Complex Oil Spill Remediation beneath Operating Hospital,
Montfort Hospital, Ottawa, ON

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Category:
Environmental Remediation

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the final remediation objectives (background, potable water, non-potable water or site specific criteria). The third phase, if required, would be to examine additional treatment technologies that could be used to reduce the length of time required to attain the desired final remediation objectives once all of the furnace oil product had been recovered (i.e. the addition of surfactants, oxygen releasing compounds, etc.).

Based on the site conditions (i.e., municipal water supply with neighbours within 100 m that rely on potable groundwater for drinking water), and the hospital's concern for their adjacent neighbours, it was agreed that the provincial potable groundwater criteria would be used as the remediation criteria for this site.

The four remedial options that were ultimately selected for more detailed costing were as follows: 1) Natural Attenuation; 2) Multi-Phase Extraction (MPE); 3) Partial Interior Excavation and MPE; and 4) Building Demolition and Complete Excavation. Although all of these options had their associated advantages and disadvantages, the preferred remedial option that was ultimately selected was Option 2 - MPE. MPE provided the hospital, and the insurance company, with the maximum guarantee of contaminant containment, flexibility, adaptability, and minimal disruption to staff and patients. In addition, MPE was the most environmentally friendly technology which yielded the highest social and economic benefits.

MPE Remediation System

Exp designed the multi-phase extraction system to recover: i) free phase furnace oil; ii) petroleum impacted groundwater; iii) petroleum vapours beneath the building; and, iv) enhance the biological degradation of the residually impacted soil beneath the building that could not be removed.

The MPE system involved the installation of 16 interior recovery wells within the basement of the building and 13 exterior recovery wells along the southern property boundary to prevent off-site contaminant migration. Several interior drilling techniques were tried before settling on a modified one. The location of the recovery wells was carefully chosen based on the subsurface oil plume geometry, subsurface concrete slabs, high security areas of the hospital, and the presence of hospital utilities embedded in the concrete floor. Once constructed, all of the recovery wells were equipped with pneumatic submersible pumps which recover oil, water and vapours from beneath the building and direct them to an exterior, on-site facility for treatment (Figure 2).

The pumping of impacted groundwater from the subsurface depresses the local water table with the lowest point being centered at each recovery well. The cone shaped depression forces the furnace oil, which is floating on the water surface, to flow into the depression where it is recovered by the pneumatic pumps. In addition to the oil and water recovered from beneath the hospital by these recovery wells, an elaborate subfloor vacuum system was also incorporated into the MPE system to withdraw and treat petroleum vapours. These vapours where considered to be the highest potential risk to the safety of the hospital's patients, staff, general public and tenant.

The MPE system not only recovers furnace oil, impacted groundwater and petroleum vapours from the subsurface, but it also promotes natural biological degradation of the petroleum impacted soil beneath the hospital. It does this by promoting fresh, oxygenated air to enter the soil pore spaces which are being evacuated of stagnant, petroleum laded soil vapour. Bringing in oxygen rich air ensures that oxygen never becomes a rate limiting factor for the indigenous hydrocarbon degrading bacteria which consumes the petroleum as a carbon food source. The consumption of the hydrocarbons by the bacteria consumes oxygen and produces innocuous carbon dioxide and water. By ensuring that a continuous source of oxygen is available, the hydrocarbon degrading bacteria will flourish which in turn maximizes the petroleum degradation of the impacted soil.

The piping from each recovery well is directed beneath portions of the hospital floor, within wall cavities, and above the ceiling in such a fashion that would not pose any aesthetic or usability issues with the basement office space. The installation of this piping distribution system within an operating hospital required extensive planning, coordination, security, the installation of elaborate infection control barriers, and testing to demonstrate the containment and treatment of petroleum vapours within the barriers prior to their removal.

Pilot and Full Scale Remediation

Prior to the design of the full scale MPE system, a readily available, small packaged MPE unit was used on-site in order to: i) provide some immediate control of the subfloor vapour emissions; ii) collect and recover some of the furnace oil product; iii) confirm the appropriateness of using MPE at this location; iv) obtain site specific hydraulic conductivity and air permeability measurements; v) assist in sizing of the vacuum blowers, water pumps, oil/water separator, etc.; and, vi) assist in determining the volumes of water and air that needed to be withdrawn from the subsurface for regulatory permitting purposes.

