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From:

Dr. Jennifer Kirk, Ph.D., QP(RA)  
Discipline Lead, Risk Assessment

Date:  
May 26, 2017

Project No.:  
351312-000

Subject:  
Human Health Review of Walker Environmental Group Southwestern Landfill  
Environmental Assessment Submissions

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## 1.0 Introduction

Arcadis has been retained by the Town of Ingersoll as experts on Human Health Risk Assessment in connection with the Southwestern Landfill Proposal (the Walker Environmental Group (WEG) landfill or waste disposal site).<sup>1</sup> Specifically, I have been retained to provide comments on reports prepared by or for WEG under the ongoing *Environmental Assessment Act* approval process for the WEG landfill.

In preparation of this memorandum, I have reviewed the following WEG document with consideration for human health impacts. I have limited my detailed review to:

- Human Health Risk Assessment and Supplementary Health Review Work Plan dated March 2017, prepared by Intrinsic.

The following additional documents were also reviewed in conjunction with the document above to provide additional context to the evaluation of human health:

- Walker Environmental Group Inc., Southwestern Landfill Proposal: Approved Amended Terms of Reference, May 10, 2016.

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<sup>1</sup> The Curriculum Vitae of the author of this report is attached as Appendix A.

- Revised Draft: Air Quality Assessment Work Plan, Dated March 24, 2017.
- Walker Environmental Group: Southwestern Landfill Proposal Environmental Assessment: Visual Impact Assessment Work Plan, Dated January 2017 (revised March 2017).
- Walker Environmental Group: Work Plan: Cumulative Effects Assessment in the Southwestern Landfill EA. Draft for Discussion dated January 12, 2017.
- Walker Environmental Group: Southwestern Landfill Proposal – Environmental Assessment Social Assessment Work Plan, prepared by SLR Global Environmental Solutions, dated January 2017.
- Walker Environmental Group: Southwestern Landfill Proposal Environmental Assessment Groundwater/Surface Water Assessment Work Plan, prepared by Golder Associates Ltd, dated February 8, 2017.
- Walker Environmental Group: Southwestern Landfill Proposal Environmental Assessment Agricultural Assessment Work Plan, prepared by Conna Consulting Inc, dated January 2017.
- Walker Environmental Group: Southwestern Landfill Proposal Environmental Assessment: Revised Draft Noise/Vibration Assessment Work Plan, prepared by RWDI Air Inc. dated March 27, 2017.

## **2.0 Background**

I have limited my review to the potential impacts to human health from the proposed work plans for the Southwestern Landfill. The purpose of this review was to determine whether the proposed work plans are adequate to consider the potential effects to human health and whether the proposed Human Health Workplan is consistent with the approved Environmental Assessment (EA) Terms of Reference (ToR) as approved by the Minister of the Environment and Climate Change on March 17, 2016, and amendments to the Work Plan arising from comments from various stakeholders.

This review is primarily focused on the assessment of human health. Other technical reviews or work plans specific to issues of ecology, hydrogeology, air quality, noise, engineering designed and geotechnical engineering are being considered under separate cover.

## **3.0 General Observations and Comments**

For the Health Assessment, Walker has proposed or has been required to include the completion of both a human health risk assessment (HHRA) and a Supplementary Health Review (SHR). A HHRA examines the potential health effects from chemical exposures where a SHR includes not only chemical exposures but also the health impacts originating from social and economic effects of the proposed landfill and comprises a more holistic view of health.

The proposed human health risk assessment is in line with a typical risk assessment completed to address exposure to parameters in the environment. There are some additional considerations that have been proposed below, however, the general approach for this type of assessment is acceptable as proposed. The objectives of a human health risk assessment are to evaluate whether adverse health effects resulting from exposures to chemicals (whether measured or predicted) are likely to occur and to provide an estimate of the exposure and relative toxicity that could be expected.

What does not appear to be adequately addressed are the health impacts resulting from the proposed project that are not related directly to chemical exposure. A screening level SHR has been added to the ToR; however, from the information provided in the work program it is not possible to evaluate whether the

SHR will be of sufficient depth to adequately address the concerns of the community and stakeholders, or to provide meaningful information into the process. The objective of the SHR should be to improve the knowledge of the potential impacts and to propose adjustments to mitigate the negative and maximize the positive impacts (National Collaborating Centre for Healthy Public Policy, 2010). While the work plan discusses the steps involved in the SHR and the health determinants, it does not adequately provide information on how the results of each of the health determinants are to be evaluated, related back to impacts to human health or how the results will be incorporated into operation and post-closure of the landfill. The steps and the process of the SHR were outlined but it was not clear how the results of the process would be evaluated with respect to impacts to human health.

