Before Independent Hearings Commissioners Appointed by Canterbury Regional Council and Selwyn District Council

In the matter of	The Resource Management Act 1991
And	
In the matter of	Applications by **Fulton Hogan Limited** for all resource consents necessary to establish, operate, maintain and close an aggregate quarry (**Roydon Quarry**) between Curraghs, Dawsons, Maddisons and Jones Roads, Templeton

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EVIDENCE OF AUDREY KATHLEEN WAGENAAR
ON BEHALF OF FULTON HOGAN LIMITED

POTENTIAL RISKS TO HUMAN HEALTH

DATED: 23 SEPTEMBER 2019

Counsel Acting: David Caldwell
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INTRODUCTION

1 My full name is Audrey Kathleen Wagenaar.

2 I am an Associate and a Senior Environmental Scientist at Golder Associates Ltd.

3 I have been asked by Fulton Hogan Limited (**Fulton Hogan**) to provide evidence in respect of its application for resource consents to establish, operate, maintain and close the proposed Roydon Quarry (**Proposal**).

4 My area of expertise for this hearing is:

4.1 The selection of and toxicological basis of air quality guidelines and standards;

4.2 Review of existing data collected by Mote (2018)[1] and the expert option of Mr Cudmore related to likelihood of contaminants of potential concern meeting applicable air quality criteria;

4.3 Specific to 4.2 above, provision of an expert opinion on potential for human health effects to occur resulting from off-site exposures associated with the proposed Roydon quarry.

Qualifications and Experience

5 I am a Diplomate of the American Board of Toxicology (DABT; e.g., a board-certified toxicologist).

6 My qualifications are a Bachelor of Science Degree in Honours Chemistry and Biology from the University of British Columbia in Vancouver, Canada (1990) and a Master of Science Degree in Medicinal Chemistry from the University of Sussex in Falmer, United Kingdom (1992). I am a professional chemist in British Columbia, Canada and I am on the board of directors for the Association of the Chemical Profession of British Columbia.

7 I am currently an Associate and Senior Environmental Scientist with Golder Associates Ltd. in Vancouver, British Columbia, Canada.

8 I have 26 years of experience in toxicology and environmental risk assessment across Canada and internationally, including Australia, Mexico, Panama, Sweden, Montenegro, New Zealand and the United States.

9 My technical skills include specialised human health toxicology assessment, human health exposure and risk modelling, development and modification of toxicity

[1] Mote Measurement Networks (Mote 2018). Yaldhurst Air Quality Monitoring. Summary Report: 22 December – 21 April 2018. 19 June 2018. Prepared for Environment Canterbury.

reference values, quantitative fate and transport modelling, development of air quality standards, development of environmental health and safety guidelines, and provision of expert advice/peer review and expert witness testimony.

10 I have significant experience conducting detailed quantitative human and terrestrial wildlife health risk assessments to support environmental impact assessments for mining, oil and gas and other development projects in Canada and abroad. My experience includes detailed risk assessments for communities located adjacent to, or in close-proximity, to mines as well as quarries.

11 I have considerable experience in managing complex multi-stakeholder processes involving industrial clients, government regulatory agencies, medical officers of health, and the public and am also experienced in human health risk communication.

12 In Ontario, Canada, I am recognised by the Ontario Ministry of the Environment, Conservation and Parks as a Qualified Person for Risk Assessment (QPRA). In British Columbia, Canada, I was appointed by the British Columbia Ministry of Environment and Climate Change Strategy (BC ENV) to the Roster of Contaminated Sites Approved Professionals for Risk Assessment and I provide recommendations for legal instruments related to risk assessment on behalf of the BC ENV.

13 Prior to joining Golder Associates Ltd, I was a Regulatory Toxicologist with the Standards Development Branch at the Ontario Ministry of the Environment (now Ontario Ministry of the Environment, Conservation and Parks) where I developed provincial ambient air quality standards.

14 I have been an expert witness for an environmental court case in the Taranaki District, New Zealand. My expert advice was related to the selection of appropriate acute and chronic air quality criteria and the potential health risks associated with measured concentrations of benzene in the region.

15 I have appended full details of my qualifications and relevant experience to this statement of evidence in **Annexure 1.**

16 I confirm that I have read the Code of Conduct for Expert Witnesses (Environment Court Practice Note 2014). My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Scope of Evidence

17 In my evidence I:

17.1 Review the public submissions related to potential health effects, the relevant s42A reports and background reports related to the evaluation of health effects at other quarries in New Zealand; and

17.2 Set out what I consider to be the most relevant and reliable literature, guidelines and criteria applicable to the Proposal.

My involvement in the Roydon Quarry Proposal

18 My involvement with the Site to date has been limited.

19 I have a general understanding of the Proposal from my Golder Associate colleagues who are more closely involved in it. I have spoken on numerous occasions with Kevin Bligh and Roger Cudmore.

20 I have reviewed the submissions related to potential health effects, the relevant s42A reports for the Proposal and a background report related to the evaluation of health effects at other quarries in New Zealand.

Submitter and/or Officer concerns regarding health effects from discharges to air

21 The submissions that I have reviewed related to potential health effects are summarised in **Annexure 2**. As there were multiple public submissions related to potential health effects, I have classified the submissions by general theme (e.g., concerns associated with air quality, groundwater quality, drinking water quality, produce quality, soil quality, existing health conditions that could potentially be exacerbated by residing in close proximity the Project (e.g., proposed Roydon quarry), and mental health and well-being concerns etc.).

22 I have reviewed the submissions and prepared **Annexure 2** to inform my selection of relevant health guidance and air quality guidelines and standards.

23 I have discerned the following matters of concern, which are within the scope of my expertise and related to air quality:

23.1 Changes in air quality affecting human health;

23.2 Concerns about specific contaminants;

- Particulate matter;
- Respirable crystalline silica.

23.3 Concerns of existing respiratory (e.g., asthma, unspecified hereditary conditions) or other health conditions (e.g., eczema, allergies) potentially being exacerbated by residing in close proximity to the proposed Roydon quarry.

Air Quality Criteria

24 **Particulate Matter**

There are no one-hour health-based air quality criteria for $PM_{2.5}$ or PM_{10} available. Acute exposures are addressed through the 24-hour exposure period.

25 24-hour Criteria

Particulate Matter less than 10 µm (PM_{10})

25.1 **New Zealand:** New Zealand has a National Environmental Standard for Air Quality (Resource Management Act Regulations; NES for Air Quality 2004)[2] for PM_{10} of 50 µg/m^3 for a 24-hour average. The metric for measurement of compliance is one allowable exceedance per year.

25.2 **US NAAQS:** The United States Environmental Protection Agency (USEPA) has developed a National Ambient Air Quality Standard (NAAQS; 150 µg/m^3)[3] which is considered to be protective against adverse health effects of inhalable airborne particles that can be deposited in the lower (thoracic) regions of the human respiratory tract. The standard is met when a 24-hour average PM_{10} concentration of 150 mg/m^3 is not exceeded more than one day per year, on average over a three-year period.

25.3 **WHO**: The guideline (50 µg/m^3)[4] is based on a 0.46 to 0.62% increase in mortality per 10 µg/m^3 increase in PM_{10}. The guideline reflects the relationship between the distributions of 24-hour means (and its 99th percentile) and annual average concentrations.

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2 Ministry for the Environment. 2004. Resource Management (National Environmental Standards for Air Quality) Regulations 2004. SR 2004/309. Reprint at 1 July 2017. Available on-line at: http://www.legislation.govt.nz/regulation/public/2004/0309/latest/DLM286835.html?search=ta_regulation_R_rc%40rinf%40rnif_an%40bn%40rn_25_a&p=3 . Accessed September 2019.

3 United States Environmental Protection Agency. 2016. United States National Ambient Air Quality Standards Table. Criteria Air Pollutants. Available on-line at: https://www.epa.gov/criteria-air-pollutants/naaqs-table. Accessed September 2019.

4 World Health Organization. 2006. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global update 2005, Summary of Risk assessment. Geneva, Switzerland. Available on-line at: http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/air-quality-guidelines.-global-update-2005.-particulate-matter,-ozone,-nitrogen-dioxide-and-sulfur-dioxide. Accessed September 2019.

26 **Particulate Matter less than 2.5 µm ($PM_{2.5}$)**

26.1 **New Zealand:** New Zealand[5] have adopted the WHO guideline of 25 µg/m^3 as a monitoring guideline (Ministry for the Environment 2016, 2002)[6,5].

26.2 **United States:** The United States Environmental Protection Agency (USEPA) has developed a National Ambient Air Quality Standard (NAAQS; 35 µg/m^3)[3] which is considered to be protective of increased health effects associated with short-term $PM_{2.5}$ exposure, including premature mortality and increased hospital admissions and emergency department visits. The metric for measurement of compliance is based on the 98th percentile of daily 24-hour concentrations averaged over three years.

26.3 **Canada:** The Canadian Council for Ministers of the Environment (CCME). CCME has proposed a Canadian ambient air quality standard (CAAQS)[7] for $PM_{2.5}$ of 27 µg/m^3 to be achieved by the year 2020, which is intended to be protective of human health and the environment. The current CAAQS is 28 µg/m^3. The metric for measurement of compliance is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

26.4 **The World Health Organization (WHO):** The guideline for $PM_{2.5}$ (25 µg/m^3)[4] is based on the same toxicological endpoint as PM_{10} where exposure is associated with a 0.46 to 0.62% increase in mortality per 10 µg/m^3 increase in PM_{10}. The PM_{10} guideline is converted to a $PM_{2.5}$ guideline using a $PM_{2.5}$:PM_{10} ratio of 0.5. This $PM_{2.5}$:PM_{10} ratio is typical of that found in urban areas of developing countries and is at the lower end of the range found in urban areas of developed countries (0.5 to 0.8).

Annual

27 Particulate Matter less than 10 µm (PM_{10})

27.1 **New Zealand:** New Zealand has adopted the WHO guideline of 20 µg/m^3 (Ministry of Environment 2016)[5].

27.2 **The World Health Organization (WHO):** Screening level (20 µg/m^3)[4] is based on the ratio of $PM_{2.5}$:PM_{10} in developed countries ranges from 0.5 to 0.8. A ratio of 0.5 has been applied to the $PM_{2.5}$ guideline by the WHO to determine the screening value.

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5 Ministry for the Environment. 2002, Ambient Air Quality Guidelines. 2002 Update. Prepared by the Ministry for the Environment and the Ministry of Health. Air Quality Report #32. May 2002. Available on-line at: https://www.mfe.govt.nz/sites/default/files/ambient-guide-may02.pdf. Accessed September 2019.

6 Ministry for the Environment. 2016.*Good Practice Guide for Assessing Discharges to Air from Industry.* Wellington: Ministry for the Environment.

7 Canadian Council for Ministers of the Environment. 2017. Canadian Ambient Air Quality Standards. Available on-line at: http://airquality-qualitedelair.ccme.ca/en/. Accessed September 2019.

28 Particulate Matter less than 2.5 µm (PM2.5)

28.1 **New Zealand:** New Zealand does not have an annual criterion for $PM_{2.5}$ (Ministry of the Environment 2016).

28.2 **United States:** The United States Environmental Protection Agency (USEPA; US NAAQS) has developed a screening level for $PM_{2.5}$ (12 µg/m^3)[3] based on an annual mean averaged over 3 years for the health protection of "sensitive" populations such as asthmatics, children, and the elderly.

28.3 **Canada:** Canadian ambient air quality standard protective of human health and the environment. The annual $PM_{2.5}$ standard represents a balance between achieving the best health and environmental protection possible and the feasibility and costs of reducing pollutant emissions; a value of 8.8 µg/m^3 is proposed for the year 2020. The current value is 10 µg/m^3. The metric for measurement of compliance is the three-year average of the annual average concentrations.

28.4 **The World Health Organization (WHO):** The WHO has derived an air quality guideline[4] of 10 µg/m^3 which represents the lowest level at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long term exposure. The above health effects were reported at concentrations ranging from 11.0 to 29.6 µg/m^3 and 9.0 to 33.5 µg/m^3 in two key studies. The WHO determined that health effects can be expected when annual average concentrations are in the range of 11 to 15 µg/m^3. Therefore, a guideline value of 10 µg/m^3 was selected, as it is considered to be less than the mean for the most likely effects.

Respirable Crystalline Silica (Non-Carcinogenic Endpoints)

29 1-hour

29.1 **Ontario Ministry of the Environment, Conservation and Parks**: A 1-hour screening value was calculated for respirable quartz silica less than 10 microns by dividing the half-hour averaging value (15 µg/m^3) by the OMOE conversion factor of 1.2 (OMOE 2011)[8]. A half-hour averaging value of 15 µg/m^3 was derived by using a meteorological conversion factor of 3 to convert the 24-hour screening value to a half-hour value (see Section 25.3 for further information).

[8] Ontario Ministry of the Environment (OMOE; now Ministry of Environment, Conservation and Parks). 2011. Basic Comprehensive Certificates of Approval (Air) User Guide. Environmental Assessment and Approvals Branch, OMOE. Toronto, ON, Canada. Available on-line at: https://dr6j45jk9xcmk.cloudfront.net/documents/1697/152-basic-comprehensive-certificates-of-approval.pdf. Accessed September 2019.

