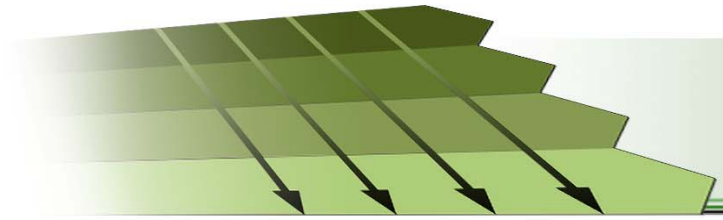

CORE
Public Health Functions for BC

Evidence Review:
Healthy Community Environments

Population and Public Health
BC Ministry of Healthy Living and Sport

October 2008

This paper is a review of the scientific evidence for this core program. Core program evidence reviews may draw from a number of sources, including scientific studies circulated in the academic literature, and observational or anecdotal reports recorded in community-based publications. By bringing together multiple forms of evidence, these reviews aim to provide a proven context through which public health workers can focus their local and provincial objectives. This document should be seen as a guide to understanding the scientific and community-based research, rather than as a formula for achieving success. The evidence presented for a core program will inform the health authorities in developing their priorities, but these priorities will be tailored by local context.

This Evidence Review should be read in conjunction with the accompanying Model Core Program Paper.

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Core Functions Steering Committee (October 2008)

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EXECUTIVE SUMMARY

This evidence review is split into two parts: Part I discusses healthy community environments, and Part II looks at liquid and solid waste management.

1.1 Part I

This evidence review addresses a wide range of environmental contaminants that impact, or have the potential to impact, the health of the BC population. The focus is on evidence that demonstrates the effectiveness of interventions to reduce, mitigate and/or prevent health hazards, particularly those interventions that are appropriate on a regional and community level. Where there is a lack of scientific evidence, information on "best practices"[1] has been added.

This review has been prepared to support representatives of the BC Ministry of Healthy Living and Sport and the health authorities to develop a model core program on health community environments that is based on evidence and continuous quality improvement processes.

Overall, a major factor in implementing effective programs is not only the complexity of the issues but also the multiple sectors and levels of governments involved in managing and developing healthy community environments. A number of reports suggest that environmental public health is one of the most poorly defined areas of public health, and that "fragmentation among agencies at all levels is a barrier to effective protection against environmental health threats" (National Center for Environmental Health [NCEH], n.d.). As a result, "it is clear that today's complex environmental public health problems require coordinated responses of multiple agencies and organizations and various professional disciplines" (NCEH, n.d.). Experts have identified the need for focused environmental health leadership on all levels to develop strategic partnerships, to create and promote a unified identity for environmental public health, and to develop performance standards and best practices (Pew Environmental Health Commission, 2000). The range of agencies that have an important role in this field include: environmental protection, health, transportation, housing, urban development, land-use planning, energy, agriculture, food and drug administration, emergency management, consumer product safety, injury control, vector control and occupational safety, as well as multiple levels of government (Pew Environmental Health Commission, 2000).

Pesticides

Exposure to pesticides is widespread and may occur through multiple routes and pathways. Although the domestic use of pesticides is common, few studies have examined intervention effectiveness or characterized non-occupational exposure levels in the general population. In summary, the findings are:

- A public education intervention involving changing the patterns of domestic pesticide use did result in a more responsible use of pesticides, according to participant feedback.

[1] The term "best practices" is used to encompass initiatives considered to be "good practices", "generally accepted practices", or "better practices" that have yielded positive results in some settings. The term is used to reflect the range of practices that are supported and/or recommended by leading jurisdictions, by experts in the field and/or by research studies. For simplicity, they are referred to as "best practices" in this document.

- Human exposure to pesticides through foods depends on many factors including the processing method. However, the effects of processing on pesticide residue levels needs to be clarified before accurate estimates of dietary intakes can be made. Organic products generally have lower levels of pesticide residues, but it is also recognized that natural toxicants need to be better identified within organic production.

- Children of farmworkers are exposed to pesticides through the presence of pesticides on parents' clothing and shoes; and they may also be exposed to spray drift from nearby farms.

The exposure studies do indicate that domestic use and diet are both significant contributors to pesticide exposure. Children living in agricultural communities may be exposed through additional pathways. Effective methods for reducing pesticide exposure from any of these sources may lead to beneficial health effects.

A best practices review that studied nine communities in Canada, the United States, and Europe found that only those communities that passed a bylaw and supported it with education, or made a community agreement, were successful in reducing the use of pesticides by a high degree (51–90 per cent). Education and outreach programs alone, while more popular, were far less effective; researchers could find none that achieved more than a low reduction (10–24 per cent) in pesticide use (Canadian Centre for Pollution Prevention & Cullbridge Marketing and Communications, 2004).

Based on the evidence and best practice reviews, it is suggested that interventions include: promotion of local bylaws to limit the use of pesticides for beautifying lawns and gardens; educational campaigns on responsible domestic pesticide use and storage; encouragement to choose organic fruits and vegetables; and educational initiatives targeting agricultural communities to reduce the take-home exposure to pesticides.

Lead Contamination

In spite of successful efforts to lower the amount of lead in the environment, lead poisoning still exists among Canadians. Children remain at the greatest risk for lead exposure and associated adverse health effects. Since even low levels of lead exposure may produce adverse health effects, there is a need for effective interventions to reduce lead exposure.

The findings from studies on intervention type (i.e., soil remediation; lead paint abatement; dust control; nutrition; and public education) are, in summary:

- Soil remediation has limited utility in treating mildly elevated blood-lead levels.

- The effectiveness of lead paint abatement is often dependent on baseline blood-lead levels. For children with higher blood-lead levels, abatement is recommended.

- Dust control results are inconsistent with regard to the efficacy of dust control on reducing blood-lead levels, due to the wide-ranging scope of dust control measures used in the various studies.

- There is sufficient evidence to indicate that public health should include nutrition as part of a lead intervention plan. Although there is insufficient evidence to indicate that

nutrient supplementation above recommended intake levels is associated with decreased blood-lead levels, the benefits of a balanced diet are considered to be substantial.

- Interventions using public education as a cost-effective alternative to other methods of secondary prevention showed a decline in blood-lead levels following at-home visits; however, there have not been enough large-scale studies to state that education is an effective intervention strategy on its own.

Based on the available evidence, the only intervention shown to be effective in reducing blood-lead levels is nutritional supplementation in children with marginal nutritional status. There is not sufficient evidence to recommend any other sole intervention strategy for low-level lead exposure. Education has been shown to result in declining blood lead, in combination with other interventions, and as it is a relatively cost-efficient measure, it should also be used in all cases of elevated blood-lead levels.

Ultraviolet Radiation

Ultraviolet radiation is the main risk factor for the development of skin cancer. This risk factor can be greatly reduced by following responsible sun protection measures and avoiding artificial ultraviolet radiation. This review was conducted to assess the evidence behind interventions aimed at reducing ultraviolet radiation.

The results of this study strongly suggest that educational interventions directed at primary school age children are effective at increasing covering-up behaviour in children. Too few studies with consistent evidence were available to evaluate the effectiveness of interventions aimed at caregivers, outdoor workers, secondary school students, health care providers and recreational settings. Although there are many intervention studies targeting these population groups and settings, the lack of standardization in intervention content and implementation, as well as variation in outcome measurements, made it difficult to reach conclusions on the effectiveness of the interventions.

Studies that evaluated appearance-based interventions targeting sun protection behaviours of college-aged students indicate that appearance-based interventions may be more effective than health-based interventions in this age group. However, this is a new area of research with insufficient evidence on which to base recommendations.

Based on the available evidence, educational interventions directly targeting primary school children are effective strategies for decreasing ultraviolet radiation exposure in children. Educational interventions in other settings may also be effective but do not have a large body of evidence to support them.

Environmental Noise

Prolonged or excessive exposure to noise, whether in the community or at work, has been found to cause permanent medical conditions such as hearing loss, and may cause hypertension and ischemic heart disease. Children are particularly vulnerable to environmental noise as studies have documented raised blood pressure, heart rates and levels of stress hormones in children

living in neighbourhoods with higher traffic noise. Noise can also disturb sleep, cause psycho-physiological effects, reduce performance and provoke annoyance responses.

The main sources of environmental noise are road traffic and aircraft noise, although other sources, depending on their noise levels and the type of exposure, can also be hazardous. These include loud music and concerts, loud toys, arcades, machinery and tools, construction and agricultural equipment, industrial sources, and certain recreational vehicles (e.g., all-terrain vehicles and off-road motorcycles).

The literature highlights the value of noise management strategies that focus on controlling and mitigating the level of environmental noise. These include:

- *Legal Measures* – Land-use planning; control of noise emission/transmission; noise mapping and zoning around roads, airports and industries; enforcement of regulations; traffic speed limits; and minimum requirements for acoustical properties of buildings (i.e., sound insulation).
- *Engineering Measures* – Noise emission reduction; traffic management; quiet road surfaces; noise barriers; passive protection (earplugs, insulation, façade design).
- *Education and Information* – Raising public awareness of the health impacts of noise; monitoring/modeling/reporting on soundscapes; increasing the number of noise experts; conducting research and development; and initiating behavioural change.

Land-use planning and local bylaws are important tools for regulating community noise levels as they present a range of options for controlling traffic noise, aircraft noise, noise from machines and equipment, as well as other noise sources. Evidence suggests that local planning measures include initiatives targeted to:

- Specific environments such as schools, playgrounds, homes and hospitals.
- Sensitive time periods such as evenings, nights and holidays.
- High-risk groups such as children and the hearing impaired.

Other Contaminants and Environmental Challenges

Climate Change

It is widely recognized that both mitigation and adaptation strategies are required to reduce the impact of greenhouse gas emissions and to cope with the current and projected impacts of climate change on the health and well-being of the population. Best practices highlight the collaborative involvement of all levels of government to address these issues, particularly the regional and local levels that deliver many of the public health programs.

Each region of Canada has specific climate-change risks and vulnerabilities. In general these may include: smog and heat waves, air pollution, extreme weather events (e.g., increased winds, storms, floods, rising sea levels, etc.), infectious diseases, water contamination, lack of food sources, as well as social and economic disruption. The most vulnerable members of society (i.e.,

children, elderly people, the poor, people with disabilities, immigrant populations and Aboriginal people) are particularly susceptible to these impacts.

In Canada, a number of regions and municipalities have been proactive in this field with initiatives such as comprehensive risk assessments, upgrading of monitoring systems, adaptation planning processes, and climate-change public education tools.

Internationally, many governments and organizations, including the World Health Organization, the European Union and the United Kingdom are urging action on all levels. In the United States, the National Association of County and City Health Officials encourage a full range of local public health activities including:

- Instituting strong and continuous programs to educate communities and their constituents on the health impact of climate change.
- Initiating and promoting scientifically based health programs, developing practice standards and recognizing best practices in the local public health response to climate change.
- Building partnerships with stakeholders to ensure inclusion of public health concerns on policies and programs related to climate-change mitigation and adaptation;
- Developing capable public health leadership and personnel to assure the capacity of public health departments, agencies and programs to respond to the health effects of climate change" (National Association of County and City Health Officials [NACCHO], 2007).

Illegal Methamphetamine Laboratories

Clandestine laboratories for the manufacture of methamphetamine (meth) and other illegal substances, are emerging as a public health hazard in many communities. Meth manufacturing leaves 5 to 7 pounds of chemical waste for each pound of meth produced. These by-products are considered hazardous waste as they produce corrosive, explosive, flammable and toxic chemicals that are health and safety hazards to all individuals involved in the process, and those who enter the site. Children who live at, or visit, these sites face acute health risks, as they are particularly vulnerable to the effects of these chemicals because of age-related behaviour as well as physiological characteristics such as higher metabolic and respiratory rates and a developing nervous system.

A number of American States have enacted regulations, and established policies and procedures for decontamination of methamphetamine drug laboratories. As well, many local health departments are actively involved in oversight of the decontamination process. Examples include:

- Forming multi-agency clandestine drug response teams.
- Educating first responders about the health hazards of meth labs (including use of protective clothing).
- Developing guidelines on how to respond to meth lab complaints.

- Passing state laws limiting the sale and distribution of meth precursor chemicals.
- Adopting local regulations that focus on the health and safety hazards associated with meth labs.
- Altering properties of anhydrous ammonia to render it useless for meth production.
- Increasing security around commercial facilities that contain meth ingredients (Horton, Haugh, & Berkowitz, 2006).

Other Contaminants

Other community environmental health hazards may also be an issue in some circumstances. These can include challenges such as: chemical spills from industrial sites; soil contamination from other toxins or waste products; petroleum contamination from rupture of underground storage tanks; and deposition of dust from smelting operations, coal burning and other sources.

In Canada, the Canadian Council of Ministers of the Environment produced the *Canadian Soil Quality Guidelines* (CSQG), which recommend criteria-based limits for contaminant levels in soil. In BC, land remediation legislation and related policies are managed by the Ministry of the Environment, in collaboration with related ministries, regional and community authorities. The involvement of health protection officials on a provincial and regional level is an important element in ensuring that the health risks from contaminated sites are fully analyzed and addressed. A coordinated approach with a team of provincial experts is used for risk assessment and risk management to protect public safety and ecological integrity. Long-term management and monitoring strategies are developed with partners on a site-specific basis.

Management and Regulatory Measures

Regulatory Measures and Coordination

Adoption of regulatory measures and guidelines are standard practice at the federal, provincial and local level when there is clear evidence of the critical levels of contaminants that are hazardous to human health.

Where evidence is not well established, particularly for emerging threats and long-term outcomes, the United Nations recommends that "the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (based on UNCED 1992). This definition is currently enshrined in the Canadian Environmental Protection Act (1999). Similarly, the World Health Organization recommends the precautionary principle from a public health perspective :

- *The Precautionary Principle* – In all cases, contaminants should be reduced to the lowest level achievable in a particular situation. Where there is reasonable possibility that public health will be damaged, action should be taken to protect public health without awaiting full scientific proof.

- *The Prevention Principle* – Action should be taken where possible to reduce contamination at the source. Land-use planning should be guided by an environmental health impact assessment that considers pollutants (World Health Organization [WHO], 1999).

Both the Pew Environmental Health Commission and the National Center for Environmental Health have pointed out the complexity of managing and developing healthy community environment initiatives, considering the wide range of agencies and government departments involved. They note that fragmentation at all levels can be a barrier to effective protection against environmental health threats. To overcome this challenge, they highlight the importance of coordinated responses of multiple agencies, organizations and professional disciplines.

Land-Use Planning

Land-use planning and local bylaws are major tools that local governments can use to control and prevent environmental pollution and protect the health of communities. The input of public health officials into community decision-making on local environmental health hazards is important to ensure that potential threats can be minimized, mitigated and/or prevented. Analysis of health impacts is necessary for a wide range of initiatives ranging from natural and man-made hazards, transportation and injury prevention, environmental noise, solid and liquid waste management, water quality, water quantity, air quality, contaminated sites, as well as the built environment.

With respect to the built environment (i.e., community and neighbourhood plans, housing developments, traffic/transit designs, and development of recreational and other community services) a parallel evidence review has been prepared and is summarized in Section 1.3 of the Executive Summary.

Health Impact Assessment

Health impact assessments (HIAs) are often a key component in planning new projects, both community-based and private sector. They are defined as a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, including the distribution of those effects within the population. Recommendations are produced for decision-makers and stakeholders, with the aim of maximizing the proposal's positive health effects and minimizing the negative effects. HIA acknowledges the complex interrelationship between social, economic, political and cultural health determinants with the natural environment. They may be initiated by public health authorities in a proactive manner, or in response to public complaints.

HIAs can vary considerably in scope, detail and level of analysis, depending upon the priority and the nature of the project. General steps for conducting an HIA are: screening, scoping, identification and assessment of impacts, decision-making and recommendations, and evaluation and monitoring.

Best practices suggest that these measures be based on scientific data, consultations with affected persons and the careful study of proposed solutions to determine their feasibility and their social acceptability. It is further suggested that setting specific limits on risk levels and criteria for

interventions can facilitate decision-making on the acceptability of risk levels (e.g., individual risk, collective risk, chemical substance thresholds and ecological risk), and assist in communicating clear public health notices and guidelines.

Complaint Processes

In addition to regulatory measures, coordination, land-use planning, and health impact assessment, an effective complaint-handling process is a key element in managing healthy community environments. Although no specific evidence was found related to effective complaint-handling processes in the environmental health field, a number of best practices were identified.

In general, effective complaint-based processes are a key component to effective community relations. The literature suggests that successful management of complaints involves initiatives that are highly visible, transparent, accessible, easy-to-use and affordable. They typically have the explicit commitment of employees at all levels of the organization; they operate quickly, provide a regular flow of information to the people involved and ensure privacy and security. Effective implementation depends on adequate financing, a good communications plan, regular review, consistency, fair treatment and open and transparent processes.

1.2 Part II

This section presents the findings of a literature search to determine the state of evidence on the relationship of current waste management practices to human health and wellness. It then identifies practices and strategies that can inform the development of core programs to be delivered by regional health authorities. Proposed practices are identified that can build upon current efforts to further advance health and wellness and limit the risks that may be associated with waste management.

The evidence suggests that scientific studies to date have been unable, for the most part, to provide any definitive proof of a negative impact of solid and liquid waste management on human health. The literature identifies the historical limitations of the scientific method in understanding the extent of waste management's impact on human health.

The literature also provides different views of what is considered evidence, ranging from the "gold standard" used in clinical trials to one which includes many forms of anecdotal information and knowledge sources. The literature on sludge spreading on land is reviewed in some detail as an important case study that highlights the various interpretations of the same evidence.

The precautionary principle, and a knowledge-based rather than scientific evidence-based approach, is introduced as a more reasonable fundamental starting point for determining Public Health core program and practice responses to potential environmental health impacts of waste management. Practices are described that reflect current thinking on leadership strategies that should be considered in developing core components of a community sanitation program in health authorities.

This paper provides and draws upon interpretations of the literature and issues related to current practices and better practices in waste management, and by implication, the role of health authorities in championing and supporting the development of those better practices.

1.3 Public Health and the Built Environment

While this subject is not discussed in detail in this evidence review, a summary of several evidence reviews on public health and the built environment are provided below to highlight this important component of healthy community environments.[2]

1. *Evidence Paper: Public Health Agencies' Influence on Planning and Policymaking for the Built Environment* (2007), by J. Deby and L. Frank.

The review examines cases where public health officials have successfully influenced land use and transportation investment decisions, noting that this influence typically occurs in one of two ways: either by influencing a policy that in turn affected transportation investments or land development actions, or through direct engagement in the development review process. Both types of cases are represented in this report. Cases were identified through a review of literature, and experiences and interviews with public health and planning-related professionals in Canada and abroad. It was not within the scope of this evidence review to assess the actual public health impacts of these interventions; moreover, recent literature suggests that this kind of evidence is not yet prevalent (Petticrew, Macintyre, & Thomson, 2004).

Health impact assessments are the most frequent format for interventions in the cases reviewed. Transportation and housing are both well-represented, with citywide, regional, and long-range planning making up most of the remainder. Universal access was addressed in one case.

Literature and interviewees supplied several useful insights about the contextual factors and specific actions that helped them achieve their goals. The following were identified as important:

- Prior relationship-building with planners, elected officials and policy-makers.
- Prior education of stakeholders, especially planners, elected officials and policy-makers about the relationship between public health and built form.
- Early involvement of stakeholders, including developers, in public health considerations.
- Ability to provide clear evidence to back up proposed changes in the interest of public health, for example results of heath impact assessments.
- Connecting health with other goals; for example, the creation of tourist-friendly streets and transit systems, or environmental protection.
- Political will or at least support from elected officials.
- Persistence in the face of resistance.
- Facilitating dialogue among other stakeholders.

[2] The reviews are not included in this paper but can be obtained for more detailed information. Full reference information is included in the References section of this paper.

Other factors identified were: focusing on the good as well as the need for improvement when doing HIAs; phrasing suggested changes constructively; allocating tasks based on the strengths of different groups in the partnership; exploring creative funding paths; and being proactive in widening the scope of existing regulations to include public health considerations.

Although the cases are few, the literature is growing. Several interviewees mentioned that they looked to Canada and British Columbia as models for designing healthy urban environments. It is clear that if British Columbia continues to explore collaborative approaches to urban planning and public health, that good documentation planned in advance would both add to the small body of literature, and would continue to draw international attention to our achievements.

2. *Creating a Healthier Built Environment in British Columbia* (2007), by L. Frank and K. Raine, prepared for the Provincial Health Services Authority.

An overview of the findings are:

- *The research supports making changes to our built environment* – The majority of the research review for the report finds a clear relationship between the built environment, physical activity and body weight. Based on existing evidence, the conclusion of this review is that there is strong support for making changes to the built environment to help promote healthy body weight and improve population health.

- *Walkable neighbourhoods are associated with changes in travel behaviour* – Walkable neighbourhoods—neighbourhoods that are compact (high density), with an interconnected network of streets and a mix of land uses—are associated with statistically significant changes in travel behaviour (i.e., less driving and more walking, cycling and use of public transit).

- *Walkable neighbourhoods are associated with lower body weights* – Personal travel patterns influence a person's physical activity levels. The current evidence shows that people located in more walkable areas are less likely to be obese and more likely to meet recommended levels of daily physical activity.

- *Increased density is associated with less pollution* – People in compact, well-serviced neighbourhoods are less likely to drive, produce less greenhouse gases and consume less energy per capita. Such neighbourhoods are also accessible to a wider range of family types and household incomes. For low-income households, increased density offers an important economic benefit by making it possible to forego car ownership.

- *Pedestrian-friendly streetscapes encourage physical activity* – Areas that are safe and attractive for pedestrians encourage higher rates of physical activity. Furthermore, the visible presence of pedestrians and cyclists has been linked to promoting higher rates of physical activity, presumably because people notice the prevalence of such behaviour in the area and feel encouraged to participate.

- *Pedestrian-friendly streetscapes are associated with fewer traffic accidents and less crime* – Narrower streets and streets with marked pedestrian crossings help to slow traffic. Features such as landscaping, sidewalks and parallel parking can further enhance

pedestrian safety by increasing driver awareness. Such streets are also associated with lower rates of crime.

- *Public transit encourages physical activity* – As most public transit trips involve walking links, the existence of a good public transit service helps promote physical activity. Furthermore, improved public transit service may achieve the greatest health benefits for low-income individuals.
- *The built environment influences nutrition* – The built environment can contribute to poor diet through the absence, in some communities, of local (within walking distance) food retailers and restaurants offering a good selection of nutritious food.
- *Improving the food environment can improve nutrition* – The local food environment can be improved through zoning to increase the number and quality of food retailers and restaurants in underserved areas.

Specific opportunities for changing the environment can include such measures as:

- Increasing density in existing mixed-use centres, bringing other land uses into neighbourhoods that are currently residential-only, increasing the connectivity of street and trail networks, and improving the appearance and safety of streetscapes.
- On the transportation side, research suggests that improved population health may be achieved through increased investments in bicycle, pedestrian and transit facilities and services.
- To increase access to healthy food choices, vacant parcels of land, particularly in neighbourhoods that lack healthy food choices, could be purchased or temporarily used for community food gardens. In neighbourhoods lacking grocery stores, it may be expedient to have developers secure grocery stores or food markets as tenants as a condition for approval of new developments.

Because land-use development takes place parcel-by-parcel, it can take time to see new regulations implemented, especially in areas where compact, mixed-use neighbourhoods are a departure from the norm. Furthermore, there is an indirect relationship between land use and physical activity. Once land-use patterns change it may take time for the corresponding changes in people's behaviour and the desired outcomes—increased physical activity and reduced obesity—to occur.

A collaborative focus on population health is crucial. Translating research into policy and action requires the commitment and cooperation of many players from a variety of areas to understand the issues, brainstorm policy solutions and oversee the implementation of recommended changes. As new policies are implemented, it is also essential to monitor their effects to assess whether the desired outcomes are achieved and, if not, what further changes are needed.

3. *Understanding the Relationship Between Public Health and the Built Environment* (2006), by R. Ewing and R. Kreutzer, prepared for the U.S. Green Building Council, the Congress of the New Urbanism, and the Natural Resources Defense Council (Summary Conclusions, pages 115–129).

This landmark document is a comprehensive 2006 report that summarizes the relationship between public health and the built environment. It is intended to help prepare for a rating system for neighbourhoods called LEED_ND (Leadership in Energy and Environmental Design for Neighborhood Development).

1.0 OVERVIEW/SETTING THE CONTEXT

In 2005, the British Columbia Ministry of Health released a policy framework to support the delivery of effective public health services. The *Framework for Core Functions in Public Health* identifies healthy community environments as one of the 21 core programs that a health authority provides in a renewed and comprehensive public health system.

The process for developing performance improvement plans for each core program involves completion of an evidence review used to inform the development of a model core program paper. These resources are then utilized by the health authority in their performance improvement planning processes.

This evidence review was developed to identify the current state of the evidence based on the research literature and accepted standards that have proven to be effective, especially at the health authority level. In addition, the evidence review identifies best practices and benchmarks where this information is available.

1.1 An Introduction to This Paper

This evidence review addresses a wide range of environmental contaminants that impact, or have the potential to impact, the health of the BC population. The focus is on evidence that demonstrates the effectiveness of interventions to reduce, mitigate and/or prevent health hazards, particularly those interventions that are appropriate on a regional and community level. Where there is a lack of scientific evidence, information on "best practices"[3] has been added.

The topics addressed within the scope of healthy community environments, for the purposes of the core public health program in this field, include the following:

- Ensuring that both solid and liquid (sewage) waste is properly managed and does not present a threat to human health.
- Identifying actual or potential public exposure to chemicals, metals, industrial contamination, radiation and environmental noise that present a threat to human health, and preventing, reducing or eliminating such threats.
- Providing input to land-use and environmental planning so potential environmental and social threats to human health are prevented, and so community planning and design contribute to the creation of healthy communities. A parallel evidence review examining the role of public health in providing input into community land use and transportation planning has been prepared: *Public Health Agencies' Influence on Planning and Policymaking for the Built Environment* (Deby & Frank, 2007). As well, *Understanding the Relationship Between Public Health and the Built Environment*, prepared for

[3] The term "best practices" is used to encompass initiatives considered to be "good practices", "generally accepted practices", or "better practices" that have yielded positive results in some settings. The term is used to reflect the range of practices that are supported and/or recommended by leading jurisdictions, by experts in the field and/or by research studies. For simplicity, they are referred to as "best practices" in this document.

Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND), provides valuable information (Ewing and Kreutzer, 2006).

- Completing risk assessment and risk management of environmental health challenges.