#### **4.0 Work Plan Reviews with Human Health Perspective**

##### **4.1 Human Health Risk Assessment and Supplementary Health Review Work Plan**

###### **4.1.1 General Observations and Comments: Human Health Risk Assessment and Supplementary Health Review Work Plan**

The proposed HHRA is following a format that is typical for HHRAs for contaminated sites; however, it does not address the concerns of the public. The main omissions may be covered in the SHR, but it appears that this SHR will be preliminary, hence the word “screening” and will not be comprehensive enough to address the community’s concerns. From my perspective, major shortcomings are:

1. Addressing the potential for engineering designs to fail and the impacts to groundwater and surface water.
2. How the quality of the Thames River for human use (i.e., recreational use and consumption of fish) is being (or is not being) addressed by WEG.
3. Consideration of contaminants of emerging concerns (i.e., PFAS), how these are being addressed.
4. Acknowledgement and consideration of the effects of stress on the residents/communities and how stress affects human health.
5. Consideration of collection of rainwater for irrigation.
6. Consideration of effects on crop species (HHRA indicates livestock, not crops) for both consumption and yield for cash crops.

It appears that the SHR is focusing primarily on dust and soil impacts, with some consideration for potable groundwater. However, there are other exposure pathways, such as vapour intrusion, significant impacts to potable water supplies (municipal and private), impacts to irrigation and livestock water, and extensive impacts to surface water, that have not been considered in the event that the landfill design and treatment system lose efficacy or there is a failure. In addition, chemical concentrations would be expected to be higher than those predicted if loss in efficacy or design failure were to occur.

###### **4.1.2 Specific Observations and Comments: Human Health Risk Assessment and Supplementary Health Review Work Plan**

1. Why is the potential impacts on home garden or the agricultural food chain from vehicle deposition not considered?
2. Are there people on the haul route that capture rain water for irrigation or livestock water; deposition onto roofs and followed by precipitation could impact the water quality. Is this being considered?

3. Section 5: The study areas are very loosely defined. At what point will these be determined so that the appropriateness of the study areas and receptors can be evaluated?
4. Section 6: Effects due to contact with contaminated surface water and groundwater: Is the consumption of fish from the Thames River being considered? Is dermal contact from surface water being considered? Section 5 indicates that impacts to groundwater and surface water would be expected. How will these be evaluated within the HHRA and/or SHR?
5. Section 6: It is not clear if the proposed indicator of predicted air concentrations (for emissions and for fine particulate) are predicted based on landfill activity only or on the incremental increase resulting from the landfill. Will the indicators consider the additive effects of the landfill to the existing quarry and other local background sources?
6. Section 6: The proposed provincial and federal groundwater standards to be relied upon should have been provided to allow for appropriate comparison with the measured and modeled predicted contaminant of potential concern (COPC) concentrations.
7. It is not clear how COPCs in surface water will be evaluated within the HHRA as only groundwater standards/guidelines have been mentioned.
8. Section 7.3: It is not clear how climate change is being considered in the HHRA. Please clarify.
9. Section 8.0: No information was provided regarding the data relied upon or consideration for background, therefore an evaluation of the data being used could not be completed.
10. Section 9.1.3: The receptors and exposure pathways have not yet been identified. The Work Plan should have included the receptors and the exposure pathways that the receptors could be exposed to allow evaluation of the comprehensiveness of the study. Since only a list of possible exposure pathways were provided, comments are limited to this and have not been fully evaluated:
  - a. Will consideration of dermal contact from groundwater and surface water be considered? Residual impacts in treated leachate would be expected.
  - b. Will consideration of ingestion of local crops be considered?
  - c. Will consideration of consumption of fish be considered?
  - d. Will consideration of incidental ingestion and dermal contact of surface water and groundwater be considered?
11. Figure 9-3 should also show the potential for landfill leachate to impact groundwater and discharge to surface water. The conceptual site model does not show the source of impacts and the potential for distribution within the environment.
12. Section 9.2, p. 15: The level of effort should be the same to assess any COPC originating (or predicted to originate) from the landfill. What process is proposed to choose the smaller number of chemicals on which to focus?
13. Section 9.2.2: The standards/guidelines proposed in this Section may not be protective of all operable exposure pathways. For example, how will COPCs relevant for the consumption of fish and dermal contact of surface water be identified using MOECC groundwater standards and Canadian Drinking water guidelines?
14. Section 9.2.3: It appears that the HHRA approach is only considering COPCs through deposition from air; however, the potential for leachate to impact groundwater if the design fails and for groundwater and/or leachate to reach the Thames River does not appear to be considered. This is particularly important given the Arcadis comments on surface and groundwater, relating to the greater potential at this proposed landfill for the sudden failure of the liner and release of contaminants and gas to the groundwater. The HHRA should also account for the potential for exposure to occur via these exposure pathways.

