicants will determine, to a great extent, the ultimate response of the respiratory tract to inhaled chemicals. After inhalation airborne contaminants may be deposited in different regions of the respiratory tract including nasopharyngeal, tracheobronchial and pulmonary region.

Toxicological Assessment of Environmental Exposures

Toxicology is the science of poisons and the study of the adverse effects of chemicals on biological systems.[20,21] Toxicology is an ever-developing science and modern toxicologists consider cellular and molecular responses as the earliest indicators of exposure with exogenous agents. Toxicological developments are due to both theoretical expansion and technical improvements of different branches of science particularly biological science, chemistry, mathematics and physics. Toxicology is a very broad science that can be classified into several branches relating to discipline, application and function.

Toxicological information about chemicals in many cases is still limited.[22,23,24,25] While data obtained from human experiences would be most useful in assessing toxic effects of chemicals, human data is not always available for developing safety evaluations on chemicals and airborne contaminants. Moreover, because of unfortunate human experiences involving environmental exposures or exposure to environmental contaminants like lead, PCBs and dioxin wastes, it is now acknowledged that the risks of contaminant exposures requires assessment before adverse human experiences occur.[26]

EXPOSURE

Exposure to environmental contaminants and the development of health problems has a massive literature wordwide, too extensive to outline in this report.

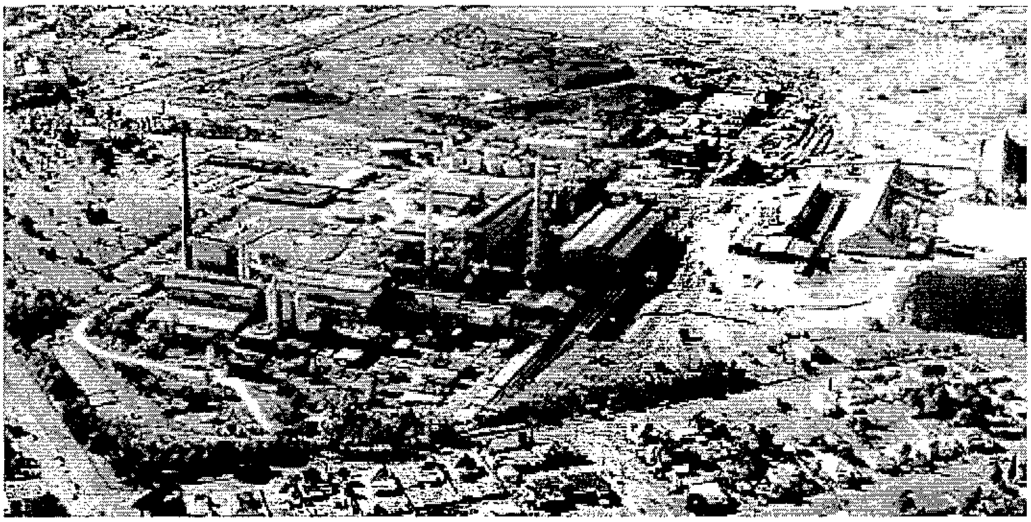
In this report, it is proposed to use four case studies to illustrate the problem:

- sediment contamination in Cockle Creek from lead containing effluents discharged by the Sulphide Pasminco Lead Smelter in Newcastle;
- contamination of fish with dioxins in the Parramatta River from industrial waste landfilling on the Rhodes Peninsula by Union Carbide,
- soil contamination from on site burying of chlorinated wastes at the ICI site at Botany and contaminated groundwater spreading off site;
- air contamination from the M5 East road tunnel ventilation system which collected vehicle emissions from the 80,000 or so vehicles using a 4 km tunnel and discharging them unfiltered and uncleaned from one stack.

Contamination of Cockle Creek (Pasminco Lead Smelter)

The Pasminco Cockle Creek smelter began operations in Boolaroo in 1897 as the Sulphide Corporation, and ceased operations on 12 September 2003. The smelter site is located at the northern end of Lake Macquarie approximately 18 km south-west of Newcastle, NSW. It was a zinc-lead smelter that produced lead bullion, zinc, cadmium, selenium, and sulphuric acid. Lead Slag was a by-product of the production process. Sulphur dioxide was a long term emission to air and lead and other wastes were discharged into Cockle Creek, discharged into the northern end of Lake Macquarie.

Figure 2: The Pasminco Cockle Creek Smelter



Source: http://www.hunter.health.nsw.gov.au/HPH/pollution/pasminco.htm

Although the smelter has now ceased operations, the accumulated contamination of the site and surrounding areas remains a significant environmental issue. In Cockle Creek and Cockle Bay, sediments are contaminated with lead, cadmium, mercury and zinc over an area of 3 km^2, to a depth of 0.6-0.7 m.[27]

Botany Groundwater Plume (Orica Petrochemicals Plant)

Botany Industrial Park is located in the Sydney suburb of Banksmeadow on the northern side of Botany Bay. ICI built the Botany Industrial Park site in 1942, creating at the time the largest chemical manufacturing site in New South Wales. In the early years, products manufactured included sodium hydroxide, hydrogen and a range of rubber chemicals. The range of products manufactured increased rapidly in the early post-war years when commodities of all types were in short supply throughout the world. Statutory controls over effluent were relatively minimal, reflecting the level of environmental awareness at the time. The 1960s saw the introduction of larger manufacturing plants and the Botany site became a petrochemical complex. This development, concentrated towards the north end of the site, was subject progressively to more detailed approval procedures and environmental requirements.