29.2 **Texas Commission on Environmental Quality (TCEQ):** The TCEQ has developed a 1-hour acute reference value (ReV) of 47 µg/m^3 for respirable silica less than or equal to 10 microns (≤ 10 µm). The acute 1-hr ReV is derived from a respiratory study by Warheit et al 1991 (as cited in TCEQ 2013)[9] and is based on a lowest-observed-adverse-effect-level (LOAEL) of 10 mg/m^3 in rats for the presence of pulmonary lesions (a marker of inflammation) one month and three months post-exposure. The LOAEL is considered the relevant point-of-departure (POD) to develop the ReV.

29.3 The critical effects of the study were a delayed/increased neutrophils (a marker of inflammation) and increased levels of lactate dehydrogenase (a marker of cytotoxicity) in bronchoalveolar lavage fluid in rats.

29.4 The rats were exposed to quartz silica at 10, 50, or 100 mg/m^3 for 6 hours. TCEQ adjusted the 6-hour exposure to a 1-hour exposure resulting in an adjusted point of departure (POD_{ADJ}) of 18.2 mg/m^3 as follows (TCEQ 2006 as cited in TCEQ 2013)[10]:

Adjusted Point of Departure (POD_{ADJ}) = [(10 mg/m^3)^3 x (6 hours/1 hour)]$^{1/3}$ = 18.2 mg/m^3

29.5 The human equivalent concentration (POD_{HEC}) was derived from adjusted point of departure (POD_{ADJ}) by utilizing a Regional Deposition Dose Ratio of 0.775 which accounts for the difference in human and rat respiratory systems. The human equivalent concentration was 14.1 mg/m^3.

29.6 A total uncertainty factor of 300 was applied to the human equivalent concentration (POD_{HEC}) to account for the following:

(a) 3 for extrapolation from a LOAEL to a NOAEL

(b) 3 for extrapolation from animals to humans

(c) 10 for to account for sensitive human subpopulations (including those with existing respiratory conditions that cause pulmonary inflammation).

(d) 3 for database uncertainty due to limited number of acute toxicity studies for crystalline silica and the small numbers of animals that have been used in each dose group in the existing acute studies. The database quality is considered to be moderate (TCEQ 2013)[10]

[9] Texas Commission on Environmental Quality. 2013. Silica, Crystalline Forms. Development Support Document, Office of the Executive Director, TCEQ. Austin, TX, USA. Available on-line at: https://pdfs.semanticscholar.org/ece9/faeb548758c13a585e94f967656a6123f990.pdf. Accessed September 2019.

29.7 The resulting acute ReV is 0.047 mg/m^3 or 47 µg/m^3 for respirable silica ≤ 10 µm.

30 24-hour

30.1 **Ontario Ministry of Environment, Conservation and Parks (OMECP):** The OMOE has developed an air contaminant benchmark (ACB) of 5 µg/m^3 for respirable crystalline silica based on cases of silicosis in workers employed in the granite, pottery, silica brick, and diatomite industries (Fulton et al. 1939; as cited in Nava-Ocampo 2019, pers. comm.)[10].

(a) The NOAEL/lowest point of departure (POD) was 0.05 mg/m^3. A total uncertainty factor of 10 was applied to derive the guideline value of 0.005 mg/m^3 (5 µg/m^3).

(b) The screening value for silica (respirable, <10 µm of diameter) applies to cristabolite, quartz, and tridymite forms of silica.

(c) There is limiting supporting information available as this air contaminant benchmark was originally derived in 1979 (Nava-Ocampo 2019, pers. comm.)[11]. As a result, this criterion was not considered further for applicability for use at this Site. This applies also to the 1-hour criterion that was derived from the 24-hour criterion (Section 25.1).

31 Annual

31.1 **New Zealand:** Based on the hierarchy of sources for criteria provided in Ministry of Environment (2016), New Zealand would select the annual criteria derived by California Environmental Protection Agency – Office of Environmental Health Hazard (Cal OEHHA) as described in greater detail below in Section 25.5.

31.2 **California Environmental Protection Agency - Office of Environmental Health Hazard Assessment (Cal OEHHA):**

(a) Cal OEHHA (2008)[11] have developed a chronic exposure reference level (REL) of 3 µg/m^3 using a benchmark dose approach based on a study of silicosis in occupational workers.

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[10] Nava-Ocampa. 2019. Pers. Comm. Personal Communication. E-mail correspondence between Victoria Hart, Golder Associates Ltd. and Alejandro Nava-Ocampa. Human Toxicology and Air Standards Section, Technical Assessment and Standards and Development Branch, Ontario Ministry of Environment, Conservation and Parks. March 19, 2019.

[11] California Environmental Protection Agency, Office of Environmental Health Hazard Assessment (Cal OEHHA). 2008. Air Toxics Hot Spots Risk Assessment Guidelines Technical Support Document for the Derivation of Noncancer Reference Exposure Levels. June 2008. Air Toxicology and Epidemiology Branch, Office of Environmental Health Hazard Assessment. Oakland, CA. Available on-line at: https://oehha.ca.gov/media/downloads/crnr/noncancertsdfinal.pdf. Accessed September 2019.

(b) The chronic REL value is based on a key study conducted by Hnizdo and Sluis-Cremer (1993; as cited in Cal OEHHA 2008)[12] from which both a No-Observed-Adverse Effect level (NOAEL) of 2 mg/m^3/year cumulative dust exposure and a Lowest-Observed-Adverse Effect level (NOAEL) 3 mg/m^3/year cumulative dust exposure were identified.

(c) Cal OEHHA (2008)[12] used a benchmark concentration level ($BMCL_{01}$) approach to derive the chronic REL. $BMCL_{01}$ is the lower bound estimate of the concentration at which 1% of the population develops silicosis.

(d) The $BMCL_{01}$ is based on occupational workers (gold miners) were exposed to dust (containing 30% silica) for an average of 24 years at 8 hours/day, 5 days/week.

(e) Adjustments were applied to the $BMCL_{01}$ to account for the duration and exposure factors specific to an occupational population so that a human equivalent concentration for a non-occupational exposure (e.g., residential) could be derived (Cal OEHHA)[12].

(i) These adjustments included the following:

(A) Inhalation rate for an 8-hour day (10 m^3) was converted to an inhalation rate for a 24-hour day (20 m^3) using a factor of 0.5 (e.g., 10 m^3/20 m^3).

(B) The number of days per week exposed were adjusted from 5 days per week for an occupational exposure (270 shifts) to 7 days per week for a residential exposure (365 days) using a factor of 0.74 (e.g., 270 shifts/365 days).

(C) The $BMCL_{01}$ which had been adjusted for inhalation rate and shifts per year worked was also divided by 24 years to yield an average experimental exposure resulting in a human equivalent concentration of 9.8 µg/m^3.

(f) A total uncertainty factor of 3 was applied to the human equivalent concentration to derive the chronic REL of 3 µg/m^3 to account for variability in the human population. (Cal OEHHA)[12]indicates that it was likely the most sensitive workers in the occupational cohorts were those that developed silicosis; however, other groups such as children, the elderly were not included in the occupational cohort.

31.3 **Texas Commission on Environmental Quality (TCEQ)**: The chronic reference value (ReV) for non-carcinogenic endpoints derived by TCEQ is 2.0 µg/m^3 for respirable crystalline silica less than or equal to 4 microns and based on silicosis in miners (TCEQ 2013)[10].

(a) The key study used to derive the chronic ReV for non-carcinogenic endpoints is the Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013)[10] study of silicosis in mine workers (which is also mentioned in the Cal OEHHA section above). Cumulative dust exposure was calculated for mine worker populations who worked at a mine in South Africa between 1940 to the early 1970s. Cumulative dust exposure was calculated up to the onset of silicosis or until the end of the exposure. Average cumulative dust exposure for the cohort of mine workers was found to be 6.6 ± 2.7 mg/m^3/year.

(b) A point of departure called a benchmark dose low01($BMCL_{01}$) which is the 95% lower bound estimate of the concentration at which 1% of the population will develop silicosis was used to derive the chronic ReV (for non-cancer endpoints). The $BMCL_{01}$ value is considered to be an occupational point of departure (PODoc).

(c) An estimated $BMCL_{01}$ value of 0.635 mg/m^3/year was derived based on estimates of cumulative dust exposure with approximately 30% quartz content to miners as reported by Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013)[10]. A subsequent study by Gibbs and Du Toitt (2002; as cited in TCEQ 2013)[10] indicate that the quartz content may have been underestimated by Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013)[10]. Gibbs and Du Toitt (2002; as cited in TCEQ 2013)[10] estimate that the quartz content was that the miners were exposed to in the Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013)[10] study was approximately 54%.

(d) Based on the supporting study (Gibbs and Du Toitt, 2012), TCEQ (2013)[10] found it to be more appropriate to adjust the quartz content to 54% rather than 30% (applying a 54/30 ratio)[12]; therefore, the $BMCL_{01}$ value was adjusted to 1.143 mg/m^3/year and was used as a $POD_{OC\ ADJ}$.

[12] It is noted that Cal OEHHA (2008) did not find this adjustment necessary based on a follow- up evaluation of the data set and confirmation with the original author of the study. It appears that there may have been an error in a footnote in the Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013) study but that the correct quartz adjustment was utilized. Cal OEHHA indicate that subsequent studies measuring quartz content in respirable crystalline silica in South African mines are indicate that the 30% assumption may be even be a bit conservative (Cal OEHHA 2008).

(e) Adjustments were applied to the $POD_{OC\ ADJ}$ to account for the duration and exposure factors specific to an occupational population so that a POD_{HEC} for a non-occupational exposure (e.g., residential) could be derived.

(i) These adjustments included the following (TCEQ 2013)[10]:

(A) Inhalation rate for an 8-hour day (10 m^3) was converted to an inhalation rate for a 24-hour day (20 m^3) using a factor of 0.5 (e.g., 10 m^3/20 m^3).

(B) The number of days per week exposed were adjusted from 5 days per week for an occupational exposure (270 shifts) to 7 days per week for a residential exposure (365 days) using a factor of 0.74 (e.g., 270 shifts/365 days).

(ii) An additional adjustment was made to the POD_{HEC}. The cumulative dust exposure is presented on an annual basis for workers and the POD_{HEC} calculated above was also divided by a factor of 70 to account for a 70-year lifetime exposure that would be representative of a residential population. This resulted in a cumulative POD_{HEC} value of 6.04 µg/m^3.

(iii) To derive the chronic REV for non-carcinogenic endpoints of 2.0 µg/m^3, the TCEQ (2013)[10] applied a total uncertainty factor of 3 to the POD_{HEC} value of 6.04 µg/m^3, which accounted for the following:

(A) 1 to account for the use of benchmark dose modelling ($BMCL_{01}$) as the $BMCL_{01}$ is considered to be the lowest observed adverse effect level (e.g., no additional uncertainty factors needed to account for extrapolation between a LOAEL and NOAEL value.

(B) 3 to account for variability in the human population. While the primary study based on exposure in people, an evaluation of occupational workers may not completely cover the range of variability in found in the sensitive human subpopulations that are part of the general population. These sensitive human subgroups may not be captured within the range of

variability in healthy adults that are typically represented by an occupational cohort.

(C) 1 for sub-chronic to chronic exposure. The mean exposure duration in the primary study (Hnizdo and Sluis-Cremer (1993; as cited in TCEQ 2013)[10] was 24 years. The mean exposure exceeds 10% of an average lifespan so it is considered to be a chronic exposure. The POD_{HEC} was also adjusted to represent a 70-year lifespan.

(D) One for database uncertainties as the database for crystalline silica is considered to be extensive.

Respirable Crystalline Silica (Carcinogenic Endpoints)

32 The International Agency for Research on Cancer (1997)[13] has classified silica as a Group 1 carcinogen, which means that it is has been linked to causing cancer in people. IARC (1997)[14] also indicates that "overall the epidemiological findings support increased lung cancer risks from inhaled crystalline silica (quartz and cristobalite) resulting from occupational exposure". IARC (1997)[14] also indicates that adequate evidence for carcinogenic potential only exists within occupationally exposed populations to silica. No epidemiological studies on environmental exposure (e.g., non-occupational exposure) were available at the time that IARC (1997)[14] classified silica. IARC (1997)[14] also indicated that the carcinogenicity of quartz or cristobalite forms of silica may be dependent on the properties of the crystalline silica itself or other factors affecting biological activity or distribution of polymorphs (e.g., various forms of crystalline silica may have similar chemical compositions but different crystal structures).

33 **Texas Commission on Environmental Quality (TCEQ)**: TCEQ is the only jurisdiction that has developed an environmental screening level for the carcinogenic endpoints associated with exposure to respirable crystalline silica.

34 TCEQ has derived a chronic environmental screening level (ESL) of 0.27 µg/m^3 for respirable crystalline silica less than or equal to 4 microns (≤ 4 µm) based on lung cancer mortality in silica-exposed workers (TCEQ 2013)[10].

34.1 The ESL is based on a unit risk factor (URF) of 0.000036 per µg/m^3 and a 1 in 100,000 excess lifetime cancer risk level (TCEQ 2013)[10].

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[13] International Agency for Research on Cancer (1997). Silica, Some Silicates, Coal Dust and para-Aramid Fibrils. IARC Monographs on the Evaluation of Carcinogenic Risk to Humans. Monograph 68. Available on-line at: https://publications.iarc.fr/86

(a) The key study to derive the unit risk factor Steenland et al. (2001; as cited in TCEQ 2013)[10], which had compiled data from ten studies to assess the dose-response relationship between silica exposure and lung cancer.

