Edithvale and Bonbeach
Level Crossing Removal Project

Report of J. Richard Murphy, M.A.Sc., P.Eng.(Ontario)

1 Introduction

I have been engaged on behalf of the Level Crossing Removal Authority in my capacity as a groundwater expert.

I have been asked to review the Environment Effects Statement (**EES**) prepared for the Edithvale and Bonbeach Level Crossing Removal Projects (**Projects**) to the extent relevant to my area of expertise and to give my opinion in respect of:

- the feasibility, effectiveness and maintenance of the passive subsurface horizontal drain contemplated for the Edithvale Project to minimise groundwater impacts; and
- any examples or case studies where a similar design or mitigation measure has been successfully applied elsewhere.

2 Qualifications and experience

Appendix A contains a statement setting out my qualifications and experience, and the other matters raised by Planning Panels Victoria 'Guide to Expert Evidence'.

A copy of my curriculum vitae is provided in Appendix B.

3 Feasibility, effectiveness and maintenance of the passive subsurface horizontal drain

It is my opinion that the proposed engineering solution, which includes the application of a passive horizontal groundwater collector and infiltration drain system can be an effective solution to reduce and limit the potential changes to groundwater levels that may result from the proposed construction of the trench at Edithvale.

The proposed trench construction will include the construction of continuous secant pile walls along both sides of the trench to a maximum depth of 24 metres below ground surface (m bgs) in an area where groundwater levels generally occur within 5 to 6 metres of ground surface and groundwater flow is generally transverse to the secant walls. Therefore the secant walls will form a barrier to groundwater flow that will interrupt the natural groundwater flow, causing it to change its pattern of flow. The influence of this interruption, in the absence of mitigation, will include a mounding or build-up of groundwater levels on the upgradient (east) side of the wall and a reduction or drawdown of groundwater levels on the downgradient (west) side of the wall. This influence, if not mitigated, has the theoretical potential to have undesirable effects including:

- Increased frequency and extent of ground surface inundation by groundwater levels to the east
- Potential hydrologic changes in Edithvale wetlands to the east
- Potential interference with groundwater well users downgradient (to the west of) the trench
- Potential increases in salinity from a shift in the saltwater intrusion wedge which extends inland from the shoreline and may extend east of the trench in the deeper groundwater system
- Groundwater drawdown could activate acid sulfate soils leading to acidification of groundwater

- Mobilization or re-routing of subsurface contaminants that may be present

Based on the EES evaluations, the first item, the potential for increased inundation issues east of the trench area, is the primary effect of concern as identified and explained in the documents reviewed. The mitigation of groundwater level changes will also further limit the potential for other undesirable effects related to groundwater level changes. It is noted that any alteration of groundwater flow systems may influence the mobility and flowpath for contaminants that may be present and related concerns can best be handled by pre-construction assessments of potential presence and monitoring of the water within the proposed collection system once constructed.

As stated above, the proposed engineering solution can be an effective solution to reduce and limit the potential changes to groundwater levels that may result from the proposed construction of the trench at Edithvale. This engineering solution is suitable minimize groundwater effects and to help achieve the Environmental Performance Requirements (EPRs) identified for the project. Implementation of a passive horizontal drain appears feasible and I view the application of a horizontal system to be the preferred technical solution for managing the potential changes to groundwater relative to other engineering means such as vertical wells and/or pumping systems. The horizontal system provides several key advantages, including:

- The horizontal orientation and lateral extent of the system provide for continuous hydrogeologic contact with the groundwater flow system along the entire length of the secant wall, maximizing hydraulic control over groundwater levels

- The horizontal orientation avoids the challenges with interspaced extraction/recharge wells with varying drawdown/mounding associated with their radial flow patterns

- Horizontal drains allow for limited drawdown at the point of collection/re-infiltration (well screen or drain pipe) which reduces the potential for introduction of air into the system and associated issues with geochemical changes or biological growth

- The system can be operated in a passive (i.e. gravity-flow driven) manner avoiding the need for active pumping systems

It is also noted that the groundwater flow system in the area of the trench is very localized and hence the associated flows to be collected and infiltrated by the proposed engineering solution are modest, placing a relatively low amount of stress on the system that can be implemented.

