October 5, 2017 Reference No. 088877

Mr. Allan Leuschen
Senior Environmental Protection Officer
Authorizations – South
Environmental Protection Division
Ministry of Environment
2080 Labieux Road
Nanaimo, British Columbia V9T 6J9

Dear Mr. Leuschen:

Re: Independent Peer Review
Upland Landfill – Waste Discharge Application
(Tracking No. 335965, Authorization No. 107689)
Upland Excavating, Campbell River, British Columbia

On behalf of the Upland Excavating Ltd. (Upland), please find enclosed the independent peer review Mr. Guy Patrick, P.Eng. of Patrick Consulting Inc. (Peer Review), as well as Mr. Patrick's curriculum vitae. This Peer Review is submitted in relation to the Ministry of Environment (MOE)'s review of the Upland Landfill Waste Discharge Application (Application).

The Peer Review considers and comments on the components of the technical reports listed below, which were included in the Upland's Application submitted to the MOE on May 31, 2017:

- Hydrogeology and Hydrology Characterization Report, Proposed Upland Landfill, Campbell River, BC, prepared for Upland Excavating Ltd. by GHD, May 27, 2016, amended May 31, 2017
    - Site setting, geology, groundwater flow direction and flux, groundwater divide, groundwater chemistry and water quality criteria.
- Design, Operations, and Closure Plan, Proposed Upland Landfill, Campbell River, BC, prepared for Upland Excavating Ltd. by GHD, May 27, 2016, amended May 31, 2017
    - Section 13 groundwater and surface water impact assessment.

On behalf of Upland, GHD Limited (GHD) is currently working to complete additional field activities, studies, and analysis to respond to the recommendations enclosed in the attached Peer Review. GHD is also preparing technical responses to address Peer Review recommendations. GHD expects to submit these technical responses to the MOE will be within two weeks of the date of this letter.

GHD and Upland trust this submission will be of assistance to the MOE in completing its review the Waste Discharge Application. Should you have any questions please do not hesitate to contact us.

Sincerely,

GHD

Gregory D. Ferraro, P.Eng.
SS/sz/13

Encl.

cc: Terry Stuart – Upland Excavating Ltd.
Brian Fagan – Upland Excavating Ltd.
Shauna Sturgeon, GHD Limited

Attachment 1
Patrick Consulting Inc Let 08SEP2017

September 8, 2017

Patrick Consulting Inc.
PO Box 581, Stn Ganges
Salt Spring Island, BC
V8K 2W2
(phone: 250-538-0215)

GHD Limited
10271 Shellbridge Way, Suite 165
Richmond, BC V6X 2W8 Canada

Attn: Gregory Ferraro, Principal

Dear Mr. Ferraro,

RE: Peer Review of Technical Reports, Proposed Upland Landfill, Campbell River, BC

In response to your request, Patrick Consulting Inc. ("PCI") has completed its peer review of two technical reports: 1) Hydrogeology and Hydrology Characterization Report and 2) 2017 Design, Operations and Closure Plan, prepared by GHD Limited ("GHD") in support of an application for a proposed engineered landfill (the "landfill") at the Uplands Excavating Ltd. property located at 7295 Gold River Highway in Campbell River, BC. (the "Site").

This review was conducted by Mr. Guy Patrick, P.Eng. of PCI. Mr. Patrick is a Contaminant Hydrogeologist and a registered Professional Engineer in BC, Yukon, Alberta and Saskatchewan, and has been practicing in the field of hydrogeology and environmental engineering since 1981. It is our understanding that GHD requested an independent peer review of the hydrogeological aspects of the two reports and of the groundwater and surface water impact assessment.

1.0 Scope of Work and Documents Reviewed

The following reports were provided to PCI by GHD for review:

"Hydrogeology and Hydrology Characterization Report, Proposed Upland Landfill, Campbell River, BC" prepared for Uplands Excavating Ltd. by GHD Limited, May 27, 2016, amended May 31, 2017 (the "HHCR");

"2017 Design, Operations and Closure Plan, Proposed Upland Landfill, Campbell River, BC" prepared for Uplands Excavating Ltd. by GHD Limited prepared by GHD Limited, May 27, 2016, amended May 31, 2017 (the "DOCP").

The scope of work comprised an independent peer review of each of the reports, with a specific focus on:

a) hydrogeological aspects of the HHCR, including the site setting, geology, and groundwater flow direction, flux, and chemistry, and
b) groundwater and surface water impact assessment (Section 13) of the DOCP.