(b) TCEQ (2013) selected the Steenland et al. (2001; as cited in TCEQ 2013)10 study because it included pooled data for 65,980 workers in several different countries and also accounted for exposure to different forms of crystalline silica at different concentrations.

(c) Dosimeteric adjustments were made to the Steenland et al. (2001; as cited in TCEQ 2013) by TCEQ (2013)10 to convert occupational exposure concentrations to environmental concentrations that represent the general population (e.g., a residential scenario).

(i) Inhalation rate for an 8-hour day (10 m^3) was converted to an inhalation rate for a 24-hour day (20 m^3) using a factor of 0.5 (e.g., 10 m^3/20 m^3).

(ii) The number of days per week exposed were adjusted from 5 days per week for an occupational exposure to 7 days per week for a residential exposure.

(iii) A log-linear model was used to estimate a URF of 0.000036 per µg/m^3 and a chronic ESL of 0.27 µg/m^3 for a cancer endpoint.

Air Quality Criteria Considered Most Relevant to this Proposal

35 Based on my review of the air quality criteria above and also consideration of the hierarchy recommended by the Ministry of Environment (2016) (for selection of air quality criteria in the absence of a New Zealand air quality standard or guideline), I consider the following criteria are most relevant to this proposal:

Table 1 – Summary of Air Quality Criteria Considered Most Relevant to this Proposal

Contaminant of Concern	Criteria	Averaging Period	Regulatory Agency	Rationale
PM10	50 µg/m^3	24-hour	Ministry for the Environment (2004)	NZ air quality standard
	20 µg/m^3	annual	Ministry for the Environment (2016)	Ministry for the Environment have adopted WHO (2005) value
PM2.5	25 µg/m^3	24-hour	Ministry for the Environment (2016,2002)	Ministry for the Environment have adopted the WHO (2005) value as a

				monitoring guideline
	10 µg/m^3	annual	WHO (2005)	WHO guideline as per Ministry for the Environment 2016
Respirable Crystalline Silica	47 µg/m^3	1-hour	TCEQ (2013)	TCEQ study; robust documentation available and recent derivation conducted with benchmark dose modelling
	NA	24-hour	NA	Key toxicological study used by OMECP very old and limited supporting documentation available.
	3 µg/m^3	annual	Cal OEHHA as per Ministry for the Environment (2016)	Consistent with Ministry for the Environment and correction associated with quartz content appears to have been appropriately resolved; TCEQ uses a slightly more conservative quartz content but does not appear to have been needed based on Cal OEHHA supporting documentation. TCEQ carcinogenic endpoint not selected because it was the only jurisdiction in the world to derive a criterion based on a carcinogenic endpoint.

Notes: NA – Not applicable

Existing Health Studies for Other Quarries in New Zealand

Respirable Crystalline Silica

36 As noted in Mr. Cudmore's evidence statement the air quality impact assessment (AQA) submitted with this application discusses a semi-qualitative assessment approach and also focuses heavily on dust emission control measures. The semi-qualitative approach referred to in the AQA included a very detailed analysis of wind conditions and frequencies of worst-case conditions and a subsequent analysis of how sensitive various isolated residential and commercial dwellings are to the Proposal. The AQA has also relied on the use of available relevant PM_{10} and $PM_{2.5}$

monitoring data including the respirable crystalline silica study that was undertaken in 2017/2018 for the multiple quarry operations at Yaldhurst, Christchurch. These monitoring data from operational quarries and subsequent assessment of PM_{10} and respirable crystalline silica can used to infer the potential for health effects from the Proposal.

37 I have reviewed the Yaldhurst Air Quality Report dated 19 June 2018 prepared by Mote Measurement Networks (Mote 2018) for Environment Canterbury and specifically the 24-hour and annual maximum and average PM2.5 and PM10 concentrations and the annual maximum and average values for respirable crystalline silica measured between December 2017 and April 2018.

38 As indicated in Mote (2018), the annual concentrations (maximum and average) of respirable crystalline silica are well below the Cal OEHHA (2008) chronic ReL.

39 With respect to respirable crystalline silica, Mr. Cudmore, in his evidence statement, reaches the following views:

39.1 Monitoring of respirable crystalline silica as part of the Yaldhurst Quarry monitoring programme determined that measured ambient levels around the much larger Yaldhurst quarry zone were well within the Cal OEHHA (2008) guideline.

39.2 The mitigation measures proposed for control of dust discharges and the associated design features would readily achieve a 10-fold reduction in the increase in ambient respirable particulate levels that have been measured for the 230 ha Yaldhurst gravel quarry area

39.3 The increase in hourly respirable crystalline silica concentrations were likely to be very low as due to wind moving across the Yaldhurst quarry. As the background concentration of respirable crystalline silica is effectively zero (concluded from the data provided by Mote (2018), then the cumulative 1hour respirable crystalline silica levels downwind of the Proposal would also be very low against the TCEQ 1-hour concentration of 47 $\mu g/m^3$.

39.4 The annual exposure to respirable crystalline silica downwind of the Yaldhurst quarry is well below the Cal OEHHA annual criteria of 3 $\mu g/m^3$. There would be an order of magnitude lower ambient effect from the Proposal on long term respirable crystalline silica levels and therefore negligible increases in the annual ambient respirable crystalline silica levels beyond the site boundary.

40 Based on my review of the Mote (2018) study and Mr. Cudmore's expert opinion that the Yaldhurst gravel quarry respirable crystalline silica concentrations are likely to be higher than those measured off-site in the vicinity of the proposed Roydon quarry, I

expect that there will be extremely low to negligible effects to human health associated with potential exposure to respirable crystalline silica as a result of the proposed Roydon quarry (e.g., exposures to ambient air quality concentrations below applicable ambient air quality guidelines or standards are not generally expected to result in unacceptable health effects).

Particulate Matter

41 The concentrations (maximum and average) of $PM_{2.5}$ and PM_{10} presented in Mote (2018) are generally well below the MES (2004) 24-hour standard for PM_{10} and WHO guidelines for 24-hour and annual $PM_{2.5}$ concentrations and the annual PM_{10} concentrations.

42 Mote (2018) indicates that there were no exceedances of the NES (2004) 24-hour standard for PM_{10} at the two Yaldhurst monitoring locations which are recorded by reference method monitors (one rural/residential and one considered to be background/rural). There were some daily exceedances of the NES (2004) 24-hour standard for PM_{10} measured at the locations recorded by non-reference methods (e.g., non-reference monitors demonstrate slightly higher readings (overpredictions) than the reference method monitors and cannot be used to assess compliance with air quality standards/guidelines). These daily exceedances occurred on two days at all the monitoring sites measured using non-reference methods (including the background location) and on seven days at the five monitoring locations measured by non-reference methods.

43 Mr. Cudmore says in his evidence statement that:

(a) *The mitigation measures proposed for control of dust discharges and the associated design features would readily achieve a 10-fold reduction in the increase in ambient respirable particulate levels that have been measured for the 230 ha Yaldhurst gravel quarry area.*

(b) *"The monitoring data around the much larger Yaldhurst quarry sites for PM_{10} and $PM_{2.5}$ concentrations, the reduced potential for dust emissions from the Roydon quarry (due to its smaller scale, design and mitigation), indicate that it is unlikely that the operation of the proposed Roydon quarry would cause the offsite PM_{10} or $PM_{2.5}$ concentrations to exceed the NES for PM_{10} or the WHO guideline for 24 hour $PM_{2.5}$.*

44 There is no prescribed method for assessing health risks of particulate matter, nor does the assessment of particulate matter lend itself to risk assessment methods in the same manner as other constituents. For many years, particulate matter in the air

has been understood to be a serious health concern (Schwarze et al. 2006)[14]. Many epidemiological studies have been conducted that identify the relationship between particulate matter and adverse health outcomes (WHO 2006)[4]. The studies have shown that there is a broad range of health effects, but predominantly there is a relationship between particulate matter and mortality and hospitalizations for respiratory and cardiac health effects (WHO 2006)[4].

45 However, there remains uncertainty regarding the causal linkage between particulate matter and health effects, and in particular how varying compositions of particulate matter contribute to health effects (Schwarze et al. 2006, Rohr and Wyzga 2012)[15,15]. An increasing number of health effects have been linked to airborne particulate matter, and research has shown that there are risks to health at levels already found in many cities across the world (WHO 2006)[4].

46 Current research generally indicates that the composition of particulate matter would be a better predictor of potential adverse health effects than the mass of particulate matter (Stanek et al. 2011)[16]. Particulate matter is composed of a mixture of different chemicals and biological components and as such, differs from individual chemicals (WHO 2006)[4]. In addition, particulate matter is considered to be a stressor that can cause negative health outcomes at any exposure level and therefore lacks a threshold that can act as a guideline (WHO 2006)[4]. Therefore, for particulate matter the guideline values are concentrations that correspond to a tolerable level of risk and are not fully protective of public health (WHO 2006)[4].

47 It is expected that exposure to particulate matter in the immediate vicinity (e.g., off-Site) of the proposed Roydon quarry will be well below applicable air quality standards and guidelines as per Mr. Cudmore's assessment (Section 28.8).

48 As the air quality guidelines for exposure to particulate matter are based on an acceptable or tolerable level of risk, rather than a completely negligible risk, it is anticipated that health risks associated with off-Site exposure to particulate matter will result in acceptable health risks (e.g.., low to negligible depending on the concentrations off-Site). Anticipated ambient air quality concentrations for particulate matter ($PM_{2.5}$ and PM_{10}) in the vicinity of the Proposal are expected to be very similar to those found in other rural areas with low population density within the Canterbury Plains.

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14 Schwarze, P. E., J. Ovrevik, M. Låg, M. Refsnes, P. Nafstad, R. B. Hetland, and E. Dybing. 2006. Particulate Matter Properties and Health Effects: Consistency of Epidemiological and Toxicological Sudies. Hum Exp Toxicol 25:559–579.

15 Rohr, A. C., and R. E. Wyzga. 2012. Attributing Health Effects to Individual Particulate Matter Constituents. Atmospheric Environ. 62: 130–152.

16 Stanek, L. W., J. D. Sacks, S. J. Dutton, and J. J. B. Dubois. 2011. Attributing health effects to apportioned components and sources of particulate matter: An evaluation of collective results. Atmos Environ 45: 5655–5663.

49 Health risks will be considered acceptable because ambient air quality concentrations are expected to be below the health-based air quality guidelines for particulate matter. As noted above, the guideline values for particulate matter are concentrations that correspond to a tolerable level of risk and are not fully protective of public health. In the case of particulate matter, it is not possible to have "no potential or zero" health risk, because:

49.1 there is a lack of a health threshold (i.e., a concentration below which there are no health risks) for particulate matter; and

49.2 there are very low potential health risks associated with exposure to background particulate matter concentrations all around the world.

Conclusions

50 Based on my review of the applicable ambient air quality data, the data available in Mote (2018) for the Yaldhurst site and the expert evidence of Mr. Cudmore, I conclude the potential health risks associated with off-Site exposure associated with the proposed Roydon quarry are expected to be:

50.1 Extremely low to negligible for respirable crystalline silica; and

50.2 acceptable (low to negligible depending the concentrations off-Site) and not dissimilar to background concentrations in other areas of New Zealand for $PM_{2.5}$ and PM_{10}.

Dated 23 September 2019

Audrey Wagenaar
Associate and Senior Environmental Scientist – Golder Associates Limited

Curriculum Vitae AUDREY WAGENAAR

Education

M.Sc. Medicinal Chemistry, University of Sussex, U.K., 1992

B.Sc. Combined Honours Chemistry and Biology, University of British Columbia, Vancouver, BC, 1990

Certifications

Diplomate of the American Board of Toxicology (DABT)

British Columbia Contaminated Sites Approved Professional Society – Contaminated Sites Approved Professional (CSAP - Risk Assessment)

Qualified Professional in Risk Assessment (Ontario) QPRA

Association of the Chemical Profession of BC - Professional Chemist (PChem)

Project Management Institute - Project Management Professional (PMP)

Golder Associates Ltd. – Vancouver

Ms. Audrey Wagenaar is an Associate and Senior Environmental Scientist with Golder Associates' Vancouver Office. Ms. Wagenaar has twenty-six years of experience in human health and ecological risk assessment, human health toxicology and environmental chemistry. Ms. Wagenaar is a Diplomate of the American Board of Toxicology (i.e., a board-certified toxicologist). Ms. Wagenaar was also appointed to the British Columbia Roster of Contaminated Sites Approved Professionals for Risk Assessment and is a Project Management Professional. Audrey is on the Board of Directors for the Association of the Chemical Profession of British Columbia.

Her technical skills include specialized human health toxicology assessment, human health exposure and risk modelling, development and modification of toxicity reference values, quantitative fate and transport modelling, development of air quality standards, development of environmental health and safety guidelines, and provision of expert advice/peer review and expert witness testimony.

Ms. Wagenaar has conducted and managed numerous human health risk assessments in accordance with Canadian federal and provincial guidelines. She has completed a number of public health risk assessments on US Superfund sites for the Agency of Toxic Substances and Disease Registry and the US National Oceanic and Atmospheric Agency. Ms. Wagenaar has significant experience conducting detailed quantitative human and terrestrial wildlife health risk assessments to support environmental impact assessments for mining and other development projects in Canada and abroad.