The suitable implementation of the proposed engineering solution does include a variety of considerations for detailed design. Such considerations are normally handled through the detailed design process with supplemental data collection, further evaluations, and design engineering once an overall design approach has been established. If the proposed trench and engineering solution are approved, such detailed design activities would be necessary; however, based on my review of the work completed to date, there do not appear to be any extraordinary or “show-stopper” challenges. Some of the key particular considerations to be addressed during detailed design would include:

- Management of the natural groundwater level gradient along the trench. This may require segmentation of the system into reaches along the trench alignment.

- Hydraulic connection with the groundwater flow system by intersection of suitable cross-sectional area of drain collector pipe and filter media to effectively transmit water (inflow and outflow) with low hydraulic head differentials between the pipe system and the surrounding groundwater system.

- Maintenance access, facilities, and plans to maintain good hydraulic function of the drain pipe and filter media relative to sediment accumulation, geochemical precipitation, and biological growth.

4 Examples or case studies

In proposing engineering solutions, it is sometimes helpful to examine precedents for other similar or related engineering implementations. Some efforts have been undertaken to identify such precedents, including consultation with experienced subsurface professionals and literature review. No directly comparable precedent has been identified by me; however, the proposed engineering solution is a simple adaptation of common measures for subsurface water management as described below.

The upgradient (east) side is a groundwater collection drain that is common use in many applications. One example is the use of foundation drains common in some parts of the world such as Canada where it is standard residential construction practice to have a below grade basement with a perimeter horizontal drain for the collection of groundwater and infiltrating water. These drains are typically a perforated pipe buried in a granular bedding. Any infiltrating water or groundwater that moves toward the basement wall is passively collected into the drain and diverted away from the building envelope by pumping or gravity drainage. While modern practice is to install such drains at the time of construction, they are also retrofitted in situations where not included during initial construction or where there are functional challenges and a repair/replacement is necessary.

More highly engineered horizontal drains are sometimes used in the remediation of contaminated sites. These drains are for the purpose of collecting contaminated groundwater for treatment. They normally include long-term pumping commitment, using a pumping chamber to remove groundwater that passively flows into the drain. In some installations the drains are combined with an impermeable or low-permeability wall to help contain the amount of groundwater inflow to the drain – such installations are analogous to the proposed horizontal drain adjacent to the secant pile wall. Landfill leachate collections systems are another common example of horizontal collection drains. I have personally been involved in the evaluation and design of a number of horizontal drains for groundwater remediation projects and landfill leachate collection over the past three decades.

The downgradient (west) side is simply the reverse of the upgradient collector, where the function is to allow the water to passively flow back out of the drain into the groundwater flow system. While it is true that I am not aware of a directly comparable precedent, I have designed several groundwater recharge systems involving the pumped flow of collected water (including groundwater) into recharge (injection) wells and ponds for the express purpose of maintaining groundwater levels and flow. Three of these systems have been operated, with one of them having been in continuous operation for more than a decade. That system maintains natural groundwater levels adjacent to a quarry for the protection of water resources, including wetlands, fisheries, and water supply wells along an alignment of more than 4,000 metres.

The proposed system is also similar to stormwater re-infiltration systems. Such systems use horizontal drains (i.e. perforated pipes in granular bedding) to allow passive (gravity flow of collected stormwater) back into the subsurface. These systems are implemented for two common purposes: 1) disposal of stormwater, and 2) recharge of groundwater to support groundwater levels and flow conditions. The standard implementation of such systems is above the groundwater table, however the construction and function of such systems is generally comparable.

It should also be recognized that the application of new solutions and adaptation of existing solutions are standard and expected activities in engineering. The lack of a precise precedent should certainly not be considered a reason for not undertaking a particular approach. I have personal experience in the adaptation of groundwater recharge and engineering technologies from other disciplines to the design and implementation of groundwater recharge systems as noted above.

Declaration

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.

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Signed

Date: **May 27, 2018**

Appendix A Matters Raised by PPV Guide to Expert Evidence

(a) the name and address of the expert;

J. Richard Murphy, 600 Willow Wood Drive, Waterloo, Ontario, Canada

(b) the expert's qualifications and experience;

Mr. Murphy is a professional engineer specializing in hydrogeology and water resources evaluation and design. Mr. Murphy's project experience ranges from contaminated site assessment and remediation, numerical and analytical modelling, aggregate resource development, landfills, and water supply; working in both overburden and bedrock environments. Mr. Murphy capably manages/executes all project aspects ranging from technical evaluations, project management, strategic planning, agency and public consultation, to providing expert witness evidence.