During my review, I noted items, data gaps, and uncertainties that have the potential to affect the findings of the impact assessment, and I assessed their significance. In the following, I first present overview comments and conclusions of my review, and then present my detailed findings including identified data gaps and comments on specific topics (e.g., Site setting, geology, groundwater flow, etc.), and uncertainties pertinent to the impact assessment. Finally, I present recommendations for consideration to address the more pertinent findings of my review.

2.0 Results of Review and Comments

2.1 Hydrogeology and Hydrology Characterization

2.1.1 Overview Comments

I note that the HHRC is well presented and complies with the checklist of requirements as presented in the 2016 BC Landfill Criteria[1]. Following my review, it is my opinion that the report provides sufficient detail to assess hydrogeologic conditions with reasonable confidence at, in the immediate vicinity, and hydraulically downgradient, of the landfill. The characterization in the HHRC is summarized within the context of a conceptual site model which, in my opinion, is sufficient to serve as the technical basis to support the groundwater and surface water impact assessment provided in section 13 of the DOCP. Two areas of uncertainty that I noted in the hydrogeology assessment are described below.

As detailed in the specific comments below, the assessment of hydrogeologic conditions hydraulically upgradient of the landfill, near and west of the west property boundary in the vicinity of the bedrock ridge, may benefit from a more rigorous assessment to more clearly define groundwater flow and flux entering the Site. Regardless, and as discussed below, the groundwater flux along the west boundary of the Site moves from west to east towards and into the relatively extensive permeable sand and gravel aquifer that underlies the landfill. This eastward groundwater flux from the west is indicated to contribute a proportionally low percentage to the total flux moving to the southeast beneath the footprint of the landfill and, therefore, would not affect the results of the impact assessment.

The data set used to estimate advective groundwater flow velocities and flux is quite limited and, therefore, carries some uncertainty that is not discussed in detail in the HHRC. However, given the magnitude of the estimated groundwater flux moving beneath the landfill towards the southeast, the variances in the flux and velocity estimates are unlikely to have a significant effect on the outcome of the impact assessment.

[1] "Landfill Criteria for Municipal Solid Waste," 2nd edition, British Columbia, BC Ministry of Environment. June 2016

2.1.2 Site Setting

Surface Water Features (Section 2.1.3):

A biological survey of potential aquatic receptors was completed over an area within 500 m of the Site. The impact assessment as presented indicates compliance with BC Contaminated Site Regulation (CSR) drinking water (DW) standards at the Site boundary, and CSR aquatic life (AW) standards hydraulically downgradient of the Site beyond 500 m of the Site boundary.

- Two surface water features were identified by the biological survey described in the HHCR that are within 500 m of the Site. These are indicated to be sourced from a small wetland swamp south and southwest of the Site. Their relevance to the Site study is not explicitly discussed in this section; however, I note that the location and elevation of the swampy area relative to the groundwater elevation at and near the Site suggests that these features do not receive groundwater from the Site.

- In addition to the two features discussed, other surface water features are located hydraulically downgradient of the Site beyond 500 m that may receive groundwater passing beneath the Site. These features, which are not explicitly discussed as potential groundwater discharge areas, include ephemeral streams to the southeast, and possibly Lost Lake to the east, which are illustrated on Figure 2.0A of the HHCR. The relevance of these features is not clearly addressed in the impact assessment and, as discussed in my comments below, further clarification should be given with respect to compliance with CSR AW standards.

2.1.2 Geology

I note that the Site geology is characterized by a native interbedded sand and gravel unit of variable thickness, overlying fractured basalt. Borehole logs indicate that the sand and gravel unit is heterogeneous, composed of multiple layers or lenses of silt, sand, sand and gravel, and gravel, consistent with glaciofluvial deposits. This heterogeneity has implications for the estimates of hydraulic properties of the unit, as discussed below.

Bedrock underlying the Site and vicinity is reported to be composed of basalt[2], which is described as highly weathered and fractured at the contact with overburden beneath the Site, and competent (i.e., few fractures), where encountered at and near bedrock outcrops west of the Site. The bedrock encountered in boreholes drilled at the Site is noted to contain fractures of various sizes, densities and orientations. In my view, because fractures transmit the majority of water through the rock, the HHCR would benefit from further discussion of the basalt and the implications of the observed fracture frequencies, orientation and degree of secondary mineralization at the various locations and depths. In particular, I note that the competent bedrock to the west of the Site along the bedrock ridge does not appear to be well described in terms of the presence, frequency and degree of fracturing.