During this time, chlorinated hydrocarbons were stored on-site in tanks and drums. From time to time, wastes were buried on site (for example, under car parks). Some of these stored or buried materials have leaked into the ground and consequently, groundwater. It is likely that contamination was also caused by accidental spills.

Contamination of groundwater at the Botany Industrial Park dates back over a period of up to fifty years and was first identified in a survey conducted for ICI in 1990. The main contaminant in the groundwater is ethylene dichloride (EDC), which may pose a serious health risk. ICI/Orica consider that the levels detected in testing at Botany are unlikely to result in adverse health effects. A risk assessment of the area has concluded there is no unacceptable risk to human health.

Figure 3: The ICI Botany Petrochemical Complex

Source: http://www.oricabotanygroundwater.com/botanysite.htm

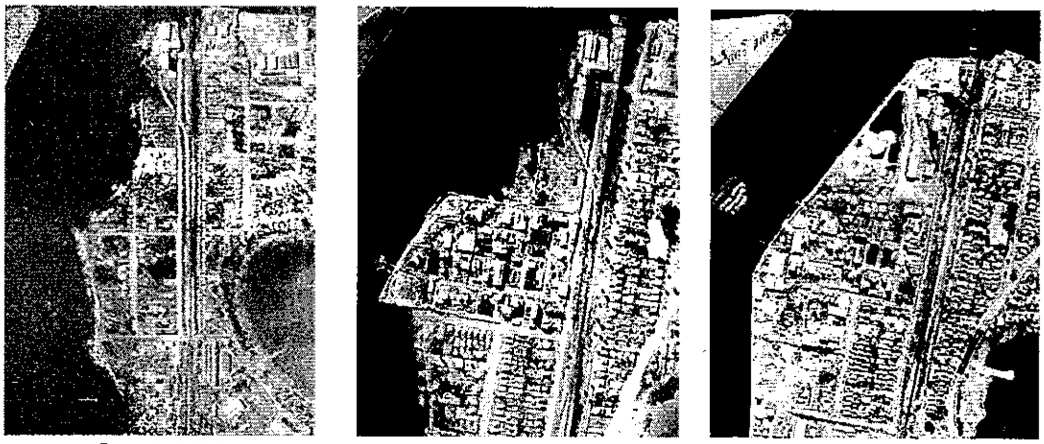
In 2003, after many years of inadequate industrial activity, the Department of Environment and Conservation ordered Orica to stop the spread of a plume of chlorinated hydrocarbon contaminated groundwater at Botany, in what the NSW Environment Minister called "one of the worst incidents of pollution in the southern hemisphere", and which was advancing approximately 100 m a year toward Botany Bay.

Note that only government direction lead to the problem given suitable attention by Orica, who have accepted responsibility for the contamination.

Contamination of Homebush Bay (Union Carbide Chemical Plant, Rhodes)

Timbrol was Australia's first major organic chemical producer, established in 1925, and operating a plant on Homebush Bay, west of Sydney from 1928. The company was taken over by Union Carbide in 1957. The company extensively reclaimed land along the Rhodes peninsula using a range of factory and industrial wastes, including chemical wastes containing chlorinated compounds (see Figure 4).

Figure 4: Reclamation of Land on the Rhodes Peninsula



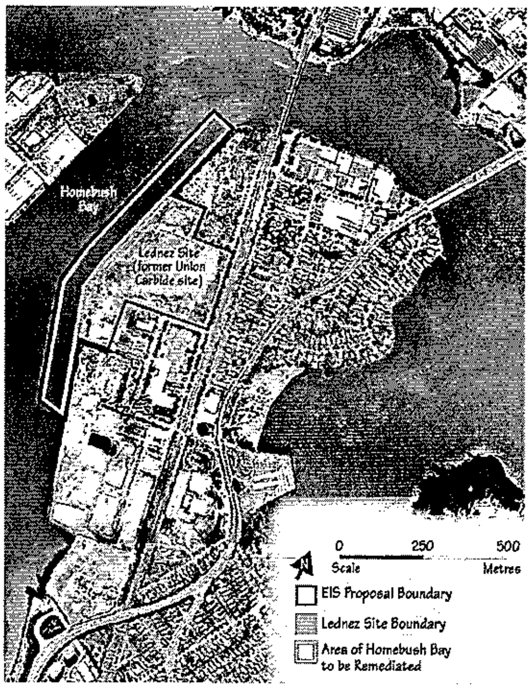
in 1930 **in 1951** **in 1970**

Source: http://www.rhodesremediation.nsw.gov.au/areahistory.html

A combination of factors, including removal of protectionist policies, newer raw materials, competition from other multinational chemical companies and introduction of newer pesticides lead to the demise of Union Carbide, and production ceased in 1985. Union Carbide were required to remediate the site to an "industrial use" standard in 1987. Union Carbide left Australia soon afterwards, and remain dismissive of attempts to contribute to the remediation process. However, even with government or developer sponsored remediation, the site remained heavily contaminated until at least the 1990s.