(c) a statement identifying the expert's area of expertise to make the report;

Mr. Murphy provides expert advice and has previously been qualified to provide expert evidence in the areas of hydrogeology, water resources, and engineering.

(d) a statement identifying all other significant contributors to the report and where necessary outlining their expertise;

Mr. Murphy is the sole contributor to the report.

(e) all instructions that define the scope of the report (original and supplementary and whether in writing or oral);

Mr. Murphy was provided with the following Scope of Work in writing by Clayton Utz:

Scope of Work

You are requested to undertake the following work:

1. Review the Groundwater Report, including the Potential Design Change.

2. Review the public submissions referred to you, to the extent relevant to the Potential Design Change.

3. Prepare an expert report that comments on:

   (a) the Potential Design Change, including:

      (i) the feasibility, effectiveness and maintenance of the Potential Design Change; and

      (ii) any examples or case studies where a similar design or mitigation measure has been successfully applied elsewhere; and

   (b) addresses any other matter that you consider relevant to your area of expertise.

(f) the identity of the person who carried out any tests or experiments upon which the expert relied in making this report and the qualifications of that person;

Mr. Murphy relied upon the information provided in the documents reviewed (refer to item g)

(g) the facts, matters and all assumptions upon which the report proceeds;

The report is based upon the information presented in the relevant project information (refer to item h) and the understanding that there would be a normal course of detailed design process, including data collection, further evaluations, and design engineering.

(h) reference to those documents and other materials the expert has been instructed to consider or take into account in preparing the report, and the literature or other material used in making the report;

Chapter 5 of the Environmental Effects Statement (EES) Summary Report

EES Technical Report A – Groundwater Impact Assessment

Additional information provided by the LXRA project team

(i) a statement identifying any provisional opinions that have not been fully researched for any reason (identifying the reason why such opinions have not been or cannot be fully researched);

Not applicable.

(j) a statement setting out any questions falling outside the expert's expertise and also a statement indicating whether the report is incomplete or inaccurate in any respect.

The report deals with matters within Mr. Murphy’s expertise and is not incomplete or inaccurate in any respect.

(k) a summary of the opinion or opinions of the expert

Mr. Murphy’s opinion is that the proposed engineering solution can be an effective solution to reduce and limit potential changes to groundwater levels that may result from the proposed construction of the trench at Edithvale. Furthermore that remaining considerations can be suitably addressed through the normal process of detailed design and ongoing maintenance and monitoring programs.

Appendix B CV

J. Richard Murphy
Principal: Engineer, Hydrogeologist

Qualified: M.A.Sc. Civil Engineering (Water Resources), University of Waterloo, 1991; B.A.Sc. Systems Design Engineering, University of Waterloo, 1989

Connected: Professional Engineers of Ontario (PEO), American Geophysical Union (AGU), National Groundwater Association (NGWA), International Association of Hydrogeologists (IAH), Ontario Stone Sand & Gravel Association (OSSGA)

Professional Summary: Mr. Murphy is a professional engineer specializing in hydrogeology and water resources evaluation and design. Mr. Murphy's project experience over more than 25 years ranges from contaminated site assessment and remediation, numerical and analytical modeling, aggregate resource development, landfills, and water supply; working in both overburden and bedrock environments. Mr. Murphy capably manages/executes all project aspects ranging from technical evaluations, project management, strategic planning, agency and public consultation, to providing expert witness evidence.

Aggregate Resources Development Services

Mr. Murphy has been responsible for the evaluation of water resources, hydrogeology, and environmental management matters pertaining to aggregate resource development. The scope of work has included site investigation, impact assessment, water management design and engineering for dewatering and mitigation systems, stakeholder consultation and approvals, expert witness testimony, and implementation of approved systems. Representative projects include:

- Armbro Pinchin Aggregate Pit, Town of Caledon, Ontario
- Dufferin Milton Quarry, Regional of Halton, Ontario
- Dufferin Acton Quarry, Regional of Halton, Ontario
- Dufferin Flamboro Quarry, City of Hamilton, Ontario
- Dufferin Paris Pit, Paris, Ontario
- Caledon Sand and Gravel Inc. Pit, Town of Caledon, Ontario
- Proposed Rockfort Quarry, Town of Caledon, Ontario
- Armbro Esker Lake Pit, Brampton, Ontario
- Lafarge Ravena Plant and Quarry, Albany County, New York
- Lafarge Woodstock Plant and Quarry, Ontario
- Lafarge Joppa Plant and Quarry, Illinois
- Nelson Quarry, Burlington, Ontario
- Penny's Lawrence Pit, Douglas County, Kansas