Figure 2.8 of the HHCR presents a contour plan of the top of bedrock elevation at and in the vicinity of the Site. The figure and text (Section 2.2.2.2) describe a bedrock ridge that extends

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[2] Borehole logs for two boreholes (MW3-14 and MW6-17) reported "granite" and not basalt, and this is understood to be a miss-identification.

from the southwest Site boundary to the northern portion of the adjoining K&D property, wrapping around the northern boundary of Rico Lake. Based on my review of the figure, I note that the depth to bedrock was not defined immediately east of Rico Lake between test pits TP3-17 and TP6-17, suggesting the possibility of a dip or trough in the bedrock in that area, which has implications for the groundwater flow across the western Site boundary, as discussed below.

2.1.3 Groundwater Flow

Groundwater Divide: The HHCR describes a groundwater divide that is induced by the presence of the bedrock ridge discussed above and illustrated on Figure 2.8 of the HHCR. Section 2.3.1 describes the bedrock ridge as composed of competent rock that is interpreted to form a "barrier" to groundwater flow, and is coincident with a groundwater divide separating westward and eastward groundwater flow.

The data support the presence of a groundwater divide. However, for a number of reasons, the groundwater divide may not strictly coincide with location of the bedrock ridge and may be located further to the west:

- The hydraulic properties and fracture frequencies of the competent rock within the bedrock ridge west of the Site were not tested and may be capable of transmitting some groundwater. However, the flux through the competent bedrock is likely to be very small in relation to that beneath the landfill within the highly fractured, near-surface bedrock and overlying the sand and gravel.

- In the area between test pits TP3-17 and TP6-17, neither the depth to bedrock nor depth to the water table are defined with certainty. Groundwater elevation contours presented on Figure 2.9 of the HHCR are not interpreted for this area of the Site. Based on the test pit log (Appendix F), the water table in TP3-17 occurs in sand about one metre above bedrock at about 178 mAMSL. Test pits TP4-17 through TP7-17 were dry.

It is suggested that the groundwater flow pattern be re-considered and re-interpreted to include features such as the approximate groundwater elevation at TP3-17, the surface elevation of Rico Lake, the groundwater elevation at MW6-17 (north of Rico Lake) and the possibility of a bedrock trough between TP3-17 and TP6-17. While the groundwater divide may occur near these test pits east of Rico Lake, it may, instead, occur at Rico Lake. In the latter case, the water level data would suggest that Rico Lake is partially recharged by groundwater from higher surface elevations to the north (e.g., in the vicinity of a groundwater mound near MW6-17) and south of Rico Lake. Rico Lake may be drained via groundwater flow through overburden and bedrock both to the west into McIvor Lake, and to the east towards and beneath the Site. This latter possibility is discussed in section 2.3.3.1 of the HHCR, although not quantified, and would not affect the results of the impact assessment. Of relevance, the data indicate that in no event does groundwater migrate from the Site towards Rico Lake.

Recharge of the Sand and Gravel Aquifer; Hydraulic Connection with McIvor Lake: The HHCR notes, and I concur, that the sand and gravel aquifer underlying the Site is a major aquifer in the region and represents the only receptor of infiltration east of the groundwater divide. In addition, the data support the inference in the HHCR that the aquifer receives groundwater from McIvor Lake to the north and, as I have discussed above, possible recharge from Rico Lake to the west. In addition, the aquifer may also receive water from discharge into the aquifer from the underlying bedrock.

With respect to recharge from McIvor Lake, the water level data presented on Figure 2.9 of the HHCR and the information presented on borehole logs for MW8-17 and MW9-17 support the interpretation in the HHCR that groundwater flows onto the Site from McIvor Lake in the vicinity of these wells. Further to the west, west of the Site, groundwater likely discharges into the lake from the area of higher elevation at MW6-17.

Aquifer Properties: As discussed in Section 2.3.2 and Appendix C of the HHCR, the hydraulic conductivity, K, of the sand and gravel aquifer (2×10^{-2} cm/s) was estimated from one single well response test conducted at MW4B-15. This is a reasonable value for a well-sorted glacial outwash sand (Fetter, 2014[3]). However, given the heterogeneous nature of the sand a gravel aquifer, as noted above, the result carries uncertainty. In my view, the K used to interpret groundwater velocity and flux should address this uncertainty either through additional supportive field tests and/or by placing reasonable upper and lower bounding estimates on K as calculations are carried through.

The hydraulic conductivity of the bedrock was estimated from single well response tests for highly fractured bedrock at MW4A-15 ($2.2. \times 10^{-2}$ cm/s) and for competent fractured bedrock at MW5A-15 (1.4×10^{-5} cm/s). Again, these data are reasonable, but limited in terms of defining bedrock aquifer hydraulic properties, and the uncertainties should be defined and carried through consequent flux calculations.

