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Decision Making in Environmental Health Impact Assessment

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Transportation and communication

Road-building projects

Quebec's road network extends over some 62,000 kilometres. Although network expansion has slowed markedly since the middle 1980s, there are still some major highway construction projects. The government also carries out regular heavy work throughout the network, bypassing cities and towns, straightening curves, leveling hills, widening bridges, etc. Justification for this work is generally that of ensuring smooth traffic flow and greater safety; this is the reason for building new city or town bypasses and altering the lie of regional roads.

There are two types of impacts related to road construction: temporary impacts associated with the construction phase and permanent impacts due to the road's existence.

Temporary impacts associated with road construction or redevelopment

One of the most obvious impacts resulting from road system development is heavy truck and equipment traffic. The problems arise from the rate of truck traffic, their speed, the noise created and the dust raised by the pounding action of the heavy machinery. Because the work schedule on the construction site is an important factor, work is usually restricted to between 7:00 a.m. and 6:00 or 7:00 p.m.

It should be remembered that the World Health Organization suggests a maximum noise level of 45 dB(A) at night in a bedroom and a maximum of 55 dB(A) outside during the day. Occasionally, the outside noise level may be exceeded when heavy trucks pass by or when certain equipment is being used (mechanical digger, grader, etc.).

Dust is actually formed by particles suspended in the surrounding air. Work such as road building, that requires the use of mechanical processes, normally produces large particles which are less of a concern with respect to contributing to health effects, than small particles which penetrate more easily into the lungs. Studies have linked particulate matter in the air

to a variety of adverse health effects ranging from transient mild respiratory symptoms to aggravation of cardiorespiratory conditions and even premature death. While generation of dust from road construction will generally result in temporary exposures for nearby residents, subsequent road traffic can generate long-standing exposures to particulate matter in relation to both road dust and vehicle emissions. Road crews are likely to experience continued exposures as they move from one site to another.

It must also be stressed that the construction phase may create safety problems for the crew, the residents and the drivers who must pass through the construction site. Explicit signage is a fundamental preventive measure for avoiding accidents. The hazards of dynamiting must also be mentioned.

Psycho-social impacts

Road construction or upgrading may lead to certain psycho-social problems, most notably expropriation, destructuring of the agricultural setting and urban spread.

Expropriation often means the relocation or even demolition of one's principal residence. When it is unnecessary to move the house, proximity to the road may lead to fears for safety in addition to noise and dust problems. The existence of a right-of-way at the home's "front door", as well as loss of landscaping, inevitably causes a depreciation in the value of the home even if the municipal assessment remains essentially unaltered. The repercussions expected in these cases are stress, a reduced quality of life and, possibly, financial loss when the property is sold.

Agricultural disorganization occurs when land is abandoned because it has become inaccessible or difficult to cultivate, due to the addition of numerous urban infrastructures. Crisscrossing the territory with expressways divides up agricultural land, restricting accessibility or reducing its quality. It also leads to latent speculation which prevents agricultural activity from starting again. Farmers, whose land is truncated or disorganized to a point that affects the quality of what remains, are likely to experience stress from these events.

Urban spread is another consequence of building roads or highways that make rural land accessible. As part of the urban spread, suburbs appear, creating a growing need for services and increased health costs, while also draining the city core. This in turn generally results in increased crime and poverty and the appearance of a relatively unhealthy environment, which is detrimental to the overall quality of life.

Noise

As seen in various road-building sites, construction or upgrading can be the source of significant noise disturbances. For example, during the upgrading of Montreal's Metropolitan expressway in the summer of 1990, the resulting noise level varied between 65 and 80 dBA within a 30 metre radius of the work, encompassing the closest homes located only about 10 metres away. This qualifies as a highly disturbing noise level that causes stress reactions, the inability to concentrate and even bad moods. Some of the work such as hydro demolition and sandblasting resulted in noise levels between 80 and 95 dbA over a 30 metre radius. Over a period of several hours, such levels are unacceptable.

Another major source of sound disturbance on the road system is traffic. Noise is usually produced by the mechanical friction between moving parts, air moving around a vehicle and friction between the tires and the road. In the last case, a vehicle doubling its speed increases sound by 9 to 13 dbA while water on the road causes a 10 dBA increase. Urban expressways are a source of significant sound disturbance. In Quebec, the average sound volume recorded within a radius equal to the distance of the first row of houses alongside urban and suburban expressways is 70 to 75 dbA, a level that is clearly stressful.

There are various ways to reduce traffic noise. Limiting speeds is one way, but speed limits are rarely respected. Another fairly effective, as well as aesthetic, means of reducing noise, is planting an absorbent vegetation zone such as trees or bushes. However, in urban and surrounding areas where available space is limited, this is impossible. For these applications, noise-reduction screens made of various materials including concrete, steel, plastic and soil embankments were selected. It is necessary to point out, however, that the resulting noise reduction of 10 to 15 dBA still leaves a moderately disturbing residual noise level of 60 to 65 dBA.

Air pollution

The primary organic pollutants generated by combustion motors are nitrogen oxides (NO_x), carbon monoxide (CO), carbon dioxide (CO_2) and volatile organic compounds (VOCs). In countries that prohibit leaded gas, manganese (Mn) has now also become an important inorganic pollutant. The presence of particles in the air carried from elsewhere by vehicles or sent into the air by high speed travel must also be emphasized.

That motor vehicles cause air pollution requires no further proof. According to a Quebec government report describing the evolution of air pollution from 1975 to 1994, the main source of atmospheric contaminants is transportation. This category alone represents 52% of all pollutant emissions, or just over 1.65 million tonnes in Quebec in 1994. CO, NO_x and VOCs are the pollutants generated in the highest amounts by vehicles.

Nitrogen oxides (NO_x) are composed of several molecules and include the nitric oxide (NO) and nitrogen dioxide (NO_2) emitted when fossil fuels are burned at high temperatures. NO_2

is a brownish, irritating, acrid gas whose toxicity is due to its ability to oxidize cellular membrane components. Mild to severe exposure to the gas causes a loss in odour perception, breakdowns in pulmonary function and eventually pulmonary oedema. One of the major effects of chronic exposure to NO_x is emphysema and reduced forced expiratory volume. It is also important to note the characteristic ability of NO_2 to react with VOCs to form the secondary pollutant, photochemical smog.

Volatile organic compounds (VOCs) are basically hydrocarbons that can vaporize at room temperature. Several of the thousands of VOCs are fairly toxic. A high concentration of benzene, a carcinogen for humans, is one of the VOCs found in gasoline.