In addition, the challenges related to the fragmentation of environmental health issues across multiple sectors and levels of government require attention. These challenges point to the need for a collaborative approach and environmental health leadership to develop strategic partnerships, to create and promote a unified identity for environmental public health, and to develop performance standards and best practices (Pew Environmental Health Commission, 2000). Agencies that have an important role in this process include: environmental protection, health, transportation, housing, urban development, land-use planning, energy, agriculture, food and drug administration, emergency management, consumer product safety, injury control, vector control, and occupational safety, as well as multiple levels of government (Pew Environmental Health Commission, 2000).[4]

The core framework document sees such programs as essential health responses to the problem of "widespread contamination of our environment and food chains with toxic substances such as persistent organic pollutants and heavy metals…and the potential impact of low levels of multiple contaminants on human health, particularly infants and young children." The ministry's goal for such programs is: "Continuing to reduce exposure to toxic contaminants…an important concern for public health" (MOH, PHW, 2005).

This evidence review is split into two parts: Part I discusses community and environmental health. Part II looks at liquid and solid waste management.

[4] Water quality and air quality are not included in this paper, as they have been addressed in separate evidence reviews that support model programs in each of these fields.

2.0 METHODOLOGY

2.1.1 Part I

This section consolidates a number of evidence reviews prepared by the BC Centre for Disease Control. These include:

- *Pesticide Exposure: A Review of Intervention Strategies and Exposure Studies* (2006), by P. Dods and R. Copes.
- *Environmental Lead Toxicity: A Review of Intervention Strategies and Human Health* (2005), by P. Dods and R. Copes.
- *The Evaluation of Interventions Designed to Reduce Ultraviolet Radiation Exposure* (2007), by P. Dods and R. Copes.

In addition, a literature review was conducted to identify research studies on environmental noise, and other community environmental hazards such as climate change and illegal methamphetamine laboratories. Also management and regulatory measures including community environmental planning, health impact assessment, and proactive complaint measures are also discussed. Where the scientific evidence is limited on effective interventions, best practices have been identified and included.

The methodology used in identifying research evidence for specific sections of this paper is outlined in the Appendices. All sections used online literature searches of PubMed/MEDLINE, and TOXNET (Environmental Health and Toxicology) databases managed by the United States National Library of Medicine, and EBSCOhost, a journal index service providing full text for nearly 4,500 journals, including many health periodicals, pamphlets and reference materials. A number of other databases and reference sources were also used in many cases.

2.1.2 Part II

The Framework for Core Functions document recognizes the challenges of identifying and relying on "gold standard" evidence (randomized trial studies in clinical medicine efforts) to identify causes and effects, in the broad context of environmental health and illnesses, that could unequivocally answer the question of health impact from waste management practices (MOH, PHW, 2005).

The literature reviewed in this paper confirms the lack of convincing "gold standard" evidence. There is, in fact, a real possibility that scientific certainty may never align with the needs of policy-makers, due to the limitations of the methodology and the complexity of the content studied (Pheby et al., 2002). This complexity includes significant confounding variables, the difficulty of controlling variables and ensuring scientific rigor, and the length of time between exposure and effect.

The methodology used for Part II of this evidence review is discussed in Appendix 8.

PART I

3.0 BACKGROUND

On the federal level, Health Canada works jointly with Environment Canada to assess the potential risks to human health posed by existing and new substances in Canada under the *Canadian Environmental Protection Act* (1999). They also provide assistance to other federal agencies in the development of environmental standards and programs to ensure adequate protection for Canadians and for fish and wildlife resources. The federal *Hazardous Products Act,* the Canadian Food and Drug Regulations, and the *Radiation Emitting Devices Act* provide additional protection. As well, the Federal Contaminated Sites Action Plan provides policies and guidelines on identifying, assessing and managing risks posed by federal contaminated sites.

On the provincial level, the BC Ministry of Healthy Living and Sport, Health Protection Branch, is mandated by the *Health Act* and Regulations to: develop and implement legislation, policies and programs in the areas of environmental health protection, and to provide advice and guidance to the Ministry of Environment, other ministries and to health authorities, on measures to minimize, mitigate and/or prevent health risks from contaminants including waste management and other potential environmental hazards. In this process, the Ministry of Healthy Living and Sport consults with other ministries and agencies regarding the development of protocols, agreements and guidelines on environmental health issues.[5] It also develops related educational resources for the public. The Ministry of Environment manages the *Environmental Management Act*, the Hazardous Waste Regulation, Contaminated Sites Regulation, and various guidelines and industry codes of practice.

The Provincial Health Services Authority (PHSA) is responsible for ensuring that high-quality specialized services and programs are coordinated and delivered within the regional health authorities. Its role includes surveillance, knowledge transfer and research. The BC Centre for Disease Control (BCCDC), an agency of the PHSA, is the host agency for the National Collaborating Centre for Environmental Health, which focuses on the needs of environmental health practitioners and policy-makers, including regional and local health agencies. BCCDC provides technical support and expertise to health authorities with respect to a wide range of community environmental health issues, laboratory services and radiation protection services.

Health authorities across the province are responsible for assessing health needs and delivering health services to British Columbians. In the area of healthy community environments this may include: advocacy with local governments on appropriate prevention policies and health promotion measures; educating and advising the private sector, community groups and the public on environment contaminants; and implementing interventions to decrease risk factors and enhance the protection of public health.

[5] The Branch is also responsible for drinking water and recreational water, which is addressed in a separate core program.

4.0 PESTICIDES

4.1 Introduction

British Columbians are exposed to pesticides from multiple sources and through multiple routes. For all but the most volatile pesticides, dietary ingestion is a significant pathway of exposure (Wilson, Chuang, Lyu, Menton, & Morgan, 2003). Inhalation, dermal absorption and unintentional ingestions may be important routes for domestically used pesticides (Bradman & Whyatt, 2005). Exposures are likely to be variable, differing dramatically within a particular group or across populations depending on use and dietary patterns. Seasonal variation in pesticide exposure also occurs, with higher exposures in spring and summer (Berkowitz et al., 2003).

Certain subpopulations within the general population may experience higher than average pesticide exposure. These subpopulations include young children and those living in agricultural communities. Young children are more likely to be exposed to these pollutants because of their continual exploration of their environments through touch and taste. Children may also be more susceptible to the health effects of pesticides due to rapid development (Wilson et al., 2004). In addition to the standard pathways of diet, drinking water and residential pesticide use, people in agricultural communities can be exposed to pesticides used in agricultural production through several additional pathways.

Although people may be exposed to pesticides on a daily basis, the health risk posed to human populations from chronic, low-level pesticide exposure is largely unknown. This review assessed published studies and systematic reviews in the scientific literature that involved intervention strategies used to reduce pesticide exposure or studies that contained exposure data. Studies were classified according to exposure sources, including: domestic use, food, and farm use.

The paper *Pesticide Exposure: A Review of Intervention Strategies and Exposure Studies* (Dods & Copes, 2006) forms the substance of this section. Appendix 1 describes the literature search methodology.

4.2 Domestic Use

As the average Canadian spends 90–95 per cent of their time indoors, the domestic use of pesticides may contribute greatly to the total pesticide exposure in the general population. Although levels of human exposure are typically well below toxic dosages, unavoidable and unintentional human contact inevitably occurs following indoor pesticide use (Rust, 2001). Residents can be exposed during pesticide application, and can be exposed to pesticide residues deposited in porous surfaces such as carpets following application (Ross, Fong, Thongsinthusak, Margetich, & Krieger, 1991). Also, outdoor pesticide use may result in tracking in pesticide residues from the lawn or garden. Certain studies have suggested that the majority of children's exposure to pesticides occur within the home environment, and that indoor exposure to pesticides in the home and school environment may be greater than outdoor exposure (Wilson et al., 2003).

Domestically used pesticides widely available for purchase include aerosol fly sprays, pest strips, wood preservatives, pesticides to treat problem insects such as cockroaches, rodenticides, and

similar products including shampoos to treat head lice, and pesticides to treat fleas on pets. Due to the wide-ranging uses for pesticides, the majority of households in BC are expected to contain at least one pesticide. In the United States, it was reported that 85 per cent of households store at least one pesticide in their homes (Bradman & Whyatt, 2005). A study of Minnesota households with children found that pesticides were stored in 97 per cent of the households investigated, and as many as 88 per cent of the households had reportedly used pesticides within the past year (Lu, Fenske, Simcox, & Kalman, 2000).

If pesticides used domestically were correctly used, stored and disposed of, domestic exposure to pesticides could be vastly reduced. A recent study found, however, that most people perceive that the pesticides they use are not toxic, and hence fail to take safety precautions, do not wear protective clothing when applying pesticides, throw empty containers in the trash, and often exceed recommended mixtures. In addition, most people do not lock pesticides away or otherwise keep them out of reach of children (Grieshop & Stiles, 1989).

Although labels on pesticide products are the most important source of safety information, an American study has suggested that labels do not impact user practices, as they are not sufficiently strong in their warnings and recommendations (Grieshop & Stiles, 1989). An observational study of United Kingdom parents related to pesticide labels showed that little notice was taken of the instructions on the labels, and subjects stated that few read the labels except to find out how to use the pesticide, and fewer read the safety information. The study found that a third would not follow the product label exactly when using a product; just under half felt labels were both inadequate and hard to understand; and about 10 per cent would not take notice of warnings on the pesticide label (Grey et al., 2005).

An intervention program was developed in Salt Lake County, Utah, to educate residents about the proper use of household chemicals and the hazardous waste facility (Werner & Adams, 2001). The program goal was to change how people think about usage, storage and disposal of toxic household chemicals. The authors of the study provided interactive seminars and follow-up visits that emphasized behaviours that could reduce exposure to domestically used chemicals. Behaviours that were designed to minimize potential harm included the use of low or non-toxic products as a first choice, and toxic products only as a last resort. Waste reduction behaviours included: buying small quantities, making joint purchases with friends, storing chemicals at proper temperatures to extend shelf life, and using up leftovers or sharing them with friends instead of disposing of them. The feedback from participants indicated that the program induced 33 per cent of participants to begin treating toxic substances in a more responsible manner. Participants were especially pleased with recipes for homemade non-toxic alternatives.

Besides the use of pesticides indoors, pesticides applied on lawns and gardens can be transported indoors. Walking over treated lawns as much as one week after application can transport residues on shoes from turf to carpet (Nishioka et al., 1996; Nishioka et al., 2002). The authors of a study on comparative exposure from various media after lawn application of 2,4-D, reported that track-in from shoes was the dominant mechanism for contribution of residues to floors (Nishioka et al., 2001). In support of this finding they also observed a concentration gradient in 2,4 D levels that followed the traffic density pattern within the home. The highest 2,4 D levels in indoor air were associated with homes with active children and pets, with about 60 per cent of the residues on the

living area floor and 80 per cent of the residues on the tables and sills attributable to the dog. An interesting finding in this study was that the home with the highest deposition rate had the lowest levels indoors through careful control of track-in. We can deduce that behavioural factors, such as the consistent removal of shoes upon entering the house, have a greater effect on indoor residential exposures than application factors (Nishioka et al., 2001).

A best practices review, conducted in 2004 by the Canadian Centre for Pollution Prevention and Cullbridge Marketing, studied nine communities in Canada, the United States, and Europe that were leaders in reducing their pesticide use for cosmetic lawn and garden use. Only those communities that passed a bylaw and supported it with education, or made a community agreement, were successful in reducing the use of pesticides by a high degree (51–90 per cent). Education and outreach programs alone, while more popular, were far less effective; researchers could find none that achieved more than a low reduction (10–24 per cent) in pesticide use.

In those communities that used the law as their primary tool, education was still vital to their ability to reduce the use of pesticides, along with effective enforcement and a permitting system that allowed use of banned pesticides. The Quebec communities that were studied and Halifax, required residents to apply for their own permits, rather than allow lawn care companies to do so. This proved to be a valuable opportunity for authorities to educate residents one-on-one regarding the potential hazards of pesticides, and the benefits of alternative methods (Canadian Centre for Pollution Prevention & Cullbridge Marketing, 2004).

The review found three approaches to designing bylaws, all taking into consideration the fact that pesticide products routinely changed. One community identified specific low-impact products as alternatives, another banned specific ingredients, and a third referenced a third-party list of prohibited materials that is regularly updated. It was also noted that public education and outreach can profit from controversy and public discussion. In Hudson, Quebec, sales of herbicides decreased by 90 per cent before the bylaw came into effect, following intense discussion on the issue (Canadian Centre for Pollution Prevention & Cullbridge Marketing, 2004).

The best practice programs that relied on education and outreach alone, used a wide variety of tools including workshops on sustainable gardening practices, articles in newspapers, information packages, lawn signs, lawnmower decals, horticultural calendars, kiosks at special events, interviews with the media, websites, advertisements, newsletters and fact sheets (Canadian Centre for Pollution Prevention & Cullbridge Marketing, 2004).

4.3 Food

Diet may be the primary exposure pathway for certain pesticides (Bradman & Whyatt, 2005; Eskanazi, Bradman, & Castorina, 1999). Traces or residues of pesticides may persist on the surfaces of fruits and vegetables and sometimes within the food itself. Residues may also be found in the meat and milk of animals that received pesticide-treated feed (Campt, 1990). Diet is a potentially significant pathway of exposure to pesticides for children (Bradman & Whyatt, 2005). In fact, the daily exposure of infants and children to pesticide residues will generally be higher than that of adults, at least for the foods most often consumed by children. Infants and

children consistently eat more food in proportion to their size and body weight, and more of certain types of food, than the rest of the population (Campt, 1990).

The amount of pesticides that people are exposed to through their diet depends on two factors: the level of pesticide residues remaining on various foods when eaten, and the quantity of these foods eaten. The amount of pesticide residues in consumed foods depends in turn on a number of factors such as how foods are processed and cooked.

Predicting dietary exposures to pesticides is not an easy task. There is high variability in individual diets and pesticide concentrations vary significantly across foods. Many foods contain pesticide concentrations at such low concentrations that food analysis results in low detection frequencies Bradman & Whyatt, 2005). The Canadian Total Diet Study conducted in Whitehorse revealed that the majority of pesticides had a detection frequency of <5 per cent. In general, pesticides in food composites were well below residue limits established in the Canadian Food and Drug Regulations. No dietary intakes above the acceptable daily intakes were observed (Rawn et al., 2004).

There have been several recent studies that have examined the difference in pesticide levels between conventionally and organically produced products. Organic products contain a clear advantage in that they contain less pesticide residues than conventional ones. It is possible, however, that organic production could be more affected by natural toxicants such as mycotoxins and phytotoxins (Pussemier, Larondelle, Van Peteghem, & Huyghebaert, 2006). Reviews of published studies reporting contamination by mycotoxins of conventionally and organically grown cereals report contradictory results in this matter. Recent literature indicates that as organic growers become more aware of good agricultural and manufacturing practices, contamination of organic products is becoming much less common (Pussemier et al., 2006).

Although pesticides are mostly used in conventional food production, there is also a possibility of pesticide contamination of organic products via the environment. For example, pesticides may enter through intense contact with the soil by free-range animals, through organochlorine pesticides, or other routes such as spray drift from adjacent fields (Pussemier et al., 2006).

Solid food rather than beverages is the main contributor to pesticide ingestion (Clayton et al., 2003), as pesticides are often found at higher concentrations in peel and pulp than in juice. Expected pesticide levels in juices and beverages are very low (Tadeo, Sanchez-Brunete, Albero, & Gonzalez, 2004). It is possible that rural wells may be contaminated with agricultural pesticides leading to chronic exposure in rural areas; however, exposure through drinking water is limited to isolated communities or households and does not result in population-wide exposures (Bradman & Whyatt, 2005).

4.4 Farm Use

Although it is outside the scope of this report to discuss occupational exposure to farmworkers, families of farmworkers may be exposed while at home. Children are at risk of higher exposure to pesticides than adults, due to their activity patterns and behaviour. Children who live in agricultural communities are regarded as particularly high risk for exposure because of

residential proximity to pesticide-treated farmland and the transfer of pesticides from the workplace to the home.

Many studies have shown higher pesticide exposure in children of farmworkers. Children of migrant workers have increased risk of exposure to organophosphate pesticides because of carry-home transport processes and residential location (Harris & Gaston, 2004). Potential for widespread low-level chronic exposure exists (Lambert et al., 2005). Fenske et al. (2000) measured dialkyl phosphate metabolites of organophosphate (OP) pesticides in the urine of children of agricultural workers. They found that metabolite levels were elevated for agricultural children when compared to reference children, and when compared to children in the Seattle metropolitan area. They also reported a relationship between OP metabolites and proximity to farmland. Proximity to farmland was associated with increased OP pesticide concentrations in house dust and OP pesticide metabolites in urine. Several pathways exist by which pesticides could be transported indoors, including spray drift, volatilization, soil resuspension and tracking in on shoes/clothing.

Not only may children in rural areas be at a higher risk of exposure to pesticides at home but also at school if the school is located in close proximity to farmland. A recent study analyzed surveillance data from 1998 to 2002 of 2,593 persons with acute pesticide-related illnesses associated with exposure at schools. The results indicated that pesticide exposure at schools produced acute illnesses among school employees and students. Most reported illnesses were associated with insecticides (35 per cent), disinfectants (32 per cent), repellants (12 per cent) or herbicides (11 per cent). Of 406 cases with detailed source information, 69 per cent were associated with pesticides used at schools and 31 per cent with pesticide drift from farmland (Alarcon et al., 2005).

4.5 Summary of Results

The literature on pesticides reveals a large number of pesticide exposure studies but few studies on intervention strategies. Much of the pesticide exposure data has been collected from specific cohorts, which makes the data of limited generalizability to larger and more varied populations. Many studies have focused on characterizing the risks experienced by agricultural communities, while those risks experienced by other groups are not defined (Kass, Their, Leighton, Cone & Jeffery, 2004).

Populations residing in large urban areas may also face special health risks from a variety of environmental concerns. Environmental hazards, such as pesticides, tend to concentrate spatially, ethnically and socio-economically. However, pesticide exposure in urban populations is not well characterized; thus, public health agencies play a largely reactive role to public concerns (Kass et al., 2004). As exposure patterns and usage becomes better understood, public health could play a more preventative role. Since a high percentage of households/families/children tend to have low exposures (Sexton et al., 2003), it is necessary to find cost-effective ways to identify and screen subpopulations that are at higher risk of pesticide-related health effects. At this time, there are few studies that provide baseline data on the distribution of children's exposures in both urban and non-urban areas.

Residential exposure is an important contributor to overall pesticide exposure. The largest determinant of exposure is user behaviour. An intervention involving the education of residents on proper use of pesticides did result in a more responsible use of pesticides according to participant feedback (Werner & Adams, 2001). However, it is a public health concern that product labeling instructions may not always be understood or followed (Grey et al., 2005). Also, in some cases, it may be more effective to target interventions at the causes for pesticide usage rather than user behaviour. For example, the quality of housing was a significant predictor of both whether pests were sighted in the home, and whether pest control measures were used. These findings have important implications for interventions. It may be more effective in reducing pesticide exposure to require action from those responsible for building maintenance rather than the users themselves (Whyatt et al., 2002).

The food supply is known to be a major source of uptake of organic contaminants (Health Canada, 1997). Some of these contaminants may be transferred through the food chain, leading to human exposure. Due to their different diet composition, children may experience the highest exposures through ingestion. Human exposure to pesticides through these foods depends on many factors, including the processing method. The effects of processing on pesticide residue levels needs to be clarified before accurate estimates of dietary intakes can be made (Harris & Gaston, 2004). Organic products generally have lower levels of pesticide residues, but it is also recognized that natural toxicants need to be better identified within organic production (Pussemier et al., 2006).

Data suggests children of agricultural families can be exposed to pesticides through pathways other than diet, drinking water and residential pesticide use. Children of farmworkers receive carry-home exposure via transport on their parents' clothing and shoes (Fenske et al., 2000). They may also be exposed to pesticides through spray drift from nearby farms.

4.6 Conclusion and Recommendations

There is little research evidence on effective interventions that reduce the health impacts from non-occupational-related pesticide exposure. There is, however, some analysis of best practices based on the use of local bylaws to limit the use of pesticides in yards and gardens. Also, there is sufficient evidence for reducing pesticide exposure through promotion of responsible user behaviour (summary of intervention study can be found in Appendix 2). In urban areas where pest problems are common due to the poor quality of the built environment, effective interventions may also require policy changes and structural solutions. At this time, consuming organic foods over conventional foods appears to be beneficial due to lower pesticide residue in the former, although the added risk of natural contaminants in organic foods needs to be further examined. The exposure experienced by the children of farmworkers can be reduced through careful cleaning practices by farmworkers. A recent study suggested that exposure to schoolchildren in rural areas could be reduced by implementing integrated pest management programs in schools, establishing practices to reduce pesticide drift and adopting pesticide spray buffer zones around schools (Alarcon et al., 2005).

Based on the scientific evidence and best practices identified in the literature review, the following recommendations are directed at reducing pesticide exposure in the general population

as well as in subpopulations that may experience elevated exposures. As well, it is recognized that certain situations such as occupational exposures and agricultural communities that experience elevated exposures due to improper pesticides practices, may require a situation-specific evaluation of appropriate intervention strategies. Recommendations for action by public health are:

1. Advocate promoting the use of bylaws by local governments to limit the use of pesticides for beautifying home lawns and gardens.
2. Conduct educational campaigns dealing with responsible domestic pesticide use and storage. The messages sent to the public should be simple, with a clear emphasis that health effects of pesticide exposures are related to behavioural patterns. The educational campaigns should be conducted in spring and summer when residential use is highest.
3. Encourage the public to choose organic produce over conventional produce when possible. Including a wide range of fruits and vegetables in the diet should also be encouraged, to minimize the exposure to any one pesticide.
4. Focus educational campaigns targeting agricultural communities on reducing the take-home exposure to pesticides. Parents should be encouraged to use behaviours that will minimize pesticide residues transported on clothes and shoes. Campaigns should be tailored to the beliefs and values of the targeted communities.

5.0 LEAD CONTAMINATION

5.1 Introduction

Blood-lead levels of Canadians have dramatically decreased since lead in gasoline was banned, and the use of lead in consumer products was reduced. Mildly elevated blood-lead levels continue to exist due to exposure to airborne lead, environmental house dust and dirt contamination. Certain subpopulations may be at greater risk of lead poisoning due to exposure to excessive amounts of lead from various sources. These include children living in older, deteriorating homes that contain lead paint, and populations living near point sources, such as lead smelters, which have higher than average levels of lead exposure. These latter subpopulations, such as those existing in Trail, BC (Hilts, 1996) and Riverdale, Ontario (Langlois et al., 1996) have been extensively studied and will only be briefly mentioned in this review. Young children remain the highest risk group for lead poisoning due to their behaviours and higher rates of lead absorption. Since even low-level lead exposure may have irreversible, adverse effects on brain development (Needleham, Schell, Bellinger, Leviton, & Allred, 1990; Finkelstein, Markowitz, & Roxen, 1998), any public health strategies that have the potential to reduce the health risks of lead exposure should be employed.

This review assessed published studies and systematic reviews in the scientific literature that involved lead control interventions and strategies to reduce blood-lead levels. The findings are grouped by intervention type, including: soil remediation; lead point abatement; dust control; nutrition; and public education. Appendix 3 describes the literature search methodology, and Appendix 4 summarizes the studies that were assessed in the review.

Health Canada enacted legislation in 1976 to restrict the lead content of paints and other liquid coatings to 0.5 per cent by weight, on furniture, household products, children's products and the exterior and interior surfaces of any building frequented by children. To reflect current scientific and medical knowledge, amendments to these regulations to reduce the lead content of paints and other liquid coatings from 0.5 per cent to 0.06 per cent by weight are currently being prepared by Health Canada (Ministry of Health, Population Health and Wellness, 2007).

5.2 Soil Remediation

Urban soil may be contaminated by deteriorated exterior paint, past deposition of airborne lead from gasoline, and by point sources such as smelters, incinerators and other industrial sources. Soil abatement is one strategy used to reduce lead exposure. All studies retrieved focused on soil remediation as a secondary prevention strategy. It is possible that the benefits of soil remediation would be greater when preventing initial exposure.

Weitzman et al. (1993) used a randomized environmental intervention study to determine the effect of removing lead-contaminated soil on children's blood-lead levels. The children included in the study had pre-intervention lead levels between 7 and 24 μg/dL and were randomized to one of three groups. The study group underwent soil and interior dust abatement and loose paint removal, Group A underwent interior dust abatement and loose paint removal, and Group B underwent only loose paint removal. Before adjusting for potential confounding factors, the lead levels taken 11 months following initial testing, were significantly lower in the study group

compared to Group A (P=0.02) and Group B (P =0.01). However, when analyses were performed including the variables of age, race, ethnicity and occupational exposure of household members, the overall group effect was not significant (P =0.08).

5.3 Lead Paint Abatement

Interior lead-based paint has been identified as one of the major sources of lead exposure. As painted surfaces containing lead deteriorate, leaded chips are released and contaminate household dust. Abatement, the removal of lead paint from homes, is one strategy used to reduce lead risk in the home environment. One advantage of abatement is that lead exposure will be reduced regardless of individual or family behaviour. The disadvantages are the cost incurred in removing all lead-based paint, and the possible increase in lead exposure following abatement (i.e., several studies have shown an increase in blood-lead levels following abatement (Aschengrau, Beiser, Bellinger, Copenhafer, & Weitzmann, 1997). The evidence from studies on lead paint abatement as an intervention strategy indicates that the effectiveness of abatement is often dependent on baseline blood-lead levels.

A retrospective follow-up study examined the effects of lead hazard remediation and its timing on the blood-lead levels of lead-poisoned children (Leighton, Klitzman, Sedlar, Matte, & Cohen, 2003). Children, aged 6 months to 6 years old with blood-lead levels between 20 and 44 µg/dL were included in the study. After adjusting for confounding factors, the remediation effect was reported to be an 11 per cent decrease in blood-lead levels 10–14 months following the baseline test. This result was not significant. The effect of remediation appeared to be stronger for younger than for older children (P =0.06). The results of the study indicate that early intervention for lead-poisoned children through abatement of lead-based paint may contribute to a modest reduction in blood-lead levels.

Rich, Rhoads, Wartenburg, & Sweatlock (2001) conducted a retrospective study using a statewide database to study the effects of home lead abatements on childhood blood levels. All children included in the study had baseline blood-lead levels between 30 and 44 µg/dL. Home abatements were recommended for all children in the study; however, they were not completed in all cases, thus forming the control group. The authors reported that, after controlling for confounding factors, abatement reduced a child's blood lead by 2 per cent, which is not a significant decline.

Another retrospective study was conducted in St. Louis, Missouri, to evaluate the effectiveness of lead-based paint hazard remediation in reducing children's blood-lead levels (Staes, Matte, Copley, Flanders, & Binder, 1994). All children included in the intervention group had blood-lead levels greater than 25 µg/dL at baseline and had their blood-lead levels measured 10–14 months following diagnosis. The authors reported a greater effect of remediation among children whose blood-lead levels at diagnosis were > 35 µg/dL (-22 per cent in blood lead) than among those whose blood-lead levels at diagnosis were between 25 and 35 µg/dL (-1 per cent).