15. Section 9.2.4: How will COPCs be evaluated where an appropriate health-based regulatory air standard or toxicity value CANNOT be identified?
16. Section 9.2.4: Any COPC that meets the requirements of persistent or bioaccumulative substance that could be associated with the landfill should be retained and assessed for multi-media exposure, not only those that show an increasing trend or that are already present.
17. Section 9.2.4: How will contaminants of emerging concern be addressed in the HHRA (for example PFAS are associated with landfill leachates, standards do not currently exist at the Provincial level and they typically are not part of a standard routine monitoring)? Please provide an indication of how the HHRA assessment will address contaminants of emerging concern and failure or under performance of the design of the landfill.
18. Section 9.2.4: Please clarify how parameters identified in groundwater and/or surface water that have not been flagged previously for the multimedia assessment will be addressed.
19. Section 9.3.1: Will the updated Compendium of Canadian Human Exposure Factors for Risk Assessment be considered?
20. Section 9.3.1: Since only "potential" human exposure scenarios were provided and not the actual ones that will be considered in the HHRA, a thorough review of the exposure scenarios could not be completed at this time.
21. Section 11.2: Scoping of the Health Assessment:
  - a. How will stress from negative impacts of the project be considered with respect to human health effects of the project?
  - b. While the determinants are listed, it is not clear the approach proposed to be taken to address each of the determinants. Therefore, detailed comments on the work plan for the SHR could not be made at this time.
22. Appendix A: Would impact to surface water and groundwater not be considered for the wider area? Would impacts to groundwater and surface water also not impact ecology, social and land use (future)?
23. Appendix A: Would disease transmission via insects and vermin not also be a concern for human health? Please clarify.
24. Appendix A: Stress is an adverse health effect, is there any reason that criteria that could result in stress are not assessed in the SHR? Example: displacement of residents from houses, disruption to use and enjoyment of public facilities, disruption of local traffic networks etc.

#### **4.2 Revised Draft Air Quality Assessment Work Plan, dated March 24, 2017**

The Air Quality Assessment Work Plan was reviewed from the perspective of identifying human health and not with the intent of reviewing the technical aspects of the Air Quality Assessment Work Plan.

##### **4.2.1 General Observations and Comments: Revised Draft Air Quality Assessment Work Plan, dated March 24, 2017**

The air quality assessment was reviewed with the context of addressing potential human health risks and not for the technical approach of the assessment. As such, only comments pertaining to human health have been considered here.

The haul route traffic criteria listed a number of parameters to be included in the baseline and future concentrations assessment. It does not appear that the list of parameters is comprehensive and should be expanded.

Once the selection of receptor locations is provided, it is suggested these are reviewed prior to completion of the studies to evaluate the appropriateness and representativeness of receptors chosen.

#### **4.2.2 Specific Observations and Comments. Revised Draft: Air Quality Assessment Work Plan, dated March 24, 2017**

1. Section 5.2.1: According to the HHRA, the HHRA is identifying COPCs based on the results of other studies, such as the Air Quality study. This section suggests that based on the results of the HHRA, additional parameters may be considered in the Air Quality study, this appears to be a circular argument. The Air Quality study should identify any and all COPCs associated with vehicular exhaust and include these in their modeling to be incorporated into the HHRA.
2. Section 5.2.1: It is not clear how the list of parameters were identified for vehicle exhaust. Is there a reason that other constituents of automobile exhaust, such as carbon dioxide, TSP, benzene, acrolein, acetaldehyde, 1,3-butadiene and formaldehyde were not included?
3. Table 6.2.2.1: 1,1,2,2-tetrachloroethane does not have criteria, how will this be evaluated within the study?
4. Section 5.3: The consideration of an objectionable level for odour of 3 to 5 OU was stated, despite the recommendation by the MOECC of 1 OU. Since complaints at other landfills would be dependent on any number of factors, the assessment should support the rationale that 3 to 5 OU would be appropriate for this landfill given site specific considerations (distance to nearest receptor etc.).
5. Section 7.3.1: Since there appears to be mistrust from the community with respect to the historical monitoring data, it would be advisable for RWDI to complete additional monitoring around the existing Carmeuse site to validate the historical data.
6. Section 7.3.2: To clarify, is it a total of ten receptor locations for both study areas or 10 receptor locations for each study area (dust dispersion).
7. The modeling for odour and dust indicate a maximum of ten receptors to be modelled. There is no indication of what the minimum number will be. This should be understood so that it can be confirmed that sufficient modelling is completed to address receptors in the vicinity of the landfill site and the haul route.

#### **4.3 Visual Impact Assessment Work Plan, dated January 2017 (updated March 2017)**

The Visual Impact Assessment Work Plan was reviewed within the context of human health considerations only.

##### **4.3.1 General Comments and Questions: Visual Impact Assessment Work Plan**

It is not clear how the potential effects to human health (annoyance and stress) are being evaluated or addressed if visual impacts are deemed unacceptable. Once further details for the study design are presented, a review of potential impacts to health can be completed.

##### **4.3.2 Specific Comments and Questions: Visual Impact Assessment Work Plan**

1. Section 4.0: Along the Haul Routes: Other work plans have considered properties within a certain distance of the haul route (i.e., 500 m), not just those directly adjacent to these roads. Please explain why the visual assessment is only considering properties directly adjacent to the haul routes?

#### **4.4 Work Plan: Cumulative Effects Assessment in the Southwestern Landfill EA**

Comments made below pertaining to the cumulative effects assessment are related only to the potential for impacts to human health.