Chlorinated compounds, including dioxins, migrated off-site into Homebush Bay. As a result of years of leaching, sediments are heavily contaminated to a depth of one metre and stretch well out into the bay (see Figure 5).

Figure 5: Homebush Bay Contamination Zone



Source:

A commercial fishing ban was introduced in Homebush Bay in 1995. This was extended to the entire Parramatta River in 2006, after high levels of dioxins were found in the blood of fishermen and their families.

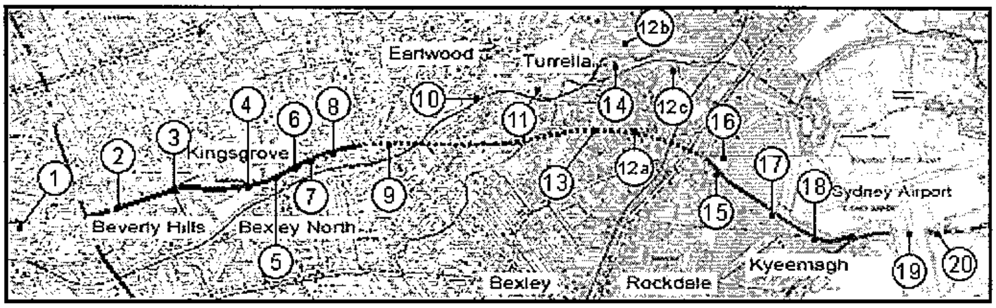
It has proved impossible to seek any financial support from Union Carbide to pay to fix for the environmental pollution the company caused.

The M5 East Road Tunnel (NSW Roads and Traffic Authority)

The M5 East Freeway was designed to link the M5 Motorway at Beverly Hills with General Holmes Drive at Sydney Airport and on to the Eastern Distributor, as part of the NSW Government's "Action for Transport 2010" integrated strategy for the development of the road network. The M5 East and included twin 4 km tunnels and a 550 metre tunnel under the Cooks River (see Figure 6).

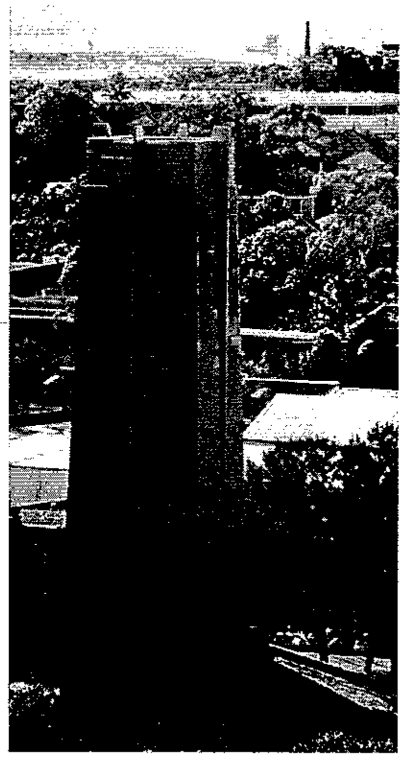
Figure 6: The M5 East Road Tunnel (NSW Roads and Traffic Authority)

/constructionmaintenance/completedprojects/M5East/index.html



The original plan was for three 15 m high exhaust stacks, two in Arncliffe, one in Bardwell Park; in 1997, this was replaced by a 700 m tunnel and single stack, 35 m high, 15 m wide, built in an industrial area at Turrella and discharging uncleaned and unfiltered emissions (see Figure 7).

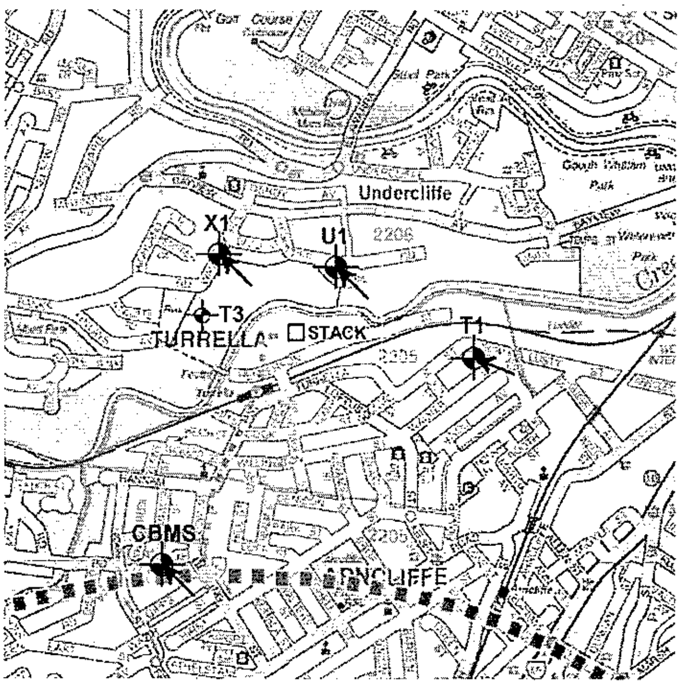
Figure 7: The M5 East Road Tunnel Stack, Turrella