5.4 Dust Control

In urban environments that have a high density of lead-painted houses, and where automobile exhaust has contributed additional lead to the soil, dust may be contaminated with lead. Lead-

contaminated indoor dust can result from deteriorating paint, or from contaminated soil being tracked in, or blown into houses from outdoors. Combined with abatement, dust control may help to reduce lead exposure in homes. However, the effectiveness of dust control as a sole prevention strategy is debatable.

Haynes, Lanphear, Tohn, Farr, & Rhoads (2002) conducted a systematic review of randomized controlled trials of low-cost, lead hazard control interventions to determine their effect on children's blood concentration. The meta-analysis included studies that met the following criteria: randomized allocation of children to either intervention or control group, low-cost intervention (<$2,500), blood-lead concentration used as measured outcome, and the trial was not conducted in a community with a continual lead emission source. Based on the review of the included studies, the authors concluded that the data showed no significant decline in mean blood lead concentrations among children in the interventions groups; however, there was a significant reduction in the proportion of children who has blood-lead concentrations above 10 µg/dL.

A randomized controlled trial carried out in New York attempted to determine the effectiveness of dust control in preventing children's exposure to lead during their peak age of susceptibility (Lanphear, Winter, Apetz, Eberly, & Weitzman, 1998). The results showed no significant difference in blood-lead levels by intervention status. Although the percentage of children with elevated blood-lead levels at 24 months were generally lower in the intervention group, the differences were not significant.

Rhoads et al. (1999) used a randomized controlled trial to evaluate the effect of an intervention consisting of maternal education and household dust control measures on blood lead in young children. The lead dust intervention group received maternal education and biweekly assistance with household cleaning. All children were tested for blood-lead levels one year following the beginning of the intervention. Contrary to the results reported by other authors, this study found that the intervention resulted in a significant decrease in blood-lead levels compared to the control group ($P < 0.05$).

5.5 Nutrition

Nutrition-based intervention strategies may be used as part of secondary prevention programs to decrease the severity of lead poisoning. Although many dietary items have been implicated with the ability to alter susceptibility to lead toxicity, only calcium and iron are assessed in this review. This was due to the lack of solid scientific evidence on other dietary items. The roles that calcium and iron play in the susceptibility of lead toxicity have been extensively studied (Barton, Conrad, Harrison, & Nuby, 1978; Yip & dallman, 1984). Inconsistencies between studies continue to exist, likely due to factors such as timing and severity of nutritional deficiencies. Few longitudinal, prospective studies have been carried out to determine the effectiveness of nutrition as an intervention strategy during low lead exposures. The studies on nutrition as a component of lead intervention strategies reinforce the importance of a well-rounded, balanced diet. The recommended diet for reducing lead toxicity is consistent with the balanced diet recommended for general health. There is not enough evidence for the promotion of nutrition as a sole

intervention strategy; however, the importance of a healthy diet should be reinforced in all cases of lead poisoning.

A recent prospective, randomized placebo-controlled study examined the therapeutic value of supplemental calcium for children whose blood-lead levels were elevated but not to the extent that medical treatment was recommended (Markowitz, Sinnett, & Rosen, 2004). The authors hypothesized that calcium supplementation to achieve 1,800 mg/day would result in a greater fall in blood-lead levels over 3 months than those in un-supplemented children. The results of this study showed no statistically significant differences in blood-lead levels between groups after 3 months of supplementation, and after an additional 3 months of follow-up.

Wright, Shannon, Wright, & Hu (1999) used a cross-sectional analysis of screening data in an urban, outpatient primary care clinic to determine whether low-level lead poisoning and iron deficiency are associated in children. Iron deficiency was classified as having a mean corpuscular volume less than 70 fL, and a red cell distribution width of more than 14.5 in children younger than 2 years of age, or a mean corpuscular volume less than 73 fL, and a red cell distribution width of more than 14.5 in children older than 2 years of age. The authors reported that after adjustment for age, hemoglobin concentration and insurance status, iron deficiency was associated with low-level (5 and 10 μg/dL) lead poisoning in children aged 9–48 months.

5.6 Education

Education could be a cost-effective alternative to other methods of secondary prevention. Jordan, Yust, Robison, Hannan, & Deinard (2003) assessed the effectiveness of a culture-specific peer education program in preventing elevated blood-lead levels in children during their peak period of risk for exposure. Mothers in the intervention group received ongoing educational sessions delivered by a peer educator of the same ethnic background. The authors reported that a greater percentage of the children in the intervention group maintained blood-lead levels < 10 μg/dL compared with the control group; however, this effect was not significant (P =0.08). The results from this study indicate that, although education may be a useful tool in reducing the severity of lead poisoning, it cannot be relied upon to prevent lead poisoning.

5.7 Summary of Results

The literature search performed for this review identified a large number of intervention strategies. There is little consensus, however, on the effectiveness of different types of interventions. The varying results are likely due to many confounding factors including baseline blood-lead levels, age of child when intervention takes place, difficulty in randomization, low response rates and differences in abatement, dust control and educational methods and standards.

Scientific studies show that there may be some benefits of lead hazard interventions for children with blood-lead levels > 25 μg/dL. The evidence is weak on the benefit of interventions for children with lower blood-lead levels. The lack of effectiveness of these intervention types for low-level lead exposure reinforces the importance of primary prevention as the most effective strategy for combating lead poisoning.

There are methodological limitations in many of the intervention studies, which create difficulties in drawing conclusions on efficacy. For example, randomized controlled studies are difficult to design for interventions such as lead-paint abatement. For this reason, many of the studies are retrospective designs, which present problems in assessing causality between intervention and blood-lead levels. As well, lead exposure occurs via several pathways, so the remedial effect of an intervention is difficult to quantify. Nevertheless, in spite of these limitations, conclusions can be drawn regarding the efficacy of intervention strategies (conclusions are described in Section 5.8).

Evidence shows that soil remediation has limited utility in treating mildly elevated blood-lead levels. The excessive costs involved in soil remediation, and the limited health benefits that result, suggest that soil remediation is not a useful intervention for treating children with low-level lead exposure. Nevertheless, it should be noted that soil remediation may be very useful in certain situations where soil has been heavily contaminated from a nearby point source.

The evidence on lead paint abatement as an intervention strategy indicates that the effectiveness of abatement is often dependent on baseline blood-lead levels. In children with only mildly elevated blood-lead levels, traditional abatement is not an effective secondary prevention strategy. It is possible that in the future, better abatement practices and technology could result in a greater effectiveness. For children with higher blood-lead levels, abatement is recommended.

The results are inconsistent with regard to the efficacy of dust control methods on reducing blood-lead levels. One factor contributing to the mixed results is likely the wide-ranging scope of dust control measures. Dust control measures used in the retrieved studies ranged from regular HEPA vacuuming, repainting all windowsills and hiring professional cleaners to teach correct cleaning procedures. The results from the literature indicate that dust control measures may be useful in reducing blood-lead levels in homes that are in poor condition with heavily contaminated dust.

There is sufficient evidence to indicate that public health should include nutrition as part of a lead intervention. Although there is not sufficient evidence to indicate that nutrient supplementation above recommended intake levels is associated with decreased blood-lead levels, it is important to reinforce the benefits of a balanced, healthy diet. The subpopulations at greatest risk for lead toxicity are often those that are most likely to suffer from poor nutritional status as well. Studies indicate that for these populations, calcium and iron supplementation may be effective in reducing blood lead.

Education is a simple and inexpensive intervention compared to other alternatives for secondary prevention of lead poisoning. Several authors reported a decline in blood-lead levels following at-home visits; however, there have not been enough large-scale studies to state that education is an effective intervention strategy on its own.

5.8 Conclusion and Recommendations

There is evidence that children with marginal nutritional status will benefit from calcium and iron supplementation. However, there is not sufficient evidence to recommend any other sole

intervention strategy for low-level lead exposure. Soil remediation, lead paint abatement and dust control measures have been reported to occasionally increase blood-lead levels, so it is not in the best interest of health to recommend these interventions at this time for low-level lead exposure. As blood-lead levels increase with decreasing condition of housing, there in an increased health benefit in lead paint abatement and dust control intervention strategies in these circumstances. The benefits of education appear to be dependent on the community and family involved. Since education is a relatively cost-efficient intervention, and has been shown by certain researchers to result in declining blood lead, this intervention strategy should also be used for all cases of elevated blood-lead levels.

Based on the evidence review, the following recommendations are directed at reducing the health effects from lead exposure in the majority of people who have elevated blood-lead levels. Certain situations, such as occupational exposures and communities located next to a point source, may require a situation-specific evaluation of the appropriate intervention strategies. The recommendations are:

1. Public health officials should continue to promote the benefits of a balanced diet when dealing with lead poisoning in subpopulations with marginal nutritional status.
2. Community-appropriate educational material dealing with lead exposure should be created and used by public health.
3. In cases where blood lead is elevated over 25 μg/dL, lead paint abatement and dust control measures should be considered.

6.0 ULTRAVIOLET RADIATION

6.1 Introduction

Excessive exposure to ultraviolet radiation (UVR) is widely recognized as a major risk factor for skin cancer (fears, Scotto, & Schneidermann, 1977). Chronic, cumulative sun exposure over an extended period of time is a risk factor for basal and squamous cell carcinoma. Intermittent intense exposure, received prior to adulthood, is thought to be a risk factor for malignant melanoma and basal cell carcinoma (Crane, Schneider, Yohn, Morelli, & Plomer, 1999). However, total avoidance of ultraviolet is not recommended, as UVR is an excellent source of Vitamin D, which plays a vital role in muscle and bone health and disease prevention (Holick, 2004).

The incidence of cutaneous malignant melanoma is increasing in light-skinned populations across the world (Boyle, Maisonneuve, & Dore, 1995). In British Columbia, there are approximately 13,000 new cases of non-melanoma skin cancers per year, with an annual average increase of 3.5 per cent (BC Cancer Agency, 2006).

While skin cancer may be among the most common cancers, it is also one of the most preventable (Gilchrest, Eller, Geller, & Yaar, 1999). Risk of skin cancers can be reduced by limiting exposure to sunlight, the primary source of UVR. Tanning beds and sunlamps are other sources of UVR. Primary preventive behaviours that limit exposure to UVR offer the best prospect for reducing the incidence of skin cancer.

This review of published studies has been conducted to assess the evidence of human health benefits of ultraviolet radiation reduction interventions. The behavioural outcomes used to measure the effectiveness of interventions included avoiding the sun during peak hours, seeking shade or wearing protective clothing. The use of sunscreen alone was not considered to be a primary defense against skin cancer. The authors cited recent research that suggests that sunscreen by itself is not an adequate strategy for UVR protection (Vainio & Bianchini, 2000; Weinstock, 1999).

Following the review of all papers retrieved during the literature search, studies were classified according to intervention settings used in the identified systematic review. Seven target groups/settings were identified: 1) primary school children; 2) caregivers; 3) recreation and tourism; 4) outdoor workers; 5) health care providers; 6) secondary school students; and 7) college age students. Appendix 5 describes the literature search methodology, and Appendix 6 summarizes the studies that were assessed in the review. These included a systematic review (Saraiya et al., 2004) that assessed 85 studies.

6.2 Primary School Children

Intermittent and cumulative UVR exposure in childhood plays an important role in the subsequent development of skin cancer (Marks, 1987; Weinstock, et al., 1989). Interventions that reduce UVR in the first 18 years of life could reduce the lifetime incidence of skin cancers.

Saraiya et al. (2004) conducted a systematic review that included 33 studies on the effectiveness of educational and policy interventions in primary schools (5 were excluded due to low quality and 8 were already included in another study). The interventions included a wide range of educational activities including classroom teachings, health fairs, interactive and home-based activities, an educational picture book, interactive CD-ROM multimedia programs, teaching by medical students and peer education.

The results from 20 qualifying studies provided sufficient evidence of the effectiveness of interventions to improve the use of protective clothing and covering-up behaviour in primary schools. Covering-up behaviour includes wearing long-sleeved clothing, pants or a hat. Inconsistent results prevented a conclusion regarding the effectiveness of interventions in improving other sun-protective behaviours, such as avoiding the sun during peak hours or seeking shade.

The researchers found that study design markedly influenced the effect size of the data. For example, for covering-up behaviours, the median relative change ranged from 25 per cent in concurrent comparison studies to 70 per cent in before-and-after studies (Table 1).

Table 1: Median and Interquartile Relative Changes in Sun-Protective Behaviours from Interventions in Primary Schools

Outcome Behaviours	Relative Change		
	25th	Median	75th
Studies with Concurrent Comparison Groups			
Avoid sun	0.92	1.04	1.16
Cover up	31.01	1.25	1.04
Use sunscreen	1.02	1.17	1.32
Before- and- After Studies			
Avoid sun	NA	1.16	NA
Cover up	1.42	1.70	2.00
Use sunscreen	NA	1.34	NA

An additional study reported the results of an evaluation of the Environmental Protection Agency's SunWise School Program (United States Environmental Protection Agency, n.d.). This program was pilot-tested in 130 schools during the 1999/2000 school year, and national implementation began in the 2000/2001 school year. The classroom component of the intervention consisted of cross-curricular classroom lessons and Internet learning. School components included suggestions for infrastructure enhancements and ideas for school-based sun safety activities. Evaluation of the program was carried out through teacher and student surveys—data from over 6,000 student pre-tests and post-tests were analyzed. The results indicated that student knowledge regarding covering-up behaviour, the UV index and the SPF factor increased pre-test to post-test. Children aged 5–9 years experienced a 10 per cent decrease in the attitude that a tan is healthy. Children in the control schools had no changes in knowledge or attitudes during the comparable period. The responses of surveys completed in 2002 indicated that changes in attitude and knowledge were maintained the following year, and only 55 per cent of children experienced sunburns in 2001 compared to 66 per cent in 2000.

6.3 Caregivers

Caregivers, such as parents, early childhood educators and other role models are important targets for intervention strategies due to their influence on the sun-protection habits of children under their care. No additional studies were found other than the studies included in the systematic review (Saraiya et al, 2004). The review identified a total of 25 reports that evaluated the effectiveness of interventions directed at caregivers. Eleven of these studies qualified to be included in the review.

Interventions included workshops for staff, an activity packet for parents, role-playing, education by small media and activities for children. The reports demonstrated insufficient evidence of the effectiveness of these interventions, due to the small number of reports and inconsistent results.

6.4 Recreational and Tourism Settings

Interventions in recreational and tourism settings involve efforts to promote sun-protective behaviours among adults and children and their parents. UV exposure often occurs during recreational activity, making recreational settings important sites for sun-protection programs. The systematic review (Saraiya et al., 2004) identified 18 reports, of which 11 qualified to be included in the review.

The interventions included interactive activities, poolside curriculums, home-based activities, brochures, posters and peer-leader modeling. Outcomes measures included changes in self-reported sun-protective behaviour, incidence of sunburn, degree of tan, and changes in knowledge, attitudes and beliefs. Evidence from three studies indicated that the interventions were effective in increasing adult covering-up behaviour, showing a median relative difference of 11.2 per cent. The evidence was inconsistent for adult incidence of sunburn and children's sun-protective behaviours.

6.5 Outdoor Workers

Outdoor workers are at a high risk of developing non-melanoma skin cancer and possibly melanoma due to the extended time they spend in the sunlight (Rosso et al., 1996; Weiss, Bertz, & Jung, 1991). Data from a Canadian survey on sun exposure and protective behaviours in outdoor workers show low levels of sun protection among workers (Shoveller, Lovato, Peters, & Rivers, 2000).

In the systematic review (Saraiya et al., 2004), 14 reports evaluated the effectiveness of interventions in outdoor occupational settings; 8 of these met the study criteria. Numerous intervention activities were examined in the reports, including sun-safety training, education sessions, skin exams by physicians, role-modeling and educational brochures. A variety of outcomes were measured, including changes in sun-protective behaviours, incidence of sunburn, and knowledge, beliefs and attitudes. However, too few studies and inconsistent results provided insufficient evidence to determine the effectiveness of the interventions on the measured outcomes.

An additional study identified employees at ski areas through a campaign labelled Go Sun Smart. This worksite sun safety program was evaluated in a pair-matched, group-randomized, pre-test/post-test controlled design involving employees at 26 ski areas in Western North America (Buller et al., 2005). It included written, visual, electronic and interpersonal channels of communication to promote sun-safe practices. Two outcome measures assessed were employee awareness of Go Sun Smart, and the number of sunburns received while skiing or snowboarding during the winter. Employees at the intervention ski areas reported higher awareness and less sunburns at post-test than employees at the control area ($p<0.05$).

6.6 Health Care Providers

Health care providers are in a unique position to provide advice and preventive services to the general population, making health care providers an important source of health information. No studies were found other than those covered in the systematic review by Saraiya et al. (2004).

In the systematic review, 21 reports addressed interventions aimed at health care providers or interventions placed within a health care setting; 11 qualified for inclusion in the review.

The interventions included brief educational sessions for physicians and staff, skin cancer prevention curriculum for medical students, Internet training, videotapes, role-modeling procedures and involvement of a community drugstore. Outcome measurements were diverse and inconsistent across studies. Several studies measured intermediate outcomes such as knowledge and attitudes but not behaviours. The lack of measurement of sun-protective behaviours and health outcomes, and lack of consistent results, provided insufficient evidence to determine the effectiveness of interventions in health care settings.

6.7 Secondary School and College Students

Despite higher levels of knowledge about the health effects of prolonged UV exposure, adolescents and young adults are less likely than children to practice sun-protective behaviours. High-risk behaviours increase among this age group and parents have less influence in promoting sun protection (Marks & Hill, 1988). Five studies in addition to those included in the systematic review were found. Four of the five studies focus on the possible benefits of appearance-based interventions compared to health based interventions in college students. Appearance-based interventions are discussed in Section 6.8.

Saraiya et al. (2004) identified 17 articles on the effectiveness of interventions in secondary schools and colleges (13 of these reports qualified to be included in the review, with 4 studies being excluded due to the limited quality of study methodology). The intervention activities included classroom teaching, Internet and home-based activities, and small media. Only four reports measured sun protective behaviours, and each report measured a different behaviour. The inconsistency of evaluation and outcomes measures did not allow the determination of the effectiveness of the interventions.

Adams and Auburn (1997) completed a study that was designed to clarify how skin cancer education affects behaviours, knowledge and attitudes relevant to skin cancer prevention. An educational intervention was provided to half of 30 college co-eds. Outcomes measures were

knowledge and attitudes towards skin cancer and tanning. Skin colour was also measured throughout the intervention, using a spectrophotometer. Sunscreen use was estimated by weighing the sunscreen bottles provided to the participants. The results show that the intervention significantly increased knowledge about skin cancer and skin cancer prevention, but had no effect on behaviour in terms of UV reduction or sunscreen use.

6.8 Appearance-Based Interventions

Young adults are continuing to receive large amounts of both intentional and unintentional exposure to UVR. This age group is highly motivated to tan due to the perceived appearance-enhancing benefits of tanned skin (Robinson, Rigel, & Amonette, 1997). Among college students, improving physical appearance immediately may be more important than the possibility of developing skin cancer in the long-term (Mahler et al., 2005).

Three appearance-based interventions in college students were included in the systematic review by Saraiya et al. (2004) (Johnes & Leary, 1994; Mahler, Fitzpatrick, Parker, & Lapin, 1997; Prentice-Dunn, Jones, & Floyd, 1997). The interventions ranged from appearance-based essays, to showing participants UV photos of sun-damaged skin. The results of all the interventions indicate that college students may be more influenced to change tanning behaviours due to appearance concerns rather than health concerns.

Mahler et al. (2003) completed several studies on the effects of appearance-based interventions on sun protection intentions and self-reported behaviours. In the first study, 68 college students and 76 beachgoers were randomly assigned to receive, or not receive, a photoaging information intervention and, separately, to receive or not receive a novel ultraviolet photo intervention. The UV photographs highlighted the skin pigmentation that results from UV exposure. Questionnaires on sunscreen use and other cognitive mediators were completed by participants pre and post intervention. The UV photo intervention significantly increased the intentions of both college students and beachgoers to use sunscreen in the future. A follow-up conducted with the beach sample indicated that the combination of UV photo and photoaging information resulted in lower reported sunbathing.

Another study evaluated an appearance-based intervention that was used to reduce UV exposure from tanning booth use among college students (Gibbons, Gerrard, Lane, Mahler, & Kulik, 2005). The intervention used a UV photograph to highlight the damage to facial skin caused by previous UV exposure. After controlling for baseline measures, students who viewed their UV photo reported significantly less booth use at a follow-up session 3–4 weeks later than did students not shown a copy of their photograph.

Mahler et al. (2005) examined the efficacy of UV photographs and information about photoaging in increasing the sun protection intentions and behaviours of young adults. They also studied whether any effects of this appearance-based intervention could be enhanced by providing a non-UV alternative for achieving a tan, such as using sunless tanning lotion. The design involved a randomized control trial with a one-month follow-up. The outcomes measures were sun protection intentions and sun protection behaviours. The intervention resulted in significantly stronger sun protection intentions ($p<0.001$) and greater sun protection behaviours ($p<0.05$)

relative to controls. The groups that also used sunless tanning lotion tended to engage in greater sun protection behaviours than the group that received the intervention alone; however, this result was not significant ($p<0.08$).

An appearance-based skin cancer prevention intervention involving college-aged females was implemented in the Southeastern United States (Hillhouse & Turrisi, 2002). One hundred and forty-seven respondents were randomly assigned to treatment or control groups. Treatment respondents received a short workbook describing the appearance-damaging effects of indoor tanning. At the two-month follow-up, participants in the intervention group reported significantly fewer visits to tanning booths in the two-month follow-up period than those in the control group.

6.9 Summary of Results

There is sufficient evidence to demonstrate the effectiveness of interventions in primary schools for covering-up behaviour. These interventions included the provision of information, sun-protection activities and environmental and policy changes. Inconsistent results prevented determination of the effectiveness of interventions in primary schools for other behaviours, such as seeking shade and avoiding peak hours. The study design was found to greatly influence the effect size of the data for all behaviours.

Evidence was insufficient to determine effectiveness of interventions aimed at caregivers, outdoor workers, health care providers and secondary students on reducing UVR exposure. The results of the many studies evaluated indicated that while educational interventions may increase the knowledge of people, increased knowledge does not always lead to changed behaviour. The effectiveness of these interventions could not be determined due to the variability in interventions and evaluated outcomes.

The systematic review by Saraiya et al. (2004) reported sufficient evidence to demonstrate the effectiveness of interventions in the recreational and tourism setting. The results of three studies demonstrated evidence for effectiveness of interventions on adult sun-protective behaviour (wearing protective clothing), although the interventions targeted different populations and employed varying interventions. Evidence of the effectiveness of interventions on adult incidence of sunburn was inconsistent, as was all evidence for interventions targeted to children.

The ability of health-based interventions to influence intentions, but not behaviour, among college-age students prompted the design of appearance-based interventions. Appearance-based interventions were designed with the hypothesis that concern about appearance may be more effective than health warnings alone, in countering tanning behaviours. To date, there are a small number of studies suggesting that an effective strategy may be to emphasize that UV exposure can have negative consequences for appearance. College students who viewed their own UV photo reported less use of tanning booths 3–4 weeks following the intervention (Mahler et al., 2005). Other studies showed that college students who viewed their UV photo and were given photoaging information had greater sun protection behaviours than control subjects (Gibbons et al., 2005; Mahler et al., 2003).

Despite the large number of studies involving UVR reduction strategies, there are several research issues that make the evaluation of UVR reduction interventions difficult. An important issue is the lack of standardization in intervention studies. There is great variation in the interventions, study designs, measures of UVR exposure and measures of outcomes, which make it difficult to compare and contrast the studies.

Many of the studies examined outcomes such as knowledge, attitudes and intentions, rather than sun-protective behaviours. More behavioural outcomes need to be examined, as the relationship between intentions and behaviour is not clear. In addition, the behavioural outcomes that were reported were often self-reported behaviours rather than physical measures.

Finally, many of the studies had short-term follow-up periods. This makes it difficult to evaluate the effect of interventions on behaviour change, as short-term behaviour changes may not be indicative of long-term habits. Future studies need to follow participants over a greater time period to determine the effectiveness of interventions on changing long-term sun protection behaviours.

6.10 Conclusion

Based on the available evidence, the following conclusions were made:

- Educational interventions focused on primary school-aged children are measures that are effective in reducing ultraviolet radiation in children through increasing covering-up behaviour.
- Educational interventions focused on caregivers, secondary school and college students, outdoor workers, health care providers and recreational settings may also be effective but there is not consistent evidence to recommend these interventions.
- The results from appearance-based interventions indicate that college students may respond better to interventions that address appearance concerns rather than health outcomes; however, this is a new area of research and there is not enough evidence to recommend appearance-based interventions at this time.

7.0 ENVIRONMENTAL NOISE

7.1 Introduction

Environmental noise includes community noise emitted from all sources except noise at the industrial workplace. The most important source of environmental noise is transportation and traffic noise, principally from motor vehicles but also from aircraft and railroads. Other prominent sources are office equipment, construction equipment, machinery, appliances, power tools, lighting hum and audio entertainment systems. Noise from recreational vehicles such as all-terrain vehicles and off-road dirt motorcycles can be a problem in some rural areas. Poor urban planning may give rise to environmental noise pollution, since juxtaposition of industrial and residential land uses may result in adverse consequences for the residential environment.

Although environmental noise has been often viewed as an annoyance, it is increasingly being viewed as a potential biological stressor. Although hearing loss is the most clearly measurable health hazard, noise is also linked to other physiological and psychological problems; "excessive exposure to noise…may contribute to the development and aggravation of stress related conditions such as high blood pressure, coronary disease, ulcers, colitis, and migraine headaches" (Kryter, 1971) Research evidence in this field has been sporadic and often inconclusive, in part because noise can be intermittent and difficult to measure in a consistent manner. Some proponents of increased action claim that it has become a growing problem over the past decades and suggest actual sound levels are doubling every ten years (Canadian Broadcasting Corporation, 2001).

This review focuses on environmental noise as an area of increasing interest to public health protection professionals. Occupational noise is not included, except for comparison purposes, as standards and resources in this field are well established within occupational health and safety regulations. Evidence on the health effects of exposure to environmental noise is highlighted, as this area has not generally been well documented from a public health perspective. Intervention strategies are also included. However, few studies were identified on the effectiveness of specific interventions to minimize environment noise, so a number of best practices are presented and discussed. Appendix 7 provides a summary of international regulatory measures on noise control.