She has considerable experience in managing complex multi-stakeholder processes involving industrial clients, government regulatory agencies, medical officers of health, and the public. Ms. Wagenaar is also experienced in human health risk communication.

Employment History

Golder Associates Ltd. – North Vancouver and Burnaby, BC
Associate, Senior Environmental Scientist (2004 to Present)

Responsibilities include conducting human health and ecological risk assessments; providing expert advice on potential health effects based on evaluation of toxicological information; developing chemical-specific toxicological criteria; providing senior review; managing projects; business development and marketing; and managing and mentoring staff.

EVS Environment Consultants – North Vancouver, BC
Senior Environmental Scientist (2002 to 2004)

Conducted human health risk assessments, managed and provided senior review for ecological risk assessments; managed projects; business development and marketing.

Golder Associates Ltd. – Mississauga, ON
Senior Risk Assessor/Toxicologist (2001 to 2002)

Conducted site-specific human health risk assessments and developed remediation criteria; peer reviewed site-specific risk assessments; provided expert advice on potential health effects; and managed projects.

Ontario Ministry of the Environment – Toronto, ON
Senior Regulatory Toxicologist (1999 to 2001)

Provided expert human health toxicological advice for community-based risk assessments; developed provincial air standards based on human health toxicological data; and reviewed site-specific risk assessments to determine compliance with the Ontario Guideline for Use at Contaminated Sites; and risk communication.

Eastern Research Group – Lexington, MA
Environmental Scientist (1997 to 1999)

Provided technical advisory services to various government and corporate clients in the areas of human health risk assessment, ecological risk assessment, medicinal chemistry, and database development.

Environment Canada – North Vancouver, BC
Toxic Substances Evaluation Scientist/ Controls Program Officer (1993 to 1997)

Evaluated the environmental toxicology of chloramine - a drinking water disinfectant - under the Priority Substance List (PSL) of Canadian Environmental Protection Act (CEPA). The project involved collecting chloramine-related toxicological data, developing of a Microsoft Access database, evaluating data and data quality, and determining appropriate assessment endpoints. In addition, general advisory and consulting services in the area of toxicology were provided to senior management, other departmental scientists, federal/provincial agencies, industry and the general public.

University of British Columbia, Department of Soil Science – Vancouver, BC
Laboratory Technician, Soil Chemistry Lab (1992 to 1993)

Conducted chemical analyses of soil and supervised graduate student experiments.

PROJECT EXPERIENCE – HUMAN HEALTH RISK ASSESSMENT (HHRA)

Head Technical Report – Human Health Risk Assessment
Melbourne, Australia

Principal toxicologist responsible for planning, managing, and conducting a detailed quantitative human health risk assessment to assess the uptake of contaminants (metals, PAHs, and pesticides) from sediment by ecological receptors (three species of fish and mussels) as the result of proposed dredging activities in Port Phillip Bay, and the subsequent consumption of these fish and mussels by recreational and subsistence fisher populations. The human health risk assessment was developed as part of Environmental Impact Assessment for regulatory approval. Responsibilities included providing direction for data screening, problem formulation, development of site-specific bioaccumulation factors and food chain modelling, toxicity reference value selection as well as conducting the HHRA. The head technical report was presented at an independent panel hearing as part of the process for the Australian government to decide whether to proceed with the project and was accepted. (2006 – 2007).

Petaquilla Mine Baseline Environmental and Social Impact Assessment
Panama

Technical lead for human health and ecological risk assessment developed as part of an Environmental and Social Impact Assessment for regulatory approval of a proposed mine development in Panama. Responsibilities included the development of the problem formulation, sampling and analysis plan, and data quality objectives for human health and terrestrial components of the project and conducting the baseline and impact case human health risk assessments. Primary contaminants of concern included in the assessment were metals, PAHs, PCBs, and pesticides. Key elements of the study included assessment of multiple types of traditional foods (including fish) used by three distinct populations of subsistence users, a detailed toxicity assessment, an air quality assessment and the use of fate and transport modelling in conjunction with measured environmental data and site-specific bioaccumulation factors to predict future conditions. (2007 – 2010).

Morelos Gold Environmental and Social Impact Assessment
Mexico

Technical lead for human health and ecological risk assessment in support of an Environmental and Social Impact Assessment for regulatory approval of a proposed mine development in Mexico. Responsibilities included the development of the overall approach and strategy for the human health and terrestrial components of the project, overseeing the baseline and impact case risk assessments and conducting senior review. Primary contaminants of concern included in the assessment were metals as the project was located in an area containing naturally elevated arsenic concentrations in soil and water. Key elements of the study included assessment of multiple types of traditional foods (including fish, corn and other backyard produce), an air quality assessment, a detailed arsenic toxicity assessment, and the use of fate and transport modelling in conjunction with measured soil, sediment, surface water, fish and air data and site-specific bioaccumulation factors to predict future conditions. (2012 – 2014).

Faro Mine Complex, Environmental Assessment,
Faro, Yukon

A human and wildlife health risk assessment was completed to evaluate the potential risks associated with remediation and closure of an abandoned open-pit lead and zinc mine site. The human health risk assessment included an evaluation of air quality, particulate matter and multimedia exposure. Responsibilities included technical lead for the human and ecological health risk assessments including providing technical direction to the team, reviewing technical documents and appendices, and extensive communication with consultants, the local Indigenous groups and federal and provincial regulators (Health Canada, Environment Canada, Yukon Environment and CIRNAC), and presenting the work to an independent peer review panel of international mining experts for their review and comment. The results of the risk assessment include the effects on populations of people exposed to chemical contaminants. Site-specific soil clean-up criteria are being developed for metals including lead and site-specific bioaccessibility testing for arsenic and lead have been incorporated into the risk assessment. (2016 – ongoing)

Human Health Risk Assessment, Manufacturing Facility
Kentucky, US

Senior Human Health Risk Assessment Advisor and Reviewer for a multi-media human health risk assessment of a manufacturing facility which is a US EPA Superfund site. The risk assessment was part of the process to apportion environmental liability between the current and historic owners of the facility. Primary contaminants of concern included in the assessment were volatile organic compounds (including trichloroethene and tetrachloroethene), metals, PAHs, and pesticides, which are currently found in site soils, sediment, seep water, and surface water. The risk assessment also included detailed air quality assessment for adjacent residential communities from facility emissions and vapour intrusion to outdoor air resulting from on-Site groundwater contamination. The risk assessment was conducted to CERCLA standards and involved a complex multi-stakeholder (US EPA, State of Kentucky Department of Health, current and former owners) and regulatory review process. (2012 – 2013).

Human Health Closure Risk Assessment,
Ft. McMurray, AB

A Human Health Risk Assessment (HHRA) was conducted of reclamation and closure landscapes planned for operational oil sands sites at four facilities in Northern Alberta, Canada. The HHRA was used to determine whether there are any potential health risks associated with people using the current reclaimed landform plans: (a) immediately after reclamation; and (b) in the future after mine closure and reclamation certification is achieved. The HHRA was also used to develop mitigation options to optimize and revise future reclamation landscape designs, such as material placement, if potential health risks to people are identified. (2015 – ongoing).

Public Health Risk Assessment for Superfund Site - Mountain Home Air Force Base
Mountain Home, ID

Scientist responsible for preparing the human health risk assessment of a drinking water supply containing elevated levels of trichloroethene at Mountain Home Air Force Base. The risk assessment was prepared for the US Agency for Toxic Substances and Disease Registry (ATSDR) and involved consultation with ATSDR and U.S. Army officials. (1998 – 1999).

Peer Review of US EPA Toxicity Reference Values for Tetrachloroethene
Sweden

Senior Toxicologist responsible for the peer review of the US EPA toxicity reference values for tetrachloroethene on behalf of the Swedish EPA to determine whether they should adopt the US EPA toxicity reference values or continue to utilize the World Health Organization toxicity reference values. The project involved a detailed comparison of the toxicological basis of both the US EPA and WHO toxicity reference values, a literature review of the basis of toxicity reference values used by other jurisdictions including Health Canada and contacting several of these jurisdictions to determine whether they are planning to review their toxicity reference values for tetrachloroethene. A key part of the toxicological review was an assessment of the genotoxicity and mutagenicity data for tetrachloroethene. (2012).

Human Health Risk Assessment – Commercial Property
Burnaby, BC

Principal Human Health Risk Assessor responsible for risk assessment of a former commercial building which historically contained an industrial site with degreasing activities. A plume of chlorinated solvents (tetrachloroethene and trichloroethene) is present beneath the commercial building and it extends off-site to a low density residential neighbourhood, a food processing facility, roadways and a city park and wetland. Risk assessments have been conducted for the former commercial building as well as the low density residential neighbourhoods and construction workers accessing the utilities beneath the roadway. Risk assessment activities are ongoing for the re-development of the former commercial site to a high density residential area and the city park and wetland. The risk assessment involves evaluation of soil, groundwater, surface water, sediment soil vapour and indoor air data to determine risks to building occupants and ecological receptors. (2008 – ongoing).

Expert Opinion Provided on Evacuation of Building Occupants as the Result of Potential Exposure to Trichloroethene
Vancouver, BC

An expert opinion was provided based on a review of recent toxicological data on trichloroethene as to whether or not building occupants needed to be evacuated from a commercial building impacted by a historic trichloroethene plume in the floor slab. The review of the trichloroethene toxicological data focused on acute and sub-chronic exposure to pregnant women. A mobile field laboratory from the Vancouver Fire Department was used to analyze the trichloroethene concentrations measured directly above the cracked floor slab and at several locations at breathing height within the building. Parallel analyses were submitted to a local analytical laboratory. Field measurements indicated highly elevated concentrations of trichloroethene. Based on a review of current trichloroethene toxicological data, a recommendation was made to evacuate the employees from the building while engineers installed a vapour mitigation system and indoor concentrations of trichloroethene returned to acceptable levels. (2015).

Public Health Risk Assessment for Superfund Site – Marine Corps Logistics Base Barstow
Barstow, CA

Scientist responsible for preparing the human health risk assessment of a drinking water supply containing elevated levels of trichloroethene, vinyl chloride, and cis-1,2-dichloroethene at Marine Corps Logistics Base. The risk assessment, which was prepared for the US Agency for Toxic Substances and Disease Registry (ATSDR), addressed both on- and off-Site impacts of the chlorinated solvents. The health risk assessment involved extensive communication with ATSDR and U.S. Marine Corps officials. (1999).

Preliminary Quantitative Human Health Risk Assessment, Shopping Mall
Kelowna, BC

A preliminary quantitative human health risk assessment was conducted for shopping mall which contains a dry cleaning facility. Due to historic operations, a plume of trichloroethene and tetrachloroethene is present in the soil and groundwater beneath the shopping mall and the adjacent laneway. Some remedial works have been undertaken to remove accessible soil beneath the laneway. A vapour mitigation system is present inside the dry cleaning operation. The risks to workers, visitors to the shopping mall and local residents were assessed. The risk assessment included an evaluation of current trichloroethene and tetrachloroethene toxicological data particularly with respect to short-term exposure. The risk assessment was submitted to the British Columbia Ministry of Environment for regulatory review and a certificate of compliance was issued. (2014 – 2016).

Human Health Risk Assessment – Shopping Mall
Surrey, BC

Principal Human Health Risk Assessor responsible for risk assessment of a shopping mall impacted by a fire at a former drycleaner site. A plume of chlorinated solvents (tetrachloroethene and trichloroethene) is present beneath a portion of the shopping mall. The risk assessment involves evaluation of soil, groundwater, soil vapour and indoor air data to determine risks to building occupants and customers. The assessment also included a critical evaluation of the available toxicity reference values for trichloroethene. (2010 – 2013).

Screening-Level Risk Assessment, Commercial Office Tower
Vancouver, BC

Human health risk assessor responsible for conducting a human health risk assessment of a commercial office tower constructed on the site of a former drycleaner operation. The risk assessment was conducted to determine potential risks to building users and off-site receptors resulting from elevated concentrations of tetrachloroethene present in site groundwater. (2002 – 2003).

Human Health Risk Assessment, Aurora Oil Sands Mine Expansion
Northern Alberta

Technical lead for the human health component of a risk assessment in support of an Environmental Site Assessment Update of a proposed expanded Oil Sands Mine Development. The risk assessment was used to determine whether there would be potential human health risks associated with the expansion compared to the background scenario as well as a cumulative impacts scenario which accounted for the combined effects with other proposed projects. An air quality risk evaluation (acute, chronic, and particulate matter assessments) was conducted to evaluate the inhalation route and a multimedia risk evaluation was conducted to determine the chronic effects associated with chemicals that might be present in both air and food pathways. (2009 – 2010).

Human Health Risk Assessment, Dover Commercial Oil Sands Project
Northern Alberta

Technical lead and project manager for the human and wildlife health component of a risk assessment in support of an Environmental Site Assessment for the Dover Commercial Oil Sands Project. The risk assessment was used to determine whether there would be potential human or wildlife health risks associated with the development of the proposed project. An air quality risk evaluation (acute, chronic, and particulate matter assessments) was conducted to evaluate the inhalation route and a multimedia risk evaluation was conducted to determine the chronic effects associated with chemicals that might be present in both air and food pathways. (2010 – 2013).