Source: http://savewollicreek.8m.com/stack.html

Planning approval was given in December 1997, construction started soon afterwards. The Tunnel was completed in 2001 and opened in December that year. As one of the conditions of approval, for air quality monitoring was required. Five air quality monitoring stations were established in the Wolli Creek Valley to collect meteorological information and air quality data before and during operation of the Freeway (see Figure 8).

Figure 8: The M5 East Road Monitoring Stations



http://www.rta.nsw.gov.au/constructionmaintenance/completedprojects/M5 East/index.html

Sites at T1, U1 and T3 were established in June 2000 to collect background air quality information before commencement of the Freeway. Sites at X1 and CBMS (community based monitoring station) were established in November 2001. Monthly summaries of CO, NO_2, PM_{10} and volatile compounds have been available from the RTA website since June 2000.

Soon after opening, residents and tunnel users reported air quality problems in the tunnel and around the stack. A haze developed in the tunnel westward of the ventilation fans, and reports of stinging eyes and respiratory discomfort were reported by tunnel users. In about 2004, NSW Health reported that pollution levels in the M5 East tunnel were high enough to pose a serious risk for asthmatics, the elderly and those with heart and chest conditions and advised drivers to close windows and turn air conditioning to recirculation. Thereafter, the RTA issued a tunnel safety leaflet, continuing to assert that tunnel air quality was sufficient to protect public health (see Figure 9).

Figure 9: Extract from RTA Traffic Safety Leaflet

Sorce : http://www.rta.nsw.gov.au/roadsafety/downloads/tunnel_safety.pdf

Do you need to close your vehicle's windows while travelling in a tunnel?

Sydney's tunnels are required to meet air quality standards set to protect public health.

However, NSW Health advises that closing your windows and switching your vehicle ventilation to re-circulate will further reduce your exposure to vehicle emissions.These benefits can be achieved whether or not your air conditioning system is in use.

Three NSW Legislative Council inquiries were held finding that health risks pose by poor air quality both within the tunnel and in surrounding areas make it essential that the government install in tunnel filtration for the Tunnel. These were ignored by the tunnel operators. It was only in July 2006 that the NSW Minister for Roads announced that a trial plant would be installed at the westbound end of the tunnel to filter particulate pollution.

Common Factors in the Case Studies

In analysis of these case studies, a number of common factors emerge, that made substantial contributions to the magnitude of their impacts:

- **Lack of information:** An absence of information places individuals in a position of helplessness. Information may be lacking on many things, including:
  - The nature of the impact;
  - The nature of the impact of the impact on workers, the public or the environment;
  - Means by which the impact can be alleviated.
- **Inadequate information.** For example, the operators of the Union Carbide factory at Rhodes were basically unaware of the toxicity of waste they were producing. Further, when the problem of substantial environmental contamination emerged, there was no information about how much waste had been dumped, what type was it, and where it had been buried.
- **Overconfidence in only part of the benefits of the development.** For example, the NSW Roads and Traffic Authority planned the M5 East freeway to connect to Sydney Airport and designed and built a 4 km road tunnel that collected emissions from 80,000 vehicle movements into a single emission stack. Only a cursory assessment of the health impact on the local community was considered, with

community concerns ignored. Users of the tunnel were not considered at all.

- **Narrowly focussed hazard assessments.** Operation of a Chemical factory in the middle of the Botany sand dunes in the 1940s may have seemed a good idea at the time. But subsequent residential developments meant that operations in 1970s, 1980s and 1990s should consider impacts on the community. Mostly, ICI operated on a "we were here first" basis.
- **Poor design.** Both ICI and Union Carbide are continue to assert that where the design of facilities was carried out to (at the time) appropriate standards, but subsequent devlopments rendered the those standards out of date, and eventually, inadequate. These may seem logical, but a simple assessment of their activities of using chemical wastes for land reclamation or burying wastes in the futile expectation that it will stay is somewhat dubious.
- **Poor application or inappropriate consideration of suitable controls.** For example, many of the actions adopted by Orica at Botany were carried out for reasons that were not related to plant safety or environmental protection. Burying hazardous waste was an "out of sight, out of mind" solution. But waste rarely stays where it is put. This assisted in increasing the scale of the disaster.
- **Poor consideration of systems for failure or loss of control.**
- **Reluctance in admitting error.** Of all the factors in identifying safety, health or environmental problems, the ability of organisations to resist change is impressive and in some cases, odious. While not discussed as a case study in this report, the role of the tobacco lobby in asserting the continued use of tobacco products is a well known example. However, the role of the lead lobby that delayed the removal of lead from petrol, the asbestos industry that continued to assert that asbestos was safe in normal use, are cases in point. Indeed, there is a tried and tested hierarcy of approach by industry for dealing with new threats to its business: denial, bluster, threat, and slow acquiescence only if public or political pressure is strong enough to force change. It is axiomatic that at some point in this process, they will also lie. This must be contrasted with the reactions of victims of such problems: fear, guilt, depression, anger.
- **Arrogance.** Union Carbide's quitting of Australia came at a time when the worldwide reputation of the company had suffered after the Bhopal disaster in India. Its inability to contribute to subsequent remediation activities on the basis it