An oxidation reaction between NO_x and VOCs causes the formation of secondary pollutants collectively known as photochemical smog. At ground level (the troposphere), this smog contains ozone (O_3), different free radicals, aldehydes, formaldehyde and a group of substances called peroxyacetyl nitrates (PAN). All these substances are highly irritating to the respiratory system and some are even mutagens (PAN) or carcinogens (formaldehyde).

Water pollution

Vehicular traffic causes a variety of substances to be deposited on the road surface: oils, grease, hydrocarbons and different body metals. Tire wear releases approximately 50 milligrams of hydrocarbons per kilometer. Deposits of these pollutants on the roadway or the shoulder are later washed away by rain or snow-melt runoff into nearby watercourses. Several heavy metals, most notably cadmium, copper, lead, iron and zinc, can be identified in the runoff. Iron and zinc are found in the highest concentrations. Public health problems arise when potable water wells are contaminated by any of these pollutants.

Snow and ice removal products

Each time there is snow or ice on roadways, a variety of ice melters and abrasives are spread on them. The most common ice melter is sodium chloride (NaCl). However, below -15°C, calcium chloride ($CaCl_2$) must be used as it provides more effective melting at very low temperatures. The abrasives used to prevent slipping and sliding on icy sidewalks or roads contain sand, gravel or crushed rock.

Water produced by road ice melting is usually characterized by an alkaline pH (pH of 8.5), high conductivity and turbidity, and the presence of chlorides, and sodium and calcium ions. The concentration of chlorides in the runoff water can range from 3,500 to 10,000 mg/L. This is a very high content considering that, for sensory purposes, the acceptable limit in raw feed water should not exceed 250 mg/L. Chlorides in the runoff do not usually present a direct health risk for humans unless free ground water contaminates wells supplying drinking water.

Impacts of road network upgrading

The impacts of building or redeveloping roads are not solely negative. Straightened curves, leveled and re-paved road surfaces, better intersection layout, improved signage and lighting, the presence of guardrails and crash barriers all help reduce the number of traffic accidents and consequently, mortality and morbidity.

Sector: Transportation and Communication
Activity: Roads and Highways

STRESSOR/ EXPOSURE	Type of Stressor	Environmental Impact	Affected Zone	Control Measures	Standards or Recommendations
Technological disaster					
Gaseous or atmospheric emissions	- suspended particles	- pollution	- local and regional	-	- 150 Fg/m^3 (24 h); Q-2 atm. qual. reg.
	- nitrogen dioxide (NO_2)	- pollution	- local and	- catalytic reduction	- 0.2 ppm (1 h) and 0.1 ppm (24 h); Q-2 atm. qual. reg
	- volatile organic compounds (VOC)	- pollution	regional	- catalytic reduction	- none
	- photochemical smog	- pollution	- local and regional	- reduce No_x and VOC	- 0.08 ppm (1 hr); Q-2 atm. qual. reg
	- carbon dioxide (CO_2)	- climate warming	- local, regional and continental - global	- reduce combustion	- none
Liquid or waterborne emissions	- heavy metals:	- toxicity to aquatic organisms	- captor watercourses	- none	- 0.05 mg/L for Pb (Q-2 drinking water qual. reg.)
	primarily Cu, Fe,	- toxicity tp aquatic organisms	- captor watercourses	- none	- 250 mg/L, Env. Can. guideline for raw water supply
	Pb and Zn - oil and grease - chlorides	- toxicity to aquatic organisms	- captor watercourses	- reduce use of de-icing salts	- none
Solid or soil-borne emissions					
Disamenities	- noise	- salubrity	- along the roadside - construction site	- speed limits; sound-absorbing screen	- L_{eq} 45 dBA 8h nighttime and 55 dBA daytime
Indirect impacts or other exposure	- risk of vehicles striking animals	- death of animals struck	- on the roadways	- restrict animal crossings (fencing) and post crossing signs	- road safety
	-accidents during construction	- N.A.	- construction site and perimeter	- impose speed limits, preventive measures	- guidelines for construction contractors
	- subdivision of agricultural lands	- disorganization, downgrading of agricultural lands	- agriculture in suburban settings	- protect agricultural lands	- Agricultural Lands Protection Act

STRESSOR/ EXPOSURE	Effects on Health	Population at Risk	Probability of Occurrence	Biol./Environmental Monitoring Indicators	Information/ References
Technological disaster					
Gaseous or atmospheric emissions	- irritations, respiratory problems, infections	- mostly workers	- rare to occasional	-suspended particles in ambient air	- Lajoie (1997) Hamilton and Harrison (1991) Bisson and associates (1997)
	- respiratory tract irritation, pulmonary edema	-urban zone residents	- rare or unknown	- ambient air NO_2 measurement	
	- benzene: carcinogen; toluene: fetal malformations	- urban zone residents, pump tenders (gas pumps)	- rare or unknown	- ambient air VOC measurement (notably benzene and toluene)	
	- ozone: pulmonary tissue inflammation	- urban and suburban zone residents	- rare to occasional in Canadian cities	- ground-level (tropospheric) ozone measurement	
	- climate changes	- global	- frequent	- atmospheric CO_2 measurement	
Liquid or waterborne emissions	- varied toxic effects (no carcinogenic metals in this case)	- people drinking polluted water	- unknown	- level of heavy metals in drinking water	MEF (1991) Environment Canada (1987) Goyer (1980) Hamilton and Harrison (1991) Delisle *et al* (1991)
	- if PAH present: possible carcinogenic and mutagenic effects	- people drinking polluted water	-unknown	-level of PAH in drinking water	
	- no remarkable effect	- people drinking polluted water	- N.A.	- level of chlorides in drinking water	
Solid or soil-borne emissions					
Disamenities	- sleep quality, stress - stress, hearing problems	- vicinity - workers	- frequent to very frequent - occasional to frequent	- dBA measurement at various distances from the road system	- BAPE reports ; Lévesque and Gauvin (1996)
Indirect impacts or other exposure	- injuries, death	- vehicle drivers and passengers	- occasional	- public safety, morbidity/mortality reports	
	- injuries, death	- workers, residents, drivers	- rare	- public safety, morbidity/mortality reports	

	- stress, social conflict	- farmers	- occasional to frequent	- complaints, perception studies	

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Hydro lines

As mentioned in the section dealing with the impacts of hydroelectric dams, Quebec is the world's third-ranking producer of electricity, with a power base of 40,000 megawatts (MW), 75% of which is produced by the provincially owned corporation, Hydro-Québec. Electricity is sent to users first over the transmission network and then over the distribution network. The first carries the electricity over great distances using high voltage lines of 44 to 735 kilovolts (kV). For simplicity's sake, we can say that the transmission cables are normally strung from metal towers. The subject of this section is Hydro-Québec's transmission network, which extends over some 37,000 kilometres. The distribution network used to carry electricity to each point of use is more than 96,000 kilometres long. At less than 34.5 kV, the distribution network's electric transmission cables are lower voltage and are normally strung from wooden poles.