Human Health Risk Assessments, Red Chris Mine,
North Western BC

A baseline and predicted effects human health risk assessment are being conducted to evaluate the potential risks associated with the construction and operation of the Tailings Impoundment Area South Dam to satisfy a Permit amendment pursuant to the Environmental Management Act. To support the requirements of the Permit amendment, Golder completed a baseline human health risk assessment in 2018 to evaluate the potential risks associated with exposure to the receiving environment downstream of the Tailings Impoundment Area South Dam. Responsibilities included providing technical direction to the risk assessment team, conducted senior technical review, liaised with the client and expert working group (BC Ministry of Environment, First Nations Health Authority and Northern Health Authority) and members of Indigenous stakeholder groups. (2017-ongoing).

Human Health Risk Assessments, Former Canada Creosote Site,
Calgary, AB

Technical lead for several human health risk assessment of off-site contamination originating from the former Canada Creosote Site, in Calgary. Preliminary Quantitative Human Health Risk Assessments (PQRA) were conducted for the residential areas north of the Bow River as the area south of the Bow river in anticipation of future redevelopment of the Canada Creosote Study Area. The PQRA conducted for the northern portion of the site included the development of risk-based screening criteria for soil vapour and indoor air that are being used to screen ongoing monitoring results obtained from residential homes in the area. (2011 – 2015).

Development of Human Health Toxicity Reference Values
North Haven, CT

Principal Human Health Toxicologist responsible for evaluating and/or developing toxicity reference values for 38 novel substances found in soil, groundwater, and surface water at a former chemical manufacturing site. The site is undergoing a US RCRA evaluation in consultation with state government. The evaluation process included determining whether toxicity reference values (TRVs) were available for a substance, conducting a comprehensive literature search to obtain current toxicological information for the substances, and then assessing the non-carcinogenic, carcinogenic, and mutagenic effects of the substances. The assessment also involved application of modifying factors to account for potential mutagenicity and carcinogenicity to existing reference values and developing oral and inhalation reference doses for chemicals which currently lack toxicity reference values. Toxicity profiles were prepared to document the assessment of each substance and provide a rationale for selection/derivation of TRVs for each substance. The TRVs were subsequently utilized to develop site-specific risk-based clean-up standards for these substances. (2006 – 2008).

Liquefied Natural Gas Facility Environmental Assessment
Delta, BC

Technical lead for public health assessment developed in support of an Environmental Impact Assessment for regulatory approval of a proposed marine jetty with berthing and mooring facilities and LNG line linking to FortisBC's Tilbury LNG facility in Delta, BC. Responsibilities included the development of the overall approach and strategy, overseeing the public health assessment, conducting senior review and responding to information requests from government expert reviewers or key stakeholders and presenting technical materials to government representatives and stakeholders. Key elements of the study include a detailed air quality risk assessment. (2013 – ongoing).

Human Health and Terrestrial Wildlife Risk Assessment, Jay Pit, Diamond Mine Northwest Territories	Technical lead for the human health and terrestrial wildlife component of a risk assessment developed in support of an Environmental Impact Assessment for regulatory approval of the expansion of an existing diamond mine. The main contaminants of potential concern were particulate matter and metals. An air quality risk evaluation (acute, chronic, and particulate matter assessments) was conducted to evaluate the inhalation route and a multi-media risk evaluation was conducted to determine the chronic effects associated with chemicals that might be present in both air and food pathways. A detailed toxicity assessment was completed for air quality parameters, including particulate matter, as well as the multi-media contaminants. Responsibilities included responding to information requests from government expert reviewers and key stakeholders (2013 – 2016).
Risk Assessment of Rural Public Water Supplies Mexico	Risk assessment of downgradient community water supply wells in rural Mexico to determine if groundwater plume migrating from tailings storage facility has impacted public water supplies. Arsenic, nitrate and sulphate were primary contaminants of potential concern and analysis indicated that potable water supplies were not currently impacted. (2015 – 2018).
Review of Human Health Toxicity Reference Values for Ammonia BC	Senior Human Health Toxicologist responsible for reviewing the current basis for BC Ministry of Environment soil vapour quality guidelines for ammonia to support an assessment of indoor air quality in a community impacted by an ammonia in groundwater plume. The assessment also included a review of the inhalation toxicity reference values for ammonia from various regulatory jurisdictions and also the literature to determine whether there might be more current information available that could be used to update the ammonia inhalation toxicity reference value. (2012).
Human Health Risk Assessment, Baker Creek Yellowknife, Northwest Territories	Principal toxicologist responsible for human health risk assessment of sediment, surface water and fish for recreational users of Baker Creek, part of the former Giant Mine property. The risk assessment focused on the assessment of arsenic trioxide, and other metals identified in the sediments of Baker Creek and included the evaluation of both sub-chronic and chronic exposure scenarios for recreational users. (2011 – 2013).
Human Health Risk Assessment, Giant Mine Yellowknife, Northwest Territories	Principal toxicologist responsible for human health risk assessment of workers at the Giant Mine exposed to soil, dust and air containing arsenic trioxide as part of their daily activities. The risk assessment evaluated several different types of workers (those involved in remediation works, underground stabilization of the waste and maintenance activities). Current and future conditions were assessed using soil and air quality monitoring data to determine potential risks. The risk estimates were compared to biomonitoring data and recommendations for on-going worker health and safety were provided. (2015 – 2016).
Aggregate Mine Project Environmental Assessment South Western BC	Technical lead and project manager for human health risk assessment developed in support of an Environmental Impact Assessment for regulatory approval of a proposed aggregate mine project in south western BC. Key elements of the study included a detailed air quality assessment for local residents and recreational users, a risk assessment of recreational use of pit lake and a baseline assessment of the quality of traditional foods. (2013 – 2016).

Liquefied Natural Gas Facility Environmental Assessment
South Western BC

Technical lead for public health assessment developed in support of an Environmental Impact Assessment for regulatory approval of a proposed liquefied natural gas (LNG) production, storage, and marine carrier transfer facility in south western BC. Responsibilities included the development of the overall approach and strategy, overseeing the public health assessment, conducting senior review and responding to information requests from government expert reviewers or key stakeholders and presenting technical materials to government representatives and stakeholders. Key elements of the study include a detailed air quality risk assessment and an assessment of key determinants of health for the local population. (2013 – 2015).

Quantitative Health Risk Assessment of the First Nations Communities of Tsay Keh and Kwadacha, BC
Tsay Keh and Kwadacha, BC

Project manager and Senior Human Health Risk Assessor responsible for conducting a quantitative risk assessment of particulate matter for two Northern BC communities impacted by seasonal dust storms related to "draw down" effects from a large water reservoir. The quantitative assessment of fine and coarse particulate matter included the following approaches: (1) SUM15/SUM25 Approach - Comparison to a Health Threshold Effect [Health Canada and Environment Canada 1999], (2) comparison to Background Concentrations (BC Lung Association 2003), and (3) comparison to key epidemiological studies focussed on health effects associated with particulate matter from crustal sources. (2009 – 2010).

Human Health and Terrestrial Wildlife Risk Assessment, Gahcho Kue, Diamond Mine
Northwest Territories

Technical lead and project manager for the human health and terrestrial wildlife component of a risk assessment developed in support of an Environmental Impact Assessment for the regulatory approval of a proposed diamond mine. An air quality risk evaluation (acute, chronic, and particulate matter assessments) was conducted to evaluate the inhalation route and a multi-media risk evaluation was conducted to determine the chronic effects associated with chemicals that might be present in both air and food pathways. The main contaminants of potential concern were PAHs and metals. A detailed toxicity assessment was completed for air quality parameters, including particulate matter, as well as the multi-media contaminants. Human receptors in five community locations were assessed in the multi-media risk assessment. Responsibilities in included responding to information requests from government expert reviewers and key stakeholders. (2007 – 2012).

Rat Lake, Former Con Mine, Development of Site-Specific Clean up Criteria
Yellowknife, Northwest Territories

Human health risk assessor responsible for an evaluation of the potential human health risks associated with arsenic in residual soil that remains in place at the south end of Rat Lake on the former Con Mine property. The site has been impacted by mine tailings and future use is likely to include a low activity park area. After remediation of the arsenic in soils to site-specific guidelines, several confirmatory samples indicated arsenic concentrations above these guidelines. Additional confirmatory soil samples were collected and analyzed for chemical content and relative bioaccessibility. The results of these analyses were used in a risk assessment to determine the potential for adverse health effects to recreational users of the property. (2008 – 2012).

Human Health Risk Assessment, Former Whitehorse Tank Farm
Whitehorse, Yukon

Principal Human Health Risk Assessor and project manager responsible for the development of site-specific soil standards for industrial land use at the former Yukon Pipelines Limited Upper Tank Farm, Whitehorse, Yukon. Vapour intrusion modelling was used to derive the site-specific standards. Confirmatory soil samples, which were collected at the time of remedial excavation works conducted in 2001, were screened using the site-specific standards for industrial use. These site-specific soil standards for industrial use were developed in response to conditions imposed by the National Energy Board (NEB) their review of an Abandonment Order and subsequently accepted by the NEB. (2009).

Human Health Risk Assessment, Doris Camp, Hope Bay Mines
Nunavut

Principal Human Health Toxicologist responsible for evaluating potential health risks associated with consumption of microcystis in drinking water from the Hope Bay Doris Camp Domestic Water Supply. Currently, drinking water concentrations are in compliance with the Health Canada drinking water quality guideline for microcystin. However, cell counts are also highly variable (i.e., they do not appear to be correlated to the microcystin concentration). As a result, a site-specific toxin quota was developed for use at Hope Bay so that toxins other than microcystin produced by microcystis and other strains of cyanobacteria (i.e., anatoxin-A and cylindrospermopsin) can be related to the drinking water guideline for microcystin. (2010 – 2013).

Human Health and Terrestrial Wildlife Risk Assessment, Line Creek Phase II Extension
South Eastern BC

Technical component lead and project manager for a human health and terrestrial wildlife risk assessment developed to support an Environmental Impact Assessment for regulatory approval of a coal mine extension in south eastern BC. Responsibilities included development of the problem formulation, sampling and analysis plan, soliciting input from local First Nations regarding country food consumption and conducting the baseline and Project case risk assessments and risk communication (including responding to information requests from government expert reviewers and key stakeholders and presenting technical information to government officials, Aboriginal organizations and the public). Primary contaminants of concern included in the assessment were metals and PAHs. Key elements of the study include an air quality assessment, inclusion of multiple types of traditional foods (including cougar) consumed by First Nations subsistence users, and a detailed toxicity assessment of arsenic and selenium in country foods. (2009 – 2013).

Human Health and Terrestrial Wildlife Risk Assessment, Greenhills Operations – Cougar Pit Extension
South Eastern BC

Technical component lead and project manager for human health and terrestrial wildlife risk assessment in support of a Mines Act Permit Amendment for regulatory approval of a coal mine extension in south eastern BC. Key elements of the study included an air quality assessment, inclusion of multiple types of traditional foods consumed by First Nations subsistence users, a detailed toxicity assessment of cobalt and selenium in country foods, and a focused wildlife assessment for aquatic-feeding receptors. Responsibilities included responding to information requests from government expert reviewers and key stakeholders and presenting technical information to government officials, Aboriginal organizations and the public. (2013 – 2016).

Human Health and Terrestrial Wildlife Risk Assessment, Fording River Operations – Swift Project Extension
South Eastern BC

Technical component lead and project manager for human health and terrestrial wildlife risk assessment developed in support of an Environmental Impact Assessment for regulatory approval of a coal mine extension in south eastern BC. Operable exposure pathways included direct contact with soil (incidental ingestion, inhalation of dust and dermal contact), air inhalation (human health), consumption of surface water for potable purposes, dermal contact and incidental ingestion of sediment and surface water while swimming, consumption of fish, berries and wild game. Key elements of the study included an air quality and multi-media risk assessment for people and wildlife in the region, incorporating multiple types of traditional foods consumed by First Nations subsistence users into the human health risk assessment, a detailed toxicity assessment of arsenic and selenium in country foods. The project involved extensive communication with consultants for the local First Nations and working group participants (federal and provincial regulators). (2011 – 2015).

Risk Assessment of Rural Public Water Supplies
Mexico

Risk assessment of downgradient community water supply wells in rural Mexico to determine if groundwater plume migrating from tailings storage facility has impacted public water supplies. Arsenic, nitrate and sulphate were primary contaminants of potential concern and analysis indicated that potable water supplies were not currently impacted. (2015 – ongoing).

Human Health Risk Assessment – Lead-Zinc Mine Tailings
Mojkovac, Montenegro

Principal Human Health Risk Assessor responsible for a multimedia screening-level risk assessment of the tailings management facility adjacent to the community of Mojkovac. The tailings management facility was constructed to manage tailings from a former lead-zinc mine. Although capped, portions of the tailings are flooded and infiltration has occurred, causing migration of metals into adjacent surface water bodies. The cap is no longer intact in other areas, causing erosion and wind-generated dust. The tailings management facilities have been used for recreational purposes including fishing and swimming. The multimedia screening-level risk assessment included the assessment of dust migration to the adjacent village and impact on soil, crops and livestock as well as ingestion of water, dermal contact with water and ingestion of fish associated with the recreational uses of the flooded portion of the site. The risk assessment was used by the World Bank to address community issues/concerns and prioritize risk management options. (2004 – 2005).