> was no longer operating in Australia is an example of arrogance. The acquisition of the Royal Agricultural Show by News Corporation in 1995 was presaged by the demand that "an unfettered production environment must be provided."

Opponents of public health and environmental regulations often try to "manufacture uncertainty" by questioning the validity of scientific evidence on which proposals for change are based.[28] This strategy of manufacturing uncertainty is adversative to public health, occupational health and safety and environmental protection principles, that decisions be made using the best evidence available. Assessment of public health or occupational health and safety issues must ensure that scientific evidence is evaluated in a manner that assures the public's health and the environment will be adequately protected.[29]

Scientific uncertainty is inevitable in designing programs that deal with death, injury, disease prevention or environmental protection. But absolute certainty is rarely an option. While such programs tend to be cautious, there is a need for them to be flexible and evolutionary.[30]

As such programs must always be precautionary, this often conflicts with the campaigns by various vested interests to manufacture uncertainty, pitting advocates for safety and health protections who acknowledge scientific uncertainty against opponents who capitalise on the unknown to avert or subvert precautionary or protective action.[31]

By magnifying and exploiting these uncertainties, those opposed to change have been remarkably successful in delaying, often for decades, regulations and other measures designed to protect the health and safety of individuals, communities and the environment. Some of these uncertainties have been explored in the case studies in this report. The dumping of wastes at Rhodes occurred in the 1960s and 1970s. Only in 2006, were high levels of dioxins identified in Parramatta fishermen.

RISK CHARACTERISATION

Estimates of the burden of disease attributable to environmental factors vary between different studies, depending on the type of disease, vulnerability, genetics and population group.[32] The environment-related share of the burden of disease also depends strongly on socioeconomic aspects such as income, with the share generally being higher in lower-income countries: it is estimated to be 2–6% of the total burden of disease in OECD and 13% in non-OECD countries.[33]

Air pollution is the environmental factor with a large impact on health and is responsible for the largest burden of environment-related disease in many countries.[34] Potential sources of environmental health problems include:

- Particulate matter and especially small particles with a diameter less than 2.5 micrometres ($PM_{2.5}$). These particulates can stay suspended for even longer periods of time that PM_{10}, and can reach most parts of the respiratory system if inhaled.[35] Long-term exposure against particulate matter for years or decades is associated with elevated total, cardiovascular, and infant mortality, and effects on the respiratory and immune system.[36] More recently, epidemiological studies have linked exposure to other forms of particulate matter with health effects in human beings.[37,38]
- Asthma, especially asthma in children, has been increasing in Australia for many years, with recent data show that 14-16% of children report a diagnosis of asthma that remains a problem.[39]
- A number of chemicals are potentially carcinogenic: approximately 500 are classified as carcinogens; some are heavily regulated.[40] They may, however, reach the environment through diffuse sources, for instance in release from waste sites.
- Some persistent organic chemicals have been proved to have neurodevelopmental effects during prenatal and post-natal life in humans.[41]
- Prenatal exposure to polychlorinated biphenyls (PCBs) has been associated with negative effects on cognitive processes, motor development and reflexes in children.[42]
- PCBs and brominated diphenyl ethers (PBDEs) are indicated to interfere with the function of the thyroid hormone, which is crucial for normal neurodevelopment.[43]
- Lead, mercury, and polychlorinated biphenyls (PCBs) have been extensively studied and found to impair development at levels of exposure currently experienced by significant portions of the general population.[44] Measures are now being taken around the world to reduce, among other things, prenatal mercury exposure and to ensure that tolerable daily intakes for pregnant women are not exceeded.
- Lead is an established neurodevelopmental toxicant to humans. Recent studies on the effects of lead in humans suggest that a "safe" exposure level currently cannot be established.[45]

- o Endocrine disruptors are substances that interfere with hormone-dependent functions in the body such as embryonic development, production of sperm, control of the menstrual cycle, the onset of puberty and cancers in hormone-dependent tissues.[46] Worldwide, a decline in semen quality has been observed over the past 50 years but no clear connection to endocrine disrupters has been established.

This list is illustrative only. Many other examples exist (for example, see[3,8,9,11,16,19,26,34]).