The pilot test successfully demonstrated that a full scale MPE system would be effective at this location. The site specific soil parameters were calculated and used in the design of a full scale, permanent MPE system. The final MPE system design included: 3 large vacuum blowers, 29 pneumatic submersible pumps, a large air compressor, an elaborate sediment filtration system, liquid and vapour phase granular activated carbon, an oil/water separator, and a sophisticated control system with remote access and alarm capabilities (Photo 4). The entire treatment system was contained within a stand-alone 3m x 10 m, sound proof building situated next to the heating plant. The treatment system building had to be sound proof so as to not disturb the adjacent community.

The full scale MPE remediation system has proven to be very effective. To date, approximately 70% of the 22,000 L of furnace oil product spilled has been recovered and petroleum vapour concentrations within the hospital have been reduced to acceptable levels. The initial capital costs for the remediation system and emergency response measures was in the range of $8 to $10M and the operation, monitoring and maintenance costs for the anticipated 10 to 15 years of operation is expected to be in the range of $5 to $10M.

Indoor Air Quality

Immediately after learning of the spill event, the hospital staff became very concerned over their exposure to potentially hazardous air contaminants associated with the oil. In order to ensure the health and safety of their staff, the hospital engaged **exp** to conduct indoor air quality monitoring and provide recommendations on other mitigative measures that could be employed. An indoor air monitoring program was implemented and is presently being conducted on an on-going basis, including the regular collection of indoor air samples for laboratory analyses of volatile petroleum hydrocarbons (PHC) and real time, direct read, monitoring of total volatile organic compound (TVOC) levels.

In addition, two sophisticated, real time TVOC monitors were installed in the D Wing basement, which provide continuous readings and records all readings on a data logger. These two units are equipped with audio/visible alarms in the event of elevated readings. Although, at present, there are no Canadian or U.S. standards for TVOC, the Health Canada guideline indicates target and action levels of 1,000 and 5,000 µg/m^3, respectively, are being discussed. The European Community indicates that at a TVOC exposure over 3,000 µg/m^3, symptoms such as odours, irritation, and discomfort may occur and complaints may be expected. Since the operation of the pilot, and subsequent full scale, remediation system, the concentrations of TVOC have decreased and have remained stable in what is considered to be a normal range (Figure 3).

In addition to the field measurements, indoor air samples are collected for laboratory analyses at nine locations every three months. The sample locations are based on: i) rooms where there were previous complaints of odours, ii) unoccupied rooms awaiting occupancy, and iii) areas situated above the oil plume. The analytical results are compared to Ontario Ministry of Labour (MOL) Occupational Exposure Limits and calculated MOE risk based target levels for the tested parameters. Over the last year, all measured parameters were below the MOL exposure limits and the MOE risk based target levels. The benzene concentrations ranged from <1 µg/m^3 to 3.6 µg/m^3, which is much less than the MOL permissible occupational exposure limit for benzene of 1,600 ug/m^3.

Lastly, **exp** recommended that the ventilation system in the basement of the D Wing be adjusted to increase the air pressure so that it is positive with respect to the subfloor. With the negative subfloor pressure created by the MPE system, air flow within the basement is in a downward direction preventing potential vapours from migrating upwards into the hospital environment. To monitor air flow direction,

there are currently four manometers installed within the basement floor that record and log the pressure difference between the office environment and the subfloor regime.

Management Actions

As things quickly progressed, it became quite apparent that the complex nature of this project required a dedicated organizational structure to coordinate remedial activities and address various stakeholder concerns and needs. As a result, a Steering Committee reporting to hospital Board's Building Committee was created with a mandate of managing risks associated with the oil spill by ensuring coordination of all activities including developing solutions and implementing action plans on technical, legal, fiscal and public relations matters involving oil spill remediation work. When making decisions about solutions, action plans and priorities that have an effect or a potential effect on hospital staff's work environment, the Steering Committee realized it needed input or recommendations and a sounding board from staff representatives of the affected areas.