7.2 Cardiovascular Impacts

A 2002 meta-analysis of 43 epidemiologic studies published between 1970 and 1999 investigated the relation between noise exposure (both occupational and community noise), blood pressure and/or ischemic heart disease (Van Kempen et al., 2002). Although some of the studies had systematic limitations, the large number of studies provides a basis for some conclusions. With respect to the association between noise exposure and blood pressure, small blood pressure differences were evident. The analysis showed a significant association with hypertension for both occupational noise exposure and air traffic noise exposure. Air traffic noise exposure was positively associated with the consultation of a general practitioner or specialist, the use of cardiovascular medicines and angina pectoris. In cross-sectional studies, road traffic noise exposure increases the risk of myocardial infarction and total ischemic heart disease. "Although we can conclude that noise exposure can contribute to the prevalence of

cardiovascular disease, the evidence is still inconclusive because of the limitations in exposure characterization, adjustment for important confounders and the occurrence of publication bias" (Van Kempen et al., 2002).

The World Health Organization (WHO) reviewed the literature in 1999 and concluded that cardiovascular effects were associated with long-term exposure to 24-hour, time-averaged noise levels above 65 dBA,[6] but that the associations were weak. In 2001, Health Canada analyzed the evidence on health implications of airport noise. They concluded that "available research does not support the contention that there is a significant risk of chronic stress and/or cardiovascular disease arising from long-term exposure to outdoor daily aircraft noise levels above 65 dBA" (Health Canada, 2001). Health Canada did note that more research was necessary in this field.

In a 2004 review of literature published since 1980 (Ising & Kruppa, 2004), the Environmental Expert Council of Germany found that "numerous empirical results have shown long-term noise-induced health risks", and that these resulted not only from the sound level but also from the information conveyed by the noise. With respect to the sound level, they found that studies showed a consistent trend towards an increased cardiovascular risk if the daytime noise level exceeded 65 dBA. They also suggested that information conveyed by the noise was "very often more relevant than the sound level, as it may trigger a fight/flight or defeat reaction…Even during sleep, noise from airplanes or heavy vehicles may be categorized as a danger signal and induce the release of stress hormones." They concluded that in accordance with this hypothesis, annoyance persistent over prolonged periods of time should be regarded as causing distress, and an increase in myocardial infarction could be expected. It is noted that individual studies in this area were not conclusive due in part to the difficulty in classifying these effects (Ising & Kruppa, 2004).

A review by Babisch (2000) noted that the available literature provides little epidemiological evidence of a relationship between traffic noise and cardiovascular disease, although there is some evidence of increased risk with regard to ischaemic heart disease in subjects who live in noisy areas with outdoor noise levels greater than 65–70 dBA. Similarly, WHO reviews have found that workers exposed to high levels of industrial noise for 5–30 years may show increased blood pressure and an increased risk for hypertension. "Cardiovascular effects have also been demonstrated after long-term exposure to air- and road-traffic with LAeq,24h[7] values of 65–70 dBA. Although the associations are weak, the effect is somewhat stronger for ischemic heart disease than for hypertension. Still, these small risk increments are important because a large number of people are exposed" (WHO, 1999).

[6] The measurement use for a unit of sound pressure is the decibel (dB). The dB scale is a logarithmic scale, not a linear one, as the range of sound intensities is so great that it is convenient to compress the scale to encompass all the sounds that need to be measured. For example, sharply painful sound is 10 million times greater in sound pressure than the least audible sound. In decibels, this 10 million to 1 ratio is simplified logarithmically to 140 dB. Measurements also take into account the patterns over time; that is, whether the sound is continuous, fluctuating, intermittent or an impulse noise. In dBA, the A refers to a method of weighting the frequency spectrum to describe different environmental noises.

[7] LAeq,T is the energy average equivalent level of the dBA over a specific time period. The sum of the total energy over a time period gives a level equivalent to the average sound energy over that period. It is used to measure continuing sounds.

Babisch (2000) also found that, while the association of traffic noise with cardiovascular disease in adults is limited, "noise related increases in blood pressure are consistently seen in children." This finding was also reflected by Evans, Lercher, Meis, Ising, & Kofter (2001) in a study of the effects of low-level local traffic noise. The study analyzed data on 115 fourth graders in Austria with similar family characteristics. Half the children lived in quiet areas (below 50 dBA), and half lived in a noisier residential area (above 60 dBA). They found that noise above 60 dBA could be a stressor as it elevated psycho-physiological factors, triggering more symptoms of anxiety and nervousness when the children were stressed (i.e., when taking a test), and could diminish motivation. Specifically, the children in noisier neighbourhoods experienced marginally higher resting systolic blood pressure, greater heart rate reactivity to a test (which served as a stressor), and higher overnight cortisol levels, which are signs of modestly elevated physiological stress. The authors noted that "anything that increases blood pressure has negative implications for long-term health effects" and that "elevated blood pressure in childhood is thought to predict higher blood pressure later in life. Boosts in stress hormones also are of concern because they are linked to adult illnesses…including blood pressure, elevated lipids and cholesterol, heart disease and a reduction in the body's supply of disease-fighting immune cells" (Evans et al., 2001).

7.3 Hearing Loss

The connection between chronic noise exposure and hearing loss is well established. The International Organizations for Standardization (ISO) Standard 1999 gives a method for calculating noise-induced hearing impairment in populations exposed to all types of occupational noise including continuous, intermittent and impulse noise. The Standard specifies that at LAeq,8h levels of 75 dBA and lower, even prolonged occupational noise exposure will not result in noise-induced hearing impairment. The near-universal adoption of an LAeq,8h value of 86 dBA (or lower) as the limit for unprotected occupational noise exposure, together with personal hearing protection, has made cases of severe unprotected exposures rare. However, monitoring of compliance, and enforcement action for sound pressure levels just over the limits, may be weak, especially in non-industrial environments in developed countries (Franks, 1998).

The impact of non-occupational levels of noise on hearing impairment has not been well studied, and there were no large-scale epidemiological studies identified on this topic. However, a WHO review (1999) of scientific evidence documented hearing impairment in young adults and children 12 years and older for a variety of environmental and leisure-time exposure patterns. It found that the ISO Standard is also applicable to environmental noise, as hearing impairment was shown to occur above the ISO Standard levels with sources such as: pop music in discotheques and concerts; pop music through headphones; and music played by brass bands and symphony orchestras (WHO, 1999).

Brookhauser, Worthington, & Kelly (1992) also studied noise-induced hearing loss in children and found hearing impairment through playing in arcades, listening to music at concerts and through headphones, using noisy toys and from listening to fireworks. Although the characteristics of these exposures was not clear, the details of the publications suggest that hearing impairment occurred when exposures exceeded 70 dBA (Brookhauser et al., 1992).

Rosen and Olin (1965) found serious health effects on hearing loss as well as coronary artery disease in a study that compared Maaban tribesmen, who were insignificantly exposed to transportation or industrial noise, and a typical American cohort group. He concluded that aging is not a significant cause of hearing loss, but chronic exposure to moderately high levels of environmental noise (above 70 dBA) can result in hearing loss (Rosen & Olin, 1965).

The WHO document, Guidelines for Community Noise (1999), notes that "it is expected that environmental and leisure-time noise with LAeq,24h of 70 dBA or below, will not cause hearing impairment in the large majority of people, even after a lifetime exposure. Impulse noise exposures should never exceed 140 dBA peak sound pressure in adults; in the case of children, the peak sound pressure should never exceed 120 dBA. For shooting noise with LAeq,24h levels greater than 80 dBA, there may be an increased risk for noise-induced hearing impairment" (WHO, 1999). The WHO adapted these levels from a range of studies and the work of the ISO on occupational noise-induced hearing impairment.

In addition to hearing impairment, noise can also interfere with speech comprehension, and can mask many other acoustical signals important for daily life such as doorbells, telephones, fire alarms and other warning signals (Edworthy & Adams, 1996). The masking effect is more pronounced for hearing-impaired persons than for persons with normal hearing. People who are particularly vulnerable to these types of effects include the elderly, children in the process of language and reading acquisition and individuals not familiar with the spoken language (Lazarus, 1998).

7.4 Other Health Impacts

The most common effect of community noise is annoyance, which is considered an adverse health effect by the WHO.

Sleep disturbance is a major component of noise-related annoyance. Noise can cause a sleeper to awaken repeatedly and to report poor sleep quality the next day. The Institute of Environment and Health (1997) found in a review of observational studies that sleep disturbance is likely to occur if there are more than 50 noise events per night with a maximum level of 50 dBA. A laboratory study found that road traffic noise, at 50-60 dBA, increases the time taken to fall asleep (Ohrstrom & Rylander, 1990). Ohrstrom (1983) documented mood changes as a result of noise disturbed sleep, and Jurriens et al. (1983) found a decrease in performance during the day after sleep disturbance. Griefahn and Gros (1983) studied the impact of sleep disturbance on different ages and found that older people were more likely to have their sleep disturbed by noise than younger people.

The WHO states that additional health impacts may also result from sleep disturbance, noting that although the research is limited, there is some indication of the following: increased blood pressure, heart rate and finger pulse amplitude, vasoconstriction, changes in respiration, and cardiac arrhythmia. The WHO Guidelines state that, for a good night's sleep, the equivalent sound level should not exceed 30 dBA for a continuous noise, and 45 dBA for individual noise events (WHO, 1999).

Noise exposure may also produce after-effects that negatively affect performance, according to a WHO literature review (WHO, 1999). In schools around airports, children chronically exposed to aircraft noise under-perform in proofreading, in persistence on challenging puzzles, in tests of reading acquisition and in motivational capabilities. "It is crucial to recognize that some of the adaptation strategies to aircraft noise, and the effort necessary to maintain task performance, come at a price. Children from noisier areas have heightened sympathetic arousal, as indicated by increased stress hormone levels, and elevated resting blood pressure" (WHO, 1999).

In addition, exposure to high levels of environmental noise has been discussed as a contributing factor to the acceleration and development of latent mental disorders, although these findings have been shown to be inconclusive (Berglund & Lindvall, 1995). The only longitudinal study in the field showed an association between the initial level of road traffic noise and minor psychiatric disorders, but the evidence was deemed to be weak. It appeared that psychiatric disorders may be associated with noise sensitivity, rather than with noise exposure (Stansfeld, Gallacher, Babisch, & Shipley, 1996). Some researchers note that these and other studies point to the importance of taking vulnerable groups into account, as they may have difficulty coping with unwanted environmental noise (Stansfeld, 1992).

7.5 Interventions for Control and Mitigation of Noise

In Canada, the federal government is responsible for establishing and ensuring compliance with standards for noise emission labelling and maximum noise emission for consumer products, equipment and vehicles. These regulations do not extend to "after sale" situations where products deteriorate and exceed sound levels required at the time of manufacture. The federal government also establishes control over inter-provincial transportation systems including aircraft, trains and navigable waterways. The National Guidelines for Environmental Noise Control (1989) have been prepared for legislators at all levels of government, provincial planners, municipalities, consultants, industries and designers.

Most environmental noise control legislation in Canada has been enabled at the municipal level. Municipalities exercise environmental noise control through noise control bylaws, municipal land-use plans and zoning, traffic management and road noise barrier retrofit programs. Provincial governments establish guidelines for noise control through land-use planning. They authorize and assist municipalities in creating and implementing municipal plans and noise control bylaws to abate individual sources of noise. Most provinces, including BC, also regulate the level of occupational noise. In Ontario, the Ministry of the Environment mandate covers sound. It has issued a document entitled Noise Assessment Criteria in Land Use Planning (Ontario Ministry of the Environment, 1997), which provides principles and criteria for assessing and mitigating environmental noise.

A summary of regulatory measures to control environmental noise in other countries is provided in Appendix 7.

There were no specific studies on the effectiveness of different options for mitigating hazardous levels of environmental noise. Interventions referred to in this section are based on best practices highlighted in a number of sources, primarily those recommended by the WHO, and common

practices supported by the United States Federal Highway Administration. These are generally considered standard and common practices widely accepted by experts in the field.

Overall, the WHO recommends three management strategies for noise management:

- *Legal Measures* – Land-use planning; control of noise emission/transmission; noise mapping and zoning around roads, airports and industries; speed limits, enforcement of regulations; and minimum requirements for acoustical properties of buildings (i.e., sound insulation).
- *Engineering Measures* – Emission reduction by source modification; new engine technology; traffic management; passive protection (earplugs, insulation, façade design).
- *Education and Information* – Raising public awareness of the health impacts of noise; monitoring/modeling/reporting on soundscapes; increasing the number of noise experts; conducting research and development; and initiating behavioural change.

Land-use planning is one of the main tools for noise control. Generally, a number of activities are involved in land-use decision-making processes. These include:

- Calculation methods for predicting noise impact caused by road traffic, railways, airports, industries and others sources.
- Noise level limits for various zones and building types.
- Noise maps or noise inventories that show the existing situation.

The WHO recommends that land-use planning include: minimum distances between industrial and high-traffic areas in relation to residential areas and tranquil areas; bypass roads for heavy traffic; and separation between incompatible functions. Decision-making should take into account the technical, financial, social, health and environmental factors of concern. Cost-benefit relationships, as well as the cost-effectiveness of control measures, should be also considered in this context (WHO, 1999).

Traffic is the most widespread environmental component of noise pollution. There are a variety of strategies identified in the literature:

- *Noise Barriers* – Computerized modeling technology is a well-established approach to evaluate noise pollution from highways, and to assess the efficacy of specific noise barrier designs. Noise barriers are used frequently for noise pollution abatement.
- *Limits on Noise Emissions of Vehicles* – Limits have been introduced in many countries. In Germany, there are night-time driving bans for heavy trucks in many neighbourhoods and on freeways that abut residential areas; use of “low-noise” trucks are encouraged through reduced taxes and exemptions from night-time driving bans.
- *Quiet Road Surfaces* – The rolling noise from traffic, the main cause of traffic noise, may be reduced by using quiet road surfaces (porous asphalt), and/or quiet tires.

- *Reduce Speed Limits* – Lower speeds reduce traffic noise (e.g., reducing the speed of trucks from 90 to 60 km/h on concrete roads reduces the sound pressure level by 5 dBA; reducing the speed of cars from 50 km/h to 30 km/h reduces the level by 5 dBA).

- Other measures may include night-time driving bans for heavy vehicles, or the use of traffic controls that smooth the flow of traffic (WHO, 1999).

With respect to aircraft noise, strategies such as altering flight paths and time-of-day runway use, have demonstrated benefits for residential populations near airports (WHO, 1999). Federal Aviation Administration-sponsored residential retrofit (insulation) programs initiated in the 1970s have also had widespread success in reducing interior residential noise in affected residences across the United States.

Reduction measures to reduce noise emissions from machines and equipment have included the introduction of sound labelling to guide consumers in purchases, and the introduction of limits on the sound power levels permitted for certain groups of machines and equipment, such as appliances, all-terrain vehicles, heating and ventilation systems. There have also been promising developments in the use of active noise control techniques involving sound cancellation (WHO, 1999).

7.6 Summary and Conclusion

Prolonged or excessive exposure to noise, whether in the community or at work, can cause permanent medical conditions such as hearing loss, and may cause hypertension and ischemic heart disease. Children are particularly vulnerable to environmental noise, as studies have documented raised blood pressure, heart rates and levels of stress hormones in children living in neighbourhoods with higher traffic noise. Noise can also disturb sleep, cause psycho-physiological effects, reduce performance and provoke annoyance responses. Groups that are particularly vulnerable to the effects of noise are children, the hearing-impaired and those with mental disorders.

The main sources of environmental noise are road traffic and aircraft noise, although other sources, depending on their noise levels and the type of exposure, can also be hazardous. These include loud music and concerts, loud toys, arcades, machinery and tools, construction and agricultural equipment, industrial sources and certain recreational vehicles (e.g., all-terrain vehicles and off-road motorcycles).

The literature highlights the value of noise management strategies that focus on controlling and mitigating the level of environmental noise. These include:

- *Legal Measures* – Land-use planning; control of noise emission/transmission; noise mapping and zoning around roads, airports and industries; speed limits, enforcement of regulations; and minimum requirements for acoustical properties of buildings (i.e., sound insulation).

- *Engineering Measures* – Noise emission reduction; traffic management; quiet road surfaces; noise barriers; passive protection (earplugs, insulation, façade design).

- *Education and Information* – Raising public awareness of the health impacts of noise; monitoring/modeling/reporting on soundscapes; increasing the number of noise experts; conducting research and development; and initiating behavioural change.

Land-use planning and local bylaws are important tools for regulating community noise levels as they present a range of options for controlling traffic noise, aircraft noise, noise from machines and equipment, as well as other noise sources. Evidence suggests that local planning measures include initiatives targeted to:

- Specific environments such as schools, playgrounds, homes and hospitals.
- Sensitive time periods such as evenings, nights and holidays.
- High-risk groups such as children and the hearing impaired.

8.0 OTHER CONTAMINANTS AND ENVIRONMENTAL CHALLENGES

8.1 Climate Change

The realities of climate change are now widely accepted, and major impacts on the environment and human health have been projected. A range of mitigation measures to reduce the impact of greenhouse gas emissions are underway; however, mitigation efforts will not entirely eliminate the risk of climate change. Adaptation measures are also required to cope with the many environmental changes that are currently affecting, and are anticipated to increasingly affect, the health and well-being of Canadians (Health Canada, 2001).

Although each region of Canada has specific risks and vulnerabilities, in general, the anticipated impacts of climate change are (Health Canada, n.d.):

- *Smog and Heat Waves* – Many Canadian cities and towns are now experiencing a significant rise in the number of very hot, smoggy days, with more frequent and longer heat waves. This increase in hot weather and poor air quality, combined with an aging population, is expected to result in an increase in illness and death from heat stroke and dehydration.
- *Air Pollution* – Projections of more frequent and severe heat waves and humidity indicate that air pollution will worsen and, combined with increases in smog, pollens and mould spores will compound the situation and affect those with cardiovascular disease, allergies and respiratory disorders such as asthma, emphysema and chronic bronchitis.
- *Extreme Weather* – Projected increases in tornadoes, floods, rising sea levels, and winter storms could cause more deaths, injuries, infectious diseases (due to contaminated run-off affecting water supplies) and stress-related disorders associated with social disruptions and environmentally forced migration.
- *Diseases* – Infectious diseases such as malaria, dengue and yellow fever could appear in Canada as insects carrying these diseases migrate northward with the warming of the climate.
- *Water Contamination* – The quality and the quantity of drinking water could decline as water sources in some areas become threatened by drought.
- *Lack of Food Sources* – Many Aboriginal communities that follow a traditional diet based on hunting, fishing and other resource-based activities could be vulnerable to health problems due to predicted changes in the amount and distribution of wildlife, fish and vegetation.

Health Canada notes that these effects are expected to be particularly severe for vulnerable populations such as children, the elderly, the poor, disabled people, immigrant populations and Aboriginal Canadians. Socio-economic issues related to climate change are also of considerable concern in relation to the determinants of health and well-being (Health Canada, 2001).

Furthermore, experts stress that the wide range of health issues associated with climate change require the collaborative involvement of actors at the federal, provincial and territorial levels,

and especially the involvement of municipalities where many public health programs are delivered (Health Canada, 2001). "As an initial step, decision-makers in the health sector and related sectors need to identify and assess their 'climate-sensitive' policies and programs. Where significant concerns about health risks exist, assessments using future scenarios, climate models and expert knowledge can be used to determine the need for adaptive actions" (Health Canada, 2001).

In Canada, a number of regions and municipalities have been active in the field. At the present time, the precautionary principle is being applied to many initiatives, and "the trend seems to show that 'no-regrets' strategies are most promising. These strategies are ones that will provide benefits to communities whether projected climate changes occur or not. For example, community water conservation initiatives will benefit communities regardless of the intensity of future impacts" (Health Canada, 2001). Examples include:

- The City of Toronto has developed and implemented a heat-health alert system to adapt to projected heat waves of greater intensity. The city is also planning to widely implement use of rooftop gardens, which have been shown to reduce the urban heat island effect and reduce storm water flow (Boroumand, 2007).
- The Grand River Conservation Authority in southwestern Ontario has developed adaptation strategies focused on watershed management, water demand management, and contingency planning to address both possible droughts and floods.
- A number of cities and regions (e.g., Okanagan region [Choen & Neale, 2006], Ottawa, Halifax and Yellowknife) have been proactive in undertaking initiatives such as comprehensive risk assessments, upgrading monitoring systems, undertaking adaptation planning processes, and preparing climate change public education tools (Boroumand, 2007).

In the United States, the National Association of County and City Health Officials (NACCHO) urges national, state and local health departments and related agencies to engage with their communities to reduce the impact of climate change on human health. NACCHO recognizes the need for the local public health system to be prepared to cope with present and future climate change challenges, and notes that it is the responsibility of the public health community to participate fully in a response. The association "supports a full range of local public health activities to address climate change, including, but not limited to:

- Instituting strong and continuous programs to educate communities and their constituents on the health impact of climate change.
- Initiating and promoting scientifically based health programs, developing practice standards and recognizing best practices in the local public health response to climate change.
- Building partnerships with stakeholders to ensure inclusion of public health concerns on policies and programs related to climate change mitigation and adaptation.

- Developing capable public health leadership and personnel to assure the capacity of public health departments, agencies and programs to respond to the health effects of climate change" (NACCHO, 2007).

In Europe, the European Union completed the Climate Change and Adaptation Strategies for Human Health in Europe project in 2005 (WHO, n.d.), a comprehensive review of the health effects of climate change and a policy review of adaptation measures. It examined the health effects of heat and cold; extreme weather events; vector-borne and rodent-borne infectious diseases; and infectious diseases transmitted through food and water. Many conclusions were drawn from analysis of the health impacts of the 2002 floods and the 2003 heat wave, including the need for both urgent responses and a long-term strategy for minimizing the health risks, using a combination of planned mitigation and adaptation measures. The information is being used to design new policies and improve measure to address morbidity and mortality due to flooding and heat waves (WHO, n.d.).

In the United Kingdom, a number of assessment studies, reviews and policies have been developed (e.g., *Health Effects of Climate Change in the UK* (Department of Health & Health Protection Agency, 2008). Counties have responded with regional adaptation plans, such as the Hampshire County Council, which highlighted, in its public health *Climate Change Adaptation Response: Public Health* (n.d.), the need to:

- Take a lead in mainstreaming climate change, advocating simple changes in lifestyle and the health benefits and financial savings of producing less carbon.
- Adopt sustainability principles.
- Work with partner organizations to learn from best practice, particularly reviewing purchasing, land use, the natural environment, waste management, food and water resources, building, local employment and community engagement, travel and energy policies.

Resources that can further inform regional and local decision-making on processes and strategies to support the mitigation of, and adaptation to, climate changes in order to support the health of the population include:

- *Adapting to Climate Change: An Introduction for Canadian Municipalities* (2006), by the Canadian Climate Impacts and Adaptation Research Network – Adapts existing Canadian risk management guidelines to assist communities in assessing the risks related to climate change.
- *Local Government Responses to Climate Change: Canadian Jurisdictions Outside of BC* (2007), by N. Boroumand (prepared for the Local Government Institute, University of Victoria).
- *Climate-SMART (Climate Change Sustainable Mitigation and Adaptation)* (2006), by the Halifax Regional Municipality – Provides steps and a process for a larger urban centre, in this case Halifax, to assess mitigation and adaptation needs and responses.
- *Climate Adaptation for Land Use Planners* (n.d.), by Birch Hill Geosolutions – Reviews a variety of tools currently used in land-use planning and identifies ways in which they

could be adapted to better incorporate a changing climate into land-use planning and analysis.

- WHO, Regional Office for Europe publications including
    - *Climate Change and Adaptation Strategies for Human Health* (2006), by B. Menne & K.L. Ebi.
    - *Health and Climate Change: the "now" and "how". A Policy Action Guide* (2005), by the World Health Organization.
    - *Extreme Weather Events and Public Health Responses*, by W. Kirch, B. Menne, & R. Bertollini, 2005).
- *Methodologies and Tools to Evaluate Impacts of, and Vulnerability and Adaptation to, Climate Change* (2005), by the United Nations Framework Convention on Climate Change – Includes tools to assist all levels of government to adapt to climate change.

8.2 Illegal Methamphetamine Laboratories

Clandestine laboratories for the manufacture of methamphetamines ("meth") and other illegal substances are emerging as a problem in many communities. Meth manufacturing or "cooking" leaves behind 5 to 7 pounds of chemical waste for each pound of meth that is produced. These by-products are considered hazardous waste as they all produce corrosive, explosive, flammable, and toxic chemicals that present significant health and safety hazards to individuals involved in the process, as well as to those who enter the site (Centers for Disease Control and Prevention [CDC], 2005). The chemicals contaminate the site, and soil or groundwater may become contaminated if chemicals are dumped into a septic system or onto the ground.

The chemical residues can cause similar reactions to those experienced by meth users—it may cause breathing difficulties, skin and eye irritation, headache, nausea, dizziness and even death. Children who live at, or visit these sites, face acute health and safety risks. The age-related behaviours of young children, such as hand-to-mouth contact and physical contact with their environment, increase the likelihood they will inhale, absorb or ingest toxic chemicals, drugs or contaminated food. Their physiological characteristics, such as higher metabolic and respiratory rates and a developing nervous system, leave them particularly vulnerable to the effects of toxic chemicals.

The United States Centers for Disease Control and Prevention collected data from 16 states on a total of 40,349 methamphetamine "events" between 2000 and 2004. Of these, 1,791 were associated with illicit meth production. Meth events consistently had a higher percentage of persons with injuries than did non-meth events. Of the 1,791 events related to meth production, 31 per cent resulted in injured persons. Those most frequently injured were police officers and members of the general public. The injuries included the following: 39 per cent reported respiratory irritation; 26 per cent headaches; 8 per cent eye irritation; and 8 per cent burns. Of these, 7 per cent were treated at the scene, 29 per cent were treated at hospitals but were not

admitted, 7 per cent were treated at hospital and admitted, and 1 per cent (9 people) died (CDC, 2005).

A number of states have developed responses to meth lab contamination. These include:

- Forming multi-agency clandestine drug response teams.
- Educating first responders about the hazards of meth labs (including use of protective clothing).
- Developing guidelines on how to respond to meth lab complaints.
- Passing state laws limiting the sale and distribution of meth precursor chemicals.
- Adopting local regulations that focus on the health/safety hazards associated with meth labs.
- Altering properties of anhydrous ammonia to render it useless for meth production.
- Increasing security around commercial facilities that contain meth ingredients (Horton et al., 2006).

A number of American states have enacted regulations, and/or established policies and procedures, for decontamination of meth drug labs. For example, North Carolina amended its public health statutes (2005) to regulate the decontamination of meth labs. Property owners have the responsibility for decontaminating the site; failure to follow the rules can result in criminal or civil penalties. Law enforcement personnel are required to immediately notify the local health department when a property used as an illegal meth laboratory is released from a law enforcement investigation. The local health department must immediately notify the property owner that the property must be vacated and cleaned in accordance with public health rules. On completion of decontamination, the responsible party must submit documentation on decontamination activities and assessments. The local health department is required to review the documentation for completeness and may choose to inspect the property at any point during the process (Cline, 2005).