Characteristics of the transmission network

The type of electric transmission network was greatly influenced by how Quebec produces electricity: that is, in megaplants that are frequently far removed from consumer areas. Hence, electric transmission from the La Grande complex, from Churchill Falls (Labrador) and the Manicouagan-Outardes-Bersimis complex required stringing 735,000 volt (735 kV) transmission lines over thousands of kilometres. The cables are strung from braced lattice-type towers that can reach a height of 60 metres. Closer to major urban centres, transformer stations reduce the tension to 315 kV, and the 315 kV lines carry the current to other stations for further reduction to the distribution network.

The transmission network is therefore primarily composed of lines carrying 120, 230, 315 and 735 kV, all of which are alternating current. The cables for these lines are carried on lattice-type towers whose height varies according to the tension. For several years now, more aesthetically pleasing tubular towers have been used in urban areas. There is one exception here: the Radisson-Nicolet-Des Cantons line (near Sherbrooke) is a 1,120 kilometres long

450 kV direct current line that crosses the river at Grondines (Portneuf region) and was designed primarily to export electricity to the United States.

Tower height and width are determined by standards that set the horizontal clearance (distance between the cables), vertical clearance (the minimum distance between the ground and a cable at its lowest point between two towers) and phase clearance (distance between cables located on both sides of the tower). Since these distances increase as tension increases, vertical clearance ranges from 13 to 18.6 metres for a 735 kV line (depending on the obstacle in question, road, railway track, private road, etc.) and from 6 to 9.4 m for a 315 kV line.

Impacts related to building a high-tension line

Impacts solely related to the construction phase, which disappear once a line is in service, usually result from the presence of various machinery and traffic. Main disturbances include noise, dust, exhaust fumes, electrical appliance interference and the safety of the nearby population. They are similar to those experienced near any construction site (buildings, roads, etc.). Measures such as using dust control liquid, prohibiting machinery operation at night, etc. must be implemented to mitigate them. When the line has to span a watercourse, the presence of heavy equipment, the building of temporary dams and the disposing of plant debris in the water are likely to cause significant disturbances in the aquatic habitat. Attempts must be made to protect the habitat of migratory and sport fish. In the case of large watercourses, building temporary dams can also cause floods by backing up ice during the spring thaw.

Permanent impacts due to the presence of high-tension lines

The following is a summary of the many permanent repercussions. Note that the issue of electromagnetic fields is described in the next sub-section.

Incorporating the power line into the natural and traditional landscape

Populations living in the vicinity of high-tension lines are increasingly concerned by the visual impact. It is considered inappropriate to have electric cables appearing in unique landscapes or near historical buildings. Spans over watercourses are also a major source of aesthetic concerns. In this type of situation, public pressure forced a 450 kV line to be run underwater across the St. Lawrence River in Portneuf county. In 1996, the BAPE also recommended that the 315 kV Duvernay-Anjou line be run under the rivière des Prairies.

Static noise generated by power lines

High-tension cables give rise to discharges producing a phenomenon called a “corona effect” and “crackling” that may even be heard in dry weather. Hydro-Québec estimates the maximum noise level at the edge of the right-of-way during a light rain to be 42 decibels (dBA) and no higher than 36 dBA at the closest homes. In dry weather, the intensity of this same noise would not exceed 15 to 25 dBA, making it almost inaudible. Given that existing standards or regulations for residential areas define the limits as 40 to 50 dBA at night and 45 to 55 dBA during the day, static noise is not deemed to be a real nuisance.

Collision hazards for moving objects

Some incidents have demonstrated the risk of small airplanes colliding with high-tension lines. From 1975 to 1995, Canada recorded approximately 400 airplane collisions with cables. These accidents took the lives of more than 100 people. At the rate of 20 accidents per year, this concern cannot be ignored and it should be addressed each time high-tension lines are in the vicinity of smaller airports.

When towers have to be raised in navigable watercourses, the potential for boat collisions must be addressed. This issue applies primarily to the passage of large ships, which may require several hundred metres to come to a full stop. The problem was raised at BAPE hearings studying the 450 kV line crossing the river at Grondines.

Economic depreciation

As the study on the Duvernay-Anjou line between Laval and Montreal showed, putting a new high-tension line into service in a highly urban setting is likely to hinder residential development. Condominium and old-age home developers, as well as single family home owners expressed concern about this.

Recreation and tourism potential can also be affected. Electric towers and cables are not compatible with some existing infrastructures such as natural parks, campgrounds or even natural panoramic observation points.

Electromagnetic fields (EMF)

Perhaps the greatest fear expressed by people living in very close proximity to high-tension lines is exposure to electromagnetic fields. Much scientific literature has been published on this subject, making it relatively well documented. But, understanding the effects of electromagnetic fields first requires knowing what they are and how they act on living organisms.

The nature of electromagnetic fields

Two types of fields form an EMF: the electric field and the magnetic field. An electric field (EF) is generated the moment there is a tension variation in the line. One must realize that an EF exists the moment there is current in the cable even if no electric device is turned on (for instance, a lamp that is plugged in but turned off). The electric field is measured in volts per metre (V/m) or kilovolts per metre (kV/m). In a home, the average EF is 12 V/m, while the EF generated by a 735 kV power line can reach 10,000 V/m directly underneath the line. The magnetic field (MF) is generated by the passage of the electric current and its intensity is expressed in micro-Tesla units (FT). Contrary to the electric field, the MF is only generated when current is used (i.e., when the lamp is turned on). The ambient domestic magnetic field usually varies between 0.1 and 0.2 FT while the maximum MF produced by a high-tension line ranges from 10 to 30 FT. Unlike the EF, the MF passes through most structures, such as buildings and the human body, without changing.

These two fields (electric and magnetic) exist together in the environment, hence the term electromagnetic field (EMF). One of the characteristics used to describe an EMF is its frequency expressed in Hertz (Hz). Electromagnetic fields emitted by transmission networks have a very low frequency of 1 to 300 Hz. Domestic electrical wiring in Quebec generates an EMF frequency of 60 Hz.