##### **4.4.1 General Comments and Questions: Cumulative Effects Assessment in the Southwestern Landfill EA**

Comments pertaining to the assessment of cumulative effects have largely been captured in comments from other reports and therefore will not be repeated herein.

##### **4.4.2 Specific Comments and Questions: Cumulative Effects Assessment in the Southwestern Landfill EA**

1. Section 4: It appears that the cumulative effects of the quarry (and other local activities) and the proposed landfill are being considered through the evaluation of baseline conditions. What is not apparent is if “background” conditions are being considered i.e., those without the quarry and/or landfill.
2. Section 5.2: The report indicates that certain types of impacts will be characterized to the extent possible. The footnote (number 8) indicates that noise, odour and visibility cannot easily be added quantitatively. What is not clear, is if the potential health impacts associated with the above, such as stress caused by the annoyance of noise, odour and visibility will be evaluated within the cumulative effects? Please clarify.

#### **4.5 Southwestern Landfill Proposal – Environmental Assessment Social Assessment Work Plan, prepared by SLR, dated January 2017**

The Social Assessment work plan was reviewed within the context of impacts to human health only.

##### **4.5.1 General Comments and Questions: Social Assessment Work Plan, SLR dated January 2017**

The Social Assessment Work Plan appears to be inclusive of concerns raised by the community. However, it is not clear how the results of the Social Assessment will be incorporated into an overall evaluation of human health. Therefore, evaluation of the appropriateness with respect to human health cannot be made at this time.

##### **4.5.2 Specific Comments and Questions: Social Assessment Work Plan, SLR dated January 2017**

1. Section 7.2.2: What is the expected response rate of the questionnaire? For people in close proximity to the landfill it would be advisable to provide all residents with the questionnaire, not 1 in 4 households as suggested, so that the sample size of returned questionnaires is suitable to draw meaningful information from.

#### **4.6 Southwestern Landfill Proposal Environmental Assessment: Groundwater/Surface Water Assessment Work Plan, prepared by Golder, dated February 8, 2017**

The Groundwater/surface water Assessment Workplan was reviewed for consideration for human health only and is not reviewed for the technical robustness of the work plan.

#### **4.6.1 General Comments and Questions: Groundwater/Surface Water Assessment Work Plan**

From a human health perspective, the information collected from this study will be used to evaluate potential exposures to humans via groundwater and surface water exposure. It is not clear, based on the human health work plan whether recreational use of surface water bodies has been considered including the consumption of fish.

#### **4.6.2 Specific Comments and Questions: Groundwater/Surface Water Assessment Work Plan**

1. Suggest that groundwater quality in private drinking wells or wells used for irrigation within the study area be characterized to establish pre-landfill conditions.

#### **4.7 Southwestern Landfill Proposal Environmental Assessment – Agricultural Assessment Work Plan, prepared by Conna Consulting Inc, dated January 2017**

The Agricultural Assessment work plan was reviewed from the perspective of potential impacts on human health only.

#### **4.7.1 General Comments and Questions: Agricultural Assessment Work Plan**

It appears that the information from the Agricultural Work Plan will be incorporated into the HHRA. It is not clear at this point how the socio/economic factors related to agricultural will be assessed within the SHR. This will be reviewed upon completion of the EA.

#### **4.7.2 Specific Comments and Questions: Agricultural Assessment Work Plan**

1. It doesn't appear that the work plan is considering the potential loss of yield resulting from impacts to air quality or groundwater impacted by the landfill.

#### **4.8 Southwestern Landfill Proposal Environmental Assessment – Revised Draft Noise/Vibration Assessment Work Plan, prepared by RWDI dated March 27, 2017**

The Noise and Vibration Work Plan was reviewed for the potential of impacts to human health and was not a technical review of the work plan.

#### **4.8.1 General Comments and Questions: Noise/Vibration Work Plan**

The results of the Noise/Vibration studies will feed into the SHR to evaluate health impacts. Until such time that specific receptors are identified and an explanation of how the results of the assessments will be interpreted within the SHR, a review with respect to human health cannot be completed.

#### **4.8.2 Specific Comments and Questions: Noise/Vibration Work Plan**

1. It is recommended that a review of the final receptor locations be completed prior to completing the studies to allow input from the community and stakeholders.



## 5.0 Overall Conclusions: Human Health

The impacts to human health, whether directly by impacting drinking water/irrigation supply, dust and air quality, or indirectly by increasing stress (for example through annoying odours, pests, noise and increased traffic), reducing quality of agricultural practices/products or reducing enjoyment and use of the community and recreational areas, are major concerns of the local residents. The proposed HHRA will likely be suitable to address the predicted impacts to human health through exposure from air, groundwater, and surface water. The HHRA does not seem to propose to account for the possibility of failure or under-performance of mitigation measures that could result in higher exposures than predicted. It also does not appear, based on the information provided in the work plan, that the SHR will be of sufficient robustness to address the concerns of the community that are non-chemical related. It is recommended that the work plan be revised to provide a better indication of how the evaluation of health effects will be completed, how the results of the evaluation will be related to impacts to human health and to have Walker provide a commitment to the community that adverse effects to human health will be mitigated.