Shallow Aquifer: Sections 2.3.3.1 and 2.3.3.2 of the HHCR discuss the presence of a shallow aquifer in the overburden soils overlying bedrock, east and west of the groundwater divide. Given that the location of the groundwater divide west of the Site is somewhat uncertain, the distinction between the east and west portions of this water table aquifer is not critical to the assessment. Further, it is not clear that the shallow aquifer is or is not hydraulically connected to either the underlying bedrock (there is no reference to information provided to indicate that the shallow aquifer is perched) or laterally to the sand and gravel aquifer. Of relevance, however, is that the configuration of the water table and inferred hydraulic gradients support the finding that groundwater also enters the sand and gravel aquifer beneath the Site from the west, either through migration from the shallow aquifer and/or through discharge from bedrock.

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[3] Fetter, C.W. 2014. Applied Hydrogeology, 4th Edition. Pearson.

2.1.4 Groundwater Velocities and Flux

Section 2.3.4 of the HHCR presents a summary of measured hydraulic gradients in the sand and gravel aquifer (about 0.03 m/m), and estimates of groundwater velocity (about 1.7 m/day or about 620 metres per year). As discussed above, these estimates carry uncertainty although, in my view, they are reasonable for the hydrostratigraphic conditions encountered at the Site.

Groundwater flux passing beneath the footprint of the proposed landfill is estimated in Section 3 of the HHCR to be 706 m^3/day, or 258,000 m^3 per year. In my view, and in absence of further information, these values imply a level of certainty that is not justified, and should be rounded to one significant figure (i.e., 700 m^3/day, or 300,000m^3 per year) and reported with a reasonable level of uncertainty. For illustrative purposes, I have placed the uncertainty in flux on the order of +/- 50% (i.e., 300 to 1,100 m^3/day, or 100,000 to 400,000 m^3 per year).

2.1.5 Groundwater Chemistry

Section 4.1 Applicable Water Quality Standards:The HHCR considered the applicability of CSR AW standards and concluded that they do not apply at the boundary of the Site because a) there are no aquatic receiving environments within 500 m hydraulically downgradient of the Site and b) groundwater quality modelled using a water balance approach 500 m downgradient of Site boundary demonstrated that the water quality met CSR AW standards. As referenced in the report, Protocol 21 developed by BC MoE states that AW standards apply to groundwater beyond 500 m of a receiving environment if the groundwater contains substances exceeding AW and has the potential to migrate within 500 m of the receiving environment. Given the possible presence of aquatic receiving environments located on the order of one to two kilometres downgradient of the Site boundary, and an advective groundwater travel time on the order of 600 m/year, it is not clear that AW standards are not applicable.

Section 4.2.1 Indicator Parameters: I concur with the list of indicator parameters presented to serve as baseline indicators of groundwater quality. I note that other parameters, including redox parameters such as field-measured dissolved oxygen and/or oxidation-reduction potential (ORP) and other major cations (i.e., sodium, potassium, calcium and magnesium) have been monitored previously at the Site, and these may serve as useful parameters to assess on occasion in future. For example, inclusion of the major cations with indictor anions will allow calculation of charge balance errors to serve as a means of quality control on the laboratory analysis.

Contaminant Mass Balance and Compliance Assessment: Given the range of flux estimates as presented above, the mass balance estimates presented in the HHCR and brought in to the impact assessment in the DOCP will similarly carry a range of uncertainty, which may have implications for the compliance assessment presented in the DOCP. I note, however, that groundwater quality is predicted to meet DW standards at the property boundary even if concentrations are doubled. Given the advective travel time for groundwater to migrate from the Site towards possible aquatic receptors (on the order of two years), the non-applicability of CSR AW standards to the Site should be clarified.

2.1.6 Other Comments

Figures:

- Figure 2.0A and 2.1. Lost Lake (referenced in Section 2.1.2) should be labelled on these figures;
- Figure 2.0A. The figure references a "Freshwater Atlas". Is this the BC Water Resource Atlas (2017) referenced in the text?
- it would be useful if copies of relevant aquifer maps (e.g. Aquifer 975 IIA) from the BC Water Resource Atlas (2017) were provided (referenced in Section 2.1.2);
- Figure 2.8. The HHRC (Section 2.2.2.2) references the bottom of Rico Lake to be reported as 168 mAMSL. This should be noted on the figure.

Technical References:

The report would benefit from references to support:

- the described geomorphology of the Site and vicinity (Section 2.1.1 "Topography");
- the term "tertiary" water sheds (Section 2.1.2 "Watersheds").