Remedial Investigation/Feasibility Studies

Mr. Murphy has been responsible for evaluating hydrogeologic conditions for a number of Remedial Investigation/Feasibility Studies. Duties included hydrogeologic characterization, planning of supplemental investigations, calculation of groundwater flow and contaminant migration rates, prediction of required pumping rates and durations for potential remedial alternatives and recommendation of hydrogeologically suitable remedial alternatives. Evaluation techniques involved both analytical and numerical simulation techniques. Representative projects are listed below:

- Novak Farm Site, Chenango County, New York
- Former Hart Chemical, Guelph, Ontario
- Bristol Aerospace, Winnipeg, Manitoba
- Phelps Dodge Landfill Remediation, Maspeth, New York
- VacAir Alloys Division, Frewsburg, New York
- Fons and Old Wayne Landfills, Ypsilanti Township, Michigan
- Textile Road Site, Ypsilanti Township, Michigan
- Pristine Site, Reading, Ohio
- Henkel Site, Hamilton, Ontario
- Sealand Restoration Site, Lisbon, New York

Remedial Design/Remedial Actions

Mr. Murphy has been responsible for the design of groundwater and soil remediation systems. Duties have included hydrogeologic characterization, planning of supplemental investigations, determination of suitable cleanup objectives, specification of the locations and flow rates for groundwater extraction systems, prediction of performance impacts due to design and operational variations. Evaluation techniques have involved both analytical and numerical simulation methods. Representative projects are listed below:

- Summit National Superfund Site, Deerfield, Ohio
- Spiegelberg Site, Livingston County, Michigan
- Hyde Park Landfill, Niagara Falls, New York
- Buffalo Avenue Plant, Niagara Falls, New York

- S Area Site, Niagara Falls, New York
- Former Hart Chemical, Guelph, Ontario
- Former Uniroyal Chemical, Elmira, Ontario
- G&H Landfill, Macomb County, Michigan
- Pfohl Brothers Landfill, Cheektowaga, New York
- Libbey Glass, Toledo, Ohio
- Caterpillar, East Peoria, Illinois
- Miami County Incinerator Site, Miami County, Ohio
- Fisher Calo Site, Kingsbury, Indiana
- Rockaway Borough Well Field Site, Rockaway Borough, New Jersey
- Schenectady International, Inc. Site, Rotterdam Junction, New York
- Hooker/Rucco Site, Hicksville, New York
- Rocky Hill Municipal Well/Montgomery Township Housing Development Superfund Sites, Somerset County, New Jersey
- JIS Landfill, South Brunswick, New Jersey

Water Supply/Wellhead Protection Studies

Mr. Murphy has been responsible for the evaluation of hydrogeologic impacts and wellhead protection areas for municipal and commercial groundwater supplies. Evaluation of techniques employed include numerical steady state and transient groundwater flow and capture zone simulations, vulnerability assessment, and evaluation of studies by others. Representative projects are listed below:

- Waterloo Landfill Site. Confirmation of findings of Erb Street Well Field Evaluation, Region of Waterloo, Ontario
- Sauble Beach Groundwater Supply Study, Township of Ambel, Ontario
- Fisher Calo Site, Kingsbury, Indiana
- Ontario Source Water Protection Projects:
  - Various client site assessments
  - Saugeen/Grey Sauble Vulnerability Study and Threats Assessment

Solid Waste Management Sites

Mr. Murphy has been responsible for planning and carrying out water quality impact assessments for existing and proposed solid waste management sites. Duties included site characterization, contaminant migration simulation, impact prediction, and recommendations for engineered systems. Simulation techniques range from analytical models to numerical models involving unsaturated and multidimensional solution domains. Representative projects are listed below:

- Waterloo Landfill, Waterloo, Ontario
- Keele Valley Landfill, Toronto, Ontario
- St. Marys Landfill, St. Marys, Ontario
- Valentine Road Landfill, Kincardine, Ontario
- Mid Huron Landfill, Goderich, Ontario
- Greenlane Landfill, Southwold, Ontario
- Sarnia Landfill, Sarnia, Ontario
- Cedartown Municipal Landfill, Cedartown, Georgia
- Wauconda Landfill, Chicago, Illinois
- East Bethel Landfill, East Bethel, Minnesota