Health and safety oversight and human resource supports were structured to allow for clarity in consultations, communications, and decision making. A small working group was established much like a sub-committee of a regulated health and safety committee. Employees representing the affected areas, who had expressed concerns about exposure to potentially hazardous air contaminants, and their union representative were approached and happily agreed to take part. Terms of reference for the working group were drafted and approved. Meetings were held with the outmost transparency, respect and concern for staff health and safety.

Environmental Impact

Had a conventional remedial strategy been employed, it could have had a much larger environmental impact than the spill event itself. By implementing the chosen MPE system, no large scale excavation was required. Furthermore, the MPE system promotes and relies upon natural biological processes to reduce the petroleum concentrations beneath the hospital. This environmentally friendly process is enhanced through the addition of oxygenated water and fresh air. By ensuring a sufficient oxygen supply to the hydrocarbon degrading bacteria, we ensure that the rate limiting step of the degradation process (i.e. lack of oxygen) is prevented thus permitting the bacteria to proliferate and hence accelerate the natural consumption/degradation of the hydrocarbon contaminant.

A significant amount of waste material would have been generated had any other remedial method been employed. For example, had the building been demolished in order to gain access to the furnace oil, millions of tonnes of building material would have been trucked through residential neighbourhoods to be disposed of at a local landfill site. Similarly, had excavation beneath the hospital been employed by either tunneling or breaking up the basement concrete floor, thousands of tonnes of impacted soil would have simply been transferred from beneath the hospital to a landfill (i.e. not treated – just moved).

The MPE system uses a very small footprint and it will result in the enhanced, natural degradation of the hydrocarbons – albeit over a longer period of time. Nevertheless, time is not always the crucial factor and in this case, the environmental benefits of a longer operating/remediation period far outweighed any potential benefits of taking a more conventional, “brute force”, approach to remediation.

MOL Investigation and Findings

To ensure due diligence, the hospital’s working group discussed at great length the need for a third party validation to help close the loop on everything that had been accomplished to date. As a recommendation was brought forward by the working group to the Steering Committee for third party validation, two anonymous employees expressed their concerns to the local Ministry of Labour (MOL) office which automatically triggered an investigation. Given the sensitivity of the issue, the MOL conducted a comprehensive investigation over the next few months to determine whether the remediation system and the associated monitoring programs were sufficient to safeguard the staff from being exposed to unacceptable health risks associated with the furnace oil spill event.

The MOL investigation included: a detailed site inspection; a tour of the entire remediation/treatment system; and, a review of: i) volumes of documentations; ii) chronology of events; iii) numerous reports; iv) analytical results of indoor air quality testing; and, v) indoor air monitoring results. After their comprehensive review, the MOL. concluded the following:

- The site remediation system has proven to be effective;
- No significant worker exposure to airborne petroleum hydrocarbons occurred;
- The hospital's consultant had correctly identified and monitored the chemical agents of concern in worker exposure and indoor air quality effects associated with the fuel oil leak;
- Throughout the remediation process, the hospital and their consultant provided rapid corrective measures to evaluate, control, and eliminate contaminant routes and odours as events developed; and,
- There is no evidence to indicate that a chemical hazard presently exists for workers at the hospital due to exposure to airborne petroleum hydrocarbons associated with the fuel oil spill.

Based on their investigation, the MOL was satisfied with the hospital's and **exp**'s efforts to remediate and monitor the affected locations and they acknowledged the efforts made by the hospital to develop a response plan and internal committees to deal with staff questions and concerns. Based on their findings, the MOL concluded that the situation was well handled, is under control, and that no additional measures were required.

Conclusions

A major furnace oil spill occurred beneath a brand new, $ 50M, state-of-the-art hospital building in Ottawa. This spill event was complicated by the existence of: i) a complex subsurface geological/hydrogeological regime, ii) multiple stakeholders with diverse issues/concerns; iii) the ongoing operation of the building as an operating hospital; iv) an adjacent residential subdivision which relies on the groundwater regime as a source of potable water; v) an adjacent apartment building undergoing a property ownership change; vi) hospital staff members concerned over potentially harmful hydrocarbon exposure rates; vii) an ongoing $300M hospital expansion project; and viii) the timely communication and management of all of these issues.