Based on the information reviewed it is not clear if the potential for failures or under-performance of the design of the landfill has been accounted for in the prediction of effects for human health or on the implications of drinking water supply and agricultural practices in the community. It also does not appear that consideration for exposure through recreational uses of surface water (i.e., swimming, fishing, wading etc.) have been accounted for.

While the proposed Human Health Work Plan provides a good basis for the assessment of health impacts, there are areas needing improvement.



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Dr. Jennifer Kirk, Ph.D., QP(RA)  
Discipline Lead, Risk Assessment

# APPENDIX A

## Curricula Vitae

Jennifer Kirk

## Jennifer Kirk, Ph.D.

Senior Environmental Risk Assessor and Discipline Leader

### Education/Training

B.Sc. (Environmental Toxicology), University of Guelph, Guelph, ON 1998

Ph.D. (Environmental Toxicology and Microbiology), University of Guelph, Guelph, ON 2005

### Professional Designations

Qualified Person in Risk Assessment (QP<sub>RA</sub>), Ontario Ministry of the Environment and Climate Change.

### Continuing Education:

Environmental Investigations of PFAS in Ontario and Fish Consumption Advisories, MOECC Environmental Health Webinar, July 2016.

Practical Approaches to Vapour Intrusion, Laurentian SETAC, 2015

Human Health Risk Assessment PQRA Training, Health Canada 2010

Fundamentals of Toxicology, 2008  
Pharmacology and Toxicology 2008

### Professional Memberships

Society of Risk Analysis (SRA), Associate Member

Society of Environmental Toxicology and Chemistry (SETAC)

Society of Environmental Toxicology and Chemistry (SETAC) Laurentian Chapter

### Years of Experience

Total - 17

With Arcadis - <1

Dr. Kirk holds a Doctor of Philosophy in Environmental Toxicology and Microbiology and a Bachelors of Science (Honours) in Environmental Toxicology, both from the University of Guelph. Dr. Kirk is a Senior Risk Assessment Specialist and Discipline Leader for Human Health and Environmental Risk Assessment. Dr. Kirk has over 18 years of toxicology experience and over 12 years of risk assessment experience.

Dr. Kirk provides senior technical advice, senior review, project management and quality control/quality assurance reviews for a variety of human health and ecological risk assessments for both public and private clients. She has completed all aspects of human and ecological risk assessments under various regulatory frameworks, including the Ontario Ministry of the Environment and Climate Change (MOECC) Regulation 153/04, Health Canada and the Canadian Council of the Ministers of the Environment (CCME), for various land uses such as for brownfields, landfills, and mining sites. She has developed species sensitivity distributions, derived site-specific toxicity benchmarks for ecological receptors, and has conducted bioaccessibility testing to adjust human health exposure to metals through the oral exposure pathway. Dr. Kirk also has research and testing experience with a wide range of contaminants, completes technical reviews of risk assessments and risk management plans and has extensive public speaking experience. Dr. Kirk is a reviewer for the MOECC for risk assessments completed under Ontario Regulation 153/04 and for the journals of Environmental Toxicology and Human and Ecological Risk Assessment.

### RELEVANT PROJECT EXPERIENCE

**Ontario Ministry of the Environment and Climate Change (MOECC) Expert Multidisciplinary Scientific Reviews of Brownfield Risk Assessments.** Dr. Kirk was the Project Manager and Senior Technical Lead for the Ministry of the Environment and Climate Change (MOECC) Vendor of Record project team consisting of human and ecological experts as well as Hydrogeologists, Geologists and Risk Management Engineers. Many scientific and engineering reviews of Risk Assessments (RAs) and Pre-Submission Forms (PSF) have been carried out on behalf of the MOECC, and without exception, the coordinated reviews were delivered on or before due dates, and at or below budget estimates. These reviews consisted of complex RAs and Risk Management Plans (RMP). The reviews are completed to ensure scientific robustness and regulatory compliance. (2009-on-going).

**Site-Specific Human Health and Ecological Risk Assessment – 5 Sites on Alaska Highway.** Client - Public Services and Procurement Canada – Pacific Region (PSPC; formerly Public Works and Government Services Canada). Arcadis was retained to complete supplementary site investigations, ecological evaluations and site-specific human health and ecological risk assessments for 4 sites that are vacant and wildlands and one that is currently used as a parking lot for workers employed in the area and living in the adjacent lodge (Wonowon Lodges), in northeastern British Columbia. Dr. Kirk completed the data-gap analysis and was the senior technical advisor and reviewer for the risk assessments. Risks were assessed from exposure to PAHs, PHCs, BTEX and metals in soil, groundwater and soil vapours to human health and ecological receptors. Risk management measures and administrative controls were recommended to mitigate risks to a sub-surface construction worker on the one site (parking lot), no unacceptable risks to humans or ecological receptors using the remainder of the Sites or adjacent wildlands and waterbodies were identified. NCSC scoring and the Site Closure Tool were updated and completed for Sites.2016.