EMF sources and exposure levels

The levels of exposure to a natural electric field and magnetic field are very low, at about 0.001 V/m for the EF and 10^{-12} FT for the MF. Average domestic exposure to an EF of 12 V/m and a MF of 0.1 to 1 FT is caused by the presence of our industrial society's electrical lines and apparatus. The daily use of various appliances generates a significant amount of EMF. Appliances such as toasters, irons, refrigerators and colour televisions generate an EF of 30 to 60 V/m and a MF ranging from 0.3 to 4 FT. It is noteworthy that a hair dryer produces an EF of 60 V/m and a MF ranging from 7 to 70 FT over a usage distance between 30 cm and 15 cm. An electric blanket generates a MF of 10 FT at a distance of 1 cm, but an EF of about 10 kV/m.

The EF generated by various household appliances and the average domestic EF are much lower than that generated by a high-tension power line. At ground level under the lines, the maximum EF of the line is 10kV/m while at the edge of the right-of-way it is 2 kV. And the maximum 30 FT MF under the cables of a 735 kV line decreases to 14 FT at the far edge of the right-of-way. At a horizontal distance of 100 metres from the cable, the MF would only be 0.1 FT, or similar to the average domestic MF exposure.

The concept of fields and induced currents

Since they are good conductors, living organisms capture what are called induced currents emitted by the EMF. These are measured in milliamperes (mA). Because the currents

induced by the EF and the MF are normally perpendicular, the EF induces a current that flows from head to foot in the body of a person standing under an electric line, while the MF induces a current that flows in a more circular pattern through the body's most conductive fluids, tissues and organs.

In the case of a 10 kV/m EF, which corresponds to the maximum intensity measured at ground level beneath the cables of a 735 kV line, the maximum induced current in the organism is about 0.16 mA. This is well below the 0.66 to 1.0 mA sensory threshold. For reference, the sensory threshold is 0.5 to 1.0 mA. Respiratory arrest can occur from muscle tetany at between 18 and 30 mA, and cardiac arrest from ventricular fibrillation can be caused by a current ranging from 30 to 120 mA.

Biological effects of EMF under experimental conditions

Numerous studies conducted between 1975 and 1995 have shown a whole series of biological effects on a variety of animals. In terms of the neuroendocrinological system, disturbances of the diurnal rhythm and a marked decrease in melatonin secretion in the rat and mouse were observed at an EF ranging from 2 to 130 kV/m. An EF between 3 and 30 kV/m upsets the nervous system primarily by affecting dopamine and serotonin. In the human, a slight decrease in cardiac rhythm was observed at an EF of 9 kV/m and a MF of 20 FT. Chicken and bird embryos showed significantly more deformities in the presence of a MF ranging between 100 and 1,200 FT.

Possible carcinogenic effects of EMF on humans

Due to the existence of many contradictory studies, or studies which present more or less significant results, the carcinogenic effect of EMF is a highly controversial subject. What can be said is that there is no direct proof that an EMF stimulates cancer in adult humans. Even the most recent, strictly controlled studies provide inconsistent results. They neither prove nor disprove the hypothesis of a link between EMF and cancer. Although there is no clear trend, several results indicate relatively positive risks (>1) that are still insignificant (less than 2). On the other hand, epidemiological studies of children support some type of relationship between cancers and the levels of the magnetic fields generated by power lines. The results of various studies show that, generally speaking, children with leukemia lived close to electric infrastructures more frequently than children in good health. Although a causal relationship cannot be proven, the possibility of such a relationship should nevertheless be considered.

EMF exposure criteria or standards

There is no specific regulation for general EMF exposure. The International Radiation Protection Association (IRPA) recommends that the general public's exposure over 24 hours

be limited to 5 kV/m for EF and 100 FT for MF. For the workplace, these recommendations are 10 kV/m and 500 FT respectively. Currently, there are no recommendations or guidelines for EMF exposure in Canada. The few American states that have regulated exposure to the electric field within a high-tension line right-of-way have set the limits between 8 and 10 kV/m.

The concept of careful avoidance

It must be said that, just as scientific research on the effect of EMF on public health has not clearly indicated the existence of a significant risk, neither has it proven the complete absence of risk. In this situation, careful avoidance is recommended. This concept, developed at Carnegie Mellon University, Pittsburgh, recommends taking certain simple measures to reduce the population's exposure to EMF. Because of the precedents it embodies, the application of this concept has given rise to much debate among business, public and scientific organizations. In 1996, Hydro-Québec felt that careful avoidance represented a conceptual departure from the ethics of public health, since the carcinogenic properties of EMF had not yet been identified.

Maintaining high-tension line rights-of-way

Approximately 20,000 of Hydro-Québec's 120,000 hectares of rights-of-way require annual maintenance to remove bush and tree growth so towers and lines can be maintained. Removing this dendriform vegetation also helps limit potential damage from forest fires, of which the canopy flames burn at temperatures up to 800°C. Vegetation beneath the cables must be low and the right-of-way wide enough to prevent the forest fire's convection column from affecting the conductors.

There are two possible means of removing vegetation: mechanical clearing and clearing with phytocides (herbicides).

Mechanical Clearing

A certain number of occupational health hazards accompany the use of chain saws and strippers. For the whole of the country, workers in forestry operations have more work-related accidents than in any other trade in Canada. Between 1987 and 1989, there were 1,579 work accidents, for a total of 87,108 lost days of work, in Quebec among forest workers using chain saws. In addition, the use of vibrating tools for long periods of time leads to what is known as the "white hand" syndrome. The average prevalence of this syndrome is 30.5% among chain saw users but it increases with the number of years this work is done. After 20 years, 53% of workers are affected. The use of tobacco is an aggravating factor here. Acoustic trauma is another health hazard for workers using chain saws. At full speed, the noise level of a mechanical saw rises to between 105 to 115 dBA and after 10 years at such noise levels, 55% of workers run the risk of professional deafness.

Risk studies also focus on exposure to gaseous pollutants emitted by motorized tools. The main pollutants to which these workers are exposed include benzene, carbon monoxide, formaldehyde and polycyclic aromatic hydrocarbons (PAH).