From the onset of the realization that a major spill event occurred, the hospital's primary objective was always the health and safety of their patients, visitors, staff, tenant and the community. Other needs included: i) ensuring the continued operation of their hospital facility as a whole; ii) ensuring that all regulatory obligations associated with such a spill have been met; and iii) not delaying the grand opening of this new, state-of-the-art facility, if possible.

The chosen in-situ, MPE remediation system and the subsequent monitoring program implemented at this location ensured that all of these needs were met. The new hospital wing officially opened on schedule to a gala event which was attended by the Premier of Ontario, the Mayor, and other dignitaries.

In addition, a comprehensive, independent assessment by the Ontario Ministry of Labour (M.O.L.) confirmed that throughout the emergency remedial measures and the implementation of the permanent remediation system, the hospital staff, visitors, tenant and the community were never exposed to an unacceptable risk.

To date, approximately 70% of the 22,000 L of furnace oil product spilled has been recovered by the MPE system and petroleum vapour concentrations within the hospital are being maintained at acceptable levels.

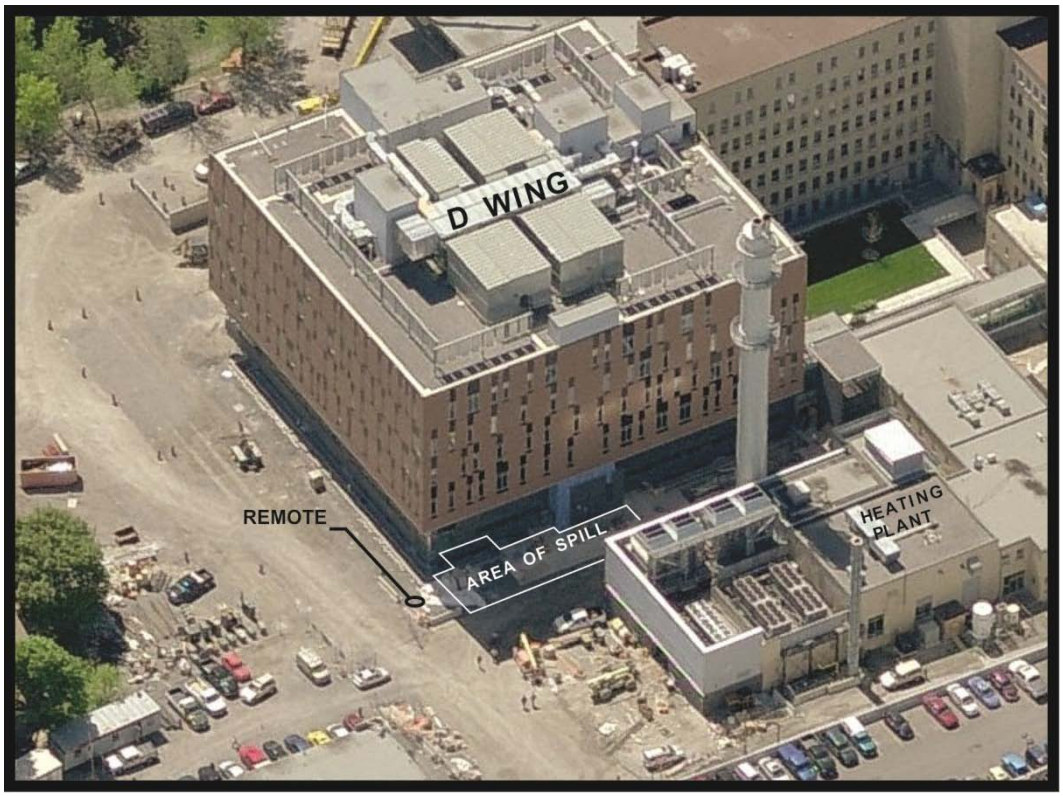

Photo 1 - Aerial view of the Montfort Hospital showing the brand new $50M D-Wing building and the furnace oil spill location.