2.2 Design, Operations and Closure Plan - Groundwater and Surface Water Impact Assessment

2.2.1 Water Balance – Groundwater Flow Beneath Landfill

Groundwater Flux: the same flux estimates are presented in Section 13.1.1 of the DOCP as those presented in the HHCR. As discussed above, these estimates have uncertainty that should be carried through the subsequent calculations and estimates. Using my estimated factors of uncertainty above, the groundwater flux may range from about 100,000 to 400,000 m^3 per year. As a check on the flux estimate, I recognize that most of the water entering the aquifer will occur via infiltration of precipitation. Therefore, I estimated the approximate flux passing beneath the landfill assuming that 71.9% (see Section 13.1.4) of the annual precipitation of 1.49 m infiltrates over an area upgradient of the landfill of about 250 m x 500 m. This yields a flux of approximately 130,000 m^3 /year, which falls within the lower estimated range presented above. Recognizing that some components of the actual flux beneath the proposed landfill also enter from McIvor Lake and, to a lesser extent, from Rico Lake and from upward hydraulic gradients from the bedrock, the estimated flux begins to approach the estimate provided in the DOCP (257,000 m^3/year).

Leachate Generation: In Section 13.1.2, the estimated rate that landfill leachate may leak through the landfill base and enter the underlying groundwater mixing zone is reported to be 0.121 m^3/year (about 1/3 of a litre per day). In my view, this estimate is reasonable for the proposed design, although I did not independently run the referenced HELP model to verify this finding, and assume that the calculations were internally checked for accuracy as part of a QA/QC program for the impact assessment. Of relevance, the estimated rate is a very small percentage of the total groundwater flux estimated to move beneath the proposed landfill footprint (i.e., about 0.0001% to 0.0004% using my estimated factors of uncertainty).

Other Comments:

- Section 13.1.1: reference is made to a period of "over several decades" before landfill leachate will reach the saturated part of the sand and gravel underlying the landfill. I did not see reference to the supporting calculations for this statement.
- At the end of Section 13.1.1, the calculated cross sectional area for groundwater flux is stated to be 365 m^2 but should read 1,365 m^2. This appears to be a typographical error as other calculations are correct.
- Section 13.1.4, last paragraph: the stated thickness of 4.46 m for the mixing zone in the aquifer appears to be a typographical error and should read 5.46 m, as referenced in Section 13.1 1.

3.0 Recommendations

Based on my review, the following recommendations are offered.

1. The data set used in the HHCR to estimate advective groundwater flow velocities and flux is quite limited and, therefore, carries uncertainty. It is recommended that additional data, preferably the form of a pumping test or tests on-Site and slug tests near McIvor Lake, be conducted to support the current estimates of the hydraulic conductivity of the sand and gravel aquifer, advective groundwater velocity and flux, and predicted contaminant mass and concentrations.

2. The groundwater flux along the west boundary moves from west to east towards and into the relatively extensive permeable gravel aquifer that underlies the proposed landfill. The flux has not been quantified and is likely very small relative to the flux entering the aquifer via infiltration of precipitation. Nonetheless, to reduce this uncertainty and further support the findings of the impact assessment, it is recommended that a more rigorous assessment be undertaken in the form of revised groundwater elevation contours supplemented with additional water level data, to more clearly define groundwater flow and flux entering the Site from the west.

3. Given the advective travel time for groundwater to migrate from the Site towards possible aquatic receptors (on the order of two years), in addition to applying CSR drinking water (DW) standards at the Site boundary, further clarification should be provided and/or assessment conducted with respect to the applicability of CSR AW standards based on anticipated groundwater quality within 500 m of likely aquatic receptors.

4.0 Limitations

This review was conducted for the exclusive use of GHD Limited and their client. The report is intended to provide a technical review and opinion of information provided in the documents referenced above respecting the adequacy of the environmental Site investigations and remediation conducted at the subject Site. This report is not meant to represent a warranty, or a legal opinion regarding compliance with applicable laws. The reviewer makes no other representation or warranty as to the accuracy or completeness of the information provided.

This review followed the standard of care expected of professionals undertaking similar work in British Columbia under similar conditions. The reviewer's conclusions and opinions are entirely based on the information provided. The reviewer has relied on the accuracy and completeness of the background materials upon which the reported information was based, and is not responsible for errors or omissions in such background materials.

Any use by which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. The reviewer accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

5.0 Closure

We trust that you find this letter report satisfactory and welcome the opportunity to discuss any of the above at your convenience.