Many of the studies conducted since the 1980s agree that exposure to benzene increases the risk of leukemia. In epidemiological investigations, exposure to high concentrations of benzene in the occupational environment has consistently been associated with increased risk of leukemia. Chain saw operators inhale air containing between 0.1 and 2.4 mg/m^3 of this gas. The United States Occupational Safety and Health Administration (OSHA) has set an exposure standard of 3 mg/m^3 in the work atmosphere while the National Institute of Occupational Safety and Health (NIOSH) recommends that the standard be reduced to 0.3 mg/m^3. In Quebec, the workplace exposure standard used by Hydro-Québec for its risk assessments is 30 mg/m^3.

On average, workers are exposed to 34 mg/m^3 of carbon monoxide (CO), a level that represents 60% of the maximum 57 mg/m^3 exposure. However, the American Conference of Governmental Industrial Hygienists (ACGIH) suggests that exposure be limited to 29 mg/m^3. The average level of carboxyhemaglobin found in chain saw operators is 5%.

The air surrounding chain saw operators also contains 0.08 mg/m^3 of formaldehyde. This is lower than the 2 to 3 mg/m^3 level which causes symptomatic irritation of the respiratory mucosa and the eyes. Formaldehyde has been classified as a potential human carcinogen.

Lastly, the average 0.02 mg/m^3 of PAH inhaled by workers is 10 times lower than the 0.2 mg/m^3 standard set by the Quebec Workplace Quality Regulation. In Sweden, however, the allowable limit is 0.04 mg/m^3. Many PAH compounds have been recognized as suspected or proven human carcinogens, particularly in the case of lung cancer.

Use of phytocides

Of the ten or more types of phytocides[9] that can be used to destroy vegetation (grass, scrub and dendriform), Hydro-Québec usually selects three: 2,4-D, picloram and dicamba. These three substances are homotypes of the auxin plant hormones, which act by disrupting plant metabolism and causing disorganized growth, malformations and death. As a group, herbicides are much less toxic to animals than insecticides.

Given its suspected, but as yet unproven, carcinogenic and teratogenic potential, 2,4-D is a controversial herbicide. Moreover, traces of dioxins (except TCDD) can sometimes be found

[9] Phytocide is the agreed term in forestry and herbicide is the term used in agriculture and landscaping. The same basic product can be used in both instances.

in commercial 2,4-D preparations. The NOEL of 2,4-D ranges from 1 to 15 mg/kg/d for a variety of animals species. Exposure scenarios developed by Hydro-Québec claim the total exposure dose is about 0.03 mg/kg/d. It must be added that the human ADI is estimated to be 0.003 mg/kg/d. Since 2,4-D is adsorbed by the organic material in the soil, leaching into the aquatic environment will be greater from soil poor in organic material. The half-life of 2,4-D in water varies between 7 and 14 days.

Even though picloram is a very powerful herbicide whose use is now restricted to forest applications such as clearing hydroelectric rights-of-way, no carcinogenic, teratogenic or mutagenic properties have been detected in it. This herbicide is rapidly absorbed in the gastrointestinal tract and has a half-life of 20 minutes. Nearly 90% of it is absorbed and excreted by the urinary system within 48 hours. Picloram's NOEL was set at 7 mg/kg/d and Hydro-Québec estimates the daily exposure dose to be 0.008 mg/kg/d. The ADI was set at 0.07 mg/kg/d. In 1997, based on a two-year rat study, the United States Environmental Protection Agency set a NOEL of 20 mg/kg/d and an ADI of 0.2 mg/kg/d for picloram. It must be stressed that commercial picloram preparations can be contaminated by hexachlorobenzene, a compound in the category of probable carcinogens. Like 2,4-D, picloram is retained by soil containing organic matter. Its half-life in water is about 10 days.

It is believed that dicamba, a herbicide in the benzoic acid group, may possibly be teratogenic. More than 95% of the dicamba absorbed by an animal is excreted within 48 hours. In view of the possible reproductive effects, the NOEL was set at 3 mg/kg/d while forestry workers' total exposure is estimated at 0.019 mg/kg/d. The ADI has been set at 0.030 mg/kg/d. The US EPA set the ADI for dicamba at 0.45 mg/kg/d, based on a NOEL of 45 mg/kg/d, after finding no evidence of teratogencitiy in rats or rabbits. Since dicamba is relatively mobile in soil, it leaches more readily into the aquatic environment, where its half-life is approximately seven days.

Sector: Transportation and Communication Activity: Electric Power Lines

STRESSOR/ EXPOSURE	Type of Stressor	Environmental Impact	Affected Zone	Control Measures	Standards or Recommendations
Technological disaster					
Gaseous or atmospheric emissions	- combustion gases (mechanical cutting of vegetation)	- air pollution	- site and perimeter	- use fuels containing less Hx and limit exposure time	- 30 mg/m^3 (QC work standards)[10]
	-benzene	- air pollution, vegetation destruction	- site and perimeter	- limit wind drift during spraying	- 57 mg/m^3 (QC work standards)
	- carbon monoxide (CO)				- 3 mg/m^3 (QC work standards)
	- formaldehyde				- 0.2 mg/m^3 (QC work standards)
	- PAH				- none
	- herbicides (2,4-D, picloram, dicamba)				
Liquid or waterborne emissions	- 2,4-D	All herbicides: water pollution and possible destruction of aquatic vegetation	All herbicides: site and perimeter	All herbicides: use the smallest possible effective quantities	- 0.1 mg/L (MEF drinking water reg.); 3 Fg/kg/d (ADI)
	- picloram				- 1 Fg/L (MEF drinking water reg.); 70 Fg/kg/d (ADI)
	- dicamba				- 30 Fg/kg/d (ADI)
Solid or soil-borne emissions	- herbicides (see above)	- same as above	- same as above	same as above	same as above
Disamenities	- presence of aerial cables	- depreciation of environment's visual and economic value	- vicinity and community	- burying cables when practical	- none
	- presence of towers	- agricultural activity disruption	- spanned agricultural land	- restrict passage through agricultural zone	- Agricultural Lands Protection Act
Indirect impacts or other exposure	- electric rights-of-way and access roads	- disturbance of animal and plant life	- site and perimeter	- none	- none
	- presence of aerial cables	- risk of aircraft collision	- site and perimeter	-buffer zone	- none
	- electromagnetic fields (EMF)	- radio communication disruption	- site and perimeter	- buffer zone	- apply prudent avoidance by limiting exposure

[10] Inhalation carcinogenic risk estimate: 1/30Fg.kg^{-1}.d^{-1} (EPA)