Human Health and Terrestrial Wildlife Risk Assessment, Elkview Operations Extension
South Eastern BC

Technical lead for the human health and terrestrial wildlife component of a risk assessment developed in support of an Environmental Impact Assessment for the regulatory approval of an extension of an existing coal mine in south eastern British Columbia. An air quality risk evaluation (acute, chronic, and particulate matter assessments) was conducted to evaluate the inhalation route and a multi-media risk evaluation was conducted to determine the chronic effects associated with chemicals that might be present in both air and food pathways. The main contaminants of potential concern were particulate matter and metals. Human receptors in twenty-five community locations were assessed in the multi-media risk assessment and specific dietary survey information for the First Nations was utilized in the exposure assessment. The role also included presentations to and consultation with First Nations living in the area as well as various regulators. (2012 – 2016).

Radiofrequency Safety Assessment
Canada

Senior discipline lead for a safety assessment on the potential conversion of the Royal Canadian Navy radiofrequency hazard safety standard to that of a controlled environment from its current uncontrolled environment application. The assessment included interviews with various personnel working in positions that involve radiofrequency hazards at the Esquimalt and Halifax naval bases as well as site visit and review of current radiofrequency health effects and regulations to determine a policy that was protective of human health. The safety assessment included determining health effects associated with the potential change to a controlled environment. (2013 – 2014).

Human Health Risk Assessment of Former Plant Nursery Operations
Washington, DC

Principal Human Health Risk Assessor responsible for a multimedia risk assessment of a 44-acre former plant nursery operation located in Washington. The site was to be redeveloped into a passive recreational park within the US National Park system and included a sensitive wetland area. Primary contaminants of concern included in the assessment were metals, PAHs, PCBs, and pesticides, which were found in site soils, sediment, groundwater, and surface water. The risk assessment was conducted to CERCLA standards and involved a complex multi-stakeholder (NOAA, Architect of the Capital, EPA, and District of Columbia Department of Health) and regulatory review process. (2002 – 2004).

Environmental Assessment of the Lower Churchill Hydroelectric Project
Newfoundland

Senior Human Health Risk Assessor and reviewer for a human health risk assessment of baseline exposure for residents of five communities living close to the dam site, who may be affected by consuming fish with increased mercury concentrations. The human health risk assessment was completed as part of the Environmental Assessment of the Lower Churchill Hydroelectric Project. The risk assessment included the evaluation of historic and current fish tissue data as well as information for other types of traditional foods, the results of a community views analysis and the review of area specific food preferences and exposure patterns. The risk assessment was conducted to support an environmental hearing for project approval. (2009 – 2013).

Cowichan Communities Health Profile
Vancouver Island, BC

Project director for a community health profile for the Cowichan communities on Vancouver Island which focused on the key determinants of health. The project was intended to help raise awareness and improve engagement of citizens with respect to improving their overall health. The project involved a participatory approach and included a number of workshops and survey tools. Data analysis on social determinants of health were conducted and detailed map packages showing health indicators were compiled and were used to create an interactive web-based community asset maps showing locations of facilities and programs that support community health. (2013 – 2014).

Development of Human Health Toxicity Reference Values Sweden	Principal Human Health Toxicologist responsible for evaluating and/or developing toxicity reference values for four substances (2-ethyl-1-hexane, hexanal, isophorone and phorone) found in soil and groundwater at a former fabric manufacturing facility in Sweden. The project included the evaluation of existing toxicological data for these substances and also choosing chemical surrogates for substances for which insufficient data were available to derive a toxicity reference value. The project involved a review of uncertainty factors used by various organizations in their derivation of toxicological reference values including the US Environmental Protection Agency, The World Health Organization and the European Community's Registration, Evaluation, Authorization and Registration of Chemical Substances (REACH) Programme. (2010).
Risk Assessment of Stormwater Run-off from a Copper Mine on Native American Reserve Gardens Arizona	Risk Assessor responsible for determining potential impact of human consumption of vegetables irrigated with stormwater run-off containing elevated levels of metals from a copper tailings area. Risk assessment was prepared for the Agency of Toxic Substances and Disease Registry (ATSDR) and involved consultation with ATSDR and the local Native American government. (1999).
Human and Ecological Health Risk Assessment, Chromium Plating Facility, Prince George, BC	Senior health risk assessor and reviewer for a human and ecological health risk assessment of a chromium plating facility for due diligence purposes. Metals in groundwater and soil were the primary contaminants of concern. A human health risk assessment was conducted for hexavalent and trivalent chromium exposure from air, dust and soil. The ecological evaluation focused on the effects of copper to soil invertebrates, plants and small wildlife. (2016).
Human Health Risk Assessment - Former Port Facility Uranium City, Saskatchewan	Principal Human Health Risk Assessor and project manager responsible for risk assessment of a historic oil spill at a former port facility into a large freshwater lake in northern Saskatchewan. The assessment included the evaluation of sediment, fish and surface water. Recreational, residential and First Nations receptors were evaluated and operable exposure pathways included consumption of fish, dermal contact with water and sediment, dermal contact with surface water, inadvertent consumption of sediment during recreational activities and consumption of surface water as a source of potable water. The primary contaminants of concern were PAHs and alkylated PAHs. The risk assessment also involved the assessment of and modification of toxicity reference values for alkylated PAHs. The risk assessment was used to prioritize potential remedial options including whether the impacted sediment could be managed in-place. (2007 – 2010).
Human and Ecological Risk Assessment Northern Saskatchewan	Project manager responsible for a human and ecological risk assessment to support an Environmental Impact Statement for the expansion of a gold mine in Northern Saskatchewan. The human and ecological risk assessment included the assessment of aquatic health for baseline and project scenarios, a quantitative assessment of terrestrial health and a quantitative assessment of consumption of fish for baseline and project scenarios by recreational users of nearby lakes. (2009).

Former Manufacturing Site, Risk Assessment Services, Edmonton, Alberta	Senior Risk Assessor for a project providing primarily risk assessment services in collaboration with a team of environmental consultants at a former chemical manufacturing facility that operated from the 1950s to 2007. This work is being conducted to support redevelopment and manage risks related to environmental impacts that have been identified at the Site since the 1980s. On-going work continues related to the development of risk assessments, risk management plans as well as other related support (e.g., development of groundwater monitoring programs). (2017- ongoing).
Human Health Risk Assessment – Recreational Water Use Wabamun, AB	Principal Human Health Risk Assessor responsible for risk assessment of sediment and surface water impacted by an oil spill into a large freshwater recreational lake, as the result of a train derailment. The primary contaminants of concern were PAHs, novel alkylated PAHs, and selected VOCs. The risk assessment involved the development of toxicity reference values for alkylated PAHs, as well as a complex peer review and multi-stakeholder consultation process. The results were presented to the local medical officer of health, who subsequently removed the non-water use advisory for recreational purposes. (2006 – 2007).
Screening Human Health and Ecological Risk Assessment Fort McMurray, AB	Principal Risk Assessor responsible for screening level human health and ecological risk assessment of a historic Oil Sands Extraction site from the 1950s. The primary contaminants of concern included petroleum hydrocarbons, PAHs and novel alkylated PAHs. The risk assessment exposure pathways included direct soil contact and vapour intrusion into indoor and outdoor air for human receptors as well as terrestrial and aquatic components for ecological receptors which included wildlife food chain modelling. The results were used to prioritize the need for further risk assessment or risk management measures for the various areas of concern at the Site. The risk assessment approach included modifying guidelines as per the Alberta Environment Tier II approach. (2010).
Finalization of Clean-up Criteria Port Hope, ON	Scientist responsible for the critical assessment of exposure models used in Ontario and other jurisdictions to derive risk-based clean-up criteria and assessment of the suitability for use in this community which had historically been impacted by uranium processing. A site-specific multimedia approach was recommended for several contaminants of concern. (2001).
Ontario Ministry of the Environment Course on the Contaminated Sites Guidelines Ontario	Key Speaker at the Ontario Ministry of the Environment's course on Contaminated Sites Guidelines for environmental consultants and municipal planners held in several locations throughout Ontario. Discussed how to conduct the human health component of a site-specific risk assessment, including best practices and technical review considerations. (2001).

Preliminary Quantitative Risk Assessment, Former Baldy Hughes Canadian Forces Station
Prince George, BC

Senior discipline lead for a preliminary quantitative risk assessment (PQRA) for the former Baldy Hughes Canadian Forces Station associated with metals and petroleum hydrocarbons remaining in soils and groundwater from historic military use as a landfill. The risk assessment evaluated potential health risks to recreational users of the site exposed to site soils and off-site users utilizing groundwater for potable purposes that had potentially been impacted by the Site activities. The potential risks to terrestrial and aquatic wildlife were also evaluated. The PQRA was used to support the development of a long-term management plan for the Site and was updated using additional groundwater and surface water monitoring data. (2009 – 2010; 2016).

Preliminary and Detailed Quantitative Risk Assessments, Works Yard
Steamboat, BC

Senior discipline lead for a preliminary and a detailed quantitative risk assessment for a highway maintenance facility on the Alaska highway. The site includes a residential area, a maintenance shop and a salt storage area. The risk assessments included determining potential health risks to workers and their families who might be present on the Site as well as terrestrial and aquatic wildlife. The risk assessments included an evaluation of contaminants in soil, soil vapour, indoor air, surface water and groundwater. Follow-up soil vapour and indoor air monitoring were conducted for several years in the maintenance shop. (2009 – 2012).

Human Health Risk Assessment and Soil Vapour Intrusion Modelling, Brochet School
Brochet, Manitoba

Principal Human Health Risk Assessor and project manager responsible for conducting a soil vapour investigation at Brochet School, in northern Manitoba, to evaluate whether Health Canada guidance's default assumptions provided reasonable risk estimates in subarctic and arctic climates. A historic fuel spill had occurred beneath the school. The purpose of the investigation was two-fold and included an improved knowledge of subsurface chemical fate and transport in northern climates (including biodegradation processes) as well as an assessment of the impact of petroleum hydrocarbons under the school and any potential risks that might still exist for students and teachers. (2009).

Preliminary Quantitative Risk Assessment CFB Shilo
Manitoba

Senior risk assessor and project manager responsible for conducting a preliminary quantitative human health and ecological risk assessments of a former shooting and rifle ranges at Canadian Forces Base (CFB) Shilo located in Shilo, Manitoba for Defence Construction Canada. The risk assessments were conducted to determine risks to ecological receptors as well as human residential, recreational users and construction workers resulting from elevated concentrations of metals and polycyclic aromatic hydrocarbons in soil and groundwater. (2008 – 2009).

Preliminary Quantitative Risk Assessment FOX-3 DEW Line Site
Nunavut

Senior human health risk assessor and project manager responsible for conducting a preliminary quantitative human health risk assessment of a former FOX-3 distant early warning (DEW) line site located in Dewar Lakes, Nunavut for Defence Construction Canada. The risk assessment was conducted to determine risks to recreational users and construction workers resulting from elevated concentrations of metals and polycyclic aromatic hydrocarbons in soil and surface water. (2007).

Screening–Level Risk Assessment, Active Drydock
Vancouver, BC

Senior risk assessor responsible for conducting a human health risk assessment of an active drydock and associated property for purposes of a land transaction. The risk assessment was conducted to determine potential health risks to drydock and construction workers as well as site trespassers to elevated concentrations of petroleum hydrocarbons and metals in site soils and groundwater. (2005 – 2008).

PROJECT EXPERIENCE – HUMAN HEALTH TOXICOLOGY

Technical Advisor, Human Health Risk Assessment
Wawa, ON

Senior Regulatory Toxicologist representing the Ontario Ministry of the Environment on the Wawa Technical Steering Committee. Responsibilities included providing expert advice, guiding and critically reviewing the human health risk assessments, human health toxicological data, and biological monitoring studies of a population living adjacent to soil containing elevated levels of arsenic. Regular meetings with the local medical officer of health, industrial stakeholders, local government, and their technical consultants were also required. (1999 – 2001).

Technical Advisor, Community-Based Risk Assessment
Pt. Colborne, ON

Senior Regulatory Toxicologist representing the Ontario Ministry of the Environment in the multi-stakeholder development of a community-based risk assessment approach for use in Pt. Colborne. Pt. Colborne has elevated metals concentrations in the soils in the area resulting from historical metal refining activities. Responsibilities included providing expert human health toxicological advice, critically reviewing the proposed community-based approach including the framework for the human health and ecological risk assessments, potential risk management measures, and implementation of these risk management measures. Risk communication at public forums and frequent interaction with the local medical officer of health, industrial stakeholders, local government, and their technical consultants was required. (1999 – 2001).

Development of a Provincial Acetonitrile Air Standard
Ontario

Senior Toxicologist responsible for developing a provincial acetonitrile air standard for the Ontario Ministry of the Environment, based on protection of human health and the environment. The development of the standard included critically assessing the current literature related to the human health toxicology of acetonitrile. (1999 – 2001).