Sincerely,

Patrick Consulting Inc.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — G. C. PATRICK # 18620

Guy Patrick, P.Eng.
Director

Attachment 2
Guy Patrick Resume 2017

Guy Patrick

Patrick Consulting Inc

P.0. Box 581, STN Ganges
Salt Spring Island, BC V8K 2W2
PH: 250-538-0215
CELL: 604-219-8437

Experience

Patrick Consulting Inc. – Salt Spring Island, BC

Director (2015 to Current)

Senior Contaminant Hydrogeologist providing expert review services and/or technical direction and oversight for major hydrogeological and contaminant investigations and remediation programs throughout BC, across Canada and internationally. Mr. Patrick's expertise is focused on contaminant fate and transport at sites affected by organic and inorganic constituents including LNAPLs (e.g., petroleum hydrocarbons), DNAPLs (e.g., coal tars, creosote, chlorinated solvents) and metals. His decades of experience encompass site characterisation and remediation in complex hydrogeological settings.

Contaminated Sites Approved Professional Society (CSAP) – Vancouver, BC

Member (2008 - Current); Board Member (2009 to 2015; 2017)

Provides direction and governance for CSAP, which is an independent professional organization that is mandated by the Provincial Government, through the Ministry of Environment, to review environmental certification applications made under the *Environmental Management Act* and Contaminated Sites Regulation. Mr. Patrick currently serves as chair of the Professional Development Committee and Co-chair of the Technical Review Committee, and previously served as chair of the Membership and Discipline Committees. https://csapsociety.bc.ca/

GeoEnviroPro – Vancouver, BC

Technical Lead and Partner (2015 to Current)

Develops high quality webinars, workshops and training for novices to professionals who desire to improve their skill set in the investigation and remediation of contaminated sites.
http://geoenviropro.com/

Guy Patrick

University of British Columbia – Vancouver, BC

Adjunct Professor (2015)

Course instructor for Civil 408, Geo-Environmental Engineering through the Department of Civil Engineering.

Golder Associates Ltd. – Burnaby, BC

Associate, then Principal (1994) (1990 to 2014)

Principal and Senior Hydrogeologist responsible for program development, management, and technical direction for major hydrogeological and contaminant investigations and remediation programs throughout BC, and across North America, Europe, and Australia. These included remedial investigations focusing on manufactured gas plant (MGP), chemical plant and wood treating sites affected by DNAPLs (e.g., coal tars, creosote, chlorinated solvents), other organic compounds and metals, and site characterisation at hazardous waste disposal facilities.

Golder Associates Ltd. – Waterloo, ON

Associate/Office Manager (1990 to 1990)

Established Golder Associates' Waterloo office and supervised a technical and support staff, providing hydrogeological services and environmental site assessments throughout Ontario, and in support of RI/FS projects in New Jersey and Massachusetts.

Golder Associates Inc. – Redmond, WA

Senior Hydrogeologist (1985 to 1989)

Technical Manager and senior reviewer for Remedial Investigations and Feasibility Studies (RI/FS) at contaminated sites in Washington, Oregon, and California. Served as Technical Director for investigation of DNAPL solvent contamination at MEW Superfund Site in Mountain View, California.

University of Waterloo – Waterloo, ON

Research Assistant (1983 to 1985)

Designed and implemented a benzene, toluene, and xylene (BTX) tracer injection test at CFB Borden, Ontario, to assess natural attenuation and biodegradation processes in a sand aquifer.

Clifton Associates Ltd. – Regina, SK

Project Engineer (1981 to 1983)

Implemented and managed ESAs at contaminated sites throughout Saskatchewan, including municipal landfills, bulk petroleum fuel tanks, a steel mill, a petroleum refinery, potash brine disposal ponds, and road-salt storage yards.

Guy Patrick

Education

M.Sc. Contaminant Hydrogeology, **University of Waterloo**, Waterloo, ON, 1986

B.A.Sc. Regional Systems Engineering (Civil), **University of Regina**, Regina, SK, 1981

B.Sc. Biology (Honours), **University of Regina**, Regina, SK, 1977

Professional Affiliations

Association of Professional Engineers of Saskatchewan (Lic. No. 5315)

Association of Professional Engineers and Geoscientists of BC (Lic. No. 18620)

Association of Professional Engineers and Geoscientists of Alberta (Lic. No. 237573)

Association of Professional Engineers of Yukon Territory (Lic. No. 1225)