RISK CONTROL

Duty of Care and the Responsibility of Organisations

It is a commonly held belief - at least among business people - that healthy businesses are good for communities. What is not always so well understood is that healthy communities are also good for business. There remain plenty of people – especially those among business people - who argue that a business's only function is to make profits and create wealth for its shareholders. Such a viewpoint does acknowledge the principle that an organisation in business draws its licence to operate from the community, and, therefore, has an obligation to that community.

This is especially the case when an organisation's operations, products or services have an impact outside its apparently normal activities. For example, some aspect that has an impact on the health of workers, the public, or the environment. While small organisations can argue only minimal impact, recent history has shown that collectively, some human activities have damaged populations and overall, have affected the global environment.[47]

Therefore, it is important to understand that under both statute and common law, there is no higher duty than duty of care. Before identification, assessment and control of risks can be properly considered, the person or organisation must acknowledge, whether publicly or privately, that they will keep a duty of care for those activities for which they are responsible.

Duty of care of directors, designers, employers, suppliers and employees is specifically outlined in OHS legislation. Environmental legislation should also impose this duty explicitly. This includes a duty of care not to cause harm to the environment sufficient to impact on human health.

Further, discharge of duty of care must be demonstrated by evidence of systems for due diligence. Failure to make this effort is negligence.

One further point about programs for dealing with organisational impacts on the environment is that they should be precautionary in nature. The Precautionary Principle is defined as a lack of "full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[48] The Precautionary Principle is widely seen as fundamental to successful policies for sustainability[49] and health.[50]

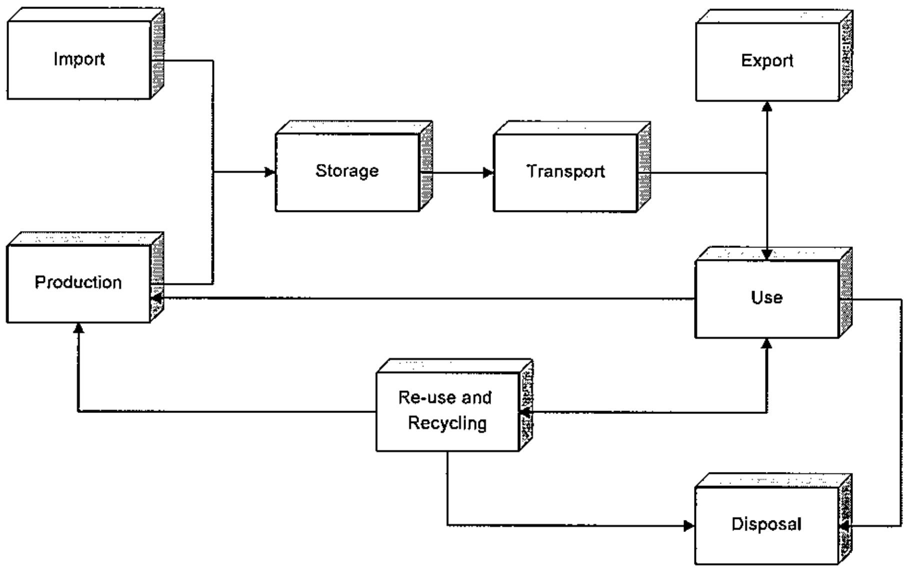
Both governments and organisations should incorporate the precautionary principle in their activities.

Risk Management

Risk management is a contemporary process that includes hazard identification, risk assessment and risk control.

For chemicals, risk management begins with understanding that there is a range of inter-related activities over the life cycle of a chemical (see Figure 10) that fall into identification, assessment and control:[5]

Figure 10: A Model of Chemicals Activities



As shown in Figure 10, the key life cycle components identified for chemicals management are:

- import;
- manufacture;
- storage;
- transport;
- use;

- o disposal; and
- o export.

These life cycle components must then be contrasted against the jurisdictional variability that exists in NSW and other jurisdictions in Australia. In a review of administrative arrangements for ministries and portfolios across Australian Federal, State and Territory governments, twelve distinct groupings can be identified. These are:

- o environment;
- o planning;
- o waste management;
- o health;
- o occupational health and safety;
- o consumer protection;
- o transport;
- o agriculture;
- o trade and industry;
- o legal;
- o waterways/marine environments; and
- o local government.

The identification of these groupings varies from government to government, so there is likely to be some variability in interpretation of the legislative review that follows.

These different life cycle or jurisdictional components can then be used to identify who regulates, or is interested in, the various aspects of chemicals management. These are identified with a ✓, and are shown in Figure 11.

What then emerges is a highly complex mosaic of jurisdictional activities and overlaps.