Photo 2 - View of furnace oil pipe break where 22,000L of furnace oil leaked into the subsurface.

Photo 3 - View of elaborate infectious control system set up to permit the interior drilling of the 16 MPE recovery wells within the operating hospital.

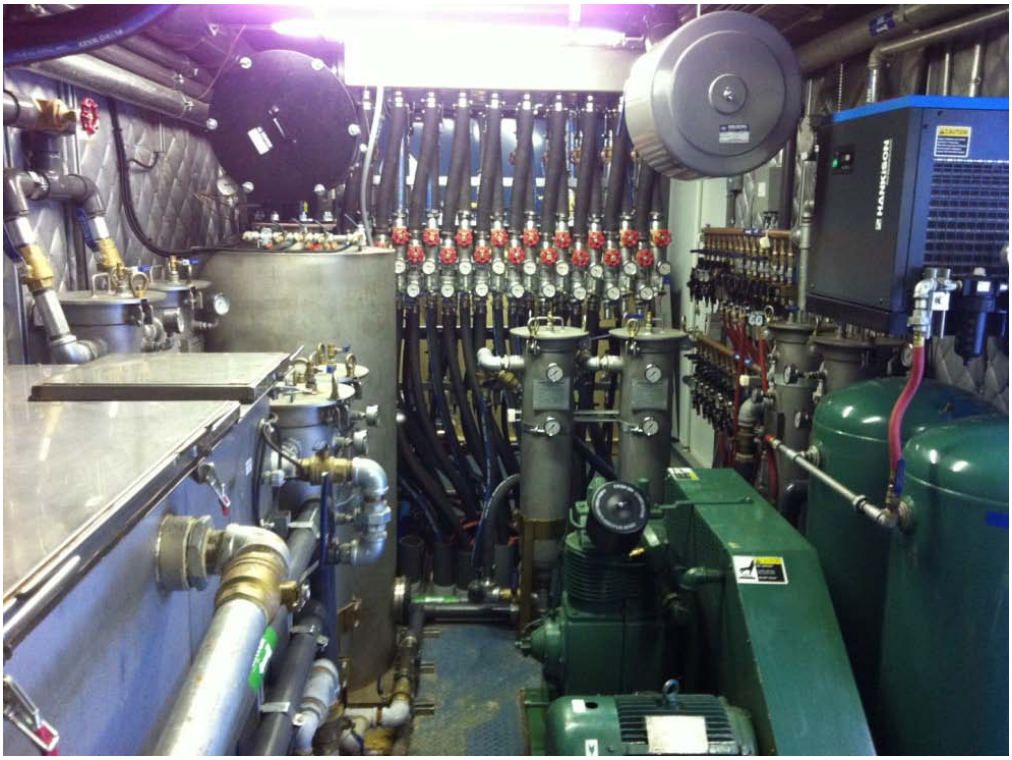

Photo 4 - Interior view of MPE treatment system contained in a stand-alone, sound proof, building situated next to the hospital's heating plant.