**Ecological Screening Assessment – CKAM TV Transmitter Site, Upsalquitch Lake, New Brunswick.** Client – Bell Media Inc. (Bell). Arcadis was retained to complete an Ecological Screening Assessment in accordance with the Atlantic Risk Based Corrective

Action (RBCA) Ecological Screening Protocol for Petroleum Impacted Sites in Atlantic Canada. The Site will be decommissioned and allowed to return to a naturalized state. Contaminants of concern identified in soil included cadmium, and PHC F1 to F3. There were no contaminants of concern identified in groundwater. It was determined that exposure pathways were present and that contaminants of concern were present above applicable guidelines, and as a result additional consideration beyond the Screening Assessment protocol was required. Arcadis completed a screening level risk assessment at the Site and concluded that unacceptable risks to PHC impacts were not anticipated. Concentrations of cadmium in soil; however, could be present at levels that could have an adverse impact on avian species at risks that could use the Site (Bicknell's thrush, Canada warbler, eastern Whip-poor-will and wood thrush). As a result a remedial target protective of individual avian species was recommended for the Site. Remediation is occurring concurrently with demolition. (2016).

**Guidance For Investigating the Impacts of Poly- and Perfluoroalkyl Substances (PFAS) (in progress-2016).** Client – Transport Canada. Arcadis was retained to develop a draft guidance document for providing guidance for consultants on how to investigate PFAS impacted sites. Consideration into sampling programs, analytical protocols, and management of impacted sites was covered in the guidance document. The purpose of the guidance document is to ensure that all Transport Canada sites are characterized in a consistent and thorough manner. Dr. Kirk was involved in the senior review of the risk assessment portion of the guidance document.

**Environmental Monitoring Advisory Board (EMAB); Yellowknife, Diavik Mine Site (in progress).** Arcadis was retained by EMAB to provide a technical review of risk based closure criteria developed by Diavik Diamond Mines (2012) Inc. (Diavik). Diavik developed these risk-based closure criteria protective of human health and the environment in response to a directive from Wek'eezhii Land and Water Board as part of their revised closure plan. Dr Kirk was the technical lead in completing this review. The objective of the review was to evaluate the basis, science, assumptions, approach and methodology that was used in the development of the risk-based closure criteria and to evaluate whether stakeholder concerns have been addressed. Stakeholders include, but are not limited to the residents of Yellowknife, the Yellowknives Dene First Nation, the Lutselk'e Dene First Nation, the North Slave Metis Alliance, the Tlicho Government (TG) and Kitikmoet Inuit Association. Risk-based closure criteria were developed following federal guidelines from Health Canada and the Canadian Council of the Ministers of the Environment (2016). Dr. Kirk has also been involved in stakeholder consultation and technical meetings with Diavik Mine. (2016).

**Moggy Environmental; Screening Level Human Health Risk Assessment – Round Lake, Ontario.** The now abandoned Long Lake Gold Mine, which operated intermittently from 1908 to 1939, has been identified as a source of metal impacts, including arsenic, in Long Lake. The abandoned Long Lake Gold Mine has also resulted in environmental impacts to Round Lake through contaminant migration and transport as Round Lake is located immediately southwest and downstream of Long Lake. Round Lake is located within the boundaries of the Atikameksheng Anishnawbek First Nation (AAFN), formerly known as Whitefish Lake First Nation. Arcadis completed a screening level human health risk assessment to evaluate whether a more detailed quantitative human health risk assessment was warranted. Round Lake is readily accessible and has year round use for drinking water, fishing and recreational use by the AAFN and local residents. Contaminants of concern originating from the mine were detected in surface water, sediment and fish tissue. The screening level risk assessment concluded that a more detailed assessment of risks is required or use of the lake for drinking and consumption of fish and waterfowl should be avoided. Dr. Kirk was the technical reviewer for the project. (2016).

**Divestment Strategy and Due Diligence Human Health and Ecological Risk Assessment, Former Pole Dipping Site, Athabasca, AB (on-going). Completed for CN-** Dr. Kirk is a senior reviewer for a due diligence Human Health and Ecological Risk Assessment for a former pole dipping site in Athabasca. The Site is adjacent to the

## Employment History

Arcadis Canada Inc.  
(2016 to Present).  
Senior Environmental  
Risk  
Assessment/Discipline  
Leader for Human and  
Ecological Risk  
Assessment

MTE GlobalTox (2010 to  
2016). GlobalTox  
Division Manager,  
Senior  
Toxicologist/Risk  
Assessor

Stantec Consulting Inc.  
(2006-2010) Risk  
Assessment Team  
Leader, Senior Risk  
Assessor

Golder Associates.  
Human Health and  
Ecological Risk  
Assessor (2005-2006)

Agriculture and Agrifood  
Canada, Post Doctoral  
Fellow (2005)

Independent Consultant  
– Ecological Toxicity  
Testing,  
Phytoremediation  
Feasibility Studies  
(occasional during  
1999-2005).