Provision of Expert Toxicological Advice to Ontario Medical Officers of Health
Ontario

Senior Regulatory Toxicologist responsible for providing expert toxicological advice to Ontario Medical Officers of Health on an “as-needed” basis. Various projects included the initiation of two blood lead screening programs for children and pregnant women exposed to lead (1) in mine tailings used for garden landscaping and paving, (2) from aerial deposition in gardens in a smelting town; and assessment of off-site odour/health issues related to remediation activities, and (3) odour and potential health issues associated with unknown noxious substances in soil. (1999 – 2001).

Development of a Provincial Uranium Air Standard
Ontario

Co-author of the provincial uranium air standard for the Ontario Ministry of the Environment based on the chemical toxicity specific to exposures by human and ecological receptors in a community adjacent to a uranium refinery. The uranium air standard was set to ensure that unacceptable levels of uranium did not accumulate in soil as the result of aerial deposition and utilized a multimedia approach. The development of the standard included a critical review of uranium human health toxicological data to determine an appropriate toxicity reference value. The development of the uranium standard involved extensive communication and consultation with the local medical officer of health, industrial stakeholders, local government, and public interest groups. (1999 – 2001).

Market Analysis – Sepsis and Septic Shock
Boston, MA

Scientist responsible for a market analysis of the disease state, sepsis and septic shock for use by pharmaceutical and biotechnology companies. The market analysis included (1) a summary of most recent understanding of cause and mode of action of disease state, (2) summary of current treatment regimens (pharmaceutical and clinical) and efficacy of these treatments, (3) summary of new pharmaceuticals in the pipeline for the treatment of sepsis, including mode of action and expected efficacy, (4) analysis of sales of major pharmaceutical products used for treatment in various markets (Europe, Asia, and North America), and (5) interviews with leading medical experts specializing in the treatment of sepsis to determine what tools would be most useful to them in the treatment of disease. (1998).

PROJECT EXPERIENCE – GUIDANCE DOCUMENTS, CLASSIFICATION SYSTEMS AND CHEMICAL ASSESSMENTS

Expert Advisory Services, Risk Assessment, Israeli Ministry of Environment,
Israel

Senior toxicologist working with an Israeli partner (Ecolog Engineering Ltd.) to update the Israeli Risk Based Corrective Action Risk Assessment Spreadsheet Tool and guidance document. Role includes providing expert advice on the development of the risk assessment model, contaminated sites investigation related to support risk assessment, vapour intrusion, background and detection limit issues in the context of setting risk-based standards. Responsibilities also include third party peer reviews of risk assessments conducted by other consultants for compliance with guidance and an evaluation of technical quality, as well as conducting workshops to teach participants about risk assessment and how to use the model. (2016 – ongoing).

Development of Soil Quality Guidelines for PFOS and PFOA,
Canada

Senior toxicologist and reviewer responsible for an update of the Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines, Soil Screening Values and the Federal Contaminated Sites Action Plan (FCSAP) Factsheets for perfluorooctoane sulphonate (PFOS) and perfluorooctanoic acid (PFOA). The guidelines were updated to be consistent with Health Canada's Drinking Water Quality Guideline (DWQG) technical documents and based on the most up-to-date science. A peer review of and update of the draft Scientific Supporting Documents created by Health Canada for PFOS and PFOA was conducted, the soil quality guidelines updated and the results were then summarized in the FCSAP factsheet documents. (2015 – 2016).

Update of the National Contaminated Sites (NCS) Classification System,
Canada

Project Manager and Principle Scientist involved in updating the existing NCS classification system which is used to rank federal sites. The NCS is used to determine priority of federal sites for further investigation and standardize prioritization for funding. The system is based on (1) the assessment of environmental fate and transport of chemicals, (2) hazard ranking of the chemicals, and (3) assessment of site characteristics that would increase risk of chemical to the environment or human health. Primary changes to the NCS included the reduction of ambiguity to assist in the standardization of responses, improved clarity, and incorporation of additional technical scoring such as northern specific issues. The updated NCS underwent trial testing using several case studies with a variety of datasets before use for prioritization of federal sites nationally. (2016 – 2017).

Update of Environmental, Health and Safety Guidelines for Base Metals Smelting and Refining
Washington, DC

Project Manager involved in updating the International Finance Corporations (IFC) Environmental Health and Safety Standards (EHS) for Base Metals Smelting and Refining (e.g., aluminum, copper, lead, nickel, and zinc). The EHS guidelines are used internationally by project managers and financiers to minimize and/or control EHS impacts during construction, operation, and decommissioning of base metals smelters and refineries. The role involved project management, liaising with IFC, providing direction to and coordinating inputs from several industry experts, data analysis, and writing the guidance document. (2010).

Risk Management of Coarse Particulate Matter in Canada
Canada

Project Manager and senior risk assessor responsible for risk management assessment for coarse particulate matter (PM2.5-10) in Canada completed for Health Canada. The project included the (1) review and compilation of information related to primary emission sources of coarse particulate matter in Canada focussing on industrial/urban and rural environments, (2) identification and compilation of risk management measures for coarse particulate matter from or proposed in other regulatory jurisdictions including interviews of regulators and other experts specializing in risk management of coarse PM, (3) identification of the major sources of coarse particulate matter in Canada and possible risk management measures that would address these major sources, and (4) prioritization of the risk management measures by identifying positive and negative effects associated with these measures. (2010 – 2011).

Development of Soil and Soil Vapour Standards for High Density Residential Land Use
BC

Project Manager for the development of soil and soil vapour standards for high density residential land use for BC Ministry of Environment and the Science Advisory Board for Contaminated Sites in BC (SAB). Responsibilities included managing and coordinating input from members of the SAB to derive soil and soil vapour standards, including organizing a workshop for peer review of the derived standards. (2010 – 2011).

Soil Vapour Intrusion Model and Updated Soil Vapour Characterization Guidance
British Columbia, BC

Project Manager for the development of a soil vapour intrusion model which provides chemical-specific attenuation factors and also updated guidance on soil vapour intrusion for the Science Advisory Board for Contaminated Sites in BC. A chemical-specific vapour intrusion model was developed which included the adaptation of an existing spreadsheet model, which implements partitioning calculations from soil and groundwater to soil vapour and models vapour intrusion according to the Johnson and Ettinger algorithm. The Johnson and Ettinger defaults are adapted from those adopted by Health Canada for their vapour intrusion guidance and incorporated in the BC MOE Technical Guidance for attenuation factors. In addition to the model development, the project included the update of a 2006 soil vapour characterization guidance document previously prepared by Golder for the SAB and the incorporation of field research on soil properties and moisture content in vapour attenuation modelling. (2009 – 2011).

PROJECT EXPERIENCE – THIRD-PARTY PEER REVIEW

Expert Opinion, Health Effects of Pesticides
Ontario

Senior health risk assessor responsible for conducting a review of historic documents and provided a preliminary expert opinion related to potential human health effects associated with DDT, DDE and PAH impacted soils. This work is related to an arbitration involving a pipeline company, the National Energy Board of Canada, and a private landowner using their property for agricultural purposes. (2016).

Peer Review, Human Health Risk Assessment, Expansion of a Coal Terminal
Vancouver, BC

Third party peer review of a human health risk assessment to support an application for an air quality permit related to the expansion of a coal terminal. The third-party peer review was conducted for a law firm and identified areas for discussion or those that were not compatible with provincial or federal requirements. Role also included provision of strategic technical advice to the legal team. (2014).

Peer Review, Human Health Risk Assessment, Fraser Surrey Docks
Surrey, BC

Senior human health risk assessor responsible for a third-party peer review of a human health risk assessment (including an air quality assessment) related to a proposed direct transfer coal facility from an expanded facility at Fraser Surrey Docks. The third-party peer review was conducted for the Vancouver Fraser Port Authority. The review was conducted twice; once for the initial project design and submission and a second time for a modified project design. (2013 – 2015).

Peer Review of Air Quality Standards for Benzene
Alberta

Senior Toxicologist responsible for peer review of the toxicological basis of the air quality standards developed for benzene by the Ontario Ministry of Environment and the Texas Environmental Quality Commission. The peer review was conducted on behalf of the Canadian Association of Petroleum Producers and the purpose of the review was to provide a recommendation as to which of the air quality criteria were most suited to use in Alberta based on the toxicological assumptions used to derive the air quality criteria. (2012).

Peer Review of Toxicity Reference Values for Petroleum Hydrocarbons Canada	Senior Toxicologist responsible for peer review of proposed toxicological reference values for Canada Wide Standard Petroleum Hydrocarbon Fraction F1 on behalf of Health Canada. The toxicity reference values had been derived by another consultant to Health Canada and the project consisted of a literature review to confirm whether the data used in the derivation were current and an assessment of the toxicological basis of the toxicity reference values and the subsequent derivation of a soil quality guideline. (2011).
Peer Review of Environmental Soil Quality Guideline for Zinc Canada	Senior Toxicologist responsible for peer review of the proposed human health component of the environmental soil quality guideline for zinc as developed by Health Canada. The project involved a literature review to determine whether the information used in the soil quality derivation was current and critical assessment of the toxicological basis of and subsequent derivation of the environmental soil quality guideline. (2010 – 2011).
Peer Review of Human Health Risk Assessment for a Natural Gas Pipeline BC	Senior Toxicologist responsible for the peer review of a human health risk assessment conducted to support an environmental impact assessment for a natural gas pipeline in BC and Alberta. Acted as an expert witness on behalf of a First Nations group and provided expert advice at a National Energy Board Hearing. The primary contaminant of concern was hydrogen sulphide which had the potential to impact health of trappers and residents living in the vicinity of the pipeline in the case of a pipeline rupture. The peer review was conducted in accordance with the protocol provided by the Alberta Energy Board. (2008).
Review of Site-Specific Risk Assessments Ontario	Senior Regulatory Toxicologist responsible for reviewing site-specific risk assessments and remediation criteria to ensure compliance with the Guideline for Use at Contaminated Sites for the Ontario Ministry of the Environment. (1999 – 2001).
Peer Review of a Toxicity Reference Value for Salt BC	Senior Toxicologist responsible for the peer review of a toxicity reference value derivation for salt and provided advice to the British Columbia Science Advisory Board. The toxicity reference value had been derived for Health Canada and would potentially be used to derive soil and groundwater standards for use at Contaminated Sites in British Columbia. The review included assessing the technical validity of the approach utilized and examining the selection of the key toxicological studies as well as providing a comparison/contrast with the proposed method of addressing salt by the BC MOE and practical considerations with regards to implementation of standards derived using the proposed toxicity reference value. (2008).
Peer Review of BC Human Health Soil Quality Matrix Guidelines BC	Senior Toxicologist responsible for the peer review of a proposed update to the BC Contaminated Sites Task Group for the derivation of human health soil quality matrix standards for contaminated sites. The peer review was conducted on behalf of the BC Science Advisory Board. The peer review included a technical assessment of the approach and exposure parameters utilized. (2008).

Peer Review of Vapour Risk Assessment
BC

Senior Toxicologist responsible for a third-party peer review of human health and ecological risk assessment on behalf of a property developer in order to assist them with providing advice as to whether the site is suitable for a residential development. Several data gaps in the site characterization were identified and recommendations included some additional site investigation work and updating the risk assessment with the measurement of soil vapours after pursuing additional source removal. (2008).

Peer Review of Four Site-Specific Risk Assessments for Off-Site Impacts
Ontario

Senior Toxicologist responsible for the peer review of four site-specific risk assessments that had been conducted to determine the potential human and ecological risks originating from an industrial facility. Soil and groundwater remedial criteria were also reviewed. The primary contaminants of concern were elevated levels of chlorinated solvents such (such as trichloroethene, vinyl chloride and cis-1,2-dichloroethene) which have migrated in groundwater to a residential neighbourhood. The peer review was conducted in accordance with the protocol outline in the "Guidance on Site-Specific Risk Assessment for Use at Contaminated Sites in Ontario". (2001).

TRAINING

Mid-America Toxicology Course
Kansas City, Missouri, April 2012

Probabilistic Risk Assessment
Harvard School of Public Health, Cambridge, Massachusetts, 2000

Expert Witness Training
Ontario Ministry of the Environment, Toronto, Ontario, 2000

Crystal Ball – Probabilistic Risk Assessment Software Training
Toronto, Ontario, 1999

Human Health and Ecological Risk Assessment
SENES Consultants and Oak Ridge National Laboratories, Vancouver, British Columbia, 1994

PROFESSIONAL AFFILIATIONS

Society of Toxicology

American Chemical Society

PUBLICATIONS AND PRESENTATIONS

Wagenaar, A. Stramer, Y and Haim, A. 2018. Revised Methodology to Perform Risk Assessments in Israel and International Perspectives. Israeli National Conference on Contaminated Soil and Groundwater. October 9, 2018. Tel Aviv, Israel.

Koppe, B., Wagenaar, A.K., Bresee, K., Meloche, L.M., Daly, C. 2018. Human health and ecological risk assessment of various reclaimed substrate materials and landform types at oil sands sites. Oil Sands Innovation Summit 2018. June 7 and 8, 2018, Calgary, Alberta.

Wagenaar, A.K., Koppe, B., Meloche, L.M., McFarland, C. 2017. Human Health Risk Assessment of Various Reclaimed Substrate Materials and Landform Types at Oil

Sands Facilities. 2017 Society of Toxicology Annual Meeting, March 15, 2017, Baltimore, Maryland, USA.