In addition, North Carolina established a multidisciplinary workgroup to develop strategies for ensuring the safety of children and of the professionals who investigate suspicions about these sites. A "Drug Endangered Children" policy was established and extensive training programs developed. Education of local public health personnel has been a priority to enable them to respond to contamination issues (Cline, 2005). The State Bureau of Investigation conducts awareness training and certification (Hazardous Waste Operations and Emergency Response) to authorize law enforcement personal to work inside meth laboratories (Hetzel, 2005).

The Colorado Department of Public Health and Environment established *Regulations Pertaining to the Cleanup of Methamphetamine Laboratories* (2005) along with guidance documents.[8] As well, the Minnesota Department of Health (MDH) issued formal guidelines and procedures (2006), along with a list of meth lab remediation contractors. The MDH provides an

[8] These guidance documents can be found at http://www.cdphe.state.co.us/hm/methlab.htm.

environmental laboratory certification program that is soon expected to be a legal requirement for contractors; in the meantime, a Laboratory On-Site Inspection Checklist is provided and must be completed and delivered to the local public health authority providing oversight for each lab cleanup.[9] Many other American states have developed guidelines for the cleanup of meth laboratories; they generally advise property owners to contract the services of a cleaning company with expertise or certification in meth lab decontamination.

New Zealand developed an inter-departmental Methamphetamine Action Plan (2003), which takes a comprehensive approach to reducing the prevalence, use and harm associated with meth use. A wide range of actions have been recommended including:

- Enhancing law enforcement action to control supply.
- Undertaking community action programs to encourage local public health initiatives, self-prohibition, and public education and information.
- Limiting the problems through increased treatment services, workforce development for drug educators, and improved support for police and others involved in work that brings them into contact with meth users.
- Expanding the research on issues and options New Zealand Ministerial Action Group on Drugs, 2003).

A range of guidance and resources are available on this topic, in addition to those cited in this review, such as:

- *Methamphetamines: An Epidemic of Clandestine Labs and Health Risk* (1999), by M.R. Chesley – Health effects in users, and information on chemicals used.
- *Chemical Hazards Related to Clandestine Drug Laboratories* (2000), by J. Hughart – Information on meth, ecstasy, rohypnol and GHB, as well as wastes produced.
- *Medical Surveillance Program*, Occupational Health Services, U.C. Davis[10] – For clandestine lab responders, including law enforcement officers and HazMat teams, whose repeated exposure may put them at risk for health effects.

8.3 Other Contaminants

Additional community environmental health hazards may also be an issue in some circumstances. These may include such challenges as chemical spills from industrial sites; soil contamination from other toxins or waste products; petroleum contamination from rupture of underground storage tanks; and deposition of toxic dust from smelting operations, coal burning and other sources.

In Canada, the Canadian Council of Ministers of the Environment produced the *Canadian Soil Quality Guidelines* (CSQG), which recommend criteria-based limits for contaminant levels in

[9] A copy of the checklist can be found at http://www.health.state.mn.us/divs/phl/cert/docs/checklistmeth.pdf.
[10] More information on the Medical Surveillance Program can be found at http://phs.ucdavis.edu/MedSurv/OHServ.php.

soil. The CSQG were derived using toxicological data to determine threshold levels on key receptors.[11] Also, Health Canada has assessed the risks of many substances (e.g., the Domestic Substances List is a compilation of 23,000 substances, used, imported or manufactured in Canada for commercial purposes between January 1, 1984 and December 31, 1986).

In BC, land remediation legislation and related policies are managed by the Ministry of Environment, in collaboration with related ministries, regional and community authorities. The involvement of health protection officials on a provincial and regional level is an important element in ensuring that the health risks from contaminated sites are fully analyzed and addressed. The goal is to remediate contaminated sites efficiently and effectively, to minimize the impact on human health and safety; on water, land and air; and on the economy. A wide variety of resources are provided by the Ministry of Environment on assessment, standards, recommendations and procedures. In many cases the Ministry leads the remediation, development, and revitalization of high-priority contaminated, brownfield and orphaned sites. A coordinated approach with a team of provincial experts is used for risk assessment and risk management to protect public safety and ecological integrity. Long-term management and monitoring strategies are developed with partners on a site-specific basis.

Occasionally, chemical and soil contamination effects air quality. Air pollution from a wide variety of sources is addressed in *Indoor Air Pollution Interventions: a Review of Published Evidence* (2004a) and *Outdoor Air Pollution Interventions with Health Impacts: a Review* (2004b), both of which were prepared by the British Columbia Centre for Disease Control. These documents discuss the literature on contaminants including radon; environmental tobacco smoke; wood combustion including smoke from outdoor fires and wood stoves; mold in homes resulting from high levels of moisture common in some parts of the province and from marijuana "grow-ops"; "off-gassing" from carpets, furniture and building materials; and a variety of airborne allergens.

[11] Groundwater and drinking water guidelines are similarly affected through contaminated sites, but these topics are addressed in separate evidence reviews.

9.0 REGULATORY AND MANAGEMENT MEASURES

9.1 Regulatory Measures/Coordination

Regulatory measures are an important component in preventing and reducing environmental health threats. There are a range of legislative measures at the federal and provincial level (e.g., the federal government's *Canadian Environmental Protection Act*, and BC's *Environmental Management Act,* and related regulations), as well as environmental guidelines and codes of practice that provide direction to the public and private sector on averting exposure to hazardous substances. Another key component to regulatory control is the ability of local governments to adopt bylaws that respond to local environmental health needs and situations. Adoption of regulatory measures and guidelines are standard practice when there is clear evidence of the critical levels of contaminants that are hazardous to human health.

Clear scientific evidence, however, is not always available, particularly in relation to emerging threats and long-term health outcomes. In such cases, the precautionary principle has been developed to guide environmental management and decision-making. The most broadly accepted definition of the precautionary principle is Principle #15 of the 1992 Rio Declaration on Environment and Development, from the United Nations Conference on Environment and Development:

> In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (United Nations [UN] General Assembly, 1992).

This definition is enshrined in the *Canadian Environmental Protection Act* (1999). Environment Canada has also drafted a number of principles to support risk-based decision-making and application of the precautionary principle (i.e., *A Canadian Perspective on the Precautionary Approach/Principle. Discussion Document* (Environment Canada, 2001).

Similarly, the WHO recommends the precautionary principle from a public health perspective (based on the Rio Declaration (UN General Assembly, 1992) and the European *Charter on Transport, Environment and Health* (WHO, *Charter*, 1999), as follows:

- *The Precautionary Principle* – In all cases, contaminants should be reduced to the lowest level achievable in a particular situation. Where there is reasonable possibility that public health will be damaged, action should be taken to protect public health without awaiting full scientific proof.

- *The Prevention Principle* – "Action should be taken where possible to reduce contamination at the source. Land-use planning should be guided by an environmental health impact assessment that considers pollutants" (WHO, Guidelines, 1999).

An important element in planning, managing and regulating environmental health is the need for coordination among the many organizations that have a role in this field. A Pew Environmental Health Commission report (2000) highlighted the complexity of managing and developing

healthy community environments, considering the wide range of agencies and government ministries involved. They noted evidence that organizational and management factors can impact the design and effectiveness of interventions. For example, the National Center for Environmental Health (NCEH) notes that a number of American reports discuss the fragmentation of the environmental public health response (NCEH, n.d.), and describe environmental health as the most "poorly defined area of public health" (Pew Environmental Health Commission, 2000). Similarly, in focus groups conducted in 2000 by the National Association of County and City Health Officials (NACCHO), responses noted that "fragmentation among agencies at all levels is a barrier to effective protection against environmental health threats" (NCEH, n.d.), and "it is clear that today's complex environmental public health problems require coordinated responses of multiple agencies and organizations and various professional disciplines" (NCEH, n.d.).

The Pew Environmental Health Commission (2000) highlighted the need for focused environmental health leadership on all levels to develop strategic partnerships, to create and promote a unified identify for environmental public health and to develop performance standards and best practices. The National Center for Environmental Health described the range of agencies that have an important role in this field, including environmental protection, health, transportation, housing, urban development, land-use planning, energy, agriculture, food and drug administration, emergency management, consumer product safety, injury control, vector control and occupational safety, as well as multiple levels of government (Pew Environmental Health Commission, 2000).

9.2 Land-Use Planning

Although there is considerable authority at the provincial level and related standards and protocols for many environmental contaminants, regional and local government authorities have significant responsibility for healthy community environments. Public health input into community decision-making on local environmental issues is important to ensure that potential health threats can be minimized, mitigated and/or prevented. Land-use planning and local bylaws are major tools that local governments can use to assist in the control and prevention of environmental pollution and to enhance the health of the community.

In British Columbia, the *Community Charter* (2003) provides municipalities with the legislative authority to regulate activities in their communities in five "spheres": public health; protection of the natural environment; wildlife; building standards; and soil deposit or removal. Local governments have the discretion to implement bylaws in these areas, considering what is best in local circumstances and in compliance with provincial laws. They are required to consult with local health authorities and obtain approval of the Minister of Health before public health bylaws can come into effect (Ministry of Health Services, n.d.).

The Ontario *Planning Act* establishes rules for land use planning in Ontario; it note the importance of "planning so that major facilities (such as airports, transportation, and sewage treatment facilities, waste management systems, industries and aggregate activities) and sensitive land uses are appropriately designed, buffered and/or separated from each other to prevent adverse effects from odour, noise and other contaminants." As well, the province has a

Brownfields Statute Law Amendment Act (2001) and a number of resource documents to guide community planning and redevelopment for under-used industrial and commercial facilities and lands where expansion or redevelopment is complicated by environmental contamination.[12]

Many local governments have established environmental protection programs, which respond to the full range of environmental health issues that pose a health threat to residents. For example, the City of Toronto has an Environmental Protection Office, which works to promote environmental quality and health. It was established in 1987 by city council to respond to growing concerns from the public and scientific community about the impact of environmental contaminants on human health. The office employs a multidisciplinary team with expertise in toxicology, epidemiology, health promotion and environmental health planning, to undertake research, education, policy development and advocacy. The office monitors and responds to emerging environmental issues, and provides technical, policy and educational support to staff within Toronto Public Health and the City of Toronto. The office works collaboratively with other city departments, other levels of government, industry, non-governmental organizations and the community. It has been actively involved in addressing emerging environmental health issues such as smog and air quality, water quality, food safety, pesticides, water management, children's health and the environment, energy conservation and toxic substances (Environmental Protection Office, n.d.).

NACCHO has developed a checklist to assist local public health agencies in their review of applications for new development/redevelopment plans in their communities. The checklist is intended to broaden the health issues addressed by public health professions during the planning process, to enable consistency in commenting on development plans and to provide a screening process for improving the quality of decision-making. NACCHO recommends that the checklist be shared with local planning departments, elected officials and the public, both to increase awareness of public health issues associated with land-use planning and community design, and to encourage appropriate referral to public health officials for review and comment. The checklist covers key issues encompassing natural and man-made hazards, transportation and injury prevention, opportunities for physical fitness, noise, solid and hazardous waste disposal, wastewater, water quality, water quantity, air quality, past site uses, bulk storage facilities (e.g., chemicals, fertilizers, etc.,), zoonosis and health equity (e.g., impact on different population subgroups, neighbourhoods, etc.) (NACCHO, 2003).

Although the built environment is not covered in this document (see the Executive Summary for an overview and references for a number of key resources on this topic), it is important to highlight the need for public health representatives to be fully engaged in planning processes related to community and neighbourhood plans, housing developments, traffic/transit designs, and development of recreational and other community services. Explicit consideration of a population's health, safety and welfare should be included in the evaluation of these land-use planning options and development proposals. A collaborative approach during this process can also build commitment and cooperation among planners from a variety of fields to enhance understanding of the issues, brainstorm policy solutions and oversee the implementation of recommended changes. As new policies are implemented, it is also essential to monitor their

[12] More information can be found at http://www.mah.gov.on.ca/Page224.aspx.

effects to assess whether the desired outcomes are achieved and, if not, what further changes are needed (Frank & Raine, 2007).

9.3 Health Impact Assessment

The European Centre for Health Policy (1999) defines health impact assessments (HIAs) as "a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population." Recommendations are produced for decision makers and stakeholders, with the aim of maximizing the proposals positive health effects and minimizing negative health effects. Health impact assessments acknowledge the complex interrelationship between social, economic, political and cultural health determinants with the natural environment.

> Given the environmental risks and uncertainties associated with increasing material and energy consumption from human activities, and intimate relationship between human health and ecosystem health, the ability to predict, assess, understand and monitor the impacts of development projects on quality of life, human health and well-being is becoming ever more imperative (Health Canada, 2004).

An increasing focus on HIA recognizes that, frequently, there has been little attention placed to social and health impacts during project development and related environment impact assessments (Sadler, 1996).

HIAs can vary considerably in scope, ranging from participation in large-scale regional environmental impact studies, to assessing health risks related to specific projects or events involving environmental contaminants. HIAs may be initiated by public health authorities in a proactive manner, or in response to public complaints.

HIAs generally apply existing knowledge and evidence of health impacts within specific community contexts, rather than generate new research or original scientific knowledge. The evidence-based recommendations of an HIA are intended to inform and improve decision-making and to enhance community health and well-being. Recommendations may focus on both design and operational aspects of a proposal. General steps for conducting an HIA are as follows (European Policy Health Impact Assessment [EPHIA] Project Group, 2004):

- *Screening* – Determining if an HIA is warranted/required.
- *Scoping* – Determining which impacts will be considered and the plan for the HIA.
- *Identification and Assessment of Impacts* – Determining the magnitude, nature, extent and likelihood of potential health impacts, using a variety of different methods and types of information (e.g., policy analysis, profiling, qualitative and quantitative data collection, impact analysis and prioritizing impacts).
- *Decision-making and Recommendations* – Making explicit the trade-offs to be made in decision-making and formulating evidence-informed recommendations.

- *Evaluation and Monitoring (and Follow-up)* – Evaluating the process and impact of the HIA, and monitoring and managing the health impacts.

Risk management is a key component in health impact assessment, and involves identifying potential sources of hazards to assess their risk and determining the measures that need to be taken to reduce the risk. Best practices suggest that these measures be based on scientific data, consultations with affected persons and the careful study of proposed solutions to determine their feasibility and their social acceptability. It is further suggested that setting specific limits on risk levels and criteria for interventions can facilitate decision-making on the acceptability of risk levels (e.g., individual risk, collective risk, chemical substance thresholds and ecological risk), and assist in communicating clear public health notices and guidelines (EPHIA Project Group, 2004).

The level of detail and analysis that is applied to HIAs depends upon priority, scope and the nature of the project. The *European Policy on Health Impact Assessment: A Guide* (EPHIA Project Group, 2004) describes three levels:

- Desk-based HIA, which takes 2–6 weeks for one assessor to complete and provides a broad overview of potential health impacts.
- Rapid HIA, which takes approximately 12 weeks for one assessor to complete and provides more detailed information on potential health impacts.
- Comprehensive HIA, which takes approximately 6 months for one assessor and provides an in-depth assessment of potential health impacts.

In addition, processes to communicate with the public in a credible manner are necessary in health impact assessments.

> Credibility is the key ingredient of successful communication. Factors that influence the credibility of those communicating with the public include the perception of empathy, competence and expertise, honesty and openness, and dedication to the cause. Ways of developing and maintaining credibility include having a high level of scientific professionalism and keeping a steady dialogue with the community and organized groups. Another essential is rendering balanced judgment while maintaining an exclusive focus on public health (Health Canada, 2004).

There are extensive Canadian sources and tools on HIA and environmental contaminants, including:

- The *Canadian Handbook on Health Impact Assessment* (2004), by Health Canada, prepared through consultation among federal, provincial and territorial officials. It provides discussion of the environmental and human health impacts associated with the implementation of development projects and activities in major sectors of the Canadian economy. The aim is to provide an integrated approach to the public health aspects within the framework of environmental impact assessment. The *Canadian Handbook* includes four volumes intended to support and assist public health officials in conducting HIAs:

Volume 1, *The Basics*; Volume 2, *Approaches and Decision-Making*; Volume 3, *The Multidisciplinary Team*; and Volume 4, *Health Impacts by Industry Sector*.

- The *Canadian Environment Protection Act* (1999) provides a framework for the identification, prioritization and assessment of existing substances and for the control or management of those substances considered to pose a risk. This framework is intended to be broad, open, transparent and evidence-based, taking into account aspects such as exposure and effects of a substance, related to the potential risk it may pose (Health Canada, n.d.).

9.4 Complaint Processes

In addition to local bylaws, land-use planning and health impact assessment, an effective complaint-handling process is a necessary element in managing healthy community environments. Although no studies were found specifically on complaint-handling related to the environmental health field, a number of "better" practices were identified. Overall, research suggests that effective management of complaints should involve initiatives that are highly visible, transparent, accessible, easy-to-use and affordable. Successful initiatives typically have the explicit commitment of employees at all levels of the organization. They operate quickly, provide a regular flow of information to the people involved, ensure privacy and security, and include incentives for compliance and disincentives for non-compliance. Effective implementation depends on adequate financing, a good communications plan, regular review, consistency, fair treatment and open and transparent processes (Government of Canada, n.d.).

Examples of "better" complaint-handling practices are:

- Some regions have established formal complaint policies and procedures to guide staff members in handling complaints. Generally these include: a system for prioritizing complaints based on the level of risk, considering the anticipated likelihood of adverse environmental, health and safety outcomes; timelines for responding to urgent, high-, medium- and low-priority complaints; confidentiality; and follow-up action, including referrals and feedback to complainants. Examples include: *Complaints Handling Policies and Procedure* (2006) from the Glasgow region (NHS Glasgow and Clyde, 2006), and *Community Disputes and Complaints Handling Policy* (2002) from a local council in New South Wales, Australia (Gwydir Shire Council, 2006).

- Many public health offices utilize websites to provide information on environmental health topics and to encourage the public to notify them of issues or concerns. A complaint form is often displayed prominently to facilitate public response. For example, Vancouver Coastal Health Authority provides such information.

- The City of Toronto responds to complaints alleging health hazards within 24 hours and works closely with the Ministries of Environment and Labour to assist in early detection and more effective response to emerging health issues. An after-hours, on-call system has been implemented in order to respond to urgent public health issues on a 24/7 basis. Coordination with other city departments, and enhanced staff training and awareness help

to ensure a heightened state of preparedness in the event of a declared emergency (Day, Fleiszer, & Basrur, 2001).

- In Boston, Massachusetts, the Boston Environmental Strike Team is a consortium used for difficult environmental problems and complaints; it includes the Environmental Health Office, Inspectional Services, Fire Department, Police Department and Code Enforcement. The Environmental Health Office coordinates field inspections and cases of exposure to hazardous materials. It also has a "Safe Shop Project" to create environmental leadership, and provides training and other resources to support safe environmental practices within Boston's auto body and repair shops (Boston Public Health Commission. (n.d.).
- The United Kingdom National Health Service has a number of initiatives to facilitate an effective complaints handling process. It has issued a *Good Practice Toolkit for Local Resolution* for local managers of health care complaints. In 2006, the NHS awarded contracts to three organizations for delivery of a new and improved "Independent Complaints Advocacy Service" across England. As well, plans are underway to adopt a single comprehensive complaints procedure (through regulations) for health and social care (National Health Services, Department of Health, 2005).

PART II

10.0 BACKGROUND

10.1 Waste Definition

Waste may be defined as "any substance or object which the holder discards, intends to, or is required to discard." (Pheby, Grey, Giusti, Saffron, 2002). Generally, waste has been burned, spread or piled on the land, buried or dumped in bodies of water. Waste is a complex mixture of different substances and objects, only some of which are intrinsically hazardous to health. However, any type of waste has the potential to affect health depending on the collection system used, the location where waste is generated, and the waste management strategy employed. For example, a plastic bottle buried in a landfill is deemed unlikely to cause harm to human health, but if it is burned in a poorly managed incinerator, it could generate dioxins that could potentially lead to an increased risk of cancer in people working or living downwind.

Sewage is any type of waste that passes through the sewage treatment process. As well as pathogenic micro-organisms from human excrement, sewage contains many other hazards to health including heavy metals and toxic compounds from road runoff waters; toxic and endocrine-disrupting compounds from toiletries, cosmetics, and detergents; pesticides from surface water runoff; and natural hormones from human urine.

“Waste is never disposed of, just moved from one environment to another”, and where it is most apparent (spread on land, piled in compost dumps or landfills) it gets the most community attention. Where waste is invisible, as in our drinking water, or when dumped out to sea, it is often ignored and seen as less threatening. The literature seems to reflect this emphasis as it focuses more on solid waste (sludge) than the other problematic forms. Any discussion of waste must discuss the handling and processing of waste and the transferring of waste as two interrelated components of the waste management challenge and potential solutions.

10.2 State of the Evidence

The evidence may be summarized as insufficient to scientifically prove cause and effect of health impacts from waste management practices reviewed. Exceptions do exist where evidence is deemed possible, probable or convincing. For example, where exposure relates to occupational health issues of workers in centralized composting sites or sewage plants, or where there is swimming in sewage-contaminated water, there is more evidence of harmful impact from exposure.

Interpretations of the evidence, however, and the judgments or conclusions reached by reviewers of the same limited evidence, vary significantly. These interpretations and the related approaches to best practices and core health program design are summarized in three schools of thought:

1. ***Stay the Course***
    - **Rationale**: There is no convincing evidence of harm to human health. Evidence is insufficient to prove a significant correlation between exposure to waste

management operations and any significant health impacts. Compared to other environmental health hazards (e.g., vehicle traffic) or compared to other causes of ill health (e.g., poor diet, diseases), waste management operations are not a major public health concern. Best practice for health authorities is to continue monitoring and "keep a vigilant eye" and respond to dumps of sewage on beaches or in water by issuing cautions and boil water advisories.

2. ***More Caution and Higher Standards Are Warranted***

   - **Rationale**: The weight of probable evidence suggests a likely connection between exposure and negative health impacts, which may increase with the composition of the waste, the individual's receptivity to exposure, the type of exposure and the time exposed. The role of health authorities must be as an active participant in municipal planning, monitoring and surveillance of illnesses and as an ecologically-oriented champion of a healthy environment and of innovative, sustainable waste-management practices.

3. ***Current Waste Management Practices Are Environmentally Unsustainable. Our Planet and All Forms of Life Are in Imminent Danger***

   - **Rationale**: The environment is us and it is in crisis. The nature of the waste footprint we are leaving on the air, land and water is a slow-motion train wreck and will be increasingly negative in its ecological/environmental/health impacts. Current practices are unsustainable. All forms of "sewering" and the long-standing "sewerage principle"—that is, moving the waste downstream as the solution—are part of the problem, not the solution. Small-scale, local waste management at source is required. Examples of solutions include composting toilets and "living machines" such as wetlands that act as natural filters and treatment facilities. The role of health authorities is to inform the public and elected officials of these dangers and the need to embrace these alternative waste management solutions.

11.0 EVIDENCE OF IMPACT OF WASTE MANAGEMENT PRACTICES ON HUMAN HEALTH

11.1 The South West Public Health Observatory Review of Epidemiological Research

Research reported in the 2002 report, *Waste Management and Public Health: The state of the Evidence: A Review of The Epidemiological Research into the Impact of Waste Management Activities on Health*, authored by the South West Public Health Observatory, [the South West Review] identified mostly insufficient, and some probable, but not conclusive evidence of the potential health impacts from improper treatment, handling and disposal of waste. It is an important document that should be reviewed carefully in its own right.

11.2 Determining Health Impacts: The Problem of Linking Exposure and Cause

The South West Review describes the challenge of finding "convincing" evidence of health impacts as related to many confounding factors. These factors include varied definitions of health impacts; the number of measurable, potentially harmful substances in waste and waste; and the difficulty in establishing a link between exposure and causality. The South West Review indicates nine factors that complicate the search for clear, convincing evidence:

1. Health impacts result from an interaction between the factors affecting health and the health status of exposed populations. The health outcomes are determined by the contaminant levels and the susceptibility of individuals.
2. Factors associated with waste management that might have an impact on health may be beneficial, damaging or neutral. They may be present in the waste or formed during the waste management process.
3. With improvements in analytical methods, contaminants can be identified at such low concentrations that their implications for human health can only be guessed at. In most cases, a mixture of different contaminants will be present. The implications of mixtures of compounds are unknown. The risks may be additive or synergistic; i.e., there may be interaction effects that make the risks higher or lower than that predicted by analyzing individual contaminants separately. There may be no interactions at all, with each compound acting independently.
4. It is difficult to determine what relationship any of these factors have to health impacts and even more difficult to quantify their effects. Information is lacking about the toxicity, persistence and ability to bio-accumulate of many of the hundreds of thousands of chemicals that end up in waste.
5. The crucial link between a health hazard and a health outcome is exposure. The risk to health depends not only on how much is present, but also on whether there is a route by which people may be exposed.
6. It is difficult to establish a cause-and-effect relationship in epidemiological studies in this area because of the incompleteness of the data, inherent variability and confounding by other unrelated factors that may explain the results as well as the factor under investigation. Confounding takes place when the exposure is associated with some other factor that also increases the risk of the health outcome studied. This includes other sources of pollutants and other factors that affect health status.
7. Information may be incomplete because of lack of exposure data, unreliable health data or low statistical power.
8. Variability occurs in both the human populations studied and the waste procedures. While it is technically possible to detect the presence of health hazards in waste sites and health impacts among people working or living nearby, there are many problems demonstrating the relationship between exposure and the health impacts observed. The main limitations of epidemiological investigations are the small sample size, lack of

exposure information, lack of toxicological data about mixtures of chemicals and the lack of specificity of indicators of adverse health effects.

9. An association, even if statistically significant, is not necessarily proof of causation. To determine causation, the cause must precede the effect and the association should be "consistent, unbiased, strong, graded, coherent, repeated, predictive and plausible" (South West Public Health Observatory, 2002).

11.3 Evidence Criteria

The model used by the South West Review employs the World Cancer Research Fund guidelines for linking food and nutrition to the prevention of cancer. There are four categories of judgement:

1. Convincing
2. Probable
3. Possible
4. Insufficient

Table 2 explains how these criteria were applied.