Work history

1991 - present	Principal, GHD (formerly Conestoga-Rovers & Associates), Waterloo, ON
	Named Principal, 2002
1990	J.F. Sykes & Associates Limited
1990	Neil Thomson Engineering Services
1989 - 1991	University of Waterloo
1988 - 1989	Conestoga-Rovers & Associates

Other related areas of interest

Recognized (Certifications/Trainings)

- Licensed Professional Engineer: Ontario
- Designated Consulting Engineer: Ontario
- Clayey Barriers for Mitigation of Contaminant Impact, University of Western Ontario, 1992

Expert Testimony

Mr. Murphy has provided expert witness testimony (depositions, Trial, and Hearings) on various aspects of hydrogeology, water resources, site investigation, analysis and remediation, including groundwater flow and contaminant transport issues, water resources, and engineering, for the following projects:

- Royal Oak Site, Royal Oak, Michigan
- Proposed South Quarry Landfill Development, Town of Flamborough, Ontario
- Armbro Pinchin Aggregate Pit Development, Town of Caledon, Ontario
- 217 Fay Avenue, Addison, Illinois
- Rocky Hill Municipal Well/Montgomery Township Housing Development Superfund Sites, Somerset County, New Jersey
- Dufferin Aggregates Milton Quarry Extension, Region of Halton, Ontario
- Proposed Rockfort Quarry Development, Town of Caledon, Ontario
- Proposed Nelson Quarry Extension, Burlington, Ontario
- Halton Regional Official Plan Amendment No. 38, Region of Halton, Ontario
- Dufferin Aggregates Acton Quarry Extension, Town of Halton Hills, Ontario
- Dufferin Paris Pit, Brant County, Ontario

Publications/Presentations

- "Protecting Water Resources with a Groundwater Recharge Well System at the Dufferin Aggregates Milton Quarry", International Association of Hydrogeologists Canadian National Conference, October 27-30, 2015 (with W.T. Armes and N. Fitzpatrick).
- "Safeguarding our future" OSSGA, Avenues, Volume 4, Issue 1 (with Brian Zeman).
- "Adaptive Management Plans in Aggregate Resources: A Good Idea and/or The New Normal?", Ontario Stone Sand and Gravel Association Annual General Meeting February 2012 (with D. Hanratty, J. Buhlman, and B. Clarkson).
- "Predicting Redox Dependent Natural Attenuation at the Plattsburgh Air Force Base", The Fifth International Symposium on In Situ and On Site Bioremediation, San Diego, California, April 19-22, 1999 (with G.R. Carey, P.J. Van Geel, E.A. McBean, and F.A. Rovers).
- "Visualizing Natural Attenuation Trends", The Fifth International Symposium on In Situ and On Site Bioremediation, San Diego, California, April 19-22, 1999 (with G.R. Carey, P.J. Van Geel, E.A. McBean, and F.A. Rovers).
- "BIOREDOX MT3DMS: A Coupled Biodegradation Redox Model for Simulating Natural and Enhanced Bioremediation of Organic Pollutants V2.0 User's Guide and Verification Manual", Conestoga-Rovers & Associates, Waterloo, Ontario, Canada, 1999 (with G.R. Carey and P.J. Van Geel).
- "Coupled Biodegradation Redox Modeling to Simulate Natural Attenuation Processes at the Plattsburgh Air Force Base (New York)", MODFLOW'98, Golden, Colorado, October 5-7, 1998 (with G.R. Carey, P.J. Van Geel, E.A. McBean, and F.A. Rovers).
- "An Efficient Screening Approach for Modeling Natural Attenuation", MODFLOW'98, Golden, Colorado, October 6-8, 1998 (with G.R. Carey, P.J. Van Geel, and E.A. McBean).
- "Full Scale Field Application of a Coupled Biodegradation Redox Model (BIOREDOX)", First International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 18-21, 1998, Monterey, California (with G.R. Carey, P.J. Van Geel, E.A. McBean, and F.A. Rovers).
- "Application of an Innovative Visualization Method for Demonstrating Intrinsic Remediation at a Landfill Superfund Site", Petroleum Hydrocarbons & Organic Chemicals in Ground Water Conference, American Petroleum Institute and National Ground Water Association, Houston, TX, November 1996 (with G.R. Carey, M.G. Mateyk, G.T. Turchan, E.A. McBean, and F.A. Rovers).
- "Two Phase Flow in a Variable Aperture Fracture", Water Resources Research, Vol. 29, No. 10, October 1993 (with N.R. Thomson).