STRESSOR/ EXPOSURE	**Effects on Health**	**Population at Risk**	**Probability of Occurrence**	**Biol./Environmental Monitoring Indicators**	**Information/ References**
Technological disaster					
Gaseous or atmospheric emissions	- proven carcinogenic potential -carboxyhemo-globin levels - possible carcinogen - some are carcinogenic - see below	Workers form the population at risk for all gaseous pollutants - see below	- frequent: signs of eye, nose and throat irritations and cephalates - low or unknown for cancer development - see below	- workplace ambient air concentration - carboxyhemo-globinemia - workplace ambient air concentration - workplace ambient air concentration - see below	BAPE (1994) Hydro-Québec (1992)
Liquid or waterborne emissions	- possibly carcinogenic and teratogenic - toxic at high doses - possible teratogenic	All pesticides: persons visiting treated rights-of-way or living in proximity	All pesticides: rare or unknown	All pesticides: residual concentration in the immediate surroundings of the rights-of-way	BAPE (1994) Hydro-Québec (1992) Keifer (1997) EXTOXNET
Solid or soil-borne emissions	see above	see above	see above	see above	see above
Disamenities	- quality of life - quality of life	- vicinity and community - agricultural land owners	- frequent - frequent	- complaints, perception studies - complaints, perception studies	BAPE (1987, 1993, 1996)
Indirect impacts or other exposure	- N.A. - injuries, trauma, death - worry, stress - suspected carcinogenic property	- local and Aboriginal communities - aircraft passengers - vicinity and community - vicinity, primarily children	- unknown - rare - occasional to frequent - unknown	- complaints, field studies of animal and plant life - accident reports - complaints, perception studies - epidemiological studies of neighbouring populations	BAPE (1987, 1993, 1996) Levallois and Gauvin (1994) Levallois *et al* (1991) Levallois and Lajoie (1997)

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Airport construction, expansion and operation

Nature of project

The information for this analysis was drawn primarily from the 1991 impact study for the expansion of Toronto - Lester B. Pearson International Airport. The project involved the construction of three new runways to accommodate high traffic volumes. For application to similar situations in Canada, information specific to Pearson Airport will not be presented in this grid.

The construction, expansion or operation of an airport impacts on all environmental components and can have consequences for health and the human environment. Impacts from noise and the risk of plane crashes, especially in urban zones, must also be considered.

Legislation

All airport projects under federal jurisdiction are subject to a number of Canadian laws, including the *Canadian Environmental Protection Act*, which makes provisions for air, water and land protection. The Act provides for the enforcement (through regulation) of air quality objectives applying to several toxic substances in Part II, while Part IV applies specifically to federal agencies and Crown Corporations. The *Fisheries Act* protects fish and their habitats from physical destruction or toxic substances. The *Dangerous Goods Transportation Act* applies to air transport of dangerous goods in accordance with an international agreement supervised by the International Civil Aviation Organization (ICAO). Federal airport projects are also subject to environmental studies as set out in the *Canadian Environmental Assessment Act.*

Various provincial and territorial laws and municipal regulations can also frame airport construction and operation. Each province usually has a general law for environmental protection that regulates air and water quality and toxic or non-toxic solid waste production. Pesticide use, particularly on grassed sections of airports, is usually regulated by provincial law. Municipalities can regulate air quality, sewer use and domestic waste processing.

Emergencies and disasters

Along with fire or explosion, plane crashes are a particular risk for passengers, flight personnel and nearby residents. The main risks in a crash are physical destruction and fire. If a plane crashes during take-off, the disaster is more severe because fuel tanks are full. Planes also carry flammable equipment made from synthetic materials that can generate toxic gases and pollute the soil or aquatic environment.

Airports must develop disaster plans jointly with the appropriate municipal services (police, fire department, hospitals) to coordinate actions. Whether the disaster occurs inside or outside the airport zone, joint action is essential for the rapid evacuation of the injured. Cooperation between airport managers and municipal services is especially important now that government cutbacks have left several airports without independent emergency services.

Air pollution

Construction/expansion machinery and normal operations (planes, buses and vehicles circulating on the terrain) create the usual atmospheric pollutants associated with fossil-fuel engines. The principal pollutants are carbon monoxide (CO), carbon dioxide (CO_2), particulates, nitrogen oxides (NO_x) and volatile organic compounds (VOCs).

Carbon monoxide (CO) is an odourless gas that increases lethal carboxyhemoglobin. Carbon dioxide (CO_2), is one of the main greenhouse effect gases. Particulates measure 0.005 to 100 micrometres (Fm) in diameter and remain airborne; only those smaller than 10 Fm are absorbed into the lungs. As well as causing respiratory problems, these particulates reduce visibility and pollute the natural and human environment.

Nitrogen oxides (NO_x) include nitric oxide (NO) which transforms rapidly into nitrogen dioxide (NO_2), a brownish gas with a sharp, irritating odour that can oxidize cell membranes. This gas can decrease odour perception, alter pulmonary function and in cases of severe exposure, can lead to pulmonary edema. One of the most significant effects of chronic exposure is emphysema and a reduction in forced expiratory volume. NO_2 reacts with VOCs to form photochemical smog (see below).

Volatile organic compounds (VOCs) are hydrocarbons that evaporate at ambient temperature and exist in vapour form in the atmosphere; they number in the thousands, and some are relatively toxic. The principal VOCs produced by combustion engines are polycyclic aromatic hydrocarbons (PAHs) that form in almost all types of incomplete combustion and contain several carcinogenic components like benzo[a]pyrene (BaP); oxygenated hydrocarbons including aldehydes (e.g.: formaldehyde), cetones (acetone), alcohols (e.g.: methanol) and organic acids (formic acid) are all respiratory tract and mucous membrane irritants. Some VOCs, including benzene, chloroform and formaldehyde, are considered carcinogenic.

The photochemical reaction of NO_x with VOCs forms secondary pollutants collectively known as photochemical smog. This smog includes ozone (O_3) on the ground (tropospheric), various free radicals, oxygenated hydrocarbons like aldehydes, and peroxyacetyl nitrates (PAN). All can be respiratory irritants, and some are mutagenic (PAN) or carcinogenic (formaldehyde). Smog is a concern because of the health problems it causes and because it is an urban atmospheric pollutant that is on the rise in Canada.

In the Pearson Airport impact study most of these pollutants originate outside the airport zone. This airport is located in one of the most densely urbanized and industrialized regions of Canada, however; in a rural context, the main source of local atmospheric pollution would probably be the airport itself. In future years, high-performance aircraft with modern engines will cause less pollution. The study notes that with more runways, idling time is reduced, reducing pollution as well.