Table 2: Categories of Judgement

Judgement	Interpretation	Criteria
Convincing	There is conclusive evidence of a cause-and-effect association.	1. The studies are on human populations, not just laboratory studies on animals or chemicals. 2. There are a considerable number of hypothesis-testing studies, with strong relative risks, preferably more than 20. 3. The association is consistent and observed in most of the studies, with few studies showing the opposite. 4. Possible confounding factors have been controlled for. 5. There are a range of hypothesis-testing study designs, preferably including prospective studies. 6. Studies have been carried out in different population groups. 7. The appearance of the hazard must precede the health effect. Data should refer to the time preceding the occurrence of the health outcome. 8. If dose-response relationships are observed, they should confirm the relationship. 9. The associations should be biologically plausible. 10. Coherence – the cause-and-effect interpretation of the data do not conflict with other knowledge of the health outcome. Laboratory evidence is usually supportive or strongly supportive. *Example: The evidence is convincing that vegetable and fruit consumption decreases the risk of several cancers. This judgement is based on 37 cohort, 196 case-control and 14 ecological studies. In 80% of the case-control studies, there was a statistically significant protective effect for cancers of the stomach, oral cavity, lung, oesophagus, pancreas and rectum for one or more vegetable and/or fruit categories (WCRF & AICR 1997, Chap 6.3).*
Probable	A causal association is likely.	There is less consistency among the studies with some not supporting the association. There are fewer studies. Laboratory evidence is usually supportive or strongly supportive. *Example: Alcohol probably increases the risk of colorectal cancer. Because there are inconsistent results from 11 cohort studies and more than 20 case control studies, the judgement is not convincing. However, the studies support a time trend, results are confirmed by animal studiese, and plausible mechanisms have been identified (WCRF & AICR 1997 Chap 5.5).*
Possible	There may be a causal relationship but the evidence is not strong enough to be sure.	Studies show an association. However, there may not be very many studies; or existing studies are of poor quality or results are inconsistent. There may or may not be supportive evidence from laboratory studies but there is strongly supportive evidence from other disciplines. *Example: Alcohol possibly increases the risk of lung cancer. This judgement is based on inconsistent results from 6 cohort studies and several case control studies where confounding factors are likely (WCRF & AICR 1997 Chap. 5.5).*
Insufficient	The evidence merely suggests a causal association. No judgement can be made	There are a limited number of studies which may be consistent but the poor quality of the studies limit the reliability of the conclusions drawn from them. *Example: No judgement can be made about the link between cadmium contamination of food and prostate cancer. Although there are several reports about occupational exposure to cadmium and prostate cancer and a plausible mechanism for carcinogenicity, there are no studies showing an increased risk from dietary exposure.*

Source: South West Public Health Observatory, 2002.

11.4 Evidence from the Southwest Review to 2000

11.4.1 Landfill

The review revealed more than 220 papers about hazards to health from landfill sites and leachate-contaminated drinking water.

Findings:

- Studies detected increased risk of diseases and symptoms, particularly reproductive outcomes such as reduced birth weight and birth defects, in populations living close to landfills.
- Exposure to emissions from hazardous waste may pose a risk to population health.

Overall Judgment:

- **Insufficient:** Exposure to landfill and any health outcomes.

11.4.2 Incineration

The review included 5 reviews, 24 discussion papers and 51 primary studies.

Findings:

- Toxic metals such as lead, cadmium, arsenic and mercury are released as highly bio-available, respirable forms and are deposited on soils, water, food and dust.
- Inconsistent findings of causal relationships may mean either epidemiological study methods cannot detect cause and effects or there are none.

Overall Judgment:

- **Insufficient:** Incineration and any health outcomes.

11.4.3 Composting

Two papers were found on the health impacts of composting.

Findings:

- Workers in centralized composting facilities are most likely to be affected.
- Symptoms include inflamed upper airways, congested nose, sore throat, toxicoses such as toxic pneumonitis and allergies, including bronchial asthma.

Overall Judgment:

- **Probable:** Composting and occupational health effects.
- **Insufficient:** Composting and health effects to residents. No studies found on residents living close to composting sites.

11.4.4 Sewage Discharges

The review included 7 review papers, 3 discussion papers and 70 primary studies on the health impacts of sewage in recreational waters or occupational exposure.

Findings:

- Significant relative risk of contracting a disease exist, especially gastrointestinal symptoms to bathers in polluted recreational waters and to workers in sewage treatment plants related to the number of indicator organisms present.
- Infective doses of viruses and protozoa were found still present after 99.9 per cent removal methods by secondary treatment.
- Pathogens undetectable by conventional methods can remain in marine water.
- Pathogens may accumulate in plankton and sediments and can be released and become infective.

Overall Judgment:

- **Convincing:** Gastrointestinal symptoms related to bathing in sewage-contaminated waters:
- **Probable**: Sewage plant workers suffer from more gastrointestinal tract symptoms, airways symptoms, fatigue and headache.
- **Insufficient:** Cancer as a result of working in sewage plants.

11.4.5 Soil Amendments (Land Spreading) of Sewage Sludge

Wastewater irrigation is banned in the United Kingdom. Health impacts of land spreading of sludge were the subject of 43 documents, including 9 reviews and 21 primary studies.

Findings:

- In 2000, Health Canada determined risks to human health as minimal.
- There is a lack of understanding of the potential for transfer of toxic compounds to food and about the degradability and persistence of some toxic contaminants.

Overall Judgment:

- **Insufficient:** Sewage sludge land spreading and health impacts.

11.5 The Southwest Review's Comments on Implications of Findings

- Data:
    - The data collected about waste are not detailed enough to make meaningful assessments of potential health impacts that might arise from waste management practices.
    - The data do not include detailed information about the composition of the waste collected nor of off-site emissions from waste management operations.
    - Accurate exposure assessments are not possible without such data.
- Research
    - The nature of existing epidemiological research in this area is such that most studies are useful for generating hypotheses, but are unable to test the hypotheses or to provide convincing evidence of an association between exposure and health impact.
    - For most waste management methods, the evidence is insufficient to claim that adverse health outcomes will result. The exception is the convincing evidence that bathing in sewage-contaminated recreational waters increases the risk of gastrointestinal symptoms, even when the water meets present guideline levels of fecal coliforms.
- Best Practices:
    - Implementation of the current waste hierarchy and the precautionary principle through the adoption of an integrated waste management strategy at national, regional and local level will be the most effective way to reduce the health risks from waste management procedures.

12.0 REVIEW OF THE LITERATURE SUBSEQUENT TO 2000

12.1 Literature Review Methodology

An extensive search was conducted using Ministry of Health Library access to three separate databases (PubMed, Agricola and Toxline). Key words and MeSH terms that mapped to five identified components of health impacts of waste management were identified and used to develop the applied search criteria. The five components include:

1. Waste Disposal Strategies
2. Exposure Paths
3. Community Vulnerability
4. Disposal
5. Health Impacts

The online search was date constrained (1995–2006) and resulted in 65 relevant citations. Based on works referenced within these documents, an additional four studies were found. In addition to the above database search, an extensive Internet search was also conducted using Google and Copernic search engines. This search resulted in 21 directly relevant articles and 37 indirectly relevant articles. A detailed search methodology is included in Appendix 8.

12.2 Uncertainty Suggests the Need for Caution in Waste Management Practices

The information in the sections that follow builds on the work done by the South West Public Health Observatory in their 2002 report, to update the literature search and determine what, if any, new (post-2000) research in the area has been conducted and what, if any, new evidence has been found. The investigation focused on the following waste management practices:

- Land Spreading of Sewage Sludge
- Landfill
- Incineration
- Composting

In the absence of convincing evidence, the debate continues to center on identifying risk and on determining the proper approach to regulating activities that are perceived to represent the greatest potential risk to human health and the environment. This review of current scientific and anecdotal evidence continues to suggest a strong probable connection between various waste treatment/disposal methods and negative health impacts on humans proportional to length and intensity of exposure and degree of toxicity. There remains, however, a high degree of uncertainty and lack of data that highlight the ongoing need for conclusive research.

To this end, the precautionary approach in dealing with waste, as stated below, remains one proposed approach to managing risk:

> Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
>
> ***When in doubt about the impact of a development, it will be managed according to the worst-case scenario of its impact on the environment and human health*** (United Nations General Assembly, 1992).

12.3 Findings from Updated Literature Search

Findings from the search of the PubMed, Agricola, and Toxline databases represent primarily peer-reviewed studies and reviews. The search was developed by adapting the MeSH terms applied in the paper entitled *Waste Management and Public Health* (Pheby et al., 2002). These terms are summarized below, organized in the same way as the South West Review to provide consistency.

12.4 Findings by Type of Waste Management Practice

12.4.1 Landfill/Composting

The review found three articles discussing the use of landfills as a waste management practice and associated technologies.

Findings:

- Legislative control and oversight regarding landfill use has increased; however, "many landfills remain "primitive" in their operation" (Hamer, 2003).
- Leachate from improperly designed or maintained landfills presents a significant source and pathway for harmful material to enter the water supply.

Overall Judgment:

- Landfills represent an economical approach to waste management, but the impact on human/environmental health is a function of proper design and operation of the facilities. Questions regarding risk and probable impact for human health as a result of failure of traditional practices, as well as overall long-term sustainability, remain unanswered.

12.4.2 Incineration

Five articles examining risk and evidence of impact of waste incineration on human health were found.

Findings:

- Intake of PCDD/PCDFs directly and indirectly (diet) appear to be within the rank recommended by the WHO. Health risk appears to be low (Domingo, 2002).
- Review of epidemiological literature on health effects in relation to incineration facilities. Several effects have been reported; however, "findings on non-carcinogen pathologies

are inconclusive… Effects of biases and confounding factors must be considered in the explanation of findings (Franchini, Rial, Buiatti, & Bianchi, 2004).

- Evidence of increased prevalence and exposure to various organic and inorganic compounds, PCBs, dioxins, furans and chlorophenols, toxic metals and irritation gases was found for people living near, and working in, incineration facilities.
- Some evidence of negative effects was found; however, "data do not provide unequivocal evidence that [a] cause-effect relationship between exposure and health risk does really exist (Starek, 2005).

Overall Judgment:

- Evidence of increased prevalence of toxic elements resulting from waste incineration has been found, as well as evidence of increased exposure to such toxic materials in those people living near, or working in, incineration facilities. However, studies suggest that levels are not dangerous to human heath. To date, various confounding factors have made establishing a conclusive cause-effect relationship difficult.

12.4.3 Land Application (Sludge/Manure)

Nineteen articles examining the effects of land application of sludge to agricultural and forest lands were found. In the case of municipal waste, the focus was on Class B sludge, which is not processed as completely as Class A sludge and contains higher concentrations of pathogens and heavy metals.

Findings (Sludge):

- Probable, but not conclusive, evidence as to level of risk has been used to develop "best standards and practices" to reduce pathogen levels in some jurisdictions.
- Variation in methods used to process biosolids into soil amendments results in a lack of clarity with respect to the level of risk to human health. Standards for Class A biosolids achieve a safe level of pathogen reduction to ensure application represents no threat to human health.
- Little data exists for the impact of various methods of processing sludge, and the level of pathogen risk has not been established. Work needs to be done to establish objective data on risk "…standard application of sludge on pastures is apparently low risk [but] does not mean that surveillance should cease since outbreaks of cysticercosis have been reported" (Cabaret, Geerts, Madeline, Ballandonne, & Barbier, 2002).

Findings (Manure)

- "Much remains to be learned about the actual acute and long-term health consequences of animal agricultural pollution, many health concerns are speculative, even though based on sound facts." The accumulation of nitrogen and potassium and the resulting growth of undesirable organisms is discussed. Also discussed are complaints and the potential for negative "mental health" effects from odour associated with spreading of manure (Donham, 2000).

Overall Judgment:

- Concern related to application of human and animal waste on land focuses both on risk due to direct contact/exposure as well as potential risk to water supplies due to runoff. Leachate is known to contain various pathogens and toxic metals; however, the ability for these compounds to transfer to humans either through the food chain or direct contact remains unclear. At current levels, material that enters the drinking water supply is removed at treatment facilities.
- Recent examples in Canada (Walkerton and North Battleford), as well as the number of boil water advisories in BC, suggest that reducing risk to human health from runoff depends upon the proper functioning of these plants.

12.4.4 Raw or Treated Sewage Discharge

Six reviews of incidents involving raw or treated sewage were found.

Findings:

- Health impact of groundwater recharge (either directly or indirectly) remains unclear – especially as the potential to impact domestic water supply increases. California has adopted a precautionary approach to this issue.
- Data with respect to acute non-occupational exposure to accidental sewage release showed two cases in England that resulted in serious symptoms.
- Studies indicate increased prevalence of pharmaceuticals in the environment and identify the need to assess the potential for these substances to enter the potable water supplies.
- Occupational diseases of sewage treatment workers:
    - A study in Poland looked at the most frequent disorders reported by municipal wastewater treatment plant workers. Included gastrointestinal infections, ocular and dermal irritation, headache and discomfort. Difficult to assess because of lack of hygiene standards with respect to airborne micro-organisms and endotoxins. Number of affected workers is estimated at 11,000–19,000 (Cyprowski & Krajewski, 2003).
    - A study was conducted to assess whether the scientific literature supports the hypothesis that workers exposed to sewage are at higher risk of hepatitis A. “An increased risk of Hep. A cannot be excluded but the association was not strong…” (Glas, Hotz, & Steffen, 2001).

Overall Judgment:

- Convincing evidence of significant health impacts from untreated sewage. Possible impact to drinking water supply associated with the practice of waste water recharge.

Additional Considerations: Impacts from Water Treatment Processes

Six articles were found that suggested that less attention should be paid to the question of "if" waste management practices are harmful, and more work should start from a position that current practices are certain to result in increased exposure to contaminants either directly or in water quality. The requirement for even greater "chemical processing" to provide safe drinking water may in itself pose a health risk, especially as the required amount of treatment increases.

While Canada has the ability to treat wastewater contaminated by the various practices noted earlier, the literature review identified two studies that explored the effects of the treatment process itself on human health. Evidence suggests that as the quality of pre-treated water deteriorates (due to current waste management practices), the by-products of the purification process may increasingly have detrimental health impacts of their own.

- "Chloroform and other chlorination disinfection by-products (CBPs) in drinking water were first reported in 1974. Chloroform and several other CBPs are known to cause cancer in experimental animals, and there is growing epidemiologic evidence of a causal role for CBPs in human cancer, particularly for bladder cancer. It has been estimated that 14 per cent to 16 per cent of bladder cancers in Ontario may be attributable to drinking water containing relatively high levels of CBPs; the United States Environmental Protection Agency has estimated the attributable risk to be 2 per cent to 17 per cent. These estimates are based on the assumption that the associations observed between bladder cancer and CBP exposures reflect a cause-effect relation. An expert working group concluded that it was possible (60 per cent of the group) to probable (40 per cent of the group) that CBPs pose a significant cancer risk, particularly of bladder cancer.
- The group concluded that the risk of bladder and possibly other types of cancer is a moderately important public health problem. There is an urgent need to resolve this and to consider actions based on the body of evidence, which, at a minimum, suggests that lowering of CBP levels would prevent a significant fraction of bladder cancers" (Wigle, 1998).

12.5 Findings Summary: State of the Evidence:

Table 3 summarizes literature "evidence" findings from the 2000 South West Review and the 2006 review conducted for this evidence review, using the same format and criteria as in the South West Review.

Table 3: Findings Summary Table

Evidence	Increased Risk (from 2006 review)	Increased Risk (from South West Review)
Convincing	• Negative health symptoms from direct exposure to untreated sewage. • Consumption of insufficiently treated drinking water (Walkerton).	Gastrointestinal symptoms and bathing in contaminated recreational waters.
Probable	Gastrointestinal infection, ocular and dermal irritations, headache and discomfort for experienced by waste water treatment plant workers.	Gastrointestinal tract problems, headache, fatigue and airways symptoms and working in sewage plants.
Possible	• Application of Class B sludge to agricultural land. • Application of animal manure to land.	Working at a centralized composting facility.
Insufficient	• Health outcomes from living near or working in waste incineration facilities. • Health outcomes from living near or working at landfill site (leachate risk excluded). • Health outcomes from exposure to odor due to nearby intensive agriculture operations (leachate risk & quality of life issues excluded). • Increased risk of hepatitis A for waste treatment facility workers.	• Any health outcomes and residence near landfill site. • Any health outcomes and working at a landfill site. • Any health outcomes and working at an incinerator. • Any health outcomes and residence near incinerator. • Any health outcomes and residence near centralized composting facility.
Additional Consideration	Possible negative health impacts from products used to disinfect drinking water.	

There has been a great deal of attention paid to understanding and quantifying the risk of potential environmental and human impacts of various waste management practices, yet a gap remains with respect to empirical studies that could be termed "convincing" regarding the health impact of these practices.

While the need for convincing, controlled studies that identify variables and exposure levels remains, the current state of the evidence suggests the probable connection and risk that waste and various waste management practices represent to the environment and human health.

13.0 CASE STUDY: THE ISSUE OF LAND APPLICATION OF SLUDGE

This section looks at four representative samples of documents (not covered in the South West Review) that attempt to determine the health impacts of sludge. A discussion of judgments reached and their implications for best practices is provided. In these papers, interpretation of limited data, opinion and orientation to risk, and views about the history of limitations of science as a guide to preventative action, are important elements of the discussion of waste treatment best practices. The potential role of health authorities in advancing the move to those practices is informed by these documents.

13.1 Examples of Studies on the Health Impact of Land Spreading of Sewage Sludge (Since 2000)

The papers reviewed on sludge included some peer-reviewed studies and many opinion pieces and interpretations of the limited evidence. A more extensive discussion of the ambiguity of the evidence is useful here to inform the understanding about the limitations of adopting clinical concepts of evidence in building approaches to best practices.

13.1.1 Potential for Increased Human Foodborne Exposure to PCDD/F when Recycling Sewage Sludge on Agricultural Land.

This paper from the University of British Columbia (Rideout & Teschke, 2004) is a review of 65 papers from the literature that excludes non-peer-reviewed documents in an attempt to discern the state of scientific evidence. The paper looks to "examine the potential impact of sludge-amended soil on exposures to polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) from plant and animal foods through a review of published empirical data."

Overall Judgment: Minimizing the PCDD/F content in sludge will reduce human exposure to those substances.

- Large increases in soil concentrations were required to achieve a measurable increase in plant contamination.
- Current available data suggest that sewage sludge application to land used for most crops would not increase human exposure.
- The use of sludge on land used to graze animals appears likely to result in increased human exposure to PCDD/Fs.
- There is a paucity of realistic data describing the potential for entry of PCDD/Fs into the food supply via sewage sludge.
- The available empirical evidence indicates that application of sewage sludge to agricultural land may have a small impact on the levels of PCDD/F found in root vegetables, above-ground plant foods and forage crops.

- The impact in animal tissues is likely to be considerably greater. Therefore, before sludge application, careful consideration should be given to the types of agricultural products grown and used as feed.
- Minimizing the PCDD/F content would also reduce human exposure potential in land application of sewage sludge.

13.1.2 The Use of Urban Sewage Sludge on Pastures: The Cysticercosis Threat

This European peer-reviewed study by Cabaret et al. (2002) begins with an assessment of the potential risk of transmission of parasites on land fertilized by sludge, depending on which process is used to produce the biosolid material. The authors also provide an overview of the potential parasitic risks found in sewage sludge, describe existing tools for obtaining an accurate estimate of prevalence of cysticercosis in particular, and finally evaluate the pros and cons of utilizing sludge in relation to the cysticercosis threat.

Overall Judgment: Current practices of spreading treated sludge represent a negligible health risk.

- Little data is available on the influence of processing and delay between processing and the use of sludge on the pathogenic risk. "Most of the cases of cysticercosis (North America, United-Kingdom, Germany or Denmark) are related to poor human hygiene or accidental flooding of sewage plants onto pastures."
- The standard application of sludge on pastures is apparently of low risk. This low risk does not mean that surveillance should cease, since outbreaks of cysticercosis have been reported. Future investigations should concentrate on the most sustainable means of reducing risk (length of storage before use, composting and other treatments).
- "The use of sludge for fertilizing pastures is ecologically sustainable compared to other processes (incineration among others). It has some disadvantages, one of them being the putative introduction of pathogens. The seeding of T. saginata eggs from municipal sludge onto pastures is of limited risk if the sludge is properly digested and eventually sanitized, and if sludge application conforms to the rules imposed in most developed countries. Sanitation of sludge and proper use is the warrant of a negligible risk for cattle and human health."

13.1.3 Other Interpretative Papers on the Impact of Sludge Spreading

The following papers are not peer reviewed studies. They focus on aspects of sludge-spreading that are interpretations of the literature and issues related to current practices. They are relevant in determining best practices in waste management, and, by implication, the role of health authorities in championing and supporting the development of those better practices.

1. Investigations of Alleged Health Incidents Associated with Land Application of Sewage Sludges

Harrison & Oakes (2002) investigated 39 incidents of illness complaints by 328 individuals living near sites where sewage sludge had been applied and sought to determine whether the application of Class B sewage sludge could be identified as the cause of these illnesses. The paper also examined whether any investigation by local authorities had been conducted regarding these complaints.

The authors outline compelling, but anecdotal, evidence of reported illnesses of the 328 people involved in the 39 incidents that are believed to be related to the land application of Class B sludge. The paper found that no substantial health-related investigations were conducted to substantiate any cause-effect relationship, but rather investigations focused on whether those spreading the sludge acted in compliance with regulations.

Overall Judgment: Eliminate sludge spreading.

The article suggests, based on limited and non-scientific data, that surface land application of Class B sludge should be eliminated and that, even for less risky applications, there is still a potential for adverse health affects that extend beyond the actual application site.

Qualified experts at the federal and state level, such as those at the Centers for Disease Control and Prevention or at state health departments, have not, thus far, been engaged in any scientific investigation of the incidents involving exposure of residents. Local health departments are sometimes involved, but do not generally possess the necessary experience and expertise. The true magnitude and nature of illness attributable to land application of sewage sludge needs to be assessed by following-up on complaints.

Reports from people living near land application sites of illness and even death suggest that risks are acute and chronic, and are related to long-term exposure.

2. Biosolids Applied to Land: Advancing Standards and Practices/Committee on Toxicants and Pathogens in Biosolids Applied to Land

The Committee on Toxicants and Pathologens in Biosolids Applied to Land, was commissioned by the United States National Research Council to conduct an independent review of the technical methods and process used by the Environmental Protection Agency (EPA) in establishing their health-based chemical and pathogen standards. As well, given those standards, the committee was to search for evidence of health impacts related to exposure to biosolids and for (best practices) approaches for identifying human health hazards, for assessing exposure to those hazards and for assessing risk from the exposures.

Overall Judgment: EPA approach is inadequate to protect the public and must improve in all aspects:

The report provides a significant critique of the EPA's approach to biosolids (sludge). It highlights uncertainty about the potential for adverse human health effects from exposure to biosolids, concern about the lack of exposure data and health information on exposed

populations, concern about reliance on outdated characterization of sewage sludge, concern about inadequate programs to ensure compliance with existing biosolids regulation and concern about the lack of resources devoted to the EPA's biosolids program. The report also highlights concerns about "anecdotal reports attributing adverse health effects to biosolids exposure, ranging from relatively mild irritant and allergic reactions to severe and chronic health outcomes".

The report recommends that:

- More epidemiological research be conducted.
- A new national survey of chemicals in sewage sludge be undertaken. Data from the survey should be used to determine whether additional chemicals should be considered for regulation.
- Using current risk-assessment practices, the EPA should reassess standards for regulated chemicals.
- Representatives of stakeholders should be included in the risk assessment process.

The committee indicates that a great deal of work is needed regarding pathogen standards:

- The EPA should conduct a national survey of pathogen occurrence in raw and treated sewage sludges.
- Quantitative microbial risk assessments should be developed and used to establish regulatory criteria for pathogens in biosolids, including the possibility of secondary transmission of disease such as through person-to-person contact.
- The EPA should foster development of standardized methods for measuring pathogens in biosolids and bio-aerosols.
- The EPA should promote research that uses improved pathogen detection technology to better establish the reliability of its prescribed pathogen treatment processes and biosolids-use controls, to achieve and maintain minimal exposure over time.

3. Risk Perception, Risk Communication, and Stakeholder Involvement for Biosolids Management and Research.

This paper (Beecher et al., 2005) does not assess the danger or impact of biosolid use, but rather discusses how the issue of risk may be assessed through public participation so that further research can be done in a more meaningful way. Public health officials can play a key role in that process because of their credibility and influence. This is an important component of "best practices" related to health authorities.

The paper makes the following case:

- An individual's perception of risk develops from his or her values, beliefs and experiences. Social scientists have identified factors that affect perceptions of risk, such

as whether the risk is knowable (uncertainty), voluntary (can the individual control exposure?) and equitable (how fairly is the risk distributed?).

- There are measurable differences in how technical experts and citizen stakeholders define and assess risk. Citizen knowledge and technical expertise are both relevant to assessing risk; thus, the 2002 National Research Council panel on biosolids recommended stakeholder involvement in biosolids risk assessments.

Overall Judgment:

- The public's knowledge and concerns need to be acknowledged; the credibility of the purveyor of information and the levels of trustworthiness, fairness and respect that he or she (or the organization) demonstrates is an important component of public health.
- Consensus-building and joint fact-finding with respect to biosolids research suggest that future research outcomes can be made more useful to decision-makers and more credible to the broader public. Sharing control of the research process with diverse stakeholders can make research more focused, relevant and widely understood.

4. The Case Against Land Application Of Sewage Sludge Pathogens

This paper (Reilly, 2001) is included as an example of a large literature of concern about the impacts of waste management practices on the environment and human health. This paper deals with the issues related to sludge spreading. The author presents her concerns as follows:

- The tragedy at Walkerton, where *Eschericha coli 0157:H7* and other pathogens contaminated the drinking water supply, show populations how vulnerable they can be to disease when agricultural practices adjoin population centres without adequate health and environmental controls.
- Sewage sludge contains pathogens and potentially harmful levels of toxic metals and environmentally persistent chemicals such as polychlorinated biphenyls and dioxins.
- With air quality concerns increasing and landfill capacity at a premium, municipalities have moved to farm disposal of these waste sludges, especially in Ontario, where almost all wastewater sludges are applied on farms.
- Have the risks to human health been adequately evaluated? Should government promote the transfer of these wastes to the countryside? Is it reasonable to ask rural residents to live next to sites where human excrement mixed with industrial waste is stockpiled and spread on the land?
- The Ashbridges Bay Treatment Plant in Toronto, Ontario, processes sludge for about 1.7 million people. There are not enough digesters to allow for the recommended minimum 15 to 30 days of digestion of sludge in anaerobic tanks. Therefore, Toronto sewage sludge may receive as little as 8 to 10 days of digestion (personal communication, Interim Compliance and Monitoring Committee, City of Toronto, Toronto, Ontario).

- The Ontario Ministry of the Environment has facilitated the spreading of this sludge with elevated pathogens by allowing the City of Toronto to average the test results according to a specific formula, so rural residents have no assurance that specific standards of disinfection have been met by sludge delivered to farms.
- Some provinces have "guidelines" or other criteria that are intended to address the environmental and health issues related to the land application of sewage sludge. However, these guidelines are not always enforceable, and most are not legally binding.
- The Environmental Protection Agency in the United States, the Ontario government and the Water Environment Association of Ontario have all acknowledged that pathogen risks from land application of sewage sludge have not been adequately evaluated.