Athabasca River and Muskeg Creek and divestment of the Site as a nature park to an ENGO is proposed. Contaminants of concern include chlorophenols, PAHs and metals (2016).

**Human Health and Ecological Risk Assessment, 34 Street, Edmonton, AB. Completed for a Development Company** – Dr. Kirk is a senior reviewer and technical advisor for a risk assessment for a private development company of an industrial site in Edmonton which is located in the vicinity of a creek. COCs are PHCs, PAHs, BTEX and metals in soil and groundwater. Risk to aquatic receptors in the creek was addressed.

**Confidential Client: Regulation 153/04 Risk Assessments for Mixed Land Use, Toronto, ON.** Dr. Kirk was the QP<sub>RA</sub> and senior technical lead for two RAs. The former industrial property was to be redeveloped for residential and commercial land uses where the commercial property would remain as the current use of a multi-tenant building. Groundwater on both Sites was impacted with high levels of chlorinated solvents and soil was impacted with metals, polycyclic aromatic hydrocarbons (PAHs), petroleum hydrocarbons (PHCs) and chlorinated solvents. Vapour intrusion and off-site transport of chlorinated solvents were a concern at the Sites. A weight of evidence approach using soil vapour and soil vapour, sub-slab vapour, indoor and outdoor air was used for the residential/commercial Site and the commercial Site, respectively. A reactive barrier wall was proposed to address the off-Site concerns. The RAs have been accepted by the MOECC and the Record of Site Conditions (RSCs) are in the process of being filed (2012-2016).

**City of Kitchener, Transit Hub RA.** Dr. Kirk was the QP<sub>RA</sub> for the Pre-submission Form Submission and the first submission of the RA report for a RA completed under Ontario Regulation 153/04. Multiple contiguous properties historically used for industrial and commercial purposes, including a regional road, were combined into two RA/RSC properties for the purposes of redeveloping the area as a Transit Hub for the new light rail system and for public buses. The redevelopment plans also include a commercial building on ground level and residential units above the commercial plaza. The RA/RSC team worked closely with the City and the designers to allow enough flexibility in the development of the Property Specific Standards and Risk Management Plans so that building designs and site plans were not restricted by the environmental constraints at the Sites. Contaminants of concern include petroleum hydrocarbons, metals, PAHs and chlorinated solvents. In addition, an off-Site naptha plume impacted a large portion of one of the RA areas (2014-2016).

**Region of Durham, Oshawa Harbour Risk Assessment.** Dr. Kirk was the technical advisor for both the human health and ecological portions of the RA and reviewed both the human health and ecological components of the RA completed under Ontario Regulation 153/04. Contaminants of concern on the Site included metals, VOCs, PHCs/BTEX and PAHs in soil, groundwater and sediment. In addition ammonia in groundwater was a concern at the Site. Human exposure to sediment, surface water and fish ingestion also required consideration in this RA. Site specific toxicity testing and benthic invertebrate studies were incorporated into the ERA (2014- 2016).

**Industrial Development, Confidential Client Ontario Regulation 153/04 Risk Assessment, Greater Toronto Area, ON.** Dr. Kirk was the QP<sub>RA</sub> for a Risk Assessment that involved a former agricultural property being developed for industrial use. The property was considered a sensitive site due to the presence of an area of natural significance. This work involved evaluation of soil, groundwater, surface water and sediment data, as well as human health and ecological exposure, and risk calculations. Soil remediation and risk management measures (soil erosion controls) were required to achieve the recommended property-specific standards. The Risk Assessment was accepted by the MOECC in 2013 (2011-2013).

**Infrastructure Ontario, St. Thomas Courthouse Due Diligence Risk Assessment, St. Thomas, ON.** Dr. Kirk was the Technical Manager, Senior Advisor and Reviewer for a Due Diligence Risk Assessment completed in the spirit of O. Reg. 153/04 (as amended by O. Reg. 511/09). The results of the Risk Assessment were used to help guide expansion plans

for the existing courthouse by developing property-specific standards and identifying any risk management measures or remediation that were necessary at the site. Dr. Kirk also attended proponent meetings on behalf of the client to discuss the environmental conditions at the site and potential constraints for the redevelopment (2010-2012).

**Chrisview Custom Homes, Residential & Commercial Development, Risk Assessment, Cambridge, ON.** Dr. Kirk was the Project Manager, Technical Lead and QPRA for an RA completed under O. Reg. 153/04, as amended to support future residential and / or commercial development of a heritage home. An above ground heating oil tank leaked in the basement of the house. Based on chemical concentrations of PHCs in soil beneath the house, vapour intrusion was a potential concern. Vapour intrusion modeling predicted a risk to human health. An indoor air assessment was completed to evaluate the petroleum hydrocarbon impacts to indoor air. A weight of evidence approach was completed and concluded that vapour intrusion was not a concern at the Site. The Site is located adjacent to an ANSI, and therefore consideration of the sensitive site status was required (2009-2015).