Pollution and disturbance of the aquatic environment

The two problems here are permanent physical construction disturbances and chemical pollution.

Runway construction can impact significantly on the aquatic milieu. The diversion of streams and draining alters morphology and destroys aquatic habitats. Expansion of asphalt surfaces increases runoff toward water bodies, increasing suspended matter and sedimentation and disturbing fish habitats, especially during critical spawning periods.

Chemical water pollution is caused by products used for plane and runway de-icing and for runway cleaning. Liquids used during firefighter training exercises are potential pollutants, but are normally contained within a specific perimeter.

Plane de-icing liquids

Wing de-icing is necessary in the winter, particularly under freezing rain conditions, and as a preventive measure to prevent ice build-up on the wings when increasing altitude. A hot solution of ethylene glycol or propylene glycol is sprayed on the wings. The solution may also contain phosphate-based anti-corrosives and wetting or thickening agents to facilitate adhesion.

Ethylene glycol ($C_2H_6O_2$) is commonly used in antifreeze. It is a highly toxic water-miscible substance, that is lethal at a proportion of 1.4 mg/kg; the ingestion of 100 ml of pure ethylene glycol can kill an average adult. Intoxication symptoms are vomiting, dizziness, respiratory difficulty and convulsions. Renal damage causing uremia and anuria is fatal. .Unlike ethylene glycol, propylene glycol ($C_3H_8O_2$) has a low toxicity since it is oxidized in pyruvic and acetic acids. Even so, lab studies show an LD_{50} (lethal dose) of 25ml/kg in rats.

More than half of the de-icing solution runs off the wings and into the local sewer system or open drainage ditches. Glycol solutions are the most significant aquatic airport pollutant. They impact harmfully on aquatic fauna, since glycol is a major organic pollutant with a high biological oxygen demand (BOD); it stimulates bacterial growth, reducing the quantity of oxygen dissolved in the water. Fish suffocate for lack of dissolved oxygen and unpleasant odours are created through excessive bacteria proliferation. The phosphates contained in certain de-icing solutions stimulate the growth of aquatic vegetation, especially algae, and cause eutrophication in receiving waters, creating conditions unfit for aquatic life and degrading recreational zones.

Runway de-icing

Runway de-icing is necessary to ensure safe take-off and landing. Most airports use sand as an abrasive and urea as an ice-melter. Pearson uses an average of 7 tons of abrasive and melters per de-icing operation, a dozen times a year. The airport is in one of the mildest climate zones of Canada; use would be higher in more northerly airports.

The abrasive helps prevent skidding, particularly at very low temperatures where ice melters are less effective. Abrasives increase the level of suspended solids (SS) in water, disturbing aquatic life, increasing turbidity and silting up watercourses.

A urea solution is used rather than traditional ice melters like sodium chloride (NaCl) and calcium chloride ($CaCl_2$), which are too corrosive and could cause operating problems. The problem here, however, is that urea transforms into ammonia (NH_3), and into nitrites and nitrates.

Ammonia (NH_3) dissolved in water is highly toxic, but under generally existing pH conditions inferior to 8.0, almost always occurs as the much less toxic ammonium ion (NH_4. In concentrations higher than 0.5 mg/L (the standard for drinking water samples), ammonia reduces chlorination effectiveness. Nitrites (NO_2 ion) are highly toxic and can form methemoglobin, which prevents the transportation of oxygen in the blood. Nitrites can also bond with organic molecules to form carcinogenic nitrosamines. However, they are very instable and transform rapidly into nitrates. Nitrates are the principal nitrogenous form found in natural waters, since the nitrate ion (NO_3^-) is very soluble and very stable. The main environmental impact is eutrophication. Ingesting water containing more than 10 mg/L of nitrates can in the long term cause methemoglobin formation.

Runway degumming

During landing, the weight and speed of the plane exert enormous wheel pressure and rubber is left on runways, which must be degummed once or twice a year to maintain friction and prevent skidding. Pearson sprays a solution of sodium hydroxide (NaOH) and sodium

metabisulfite ($Na_2O_5S_2$) on the runway to swell and soak off the rubber, which is then removed with powerful water jets. The solution and rubber particles are washed off the runway, and no particular measures are employed for their collection. Some of the solution disappears through evaporation. While a Transport Canada study did not find the solution toxic, NaOH in solution is highly corrosive. Sodium metabisulfite has a very low toxicity, and is used in some pharmaceutical compounds.

Health effects of water pollution

The principal aquatic pollutants associated with terminal operations are not likely to cause immediate public health problems. Most of these pollutants normally run into drainage canals or sewer systems. The main substances used (glycol, phosphate, nitrogen) are not persistent toxic compounds that bioaccumulate in the food chain. For esthetic and ecosystem purposes, however, their contributions to microorganism proliferation eutrophication must be considered.

Waste production and land pollution

This section covers loss of land fauna habitats, site contamination and waste production.

Airport zones take up vast areas, large parts of which are devoid of any human activity. However, several animal species inhabit the perimeters: 96 bird species and 11 mammal species were counted at Pearson. In many ways, restricted human access makes urban airports virtual animal sanctuaries. Runway construction or expansion destroys part of the land habitats, although paved or non-natural surfaces generally make up a small proportion of the perimeter (usually less than 15%). Fauna cannot move freely, however, since in most cases habitats are manipulated, animals are trapped or scaring techniques are used to chase birds off take-off zones.

De-icing liquids and fuel can also contaminate the ground. Underground fuel reservoirs are a risk and their watertightness must be checked at regular intervals. Contamination by oil spills or more toxic substances like polychlorinated biphenyls (PCBs) was found in a number of airports. Sites under federal jurisdiction must be decontaminated, and airports under provincial or municipal jurisdiction must be checked on a case-by-case basis for contaminated soil.

The domestic waste generated by normal airport operations is primarily paper or plastic restaurant garbage. Waste production rises significantly during the construction of new buildings or runways, with sand, gravel, wood and a variety of debris added to the mix. About 60% of domestic waste is recyclable. Restaurant garbage can be composted, while paper and plastics can be recovered and recycled. Larger trash like tires should also be recycled. Under the 1990 federal plan, most provinces aim to reduce solid waste by 50%. In exceptional

cases (especially in the far north), landfill sites can be located on or near the airport. They must guard against water and soil pollution (by percolation and leaching), air pollution (windborne objects and particles) and vermin.

Waste contained inside planes is considered international waste. Under Agriculture Canada, Health Canada and Transport Canada regulations, it cannot be mixed with waste from ground operations, and must be contained and incinerated as soon as it leaves the plane. Because this waste management and the related costs are the responsibility of the carriers, they may choose to return it to its place of origin (where the materials were prepared).