Overall Judgment:

"We seem to have forgotten the public health lessons of the 1800s and the underlying reason for sewage treatment plants themselves. The pathogen levels in sewage sludge are high and can even increase over time once the sludge is stored or applied to land. Land application allows sludge pathogens to be transported by weather events, and facilitates the spread of diseases to animals and humans. It is unreasonable to expect rural residents to tolerate exposure to these diseases in land, air and water."

5. The Canadian Infectious Disease Society Position on Sludge

The Canadian Infectious Disease Society (CIDS) is a non-profit organization, composed of medical and scientific professionals involved in the fields of infectious diseases and medical microbiology, providing educational, professional and research support to individuals in these fields. On May 31, 2001, CIDS stated a position on the spreading of sludge on agricultural lands.

This statement represents an application of the precautionary principle in the Canadian context by a distinguished group of practitioners, scholars and scientists. The precautionary principle is discussed in more detail in Section 13.

CIDS Call for Moratorium

"Until further detailed studies regarding the spreading of sewage sludge are available, the Society would request that a moratorium be placed on such action … This would entail that the sludge be entombed at a sanitary landfill site. The position of the Society is that the health of Canadian citizens must be protected against potential infectious agents until there is clear cut evidence that such actions will not lead to any potential public health hazard."

The Society would like to emphasize that non-decontaminated sewage, waste sludge, and other bio-materials (solid or liquid) pose theoretical risks to human health.

This is especially true if this material is placed into contact with the population's immediate environment, foodstuffs such as vegetables and plants for human consumption, or in close proximity to the water supply.

Many human pathogens found in such bio-materials can withstand, and survive in, harsh environmental conditions and remain pathogenic to humans and domestic animals for long periods of time.

Recent outbreaks of bacterial diseases (i.e., *E. coli O157/H7* in Ontario) and parasitic diseases (i.e., *Cryptosporidium parvum* in Saskatchewan) show how fragile the barriers are, which currently exist to protect humans from waste-producing disease.

Therefore, CIDS remains steadfast that the disposal of all bio-materials be done in a safe and efficient manner, and that studies be undertaken to ensure that current disposal/ spreading techniques are safe for the human population.

Source: Canadian Infectious Disease Society, 2001.

14.0 THE PRECAUTIONARY PRINCIPLE AND IMPLICATIONS FOR HEALTH AUTHORITY BETTER PRACTICES

The Framework for Core Functions in Public Health makes some important observations on the subject of limitations of scientific evidence and implications for health policy and programs:

- Research on public health services tends to focus on dated definitions of public health and is focused on infectious diseases and biological risk factors and behavioural change.
- The long timeframe and large sample size needed to pursue intervention studies in public health also present a challenge. Since such long-term studies are expensive and comparatively rare, the result is that often the evidence on prevention interventions comes from "inadequate trials, commonly based on type-II errors, and on inadequate control, compliance and follow-up" (McPherson, 2001).
- The type of research required for population health intervention studies is different from the "gold standard" randomized controlled trial of clinical medicine. It is worth noting the point made by the *Independent Inquiry into Inequalities in Health* that "the more a potential intervention relates to the wider determinants of inequalities in health . . . the less the possibility of using the methodology of a controlled trial to evaluate it" (Acheson, 1998, as cited in MOH, PHW, 2005).

14.1 International and National Views on the Importance of the Precautionary Principle

The precautionary principle is an important perspective on the lack of evidence related to the impact of waste management practices on human health and the role of agencies entrusted with protecting public health. One definition acknowledged by the World Health Organization is as follows:

> When an activity raises threats of harm to the environment or human health, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of the proof (WHO, 2001).

The WHO, in addressing increasingly complex environmental health threats, has determined the need for timely preventive action despite the lack of proof, and the relevance of precaution under scientific uncertainty (and its potential misuse). The WHO has developed an approach to applying precaution, consistent with public health values and its mission to promote and protect health, and to strive for a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2006).

The WHO had historically tended to base its recommendations on health and safety issues on confirmed scientific evidence. However, in 1999, at the Third European Inter-Ministerial Conference on Environment and Health, the WHO was asked to take into account: "the need to

rigorously apply the precautionary principle in assessing risks and to adopt a more preventive, pro-active approach to hazards" (WHO & Commission of the European Communities, 1999).

The WHO's explanation of the rationale is that the precautionary principle does not replace, but instead enhances science-based risk management and attempts to incorporate whatever is known while evaluating what is not known or incompletely understood. The WHO explains as follows:

> The overall goal of applying precautionary measures in the public health context is to reduce the potential for health risks. If the risk is eventually found not to exist, it may be that any measures undertaken will not have protected health and some resources will have been spent unnecessarily. However, this outcome is often more acceptable than one where public health measures were delayed or neglected because a risk was thought not to exist, but was eventually shown to be both real and substantial.
>
> The Precautionary Framework recognizes perspectives based both on scientific evidence and on social factors, values, and experience or observation, and provides a platform for each to be addressed. Science-based risk management relies on assessments of the peer-reviewed literature to evaluate the certainty and appropriateness of evidence for health risk assessment. Adding perspectives based on experience or observation, and recognizing the validity of people's values, helps to identify knowledge gaps and shortcomings in evidence that may elude scientific assessments (WHO, 2003).

14.2 Implications for Health Authority Core Programs on Waste Management

The implications for determining best practices for health authorities follow from this logic:

> Public health policies have always aimed at disease prevention **after** a causal relationship has been established. However, policies can be enacted to protect public health **before** risk factors have been causally established or where uncertainty remains. In this way, precaution can be naturally integrated into existing public health policy and actions (WHO, 2003).

14.3 The Government of Canada Asserts the Precautionary Principle

The Government of Canada has adopted the same position:

> Canada supports the WHO position in the statement in Principle 15 of the "1992 Rio Declaration on Environment and Development": In order to protect the environment, the precautionary approach shall be widely applied by States according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (Government of Canada, 2001).

15.0 BEST PRACTICES IN DESIGNING HEALTH AUTHORITY CORE PROGRAMS IN WASTE MANAGEMENT

15.1 Current BC Context

Table 4 summarizes the key mandates and governing legislation related to waste management in BC. The Ministry of the Environment plays the lead role in determining waste management policy and standard setting in BC.

Table 4: Key Mandates and Governing Legislation for Waste Management in BC

Disposal Method	**Regulated By *Health Act* or *Environmental Management Act* (EMA)**
Onsite (Septic) Sewage Disposal • Pressure Distribution • Mound System • Intermittent Sand Filters • Re-circulating Sand Filters • Composting Toilets • Constructed Wetlands • Aerobic Wastewater Treatment	Sewerage System Regulation (*Health Act*)
Incineration (Waste)	Municipal Sewage Regulation (EMA)
Incineration (Cremation)	*Cremation, Interment and Funeral Services Act* (responsibility of Ministry of Public Safety and Solicitor General);
Discharge into Water	Municipal Sewage Regulation (EMA)
Treatment	Municipal Sewage Regulation (EMA)
Discharge onto Land	Organic Matter Recycling Regulation(EMA)
Composting	Organic Matter Recycling Regulation (EMA)
Environmental Management Act Codes include the following:	• Concrete and Concrete Products Industry Code of Practice • Industrial Non-Hazardous Waste Landfills Code of Practice • Poultry Processing Industry Code of Practice • Primary Wood Manufacturing Industry Code of Practice • Slaughter Industry Code of Practice • Soil Enhancement Using Wastes Code of Practice • Vehicle Dismantling and Recycling Industry Code of Practice • Finfish Aquaculture Waste Control Regulation • Hazardous Waste Regulation • Municipal Sewage Regulation • Open Burning Smoke Control Regulation • Organic Matter Recycling Regulation • Agriculture Waste Control Regulation • Code of Agricultural Practices for Waste Management

Health authorities have moved away from direct involvement in licensing septic systems, and are primarily responsible for ensuring that regulations are followed and for responding to complaints. They are involved and provide expertise, to varying degrees, in major land-use planning and decision-making processes and municipal waste management planning. They are also involved in responding to complaints regarding waste management issues. Health authority websites do not indicate a major role in waste management in general, and searches of a sample

of health authority websites do not indicate that information is readily available on many aspects of waste management, such as spreading of sludge on land.

15.2 Defining Best Practices

The *Framework for Core Functions in Public Health* cites an important distinction between better practices, which are "actions and processes—plausible, appropriate, evidence-based and well-executed—that will reduce the current and future burden of disease", and best practices, which are "those actions—policies, research, programs and services—that will have the greatest impact on reducing the current and future burden of disease." In other words, better practices will have some effect, while best practices will have the greatest effect. They suggest that "best" practices are "subjective, situational, and time-sensitive" because new knowledge is always advancing our understanding of what constitutes "best" and because what is best in one situation may not work well in another. They suggest that a "better practices" approach is about an adaptive systems approach, not a prescriptive "one-size-fits-all" approach with a single endpoint (MOH, PHW, 2005).

15.2.1 World Health Organization Proposed Best Practices Related to Precautionary Principle Risk Management Options

The WHO has proposed a set of "best practices" derived from the precautionary principle. They are generally well known and are often applied. They are summarized below:

- *Decision to Take No Formal Action* **–** An appropriate response in cases where the risk is considered very small, or the evidence is insufficient to support formal actions.
- *Research* – Fills gaps in our knowledge, helps to identify problems and allows for a better assessment of risk in the future.
- *Watchful Waiting* – Monitoring the results of research and measurement and the decisions being made by standard-setters, regulators and others.
- *Communication Programs* – Can be used to help people understand the issues, become involved in the process and make their own choices about what to do.
- *Compensation* – Sometimes offered in exchange for accepting higher exposures in a workplace or environment. People may be willing to accept something of value in exchange for accepting increased exposure.
- *Regulations* – Formal steps taken by government to limit both the occurrence and consequences of potentially risky events. Regulations can take many forms. They might include, for example, economic incentives to discourage activities or processes that create risk or to encourage activities or processes that do not create risk. Regulations might also include programs designed to ensure efficient reductions in risk. Numerical standards may be imposed with defined ways to show compliance, or the regulations may state objectives to be achieved without being prescriptive.

- *Technical Options (Mitigation)* – Involves making engineering changes in the system to reduce exposure and ultimately, known or perceived risk. Mitigation may mean redesigning the system, installing shielding or introducing protective equipment.

- *Limiting Exposure or Banning the Source of Exposure Altogether* – Options to be used when the estimate of probability of harm is high, when the costs of limitations or bans are low, or both. Performance standards, in the form of exposure limits, are often preferred to design standards, because they leave more flexibility in achieving health and safety goals. At one extreme, banning an agent or activity will depend on whether or not an alternative is available. If so, the implications of the alternatives for potential health effects, costs and benefits must be evaluated. Where no alternative is available, the evaluation needs to focus on the benefits provided by the agent or activity against its potential detrimental effects.

15.3 Example of a "Vision" for Best Practices in Waste Management

Since 1989, "Natural Step"—an international organization with coalitions of scientists, businesses and advocates, in many countries including Canada—has "worked to accelerate global sustainability by guiding companies, communities and governments onto an ecologically, socially and economically sustainable path". They have produced this long-term vision for waste management:

- Waste resources will be reintegrated into natural productive systems—whether on farmland, in polyculture, aquaculture, etc.—much as they have for the last 4 billion or so years.

- Mass treatment infrastructure will have been "downsized" to meet local needs in the most resource-efficient ways. Lower demand for energy is met from renewable sources, more efficient plants means physical footprint will be reduced, and transport will be minimized through appropriate sizing and setting of plants.

- Biological processes will be utilized in treatment systems without the aid of excessive persistent and bioactive chemicals.

- Excessive inputs of heavy metals to wastewater systems will have been eliminated at source, rendering metal levels in sludge equivalent to background concentrations and safe for use on land.

- Controls on inputs from domestic and industrial sources, and a change towards biodegradable compounds in disposable products, will also have eliminated complex organic compounds. This will eliminate risks from endocrine disrupters and other substances of concern.

- Risks of pathogen transmission through sludge will have been investigated and backed up by monitoring; sludge will be safely used in all forms of agriculture.

- The quality of residual outputs from treatment will guide decisions about trade waste inputs to sewerage systems. Profit from trade waste will not be allowed to compromise the value of sludge.

- Smarter planning of housing and urban development will minimize water demand and runoff, with Sustainable Drainage Systems (SuDS) the norm for drainage and source control of pollutants.
- Toxin- and pathogen-free sludge will be acceptable for a wide range of beneficial uses, and will replace the energy- and chemical-hungry practice of using excessive artificial fertilizers in agriculture.
- Sludge-residues used to replace mined alternatives in building materials will be widespread.
- Releases to air from sewage treatment will have been contained.
- People will assume responsibility for what they put into the sewer system.
- Regulation will be targeted at delivering the end-point of full sustainability, with no compulsion beyond that point or to drive "continuous improvement" with no clear end-goal.
- Sustainability will be seen as the business opportunity of the millennium, realizing the value of biosolids and turning around today's perception that biosolids are a problem.

The Natural Step group also provides some best practices to achieve this vision, including these ones related to health:

- *Eliminate Dangerous Substances at Source* – Inputs of heavy metals and persistent organic substances into sewage systems cannot continue to be allowed to compromise the usability of outputs from that system.
- *Further Investigate and Monitor Potential Health Issues* – There is today no evidence for the transmission of either endocrine-disrupting substances or of pathogens through the reuse of sewage sludge spread to land. We need further studies to ensure that this is the case. This should not be allowed to inhibit sustainable reuse of sludge.
- *More Sustainable Regulation* – We need smarter regulation, better attuned to the genuine challenges of sustainable development. Regulations that erect insurmountable obstacles to sustainability are irresponsible, uneconomic and can only serve to harm the common good, and need to be revised.

15.4 Implications for Health Authorities Derived from this Review

Health authorities should consider how they can continue to play a role in planning and monitoring of waste management practices. That role would include the following:

- Identifying key pollutants and problematic practices.
- Talking publicly about wastewater as well as drinking water.
- Working behind the scenes to ensure sufficient resources for surveillance of waste processes.

- Identifying the new or additional competencies required to pursue best practices.
- Developing human resource plans to ensure those competencies are part of their capacity.
- Promoting innovative approaches to all aspects of waste management, driven by the precautionary principle and knowledge of potential or probable harm resulting from many current practices.

These components of the role health authorities could play are outlined further below:

1. **Strive for More Clarity About Risk**
   There is more "heat than light" about the risks to human health from current waste management practices. Health authorities can help to clarify and summarize environmental health risks according to the precautionary principle. Otherwise, scientific ambiguity can be seen to mean "there really is no risk."

2. **Focus on Clear Public Goals, Targets, Standards and Surveillance Based on Caution**
   Health authorities play a relatively minor role compared to the Ministry of Environment and municipal-based utilities and agencies mandated to regulate and treat waste. However, the credibility and influence of public health is great. The need for clear goals in legislation and related regulations and policy and planning documents, as well as higher targets that limit the presence of potentially harmful elements in waste, would be helpful practices. A review of Canadian public health framework documents indicates a wide range of approaches to these issues across provinces.

   Canadian standards are higher than American but lower than European Union standards in key areas of potential risk, such as use of sludge spreading on land. For example, the countries in which the limitations on heavy metal concentrations in sludge are the most stringent are Belgium (Flanders region), Denmark, Finland, the Netherlands and Sweden. Greece, Luxembourg, Ireland, Italy, Portugal and Spain have set limit values similar to those in the European Union directive; values for Poland are lower than the European Union standards. The United Kingdom legislation differs by not providing any limit values for heavy metals in biosolids but rather specifying the maximum annual average loads of heavy metals to soil that are similar to the directive (Canadian Infectious Disease Society, 2001).

   Switzerland and Holland have banned the spreading of sludge on farmland, and other countries, (Sweden, France, Germany, Finland and Luxembourg,) are reportedly moving in the same direction. Health authorities could create more opportunities for public discussion of these new directions.

3. **Support Models of New Waste Management and Treatment**
   European countries are moving to new incineration technologies as well as new models of separation of waste at source—in the home and in industry. Health authorities need to encourage governments to explore and move in these directions and to help identify funds to support such new technology development.

4. Create Environmental Health Goals

The provincial government should consider establishing health goals for community sanitation that foster the reduction of contamination of the environment and reduce potential threats to human health based on the precautionary principle. The health authorities can help to advocate for such a direction, working with the Ministry of Environment.

5. Provide Community Leadership in Reducing Potentially Harmful Practices

The literature on leading change provides lists of critical factors that leaders need to play to champion change. One such list of an eight-stage process is offered here (Kotter, 1996):

1. Establish a Sense of Urgency.
2. Create a Guiding Coalition.
3. Develop a Shared Vision and Strategy.
4. Communicate the Change Vision.
5. Use Credibility To Empower Broad Based Community Action.
6. Generate Short Term Wins.
7. Consolidate Gains and Produce More Change.
8. Anchor New Approaches in the Culture.

The first question this list raises is whether health authorities are committed to improving waste management practices and wish to provide leadership in this area. If so, the list provides some guidance on practices to follow.

6. Move to "Knowledge-Based" from "Evidence"-Based Waste Management Practices

In a 1999 United Kingdom government Cabinet Office document, evidence is defined as:

> Expert knowledge, published research, existing statistics, stakeholder consultations, previous policy evaluations, the internet, outcomes from consultations, costing of policy options, output from economic and statistical modeling (Nutley, Davies, & Walter, 2003).

This definition reflects the reality of political decision-making that impacts public health practices, as well as the limitations of "gold standard" science. The use of the term knowledge-based practice can help clarify the confusion created by multiple meanings of evidence in the literature and health documents. This means that health authorities must explicitly refute efforts to minimize concerns about risk where science is insufficient, and suggest that the precautionary principle guide public policy.

7. Support More Public Participation in Waste Management Planning

The debate around waste management is largely interest-based. Industry versus environmental perspectives dominates the discussion and presentation of positions about best practice. Environment ministry officials are caught in a difficult role and work within a "guidelines" context that is open to interpretation. Health authorities can help to create new forums and public councils to plan and consider long-term options and directions for improved waste management solutions.

8. Model Environmental Health Competencies

The practices discussed here could require new or additional competencies in order to pursue them effectively. Following the development of core program objectives and measures, health authorities could develop human resource plans to ensure those competencies are part of their capacity. The modeling by health authority staff of a balanced, informed leadership role in dealing with these challenging issues will make a huge contribution to environmental health. Many of the better practices described earlier require new technical, community engagement, communication and leadership competencies that could add value to the current capacity of health authorities and the BC Ministry of Healthy Living and Sport. British Columbia's health authorities could add a valuable, credible voice to finding sustainable solutions to the challenges of managing waste safely, in our province, our country and around the world.

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APPENDIX 1: LITERATURE SEARCH METHODOLOGY – PESTICIDES

A literature search was conducted to identify all published studies and systematic reviews involving pesticide interventions. When few intervention studies were found, a second literature search was conducted to identify all published studies and systematic reviews involving pesticide exposure. Both literatures searches were conducted using EBSCOhost and MEDLINE. EBSCOhost includes the following databases: Academic Search Premier, Biomedical Reference Collection and the Cochrane Database of Systematic Reviews. The published studies were limited to pesticide exposure studies and evidence-based medicine databases. The systematic reviews were limited to reviews of intervention studies.

EBSCOhost and MEDLINE were searched using a combination of the following keywords: pesticide AND exposure OR interventions AND food OR water OR domestic use OR indoors OR farming OR agriculture OR education OR prevention OR public health.

Exclusion criteria included:

- Intervention studies that examined the efficacy of interventions for occupational exposure to pesticides
- Studies that examined pesticide exposure to farm workers. Studies that included measures of exposure to family members of agricultural workers were included.
- Studies with specific focus on health impacts of pesticides rather than on pesticide exposure. This review did not cover health impacts of pesticides.

To be included in the review, the studies had to focus either on the effects of interventions on reduction of pesticide exposure or on pesticide exposure. Since few studies were identified that dealt with the effectiveness of interventions on health, studies were chosen that dealt with the effectiveness of interventions on the reduction of pesticide exposure. There has been extensive research on the relationship between pesticide exposure and health; therefore, it follows that any reduction in exposure will result in positive health impacts. Searches were first performed in EBSCOhost, followed by MEDLINE. Any studies previously identified in EBSCOhost were discarded in MEDLINE.

Following the review of all papers retrieved during the literature search, studies were classified according to exposure sources. Three major sources of exposure were identified, including food and water, domestic use and farm use. All studies related to pesticide exposure were compiled into tables outlining methodology, intervention type where available and results.

Results

A total of 71 studies were retrieved. All studies that contained the necessary details were compiled into tables. Any study that did not adequately describe the study population or methodology was not placed in the table. Due to the large number of papers identified, this results section highlights only certain studies under each exposure source. The conclusion, however, is formed after evaluating all studies on the subject.

APPENDIX 2: SUMMARY OF PESTICIDE INTERVENTION STUDY

Study	Database	Study Design	Intervention	Results	Comments
Werner & Adams, 2001 Salt Lake County, UT	EBSCO	Population: Groups of adults, majority from churches N = 73 groups	Presented a video, group discussion, handouts, follow-up visit. All dealing with domestic use of toxic substances. Feedback by questionnaire.	Program induced 33% to begin treating toxic substances properly.	Feedback by questionnaire is a subjective method to measure program success.

APPENDIX 3: LITERATURE SEARCH METHODOLOGY – LEAD

A literature search was conducted to identify all published studies and systematic reviews involving lead hazard interventions. The literatures search was conducted using EBSCOhost and MEDLINE. EBSCOhost includes the following databases: Academic Search Premier, Biomedical Reference Collection and the Cochrane Database of Systematic Reviews. The published studies were limited to intervention studies and evidence-based medicine databases. The systematic reviews were limited to reviews of intervention studies.

EBSCOhost and MEDLINE were searched using a combination of the following keywords: lead poisoning OR lead toxicity OR lead exposure AND interventions OR abatement OR remediation OR nutrition OR prevention OR education OR hazard control OR housing OR public health.

Exclusion criteria included:

- Intervention studies that examined the efficacy of interventions solely on exposure levels rather than blood-lead levels.
- Studies with specific focus on interventions for occupational exposure to lead.
- Studies that examined interventions for Class III lead poisoning. This review did not cover any chelation therapy intervention strategies.
- Nutritional intervention studies that dealt with dietary items other than calcium and iron.

To be included in the review, the studies had to focus on the effects of interventions on health. Since the relationship between blood-lead levels and health risks is well established (Berkowitz et al., 2003; Wilson et al., 2004), health was defined in terms of blood-lead (BPb) levels. Searches were first performed in EBSCOhost, followed by MEDLINE. Any studies previously identified in EBSCOhost were discarded in MEDLINE.

Following the review of all papers retrieved during the literature search, studies were classified according to intervention type. Five types of interventions were identified, including soil remediation, lead paint abatement, dust control measures, nutrition and education. All studies related to lead intervention strategies were compiled into tables outlining methodology, intervention type and results.

A total of 138 studies were retrieved. All studies that contained the necessary details were compiled into tables. Any study that did not adequately describe the study population, methodology or intervention type was not placed in the table. Due to the large number of papers identified, this results section highlights only certain studies under each intervention group. The conclusion, however, is formed after evaluating all studies on the subject.

APPENDIX 4: SUMMARY OF INCLUDED STUDIES ON LEAD

The following summary of included studies on lead is organized by intervention type.

Study	Database	Study design	Intervention	Results	Comments
Soil					
Weitzman et al., 1993 Boston, MA	EBSCO	Population: Preschool children < 4 years with BPb levels 10–20 ug/dL N = 152 Randomized controlled trial	Children randomized to one of three intervention groups: (study group) soil and dust abatement and loose paint removal, (Grp A) dust abatement and loose paint removal and (Grp B) loose paint removal. BPb levels measured pre-abatement and 6 and 11 months post-abatement.	Significant decline in BPb levels in study group (p=0.001) and Grp A (p=0.04) between pre-abatement and 11 months post-abatement.	No control group for comparison.
Langlois et al., 1996 Riverdale, ON	MEDLINE	Population: Children 3–6 years that attended school in study area Cross-sectional observational study	Intervention included soil remediation and dust control measures.	Within study area, abatement appeared to be associated with a slower decline in blood-lead levels compared to reference group.	Low response rates.
Abatement					
Rich, Rhoads, Wartenburg, & Sweatlock, 2001 New Jersey	EBSCO	Population: Children with BPb 30-44 ug/dL N = 488 Retrospective follow-up study	Abatements for homes of all participants were required. Children from homes that did not undergo abatement served as controls. BPb was measured pre-abatement and 2 months following either abatement or baseline measurements.	After controlling for confounders, abatement was associated with only a small change in follow-up BPb (-0.69 ug/dL or 2% from baseline).	Limitations of retrospective study.
Leighton, Kliltzman, Sedlar, Matte, & Cohen, 2003	EBSCO	Population: Children 6 months-6 years with baseline BPb levels 20–40 ug/dL N = 221 Retrospective follow-up study	Children were chosen from families who had a lead-based hazard identified in primary residence. Intervention group from homes that were remediated, control group from homes that were not remediated. All participants had a follow-up blood-lead test between 10 and 14 months after baseline test.	After adjusting for potential confounders, the remediation effect was a non-significant 11% decrease. The effect of remediation was stronger for 10-36 mo old children compared to 36-72 mo old children (p=0.06).	Limitations of retrospective study.

Study	Database	Study design	Intervention	Results	Comments
Clark et al., 2004 (US Department of Housing and Urban Development) 14 states, USA	EBSCO	Population: Children 6 months-6 years N = 869 Lead-based paint hazard control grant program	Homes underwent abatement using 1 of 7 indoor intervention strategies plus exterior clean-up. Children's blood-lead levels were measured pre-intervention, 6 weeks, 6 and 12 months post-intervention.	9.3% of children had a 5 ug/dL or more increase in BPb levels from pre-intervention to immediately post-intervention. BPb levels were significantly lower at each successive post-intervention stage. Declines in BPb levels were not dependent on the intensity of the intervention strategy	No controls.
Staes, Matte, Copley, Flanders, & Binder, 1994 St. Louis, MO	EBSCO	Population: Children < 6 years with BPB levels ≥ 25 ug/dL N = 54 Retrospective follow-up study	Children from remediated homes were assigned to the intervention group. Intervention involved removal of damaged paint surfaces.	1014 months following abatement, BPb levels declined 23% in children from intervention group and 12% in reference group (P=0.07).	Limitations of retrospective study.
Farfel & Chisolm, 1990 Baltimore, MD	EBSCO	Population: Children with BPb > 29 ug/dL N = 96 Serial measurements	Children selected from homes that either underwent traditional or modified abatements.	Traditional abatements resulted in increase in BPb. Modified abatement resulted in short-term decline in BPb, but by 6 months, reduction was no longer evident.	No control group.
Dust control					
Lanphear, Eberly, & Howard, 2000 Rochester, NY	EBSCO	Population: Children 6 months-4 years N = 189 Randomized controlled trial	6-month infants randomized to dust control intervention group or control. Intervention continued until children reached 24 month. BPb levels measured at 48 months.	There was no significant difference in mean blood lead between the intervention group (5.9 ug/dL) and control group (6.1 ug/dL).	
Lanphear et al., 1999 Rochester, NY	EBSCO	Population: Children 5–7 months at baseline N = 246 Randomized controlled trial Primary prevention	Children randomized to a cleaning, dust control intervention group or control group. BPb levels measured at baseline, 6, 12 ,18 and 24 months.	No significant difference was detected in BPb levels between the intervention (7.3 ug/dL) and control (7.8 ug/dL) group at 24 months.	