Association of Groundwater Scientists and Engineers, NGWA, member

International Association of Hydrogeologists, member

Instruments Issued As A BC Rostered Approved Professional

Certificates of Compliance (CoC)
Site 11788, 11789, 11790, March 13, 2017 Richmond
Site 7372, November 27, 2015, Kelowna
Site 18253, November 27, 2015, Kelowna
Site 12603, April 26, 2012, Vancouver
Site 11786, February 29, 2012, Richmond (3)
Site 4697, May 16, 2011, Vancouver
Site 3500, March 24, 2011, Kelowna
Site 7807, October 1, 2010, Penticton
Site 12276, May 18, 2010, Richmond
Site 0952, December 11, 2009, Saanich
Site 3667, July 16, 2009, Cranbrook
Site 11171, April 1, 2009, Winfield
Site 10661, November 6, 2008, Chilliwack
Site 9196, June 13, 2008, Vancouver
Site 0102, January 8, 2008. Burnaby
Site 3667, September 26, 2007, Cranbrook
Site 3293, July 18, 2006, Fort Nelson
Site 2489, May 8, 2006, Kelowna
Site 2489, May 8, 2006, Kelowna
Site 9805, May 8, 2006, Burnaby
Site 8653, December 2, 2003, Vancouver
Site 3973, March 20, 2003, Kelowna
Site 6976, September 21, 2001, Vancouver

Approvals-in-Principle (AiP)
Site 3667 September 26, 2007, Cranbrook
Site 5062, January 23, 2007, Squamish
Site 7908 (Parcel 1), May 19, 2004
Site 7908 (Parcel 4), May 19, 2004
Site 7908 (Parcel 5), May 19, 2004
Site 6477 April 28, 2000, Vancouver
Site 6975, September 24, 2001, Vancouver

Select Publications

Patrick, G.C., M. Bergeon, and W. Decker, 2015. Use and Limitations of Polyaromatic Hydrocarbon Proportions in Defining Source Signatures of Tars at a Manufactured Gas Plant Site. Presented at 5th Annual SABCS Conference on Contaminated Sites, September 24, 2015, Vancouver BC.

Patrick, G.C. and R. Zapf-Gilje, 2012. Towards a New Professionalism in British Columbia – the Contaminated Sites Approved Professional Society, presented at the 2012 Congress of the International Association of Hydrogeologists, September 16-21, 2012. Niagara Falls, ON.

Patrick, G.C. and D. Thomas, 2007. Groundwater Characterization – How Much is Enough? Presented at 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH CNC Groundwater Conference, October 21-24, 2007. Ottawa, ON.

Patrick, G.C., I. Hers, G. Bradley, and D. Thomas. 2005. Managing Creosote DNAPL in Marine and Freshwater Sediments (Abstract). Presented at Battelle Conference on Remediation of Contaminated Sediments, New Orleans, LA.

Patrick, G. and T. Anthony. 1998. "Creosote and Coal-Tar DNAPL Characterization in Fraser River Sands" in Nonaqueous Phase Liquids, Remediation of Chlorinated and Recalcitrant Compounds. G. B. Wickramanayake and R. E. Hinchee, eds. The First International Conference of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 18-21, 1998. Battelle Press.

Patrick, G., 1997. DNAPL Source Zones and Implications for Remediation (Abstract), presented at 5th North American Chemical Congress, America Chemical Society, Cancun, Mexico.

Patrick, G.C., Conlin, B.H., and Balfour, D.J., 1992. "Technical Approach and Understanding of Environmental Contamination Studies". Presented at Western Canadian Environmental Law and Regulation Conference, November 1992, Vancouver, BC.

Patrick, G.C. and A.S. Burgess, 1990. "Field Studies of Nonaqueous Phase Liquids at Two Sites in California's Santa Clara Valley." In Proceedings of the Conference on Subsurface Contamination by Immiscible Fluids, April 18-20, 1990, Calgary, AB.

Representative Projects

Senior Expert Review, Former Dry Cleaner Site, Vancouver, BC

(2016) Provided expert review services and an opinion report in support of BC Ministry of Environment position for a pending Environmental Appeal Board hearing concerning the investigation and extent of tetrachloroethylene and trichloroethene (PCE and TCE) in till and fractured siltstone/sandstone at a former dry cleaning facility.

Expert Witness and Technical Specialist, Former MGP Site, Ashland, Wisconsin USA

(2012 – 2015) Developed a conceptual site model, reviewed remedial plans, and testified on the transport and fate of water-gas tars and polyaromatic hydrocarbons (PAH) on behalf of the railroads and City at a historic manufactured gas plant site adjacent to Lake Superior. http://www.epa.gov/region5/cleanup/ashland/index.htm

Optimization Review Panel, Coal Tar Remediation, Vancouver, BC

(2015) Invited member of five-person Expert Panel to identify preferred remedial technologies and develop an optimized remedial approach to achieve closure objectives

for this former coal tar distillate and shingle manufacturing facility adjacent to tidally influenced Fraser River.

DNAPL Panel, North American Railroad

(2015 - 2017) Invited member of DNAPL panel to provide independent review and recommendations to project consultants in addressing the investigation and remediation of DNAPL contamination at various rail yards in Canada and USA.