Contaminated sites and domestic waste production are not particular public health risks; unprotected landfill sites in isolated northern regions are the only real risk.

Noise and psychological and social impacts

Noise is the major public health environmental nuisance. Noise is generally defined as any acoustic energy likely to alter physical or psychological well-being. The standard measure is the mean value of equivalent

noise level (L_{eq}) per time unit (24 hours, for example). It is measured using the decibel scale, a logarithmic scale, meaning that noise doubles in intensity with each increase of 3 decibels.

The World Health Organization (WHO) proposes an indoor residential limit of less than 45 dB(A) during the day and 35 dB(A) at night. Its outdoor daytime limit is 50 dB(A) L_{eq} and 45 dB(A) L_{eq} at night. Over 55 dB(A), the nuisance level in a residential neighbourhood is considered serious. In industrial zones or work environments, a level of 75 dB(A) L_{eq} (8 hours) is considered acceptable. These standards are currently under review.

The main problems of noise are loss of sleep, communication problems, effects on the performance and behaviour of students and a feeling of decreased quality of life. Chronic exposure can cause increased blood pressure.

Close to Pearson Airport, outdoor average noise intensity varies from 60 to 80 dBA during the day and from 50 to 70 dBA at night. During intense flight activity, peaks of 100 dBA have been recorded. Outdoor activities are affected when planes fly over residential areas. The study finds that the noise levels will not cause physical problems like hearing loss, and that nocturnal indoor levels should not disturb sleep. However, there is no mention of follow-up studies on long-term psychological or psychiatric problems. The new generation of turbojet engines are much quieter, so in the coming years noise pollution should decrease despite increased air traffic.

Reduced property values in the vicinity of airports are a common concern, and resale prices may be lowered.

Sector: Transportation Activity: Airport Construction/Operation

STRESSOR/ EXPOSURE	Type of Stressor	Environmental Impact	Area of Influence	Control Measures	Standards or Recommendations
Technological Disaster	plane crash	- destruction, pollution from toxic smoke and liquids	-site and perimeter of crash	- covering, confinement, containment	
Gaseous or air emissions	- CO	- negligible	- local and regional	- combustion control	- 35 mg/m^3 (1h)
	- CO_2	- greenhouse effect	- global	- reduce fossil fuels	- none
	- NO_x	- toxicity, smog formation	-regional and continental	- antipollution systems	- 200 Fg/m^3 (24h) for NO_2
	- VOC	- toxicity, smog formation	- regional and continental	-containment or 8 combustion performances	- none
	- suspended particulates	-deposited on vegetation, buildings, unattractive appearance	- local and regional	- containment or filtration	- 120 Fg/m^3 (24h)
Liquid emissions or discharge into water	- diversion and drainage of waterways	- destruction of wildlife habitats	- onsite waterways	- mitigation measures	- Fisheries Act
	- suspended solids	- disturbance of aquatic fauna	- onsite waterways	- mitigation measures	- Fisheries Act
	- ethylene or propylene glycol	- organic pollution, oxygen deficiency	- onsite waterways	- containment	- BOD_5 of 20 mg/L
	- urea	- pollution, eutro-phication	- onsite waterways	- containment	- no federal standard
	- sodium hydroxide (NaOH)	-alkalinization, toxicity	- onsite waterways	- containment, neutralization	- alkalinity variation limited to 25% of the natural concentration
Solid emissions or discharge into soil	- domestic waste	- appearance, environmental health, vermin	- site and perimeter	- collection, recycling, sanitary landfill	- municipal by-laws
	- international waste	- foreign parasites and micro-organisms	- N.A.	- incineration required	-international agreements (Agriculture, Health and Transport Canada)
	-dangerous waste (petroleum, PCB, etc.)	- toxicity, unsanitary	- site and perimeter	- confinement, elimination through appropriate procedures	- Canadian Environ-mental Protection Act
Nuisances	- noise	- N.A.	- local	-establish buffer zones, use new generation aircraft, prohibit night flights	- L_{eq} 45 dBA at night and 55 dBA during day (WHO standards); Canadian Environmental Assessment Act
Indirect impacts or other exposures	-social conflict, property devaluation and degradation	- economic	- local	- financial compensation limit flights	- N.A.

STRESSOR/ EXPOSURE	Effect on Health	Population at Risk	Probability of Occurrence	Environmental/ Biological Indicator (Monitoring)	Information/ References
Technological Disaster	- trauma, injury, death	- plane passen-gers and ground population	- rare	- mortality and morbidity ratios, Transportation Safety Board	- consult Transportation Safety Board (Ottawa)
Gaseous or air emissions	- 8 in % of carboxyhemoglobin, death	- local residents	- very rare	- % of carboxyhemo-globin	
	- climatic changes	- global population	- frequent	- measure in ambient air	
	- irritation of respiratory tracts	- urban zone residents	- occasional during summer period	- measure in air, epidemiological studies	
	- irritation of respiratory tracts, smog provoking inflammation	- urban zone residents	- occasional during summer period	- measure in air, epidemiological studies	
	- various respiratory problems	- urban zone residents	- rare	- measure in ambient air	
Liquid emissions or discharge into water	- N.A.	- N.A.	-N.A.	- state of fish population	
	- N.A.	- N.A.	- N.A.	- state of fish population	
	- toxic if ingested (lethal dose: 1.4 mL/kg for ethylene glycol)	- none	- N.A.	- proportion in waterways or sewers	
	-toxic if ingested or methemoglobin	-none	- N.A.	- proportion in waterways or sewers	
	- toxic if ingested	- none	- N.A.	- pH measure	
Solid emissions or discharge into soil	- hygiene and health problems	- airport users and peripheral residents	- rare to moderate	- public complaints	
	- propagation of exotic diseases	- plane passengers	-unknown	- complaints, medical follow-up after incidents	
	- toxic and potentially carcin-ogenic effects	- airport workers	- rare	- medical follow-up of workers	
Nuisances	- quality of life, sleep disturbances, stress, aggressiveness, hypertension	- residents of airport periphery	- rare to frequent	- measure of internal and external ambient noise	

Indirect impacts or other exposures	- individual and group stress	-neighbouring community	- occasional	- property assess-ment follow-up, perception studies	

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See also the texts and references of the following grids:

- Roads and highways (for atmospheric pollutants);
- Sanitary landfill (for pollution caused by domestic waste).