Study	Database	Study design	Intervention	Results	Comments
Lanphear, Winter, Apetz, Eberly, & Weitzman, 1998 Rochester, NY	EBSCO	Population: Children 12–31 months N = 104 Prospective randomized trial	Children randomly assigned to intervention or control group. Intervention consisted of families receiving cleaning supplies, cleaning information and demonstration. BPb levels 7 months following baseline.	No significant difference in the change of children's blood-lead levels by treatment group.	
Rhoads et al., 1999 Jersey City, NJ	EBSCO	Population: Children 6 months-3 years N = 99 Randomized controlled trial	Children randomly assigned to either a lead reduction group or control group. Lead reduction group involved cooperating with a cleaning program.	Blood levels fell 17% in the intervention group and did not change among controls. Children from homes cleaned >20 times/ year, had average blood-lead reduction of 34%.	
Aschengrau, Hardy, Mackey, & Pultinas, 1998 Boston, MA	EBSCO	Population: Children < 4 years with BPb 11–24 ug/dL N = 63 Prospective, partially randomized trial	Children with severe lead hazards were assigned to intervention group. Children with no severe hazards assigned to either control or intervention group. Intervention involved removal of all lead-contaminated dust and paint chips and cleaning.	No statistically significant differences were evident in BPb levels between groups 6 months following intervention.	
Nutrition					
Markowitz, Sinnett, & Rosen, 2004 Montefiore, NY	EBSCO	Population: Children 1–6 years with BPbs 10-45 ug/dL N = 67 Prospective, double-blinded, placebo-controlled, randomized study design.	Intervention group given dose of 1,800 mg Ca/day between supplement and diet, as Ca glubionate or elemental Ca.	No statistical differences on BPb levels after supplementation between groups after 3 months of supplementation and after additional 3 months of follow-up.	
Wright, Shannon, Wright, & Hu, 1999 Boston, MA	MEDLINE	Population: Children aged 9–48 months N = 3,650 Cross-sectional analysis	This was a cross-sectional analysis with no intervention group.	Iron deficiency was associated with low-level lead poisoning in children aged 9–48 months.	Limited ability to identify iron deficiency. Not able to quantify dose-response relationship.

Study	Database	Study design	Intervention	Results	Comments
Education					
Jordan, Yust, Robison, Hannan, & Deinard, 2003 Minneapolis, MN	EBSCO	Population: Pregnant mothers and mothers of infants 1–3 years N = 594 Community-based, randomized controlled trial	Intervention group offered 20 bi-weekly educational sessions over 1 year and quarterly sessions for 2 years afterwards.	Intervention participants more likely to maintain lower BPb levels before 3 years of age, but difference was not significant (p=0.08). Intervention reduced the risk of BPb levels >10 ug/dL by 34%.	
Schultz, Pawel, & Murphy, 1999 Milwaukee, WI	EBSCO	Population: Children with BPb 20–24 ug/dL N = 187 Retrospective follow-up study	Families in intervention group received an in-home educational visit on nutrition, dust clean-up, behavioural changes.	BPb levels in intervention participants declined by 21% versus 6% in reference group (P<0.001) 6 to 7 months following initial testing.	Limitations of retrospective study.

APPENDIX 5: LITERATURE SEARCH METHODOLOGY – ULTRAVIOLET RADIATION

A literature search was conducted to identify all published studies and systematic reviews involving ultraviolet radiation (UVR) interventions. The literatures searches were conducted using EBSCOhost and PubMed. EBSCOhost includes the following databases: Academic Search Premier, Biomedical Reference Collection and the Cochrane Database of Systematic Reviews. The published studies were limited to intervention studies and evidence-based medicine databases. The systematic reviews were limited to reviews of intervention studies.

EBSCOhost and PubMed were searched using a combination of the following keywords: ultraviolet radiation OR UV radiation OR UVR AND interventions OR strategies OR programs AND reduction OR education OR prevention OR public health.

Exclusion criteria included:

- Studies that did not include details on intervention type, methodology and participant descriptions.
- Intervention studies that did not conduct post-intervention measurements or surveys.
- Studies that focused on outcomes other than wearing protective clothing, minimizing exposure to the sun during peak hours or wearing sunscreen.

Following the completion of the literature search and the identification of a systematic review, the criteria were set to those listed by the systematic review (Saraiya et al., 2004). Setting similar criteria for both reviews facilitated the comparison between studies included in the systematic review and additional studies identified in this report.

To be included in the review, the studies had to focus on the effects of interventions on health. Since the relationship between UVR and skin cancer is well-established, health was defined as a reduction in UVR exposure. Searches were first performed in EBSCOhost, followed by PubMed. Any studies previously identified in EBSCOhost were discarded in PubMed.

A total of 263 studies were retrieved during the literature review. The 85 studies reviewed in the systematic review were excluded from review in this report (Saraiya et al., 2004). All studies that did not meet the inclusion criteria were also excluded, leaving 7 primary studies. A summary of the number of all primary studies identified in the systematic review, and additional studies identified in the current search, is shown in Table A.

Table A. The number of studies which met the inclusion criteria of the systematic review, qualified for the systematic review and were identified during the literature search for this report that were not identified in the systematic review.

Intervention Setting	Reports Meeting Inclusion Criteria	Qualifying Reports	Additional Studies
Primary schools	33	20	1 (USEPA, n.d.)
Caregivers	25	11	
Recreation and tourism	18	11	
Outdoor workers	14	18	1 (Buller et al., 2005)
Health care providers	21	11	
Secondary schools/colleges *Appearance- based interventions*	17 3	13 3	1 (Adams & Auburn, 1997) 4 (Gibbons et al., 2005; Mahler et al., 2003; Mahler et al., 2005; Hillhouse & Turrisi, 2002).

A systematic review of interventions designed to prevent skin cancer by reducing exposure to UVR was identified. Conducted by Saraiya et al. (2004), it examined 85 studies. Electronic searches for this review were conducted in MEDLINE, PsycINFO and CINAHL. In order to be included, the identified studies had to:

- Evaluate a specified population-based intervention for the prevention of skin cancer.
- Be published in English.
- Involve primary prevention of skin cancer.
- Evaluate effectiveness and assess at least one of the specified health outcomes.
- Be conducted in an established market economy.
- Be a primary study.

The studies identified consisted of randomized controlled trials, time-series designs and before-and-after designs. The team of researchers organized the interventions into individual-directed strategies, environmental and policy interventions, media campaigns and community-wide multi-component interventions. Both individual-directed strategies and environmental and policy changes were further organized by the setting in which they were conducted.

APPENDIX 6: SUMMARY OF INCLUDED EVIDENCE PAPERS ON ULTRAVIOLET RADIATION

This table included those evidence papers other than those covered by the systematic review.

Location and Reference	Population	Intervention	Methodology	Comparator	Outcome
Primary school children					
USEPA, n.d. USA	Primary schools N = 130 schools N > 6,000 children	Cross-curricular activities, Internet learning, community partnerships. SunWise program	Schools that participated in the SunWise program were the intervention group. Schools that did not participate served as the control. Pre-intervention and post-intervention surveys completed.	Control schools and intervention schools. Pre- and post-intervention surveys.	Measures Knowledge variables, attitudes and beliefs about tanning, sunburn frequency, intentions. Results Student knowledge of the need for SPF 15 improved from 50% pre-test to 78% post-test. Knowledge of the UV index improved from 28% pre-test to 57% post-test. Attitudes that tans are healthy decreased in the intervention group. No changes in knowledge or attitudes.
Outdoor workers					
Buller et al., 2005 Western US and Canada	Ski area employees N = 7,289	Sun safety messages disseminated through multiple media and interpersonal channels. Preventative messages were apply sunscreen, wear a hat and wear protective eyewear.	Effectiveness of program was evaluated in a randomized, pair-matched, nested-cohort, pre-test/ post-test controlled design. Unit of randomization was the ski area. Pre-test and post-test surveys were conducted.	Half the ski areas received the intervention. Other ski areas acted as controls.	Measures Awareness of sun safety program and number of sunburns received. Results Employees at intervention ski areas were more aware of the sun safety program and reported less sunburns at post-test than employees at the control areas. Program awareness was not predictive of reduced sunburns.

Location and Reference	Population	Intervention	Methodology	Comparator	Outcome
College students					
Gibbons et al., 2005 San Diego, CA	College students N = 204	Intervention uses UV photography to highlight facial damage caused by UV	Randomized controlled study. Participants randomly assigned to either a UV photo or no-UV photo group. Baseline tanning booth reported, intervention, 4 weeks later students were asked again about tanning booth use since intervention.	Intervention group. Control group.	Measures Tanning booth use. Results Students who viewed their UV photo reported less booth use 3–4 weeks later compared to controls.
Mahler et al., 2003 San Diego, CA	College students N = 68 ages 18–37 Beachgoers N = 76 ages 19–57	In the first experiment, participants were shown a photoaging videotape and UV photo. In the second experiment, participants were given a photoaging brochure and shown a UV photo.	Participants assigned randomly to a 2x2 factorial design. Initial questionnaire given, intervention, and second questionnaire were completed. In experiment 2, participants were followed up with a telephone call.	Intervention group 1: receive photoaging information and UV photo. Intervention group 2: receive photoaging information but no UV photo. Intervention group 3: receive UV photo but no photoaging information. Control group: receive neither photoaging information or UV photo.	Measures Sunscreen use and sun-protection habits. Results Both experiments indicated that the UV photo significantly increased intentions to use sunscreen. For beachgoers, the UV photo and photoaging brochure resulted in lower reported sunbathing.
Mahler et al., 2005 San Diego and San Marcos, CA	Volunteer college students N = 146	UV photographs and information about photoaging. Also provided sunless tanning lotion as a non-UV alternative.	Randomized controlled trial. One-month surprise follow-up conducted by telephone.	Intervention group 1: information about photo-aging and a UV photograph. Intervention group 2: intervention from group 1 plus self tanner. Control group group: no intervention.	Measures Sun protection intentions and sun-protection behaviours. Results Intervention resulted in significantly stronger sun protection intentions and behaviours relative to controls.

Location and Reference	Population	Intervention	Methodology	Comparator	Outcome
Adams & Auburn, 1997	College co-eds N = 30	Health education, sunscreen provided.	Knowledge, attitudes towards sunscreen and tanning were taken before and after intervention. During the first 9 weeks and at week 15, skin colour and sunscreen use were measured.	Intervention group. Control group.	Measures Knowledge, attitudes and behaviour. Results Intervention increased knowledge but did not affect attitudes or behaviour.
Hillhouse & Turrisi, 2002 Southeast USA	Female university students N = 147	Workbook given to participants in intervention group. Workbook provided information on the appearance-damaging effects of indoor tanning.	Respondents were matched following the pre-intervention assessment and randomly assigned to groups. All respondents were administered a pre-intervention assessment, a short-term (2 weeks) follow-up and a long-term (2 months) follow-up assessment.	Intervention group. Control group.	Measures Attitudes, beliefs and intentions to indoor tan. Results At the short-term follow-up, intervention participants reported a 45% reduction in times they intended to tan compared to a 10% reduction in control subjects. At the long-term follow-up, participants reported significantly fewer visits than the controls.

APPENDIX 7: A SUMMARY OF INTERNATIONAL REGULATORY MEASURES ON NOISE CONTROL

1. European Union

The toughest legislation on noise is to be found in Europe, especially Scandinavian countries and the Netherlands. Since 1970, 17 specific noise directives have been ratified by the European Union (EU), covering a large range of topics.

In 1996, the EU published a *Green Paper on Future Noise Policy* as a first step in the development of a noise policy, aimed at ensuring that no person should be exposed to noise levels that endanger health and quality of life. Following a consultation process, a new framework was established, based on shared responsibility between the EU, national and local levels. The EU Noise Directive, established in 2000, required all members of the EU to adopt and implement the regulations by January 2002. It includes measures to improve the accuracy and standardization of data and requires member states to produce strategic noise maps on the basis of harmonized indicators; to inform the public about noise exposure and its effects; and to draw up action plans to address noise issues (CBC News, 2001).

Noise emission levels have been established for motor vehicles, motorcycles, aircraft, generators, agricultural and forestry tractors, earth-moving equipment, construction equipment, and domestic appliances, including lawn mowers, food mixers and coffee grinders. Particular attention has been paid to road and air traffic, which poses a major noise nuisance. Labels are required showing the guaranteed sound power level for all equipment covered by the EU Directive (CBC News, 2001).

The Directive also states that the environmental effects of public works such as new roads (including their levels of noise) should be assessed and published as an environmental statement with legislative orders to allow public comment. The EU Parliament has repeatedly stressed the need for further cuts in limit values and improved measurement procedures. With regard to air traffic over residential areas near airports, consideration is being given to a ban on night flying, landing fees graded according to noise levels, and measures to avoid particularly noise-intensive take-off and landing manoeuvres (CBC News, 2001).

2. Germany

Some inner-city neighbourhoods and busy freeway interchanges that abut residential areas are under “night-driving bans”, which prohibit heavy trucks between 10 p.m. and 6 a.m. Similarly, night-flights bans are in effect at two of Berlin’s three airports.

Laws governing the larger cities usually restrict hours when apartment dwellers can run water or flush toilets and forbid the disposal of glass, metal and other trash later at night or on Sundays. Even smaller towns tend to have hours for the use of lawn mowers and other noisy outdoor equipment. On behalf of the Federal Environmental Agency, Larmkonter (noise office) in Hamburg has designed a computer-assisted system that makes it easier to deal with noise-related problems in municipal administrations, and thus helps citizens solve their individual problems.

3. Britain

The United Kingdom Department for Environment, Food and Rural Affairs (1999) has conducted a review of noise mapping techniques in European countries and examined existing information and strategies for local area assessment by local authorities.

Officials are setting up anti-noise patrols that cruise the streets to control the noise, confiscating stereo equipment or other sources when necessary. For offenders who persist in being noisy, there can be extremely hefty prices to pay, with fines ranging up to $10,000. There is also momentum to make noisy behaviour a criminal offence in Britain, with some politicians pushing for jail sentences.

4. Ireland

Under the *Local Government Act*, it is an offence to make any noise that is so loud, continuous, or repeated, or at such time, as to give reasonable cause for annoyance to neighbours. The act also provides for securing the abatement of noise.

Conditions may be attached to planning permission for developments to reduce emissions from and/or intrusions into structures by noise. Building regulations in 1992 provide for greater insulation to reduce noise intrusion into new houses. Most new and expanded projects, including motorways and airport runways over 2,100 m in length, are required by law to be assessed with regard to their expected impact on the local noise pattern.

5. United States

In the United States, the *Noise Control Act* was passed in 1972 but was withdrawn in 1981. It left a legacy of noise control measures at many local and state levels. The Federal Highway Administration regulations currently provide funding assistance for highway projects for which noise abatement is considered important (Federal Highway Administration, 1997). The regulations require analysis of traffic noise impacts, including:

- Identification of existing activities, developed lands, and undeveloped lands for which development is planned, designed and programmed, which may be affected by traffic noise from the highway.
- Prediction of traffic noise levels.
- Determination of existing noise levels.
- Determination of traffic noise impacts.
- Examination and evaluation of alternative noise abatement measures for reducing or eliminating the noise impacts (Federal Highway Administration, 1997).

APPENDIX 8: LITERATURE SEARCH METHODOLOGY – HEALTH IMPACTS OF HUMAN AND ANIMAL BIOSOLID USE

Outlined below is the literature search for this review. Searches were conducted online and using Ministry of Health Intranet resources, and encompassed the following database resources:

1. PubMed	Extensive
2. Agricola	Augmentation
3. Toxline	Augmentation
4. Internet:	Via: Google Search: www.google.com Via: Copernic (desktp search engine aggrigator): www.copernic.com

Note:
Strategy for hand searching via the Internet was to use both Google and Copernic and various combinations of the key words identified within the strategy overview page. The search did not cover all combinations; however, as the search progressed we saw a number of key articles reappearing, which indicated that we had achieved a "level" of completeness in the search.

Bibliography of relevant articles held on "Refworks" www.refworks.com

Group Code:	RWHHSL
User ID:	CGI
Password	cgi2pass

Tables A-D outline the complete list of key words that were used in the search either as part of our database search or as part of our "hand search" of the Internet, as well as MeSH terms that "map" to these key words. These MeSH terms were used in searching PubMed. Also included for each database is documentation of the actual search process and results.

Table A: Listing of relevant Components, MeSH Terms and Keywords

Component	MeSH Term	Key Words
Waste (human/animal)	*Hazardous Waste* *Waste Management* *Hazardous Substance* *Fluid Waste Disposal* *Soil Pollutants* *Water Pollutants*	municipal waste sludge animal waste manure slurry sewage biosolids agricultural waste waste water
Waste Disposal Strategies	*Biological Waste Disposal* *Pathogological Waste Disposal* *Sanitary Engineering* *Sanitary Drainages* *Soil Amendment*	biochemical waste treatment re-use sewage treatment pyrolysis fermentation anaerobic digestion gasification feedstock recycling substitute fuels land spreading waste incineration waste water irrigation sewage sludge industrial waste
Exposure Paths	*Disease Vectors*	water supply water purification water contamination vegetables swimming skin exposure skin absorption shellfish seawater recreation rain plant uptake occupational lifestyle ingestion - waste ingestion - food ingestion - soil ground water fresh water food contamination fish environmental exposure drinking diet

Component	MeSH Term	Key Words
Exposure Paths continued		bathing beaches inhalation agriculture
Community Vulnerability	*Environmental Risk Factors*	infant newborn human health personnel female male community children age 80 and over age factors adult adolescence
Disposal	*Waste Management:* *Sewage Treatment* *Incineration* *Soil Amendment*	refuse disposal waste disposal waste management cesspool mains drainage waste disposal fluid discharge to water sanitary engineering sanitation sewage treatment bottom ash fly ash gypsum industrial waste manure sewage sludge slurry soil amendment waste water irrigation
Health Impacts	*Adverse Effects* *Complications* *Poisoning* *Cancer*	***Included in Mesh SH:*** ***(not directly searched)*** Mercury Poisoning Lead Poisoning Cadmium Poisoning rhabdomyosarcoma Pancreatic Neoplasms pancreatic cancer Neoplasms - don't use Lung Neoplasms Liver Neoplasms leukaemia Laryngeal Neoplasms *EP

Component	MeSH Term	Key Words
Health Impacts continued	*Cancer continued*	Kidney Neoplasms
		Colorectal Neoplasms
		childhood cancer
		Breast Neoplasms
		Brain Neoplasms
		Bladder Neoplasms
		Astrocytoma
	Symptoms	urinary frequency
		sleep disturbance
		skin irritation
		Physical Fitness
		nosebleed
		neurological symptoms
		neurobehavioral effects
		Nausea
		headache
		Forced Expiratory Volume
		fatigue
		eye irritation
		dizziness
		Diarrhea
		Body Weight
		inflammation
		Adverse Effects
		Sick Leave
	Reproductive Outcome	infertility
		Spermatids
		Sperm Count
		miscarriage
		Congenital
		hypospadias and epispadias
		abdominal wall defects
		mouth abnormalities
		orofacial clefts
		gastroschisis and exomphalos
		cardiovascular defects
		Opisthorchiasis
		neural tube defects
		Cleft Palate
	Biomarker	Blood Cell Count
		Dna
		DNA damage
		genotoxic damage
		sister chromatid exchanges (SCE)
		Tumor Markers, Biological
		Cytogenetics
		Chromosome Aberrations
		Genetic Markers

Component	MeSH Term	Key Words
Health Impacts continued	*Other health impacts:*	
	Gd [Growth & Development]	Bl [Blood]
	Ge [Genetics]	Bladder
	Health Status Indicators	Bone Marrow
	Public Health	Brain
		Chemically Induced
		Disease Outbreaks
		Facial Bones
		Gd [Growth & Development]
		Ge [Genetics]
		Health Status
		Health Status Indicators
		Hematopoietic Stem Cells
		Hematopoietic System
		Kidney Tubules
		Me [Metabolism]
		Mouth Mucosa
		Occupational Diseases
		Occupational Health
		Occupational Medicine
		Public Health
		Rural Health
		Urban Health
		myocardium
		world health
		Ph [Physiology]
		disease
	Communicable Diseases	
	Parasitic Diseases	Intestinal Diseases, Parasitic
		Ascariasis
		Helminthiasis
		cryptosporidiosis
	Bacterial Diseases	Tuberculosis
		Salmonella Infections
	Gastrointestinal Diseases	Peptic Ulcer
		gastroenteritis
	Skin Diseases	
	Respiratory Tract Diseases	Respiration Disorders
		asthma
		Respiratory Hypersensitivity
		lung diseases
	Liver Diseases	Hepatitis, Toxic
	Immune Suppression	Allergies
		Hypersensitivity
		Hay Fever
	Mortality	Infant Mortality
		Longevity
		Death

Table B: PubMed Search History

DataBase: PubMed		Limits	Results	Total Relevant
Search 1	Search Terms			
#1	Search refuse disposal OR waste management			
#2	Search refuse disposal OR waste management	Limits: published in the last 10 years, Review, Humans	356	
#3	Search ((#2)) AND adverse effects	Limits: published in the last 10 years, Review, Humans	131	
#5	Select 30 document(s)		30	30

DataBase: PubMed		Limits	Results	Total Relevant
Search 2	Search Terms			
#6	Search Hazardous Waste OR Waste Management OR Hazardous Substance OR fluid waste disposal OR soil pollutants OR water pollutants	Limits: published in the last 10 years, Review, Humans	1093	
#7	Search ((#6)) AND disease vectors	Limits: published in the last 10 years, Review, Humans	1	
#8	Search ((#6)) AND environmental risk factors	Limits: published in the last 10 years, Review, Humans	65	
	Select 6 documents (new)		6	36

DataBase: PubMed		Limits	Results	Total Relevant
Search 3	Search Terms			
#14	Search bioligical waste disposal OR Pathological Waste Disposal OR Sanitary Engineering OR Sanitary Drainages	Limits: published in the last 10 years, Review, Humans	866	
#15	Search adverse effects OR complications OR poisoning OR cancer OR symptoms OR reproductive outcomes OR biomarker		353666	
#16	Search (((#6)) AND (#14)) AND (#15) Limits: published in the last 10 years, Review, Humans	Limits: published in the last 10 years, Review, Humans	206	
	Select 6 documents (new)		6	42

DataBase: PubMed		Limits	Results	Total Relevant
Search 4	Search Terms			
Full Search Using Mesh Terms Outlined in Search Strategy Overview				
#1	Search Hazardous Waste		3817	
#2	Search Waste Management		26982	
#3	Search Hazardous Substance		4281	
#4	Search Fluid Waste Disposal		7256	
#5	Search Soil Pollutants		12038	
#6	Search Water Pollutants		24496	
#7	Search ((((((#1)) OR (#2)) OR (#3)) OR (#4)) OR (#5)) OR (#6)		61456	
#9	Search biological waste disposal		1036	
#10	Search Pathological waste disposal		1036	
#11	Search sanitary engineering		60157	
#12	Search sanitary drainages		81	
#13	Search Soil Amendment		432	
#14	Search (((((#9)) OR (#10)) OR (#11)) OR (#12)) OR (#13)		60397	
#15	Search disease vectors		19517	
#16	Search environmental risk factors		17149	
#2	Search Waste Management		26982	
#17	Search sewage treatment		6874	
#18	Search incineration		2204	
#19	Search soil amendment		432	
#20	Search ((((#2)) OR (#17)) OR (#18)) OR (#19)		28260	
#21	Search adverse effects		1166492	
#22	Search complications		1651020	
#23	Search poisoning		158595	
#24	Search cancer		1847153	
#25	Search symptoms		5354087	
#26	Search reproductive outcomes		2538	
#27	Search biomarker		332890	
#28	Search growth and development		985522	
#29	Search genetics		1517719	
#30	Search health status indicators		82509	
#31	Search communicable diseases		13963	
#32	Search parasitic diseases		228556	

DataBase: PubMed		Limits	Results	Total Relevant
Search 4	Search Terms			
#33	Search bacterial diseases		74432	
#34	Search respiratory tract diseases		748256	
#35	Search liver diseases		307891	
#36	Search immune suppression		38795	
#37	Search mortality		484171	
#38	Search ((((((((((((((((#21)) OR (#22)) OR (#23)) OR (#24)) OR (#25)) OR (#26)) OR (#27)) OR (#28)) OR (#29)) OR (#30)) OR (#31)) OR (#32)) OR (#33)) OR (#34)) OR (#35)) OR (#36)) OR (#37)		9064910	
#39	Search ((((#7)) AND (#14)) AND (#20)) AND (#38)		6620	
#40	Search ((((#7)) AND (#14)) AND (#20)) AND (#38)	Limits: published in the last 10 years, Review, Humans	192	
	Select 8 documents (new)	(Duplicates Removed)	8	50

Results from hand searching/following "related article links"	Approx. 350 related (included significant duplication)	12	62

Table C: Toxline Search History

Data Base: Toxline Search #1		Limits	Results	Total Relevant
	Searched: Environmental Pollutants AND Adverse Effects AND Sanitation Search refinement was ignored and 150 top articles were ranked by date and relevance and abstracts reviewed for specific reference to measured health impacts of manure/biosolid application to land.		73 0	1

Data Base: Toxline Search #2		Limits	Results	Total Relevant
	Searched: Waste Management OR Sludge OR Biosolids OR manure AND adverse effects 50 top articles were ranked by date and relevance and abstracts reviewed for specific refernce to measured health impacts of manure/biosolid application to land.	1995 -2006	15285	0

Table D: Agricola Search History

Data Base: Agricola Search #1		Limits	Results	Total Relevant
	Waste Management & Sewage & Adverse Effects Search Further refined to include: health impacts Search refinement was ignored and 150 top articles were ranked by date and relevance and abstracts reviewed for specific reference to measured health impacts of manure/biosolid application to land.	1995 to present	1475 0	1

Data Base: Agricola Search # 2		Limits	Results	Total Relevant
	Biosolids & Environmental Exposure & Adverse Effects 150 top articles were ranked by date and relevance and abstracts reviewed for specific reference to measured health impacts of manure/biosolid application to land. A great deal of US EPA literature around American standards was found, but nothing that pointed specifically to a controlled study of health effects from the practice of land application.	1995 to present	5076	0