**City of Kitchener, 44 Gaukel Street & Road Allowances, Risk Assessment, Kitchener, ON.** Dr. Kirk was the Senior Reviewer involved in the completion of both the human health and ecological portions of the Risk Assessment under O. Reg. 153/04. The Risk Assessment was completed to support the filing of Records of Site Condition for the site which was impacted by coal tar. Extensive remediation of coal tar was completed and the risk assessment dealt with off-Site impacts to commercial properties, municipal roads and residences located in the vicinity of the Site.

**Lighthouse Sites, Residential Community, Risk Assessment, Various Locations, ON.** Dr. Kirk was Technical Advisor and Senior Reviewer involved in completing Site-Specific Human Health Risk Assessments and Screening Level Ecological Risk Assessments for various federal lighthouse sites throughout Ontario. The risk assessment results led to the development of site remediation targets that are protective of human and ecological health and allowed the management and closure of the Sites (2009-2010).

**Cameco Corporation, Ecological Risk Assessment Review of a Radiological Conversion Facility, Ontario.**

In 2009, as Senior Technical Lead, Dr. Kirk worked to complete a review of two comprehensive Ecological Risk Assessments and of a Facility Environmental Management Plan. This evaluation was done to determine whether the facility was adequately evaluating the ecological risks resulting from operations at the site. The Risk Assessments were completed following federal and provincial requirements and were subject to review by the Canadian Nuclear Safety Commission (2009).

**ATI Titanium, Discharge Limits for New Facility, Ecological Risk Assessment, Great Salt Lake, UT**

Dr. Kirk was the Senior Risk Assessor on a project that assisted in the ecological exposure assessment used to develop discharge limits under the Utah Pollutant Discharge Elimination System (UPDES) permit. The discharge was proposed to enter Great Salt Lake. Predicted concentrations of parameters were modelled and the potential future effects on the aquatic ecosystem were evaluated (2008).

**Confidential Client, Evaluation of Potential for Landfill Leachate to Impact Municipal Water Supply.** A hydrogeological study was conducted to evaluate the fate and transport of a contaminant of emerging concern (1,4-dioxane) and other contaminants of concern originating from a closed landfill to the municipal water supply extraction well. Dr. Kirk evaluated that toxicity and potential for health impacts from the transportation of this contaminant and others that were present in the landfill leachate. (2008).

**Confidential Client, Site-Specific Aquatic Criteria to Support Landfill Expansion.** Dr. Kirk developed site-specific groundwater criteria to support the EA for landfill expansion. A groundwater plume from the original landfill was migrating to an adjacent surface water body. Concentrations of some parameters at groundwater monitoring wells exceeded the Provincial Water Quality Guidelines. An evaluation of the receiving water and the groundwater/surface water chemistries were considered and site-specific groundwater values were proposed to the MOECC. These values were approved and used trigger levels for groundwater monitoring of the landfill (2008).

**Human Health Risk Assessment, Setback from Landfill, Calgary, AB.** Dr. Kirk served as the Technical Lead for a Human Health Risk Assessment completed to support an application for a variance from setback requirements from a waste disposal site. The landfill received municipal wastes and redevelopment of lands adjacent to the landfill was intended. The risk assessment was used to establish the set-back requirements from the landfill to support redevelopment of the area. (2007-2008).

**Industrial Spill in Urban Lake, Human Health and Ecological Risk Assessment, Regina, SK.** Dr. Kirk served as the Senior Risk Assessor and Technical Lead for a Site-Specific Risk Assessment conducted to determine if residual impacts from an industrial spill could result in adverse effects to human health or the environment. Characterization of soil, sediment and surface water was conducted, in addition to fish and benthic invertebrate sampling. Potential risks to onsite and offsite human health and to terrestrial and aquatic ecosystems were estimated quantitatively following guidance from Health Canada and Canadian Council of the Ministers of the Environment (2007-2009).

**City of Belleville, Meyers Pier, Risk Assessment, Belleville, ON.** Dr. Kirk served as the Technical Lead for a Human Health and Ecological Risk Assessment conducted under O. Reg. 153/04. Meyers Pier was reclaimed from the Bay of Quinte by infilling with fill, municipally-derived wastes and industrial residue-based fill materials. The risk assessment considered the redevelopment from a former waste disposal site and bulk fuel storage site to a park and marina. Extensive soil and groundwater impacts required managing through engineered controls. In addition to the Risk Assessment, the project included the site characterization, contaminant hydrogeology, and preparation of a Risk Management Plan. The Risk Assessment was completed in support of a Record of Site Condition to facilitate the redevelopment of waterfront lands as a municipal park (2006-2008).

**Wal-Mart Canada, Peer Review of Human Health and Ecological Risk Assessments, Various Locations.** Dr. Kirk was the Senior Risk Assessor retained by this multinational retailer to peer review environmental reports completed on brownfield sites being considered for redevelopment as retail stores. The purpose of the peer review work was to assess whether environmental work completed by the landlords' or vendors' consultants met industry standards, and whether the work completed was adequate to protect our client from environmental liabilities associated with leasing former brownfield sites for the operation of retail stores (2006-2007).