Senior Review, Rock Bay MGP Remediation Project, Victoria, BC

(2005-2016) Provided initial contaminant assessment and remediation expertise related to DNAPL transport of coal tars from the former Rock Bay manufactured gas plant. Supported and advised Transport Canada during remediation of Rock Bay sediment.

Technical Specialist, Ammonium Plume Characterization, Columbia River, BC

(2007-2010) Supported a multidisciplinary team characterizing the presence, extent, discharge and ecological risk of an ammonium sulphate plume migrating towards, beneath and into a reach of the Columbia River downgradient of a fertilizer plant.

Environment Yukon, Water Resources Branch, YT

(2017) Co-author of "Groundwater Investigation and Characterization, Technical Guidance for Contaminated Sites," prepared for Environment Yukon,

Source Allocation, MGP Condensate, Quebec City, Quebec

(2013) Provided technical advice and forensic assessment of the source of light hydrocarbons ultimately found to be associated with manufactured gas condensate accumulations in abandoned gas distribution piping in an historic area of Quebec City.

Creosote Assessment and Remediation, Multiple Sites, Canada

Provided technical expertise in the investigation, characterization and remediation of creosote DNAPL at wood treating sites in BC (White Pine Vancouver; Meadow Avenue, Burnaby; Domtar Coquitlam; Vancouver Shipyards, North Vancouver), Alberta (Domtar Cochrane; Canada Creosote, Calgary); Ontario (Northern Wood Preservers, Thunder Bay)

Canadian Council of Ministers of the Environment

(2016) Co-author of CCME technical guidance document for environmental site characterization in support of human health risk assessments.
http://www.ccme.ca/en/resources/contaminated_site_management/assessment.html

BC Ministry of Forests, Lands, and Natural Resource Operations (formerly Agriculture and Lands), Ladysmith, BC

(2007 – 2012) As Project Director, provided senior technical review of environmental site assessments, contaminant hydrogeology and remedial planning to address historic

coal shipping and rail yard contamination, and re-development of the uplands and sediment in Ladysmith Harbour. Contaminants of concern include metals and petroleum hydrocarbons. http://www.ladysmith.ca/city-hall/reports-publications

BC Ministry of Environment, BC

(2007 - 2010) Primary author of BC MoE's Technical Guidance #8 (July 2010), "Groundwater Investigation and Characterization," and supporting documentation. http://www.env.gov.bc.ca/epd/remediation/guidance/#tech

Rio Tinto, Kitimat, BC

(2006 – Current) Senior technical reviewer supporting prime consultant and overseeing the investigation, hydrogeologic characterization and remediation of lands and marine sediments at an aluminum smelter site in Kitimat. Characterisation included use of Mine Visualization Software (MVS) to accurately display, interpret and communicate the 3-D extent of PAHs, metals and other inorganic chemical discharges to Kitimat Arm.

Ethylene Dichloride (EDC) Spill Site, Ft. Langley, BC

(2005 – Current) Technical support to prime consultant overseeing the management and remediation of EDC in groundwater at an historic train derailment site, where EDC (also referred to as 1,2-dichloroethane) was released as DNAPL to the subsurface in an aquifer near the Fraser River.

EXXON Mobil, USA

(2007-2008) Co-author of technical guidance to address the potential for mobility of LNAPL at sites contaminated by petroleum hydrocarbons.

Electrolux, Hungary

(2004-2010) Technical Advisor providing review services and advice regarding innovative remedial approaches to address trichloroethene (TCE) and chromium VI contamination within a complex hydrogeologic system serving as a local municipal water supply.

Olin Chemical Site, Saltsville, VA, USA

(1995-2002) Provided technical input and review of EPA's proposed plan to contain mercury contamination in soils at the former Olin Chemical chlor-alkalie site.

Expert Witness, Wildwood BC

(2002) Provided expert witness services in support of an application to the BC Environmental Appeal Board to amend a Remediation Order issued against an historic site owner. The work scope included establishing the approximate date and causes of contamination of a fractured rock aquifer by gasoline. The aquifer supplies local residences with potable water.

Expert Witness, Fairlawn, NJ, USA

(2000–2004) Provided technical expertise and expert testimony to address historic sources of dry cleaning solvents and subsequent responsible parties at a former dye manufacturing facility.

Lockheed Martin, Idaho Falls, ID, USA

(1996–2000) Member of treatability study review panel tasked with evaluating natural attenuation as a remedy to address TCE plume in fractured basalt at the Test Area North (TAN) site at the Idaho National Engineering Laboratory in eastern Idaho.