Figure 11: The Regulatory Mosaic for Chemicals Control Legislation

Life Cycle Portfolio	Import	Manufacture	Storage	Transport	Use	Disposal	Export
1. Environment	✓	✓	✓	✓	✓	✓	
2. Planning		✓	✓	✓	✓		
3. Waste Management			✓	✓	✓	✓	
4. Health		✓		✓	✓	✓	

Life Cycle / Portfolio	Import	Manufacture	Storage	Transport	Use	Disposal	Export
5. OHS		✓	✓	✓	✓	✓	
6. Consumer Protection		✓			✓		
7. Transport			✓	✓			
8. Agriculture (Pesticides)		✓	✓		✓	✓	
9. Trade and Industry	✓	✓			✓		✓
10. Legal		✓			✓	✓	
11. Waterways/ Marine				✓		✓	
12. Local Government		✓		✓	✓	✓	

The piecemeal approach of separate legislation, different authorities and administrative processes, and overlapping jurisdictions adds to the complexity and generates many of the problems.

Legislation to Control Chemicals or Chemical Contaminants

The last option for the management or control of chemicals or environmental contaminants is legislation.

Many of the steps in the life cycle of chemicals (see Figure 10) have legislative controls. Taking a broad view of developments in OECD countries, there have been various phases of regulatory approach:[51]

- the minimalist period of the pre 1960s;
- the fragmented approach of the late-1960s and early 1970s, in response to potential or actual damage to health or the environment. Governments reacted to known hazards in recognised situations, with the emphasis, in the main, on reactive, prescriptive and corrective methods. These tended to fit into existing institutional arrangements;
- the sectoral approach of the 1970s and 1980s of various agencies and government departments charged with the responsibility of a specific area, such as environment, workplace, public health or transport.

Development of chemicals management infrastructure in Australia have mirrored these phases. The Australian constitution devolves most jurisdictional control of chemicals at the State and Territory level. This makes the regulatory control of chemicals quite complex. Indeed, there is a large amount of legislation that impacts on chemicals or chemical contaminants:

- Mines Inspection Act 1901
- Public Health Act 1902
- Pure Food Act 1908
- Construction and Safety Act 1912

- Weights and Measures Act 1915
- Local Government Act 1919
- Stock Foods and Medicines Act 1940
- Workers Compensation (Dust Diseases) Act 1942
- Clean Air Act 1961
- Factories, Shops and Industries Act 1962
- Clean Waters Act 1970
- Waste Disposal Act, 1970
- Therapeutic Goods and Cosmetics Act 1972
- Pesticides Act 1978/1999
- Environmental Planning and Assessment Act, 1979
- Coal Mines Regulation Act 1982
- Occupational Health and Safety Act 1983/2000
- Environmentally Hazardous Chemicals Act 1985
- Ozone Protection Act 1989
- Radiation Control Act 1990
- Hazardous Substances Regulation 1996
- Protection of the Environment Operations Act 1997
- Road and Rail (Dangerous Goods) Act 1997
- Waste Avoidance and Recovery Act 2001
- Occupational Health and Safety Regulation 2001

These statutes have developed against a background of jurisdictional uncertainty,[†] reactive (rather than proactive) development of regulation, and a non-uniform approach to control. This legislation often operates at different levels, with different jurisdictional demarcations, different agencies and different administrative arrangements.

To a great extent, all these approaches have failed. There is too much legislation. It is fragmented and operates at a bewildering variety of legislative and administrative levels.

What is needed now, is a *chemicals based approach* to the control of chemicals, involving a whole of government approach to the problem.

Two recent developments have suggested that such an approach is beginning to emerge:

- A National Industrial Chemicals Notification and Assessment Scheme's (NICNAS) discussion paper: *Promoting Safer Chemical Use: Towards Better Regulation of Chemicals in Australia* was released in April this year on proposed reforms to its existing chemicals program and enhancement of the

† Particularly with regard to application of the Australian Constitution.

administration, importation, manufacture, supply and use of industrial chemicals.[52]

- An Environment Protection and Heritage Council (EPHC) discussion paper, released in July, proposes a *National Framework for Chemicals Environmental Management* with the aim to aim is to develop a streamlined, transparent and nationally consistent approach "to ensure the ecologically sustainable management of chemicals."[53]

An Integrated Model for the Management of Safety, Health and Environment Risks

Fragmentation of safety, health and environment can produce unintended impacts, sometimes because of their very separation. A possible model of systems for safety, health and environment is shown below hat has duty of care as an overarching principle and systems for due diligence to demonstrate this duty has been discharged.

Safety, health and environment (SHE) is a topic that attempts to integrate the principles and methods of occupational health and safety and environmental protection for the better identification assessment and control of safety, health and environmental impacts, from design, through installation and operation, to disposal. These processes include general organisational systems, specific SHE impact elimination or reduction systems and systems for dealing with loss of control.