Wagenaar, A.K., Koppe, B., Meloche, L.M., McFarland, C. 2017. Human Health Risk Assessment of Various Reclaimed Substrate Materials and Landform Types at Oil Sands Facilities. Oil Sands Innovation Conference, March 21 and 22, Calgary, Alberta.

Koppe, B., Bresee, K., Meloche, L.M., Wagenaar, A.K. 2017. Ecological Risk Assessment of Oil Sands Reclamation and Closure Landscapes. Remediation Technologies Symposium (RemTech). October 11, 2017. Banff, AB.

Kempenaar, Lisa, Bjorn Weeks and Audrey Wagenaar. 2017. Challenges in Cover Design, Reclamation and Revegetation of Terrestrial Tailings in the Athabasca Oil Sands Region. Tailings and Mine Waste, November. Banff, Canada.

“New Environmental Health and Safety Guidelines for Smelting and Refining”. Audrey Wagenaar and Rick Hilton. Environmental Mining Journal. October 2008.

“Novel Mono-and bis-Metallated Complexes of Dialkyldiaziridines; X-ray Diffraction Structures of Three Platinum Complexes”. Adeyemi Adedapo, Anthony G. Avent, Duncan Carmichael, Penny A. Chaloner, Peter B. Hitchcock and Audrey Wagenaar. J. Chem. Soc., Chem. Commun., 1993, 186.

“Novel Diaziridine Complexes of Platinum and Palladium”. P. Chaloner, A. Adepo, P. Hitchcock, and A. Wagenaar, Abstracts of the Papers of the American Chemical Society, April 1992.

Dust Nuisance	Effects on Health due to Water Quality (Local Groundwater Supply/Wells)
OPP_ALISONANDKENMACKLAN_HEARD	OPP_ALISONANDKENMACKLAN_HEARD
OPP_BEVANEDWARDKILLICK_HEARD	OPP_ANDREWVAUGHANSANDRI_HEARD
OPP_CAROL GREENFIELD_HEARD	OPP_ANOMAGOONERATNE_HEARD
OPP_IANMCKINNEY_HEARD	OPP_BARBARAMARYANNWADE_HEARD
OPP_JUDYANNRAPANA_HEARD	OPP_BENSEDDON-SMITH_HEARD
OPP_MARKANTHONYCOULBECK_HEARD	OPP_BEVANEDWARDKILLICK_HEARD
OPP_MARTINFLANAGAN_HEARD	OPP_CAROL GREENFIELD_HEARD
OPP_MAUREENELIZABETHHOLMES_HEARD - closest house	OPP_EDWINJONES_HEARD
OPP_PAULODONNELL_HEARD	OPP_JIMANDNOELEENLAPSLEY_HEARD
OPP_PETERDALTON_HEARD	OPP_KARENKEELAN_HEARD
OPP_ROWLANDNORMANCHARLESBROWN_HEARD	OPP_KJCALDER_HEARD
OPP_RUTHANDKEITHACOURT_HEARD	OPP_MARTINFLANAGAN_HEARD
OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD	OPP_MARTINREXANDSHIRLEYLYNCUMMINGS_HEARD
OPP_SCOTTANDTRACEYBENTLEY_HEARD	OPP_MAUREENELIZABETHHOLMES_HEARD - closest house
OPP_SHEILAFRANCESNOKES_HEARD	OPP_NEILJAMESHAMILTON_HEARD
OPP_SOUTHERNWOODSNURSERYLIMITED_HEARD	OPP_NEWZEALANDMOTORCARAVANASSOCIATIONINC_HEARD
OPP_STEPHENTALBOT_HEARD	OPP_PAULODONNELL_HEARD
OPP_TEMPLETONPRIMARYSCHOOLBOARDOFTRUSTEES_NOT	OPP_PETERDALTON_HEARD
OPP_TEMPLETONRESIDENTSASSOCIATION_HEARD	OPP_RAYLENEADLER_HEARD
	OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD
	OPP_SCOTTANDTRACEYBENTLEY_HEARD
	OPP_SHEILAFRANCESNOKES_HEARD
	OPP_SOUTHERNWOODSNURSERYLIMITED_HEARD
	OPP_TEMPLETONPRIMARYSCHOOLBOARDOFTRUSTEES_NOT
	OPP_TEMPLETONRESIDENTSASSOCIATION_HEARD
	OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD
	OPP_WAYNEBOYD_HEARD
	OPP_WAYNETEWNION_HEARD

Effects on Plants and Produce due to Dust (Photosynthesis)	Effects on Wildlife and/or Livestock Health due to Dust Emissions
OPP_BRUCEANDVALERIERENWICK_HEARD	OPP_BENSEDDON-SMITH_HEARD
OPP_GRANTMCEWAN_HEARD	OPP_BRUCEANDVALERIERENWICK_HEARD
OPP_JENNIFERANNEBUTT_HEARD	OPP_JEANSALISBURY_HEARD
OPP_JENNIFERROSS_HEARD	OPP_JENNIFERANNEBUTT_HEARD
OPP_KARENKEELAN_HEARD	OPP_JENNIFERROSS_HEARD
OPP_MARTINREXANDSHIRLEYLYNCUMMINGS_HEARD	OPP_JIMANDNOELEENLAPSLEY_HEARD
OPP_SOUTHERNWOODSNURSERYLIMITED_HEARD	OPP_JOANNASUNDSRUM_HEARD
	OPP_MARTINREXANDSHIRLEYLYNCUMMINGS_HEARD

Effects on Plant and/or Wildlife Health due to Impacts on Water Quality	Health Effects due to Dust Emissions (Crystalline Silica)
OPP_ALISONANDKENMACKLAN_HEARD OPP_BARBARAMARYANNWADE_HEARD	OPP_ANDREWVAUGHANSANDRI_HEARD OPP_BENSEDDON-SMITH_HEARD OPP_BEVANEDWARDKILLICK_HEARD OPP_EDWINJONES_HEARD OPP_IANMCKINNEY_HEARD OPP_JENNIFERROSS_HEARD OPP_JIMANDNOELEENLAPSLEY_HEARD OPP_KARENKEELAN_HEARD OPP_KELVINDUNCAN_HEARD OPP_KJCALDER_HEARD OPP_LAURENCE GREENFIELD_HEARD OPP_MITCHELLRAINBOW_HEARD OPP_NEILJAMESHAMILTON_HEARD OPP_NEWZEALANDMOTORCARAVANASSOCIATIONINC_HEARD OPP_PAULODONNELL_HEARD OPP_TEMPLETONPRIMARYSCHOOLBOARDOFTRUSTEES_NOT OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD OPP_WAYNEBOYD_HEARD OPP_WAYNETEWNION_HEARD XXX_CANTERBURYDISTRICTHEALTHBOARD_HEARD

Health Effects due to Dust Emissions (Children and/or Elderly)	Health Effects due to Dust Emissions to Air (Pre-existing Asthma, other Respiratory Conditions, or other Health Issues)
OPP_ANOMAGOONERATNE_HEARD OPP_BENSEDDON-SMITH_HEARD OPP_BEVANEDWARDKILLICK_HEARD OPP_KALYANIPADUKKAGE_HEARD OPP_KALYANIWIAYAWARDANAPADUKKAGE_HEARD OPP_KARENKEELAN_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_SCOTTANDTRACEYBENTLEY_HEARD OPP_SHEILAFRANCESNOKES_HEARD OPP_TEMPLETONPRIMARYSCHOOLBOARDOFTRUSTEES_NOT	OPP_ALISONANDKENMACKLAN_HEARD OPP_BARBARAMARYANNWADE_HEARD OPP_BRACKENRIDGESERVICESLIMITED_HEARD OPP_GRAEMELINDSAYBRYANT_HEARD OPP_GRANTMCEWAN_HEARD OPP_JEANSALISBURY_HEARD OPP_JENNIFERANNEBUTT_HEARD OPP_JIMANDNOELEENLAPSLEY_HEARD OPP_JOANNASUNDSRUM_HEARD OPP_MARTINREXANDSHIRLEYLYNCUMMINGS_HEARD OPP_MELISSAHIMIN_HEARD OPP_MITCHELLRAINBOW_HEARD OPP_ROYMALCOLMGEARRY-DENISEGILLIANGEARRY_HEARD OPP_RUTHANDKEITHACOURT_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_SCOTTANDTRACEYBENTLEY_HEARD OPP_SHEILAFRANCESNOKES_HEARD OPP_STEPHENTALBOT_HEARD OPP_TEMPLETONRESIDENTSASSOCIATION_HEARD

Health Effects due to Dust Emissions (Particulate Matter)	Health Effects due to Dust Emissions to Air (General)
NEITHER_MINISTRYOFEDUCATION_HEARD OPP_MARTINREXANDSHIRLEYLYNCUMMINGS_HEARD OPP_NEWZEALANDMOTORCARAVANASSOCIATIONINC_HEARD OPP_PAULODONNELL_HEARD OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD OPP_WAYNETEWNION_HEARD OPP_YOLANDEHOWELL_HEARD XXX_CANTERBURYDISTRICTHEALTHBOARD_HEARD	OPP_ALISONANDKENMACKLAN_HEARD OPP_ANDREWVAUGHANSANDRI_HEARD OPP_BARBARAMARYANNWADE_HEARD OPP_BRACKENRIDGESERVICESLIMITED_HEARD OPP_BRUCEANDVALERIERENWICK_HEARD OPP_DAVIDMURRAYGIBB_HEARD OPP_GRAEMELINDSAYBRYANT_HEARD OPP_JIMANDNOELEENLAPSLEY_HEARD OPP_JUDYANNRAPANA_HEARD OPP_LAURENCE GREENFIELD_HEARD OPP_MARKANTHONYCOULBECK_HEARD OPP_MARTINFLANAGAN_HEARD OPP_MAUREENELIZABETHHOLMES_HEARD - closest house OPP_MELISSAHIMIN_HEARD OPP_PETERDALTON_HEARD OPP_RAYLENEADLER_HEARD OPP_ROWLANDNORMANCHARLESBROWN_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_STEPHENTALBOT_HEARD OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD OPP_YOLANDEHOWELL_HEARD
Health Effects Produce Contamination (Dust)	**Increased Noise (General)**
OPP_KARENKEELAN_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_SHEILAFRANCESNOKES_HEARD OPP_SOUTHERNWOODSNURSERYLIMITED_HEARD	NEITHER_MINISTRYOFEDUCATION_HEARD OPP_ALISONANDKENMACKLAN_HEARD OPP_ANDREWVAUGHANSANDRI_HEARD OPP_BARBARAMARYANNWADE_HEARD OPP_BEVANEDWARDKILLICK_HEARD OPP_BRACKENRIDGESERVICESLIMITED_HEARD OPP_GRAEMELINDSAYBRYANT_HEARD OPP_IANMCKINNEY_HEARD OPP_JENNIFERROSS_HEARD OPP_JIMANDNOELEENLAPSLEY_HEARD OPP_KALYANIPADUKKAGE_HEARD OPP_KALYANIWIAYAWARDANAPADUKKAGE_HEARD OPP_KARENKEELAN_HEARD OPP_MARTINFLANAGAN_HEARD OPP_PAMELAANNEKENYON_HEARD OPP_RAYLENEADLER_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_SCOTTANDTRACEYBENTLEY_HEARD OPP_STEPHENTALBOT_HEARD OPP_TEMPLETONRESIDENTSASSOCIATION_HEARD OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD OPP_YOLANDEHOWELL_HEARD XXX_CANTERBURYDISTRICTHEALTHBOARD_HEARD

Mental Health and Community Health and Wellbeing	Other	Visual Amenity
OPP_ANOMAGOONERATNE_HEARD OPP_BARBARAMARYANNWADE_HEARD OPP_BEVANEDWARDKILLICK_HEARD OPP_JENNIFERROSS_HEARD OPP_JIMANDNOELEENLAPSLEY_HEARD OPP_KALYANIPADUKKAGE_HEARD OPP_KALYANIWIAYAWARDANAPADUKKAGE_HEARD OPP_KARENKEELAN_HEARD OPP_MARTINFLANAGAN_HEARD OPP_MAUREENELIZABETHHOLMES_HEARD - closest house OPP_MELISSAHIMIN_HEARD OPP_NEWZEALANDMOTORCARAVANASSOCIATIONINC_HEARD OPP_PAMELAANNEKENYON_HEARD OPP_RAYLENEADLER_HEARD OPP_SAMADHIBUDDHISTTRUSTOFNEWZEALAND_HEARD OPP_SCOTTANDTRACEYBENTLEY_HEARD OPP_SOUTHERNWOODSNURSERYLIMITED_HEARD OPP_STEPHENTALBOT_HEARD OPP_TEMPLETONRESIDENTSASSOCIATION_HEARD OPP_WAIPUNA-HALSWELL-HORNBY-RICCARTONCOMMUNITYBOARD_HEARD OPP_YOLANDEHOWELL_HEARD XXX_CANTERBURYDISTRICTHEALTHBOARD_HEARD	OPP_KELVINDUNCAN_HEARD OPP_LAURENCE GREENFIELD_HEARD OPP_SCOTTANDTRACEYBENTLEY_HEARD	OPP_ALISONANDKENMACKLAN_HEARD OPP_BEVANEDWARDKILLICK_HEARD OPP_IANMCKINNEY_HEARD

Notes:

Other category includes concerns about radon, chemical dust suppressants, and dust triggering allergies in children