Design to safe standards includes:

- recognition that the designer has a duty of care
- recognition of potential for catastrophe and inclusion of failsafes for such catastrophes
- recognition of human factors in design
- recognition of potential to harm the environment
- designs of facilities, equipment and materials should be tested and assessed for SHE impacts before use

Provision of facilities:

- Recognition that the builder of a facility has a duty of care
- Construction of facilities to suitable standards that minimise SHE impacts

Installation of plant and equipment and purchase of materials:

- Recognition that the plant and equipment installer has a duty of care
- Installation of plant and equipment to suitable standards that minimise SHE impacts

- Selection of controls for known SHE impacts that are technologically appropriate for the SHE impact and practically reasonable for the organisation
- Purchase of safe materials or materials with known SHE impacts

Organisations where SHE impacts may arise through operational activities

- Recognition that the organisation has a duty of care
- Provision of general organisational systems
    - SHE management structures
    - Provision of general facilities
    - SHE impact identification and assessment procedures
    - Availability of general SHE Risk reduction controls
    - Suitable standards of supervision
    - Training of staff
    - Where appropriate, monitoring of the workplace and environmental impacts
    - Where appropriate, worker monitoring (health surveillance)
- Provision of specific controls for safe optimum operation of facilities/equipment/materials where SHE impacts may arise (using the hierarchy of controls and reasonable practicability)
    - Engineering controls to eliminate or reduce SHE impacts
    - Operational and administrative controls to reduce SHE impacts
    - Protective controls to reduce impacts to workers and the environment
    - Specific measures for injuries/emergencies
- Maintenance for optimum operation
- Specific systems for failure or loss of control, such as injury or emergency
    - Procedures for fire/explosion protection
    - First aid procedures
    - Other procedures as necessary (spills, vehicle accidents and so on)
    - Procedures for injury management and workers compensation
    - Procedures for accident investigation
    - Procedures for management of environmental impacts

- Systems for disposal of obsolete, redundant, disused, off specification facilities, equipment, materials (using the hierarchy of wastes)
- Systems for dealing with the SHE impacts of planned changes
- Monitoring and review of all organisational systems

While this model attempts to cover all organisational aspects that may have an impact on safety, health and environment, it is not meant to be comprehensive. But it provides a fuller example of how to control what can happen.

The world of work is changing rapidly. Occupational health and safety and environmental science increasingly are seen as a joint product with goods and services, requiring line-management responsibility. Because employers, governments, and workers bear major costs, they have a strategic interest in outcomes, and should be encouraged to be involved in the process to optimise the value reducing safety, health and environmental impacts in business activities.

Strategic opportunities exist in SHE for:

- the reduction of the SHE impacts on products, processes and services;
- the reduction of non-organisational health care costs;
- the reduction of non-organisational environment costs;
- having SHE follow best business practices and be prominent in the leadership of change;
- optimising human relations/labour policies and practices;
- meeting regulatory requirements.

CONCLUSION

There is a need to identify, assess and manage the links between environmental problems and poor health, to reduce diseases linked to environmental factors, to identify groups who are vulnerable to environmental exposures, and to reduce environmental degradation.

In the past, progress has been made in reducing the impact of environmental contaminants to health and the environment, by regulating polluters, introducing stricter planning process for developments that pollute, and by improving the quality of air, water and soil.

However, the situation remains far from satisfactory from the health or environmental points of view. It is important to continue to sustain existing or develop new initiatives, that continue the hierarchy of inform, persuade, compel or punish:

- improving the breadth and quality of information on –
  - the nature of possible health impacts from environmental exposures,
  - ways of measuring impacts in individuals (through better diagnosis and treatment),[54] but more especially, populations (through epidemiology),
  - better options and technologies for the elimination or control of environmental risks;
- requiring more rigourous planning processes that reflect community concerns about new hazardous developments;
- requiring better risk assessment and control processes for existing hazardous activities;
- requiring polluters to fix the environmental problems they have caused, even if they claim the pollution was created when regulatory procedures were less rigourous and community expectations were lower.
- prosecute those who do not comply with planning, use or environmental degradation legislation.

Other issues are becoming an emerging problem, such as:

- childhood dieases that may have an environmental aetiology, including (among ohers) childhood cancer, childhood respiratory health/asthma, neurodevelopmental and endocrine disorders;
- interactions of exposure to multiple sources (work, food, water, air), the "cocktail effect";
- locating hazardous industries close to residential areas;
- dependence of indiginous populations to traditonal diets that may have become polluted by contaminants biomagnifying in the food chain;
- assessing impacts between climate change and health.

There can be no faith in the present system, as no organisation that has caused environmental degradation, for example by releasing contaminants into the environment that damage the environment of affect the health of the public, has ever been forced out of business. The outcome is invariably that a breach of some legislation has occurred, an organisation is fined, but then is allowed to continue to operate, invariably as before. Imagine how much money would have been saved in environmental clean up and remediation, if Union Carbide had been stopped in the 1970s, so that the Rhodes peninsula did not become polluted, or the Sulphide Pasminco lead smelter at Cockle Creek was prohibited from discharging wastes into Lake Macquarie, or the ICI factory at Botany was not allowed to dump wastes to cause the plume of contamination which now exists.

There needs to be wider use of the duty of care and application of the precautionary principle in order to prevent significant causes of environmental contamination the can produce disease and ill health. If an organisation cannot only be in business if its activities damage the environment or harms health, then perhaps it shouldn't be in business.

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