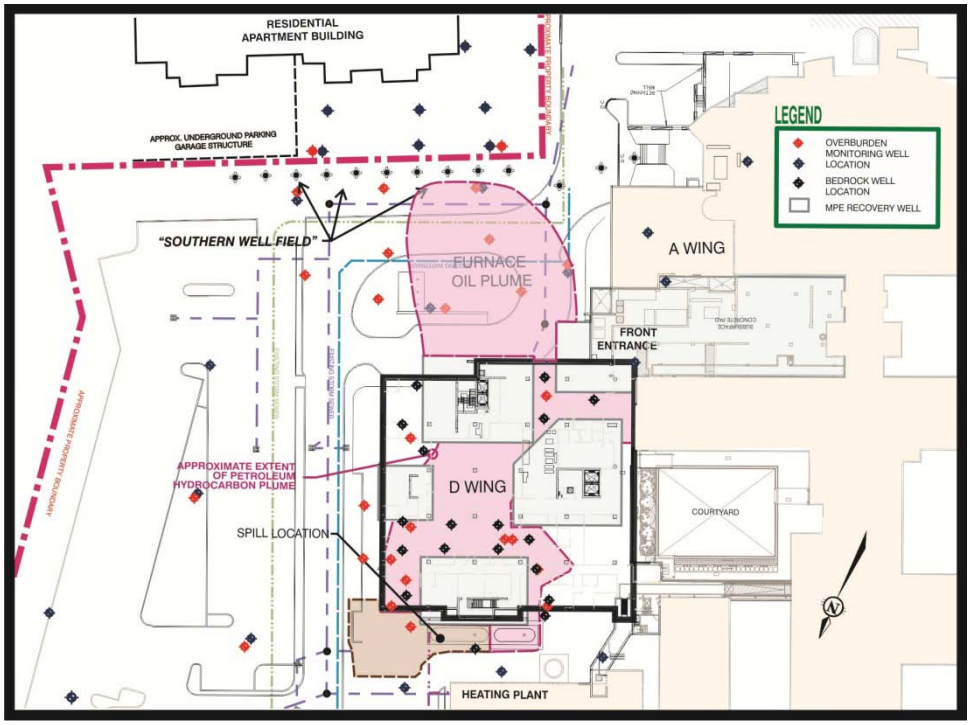

Figure 1 - Site plan showing the extent of subsurface petroleum impact beneath D-Wing of hospital.

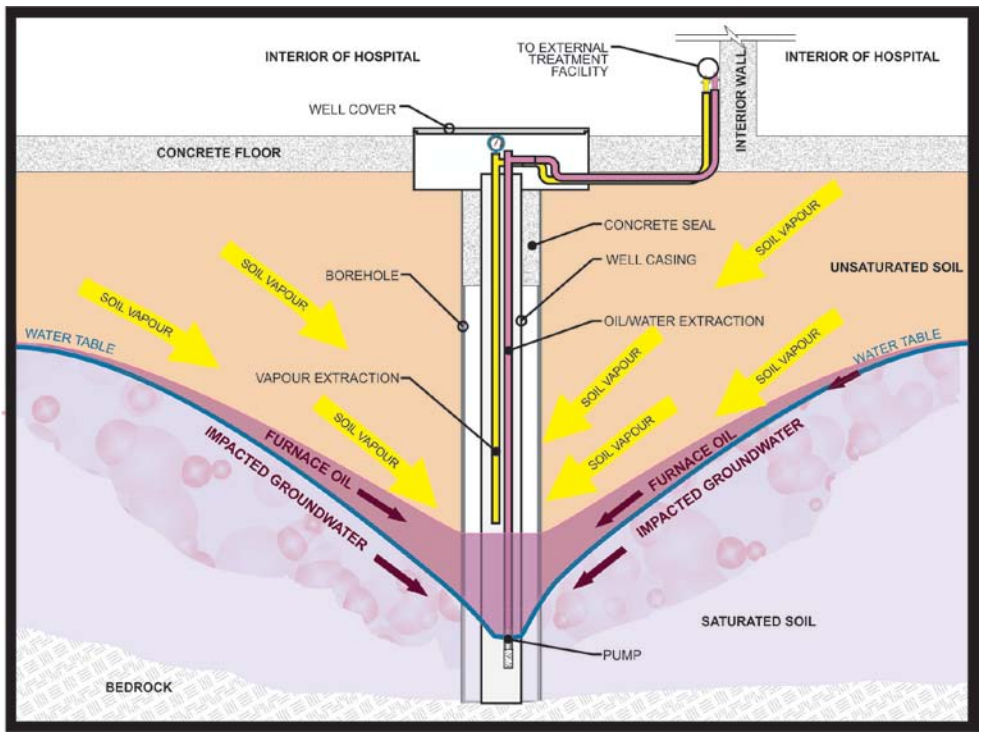

Figure 2 - Cross section of a typical MPE recovery well showing how the withdrawal of impacted groundwater promotes the flow of oil along the water table surface into the recovery well for collection. Petroleum vapours are also withdrawn by these recovery wells which safeguard the hospital staff and promotes the natural biological degradation of the petroleum impacted soil beneath the hospital.

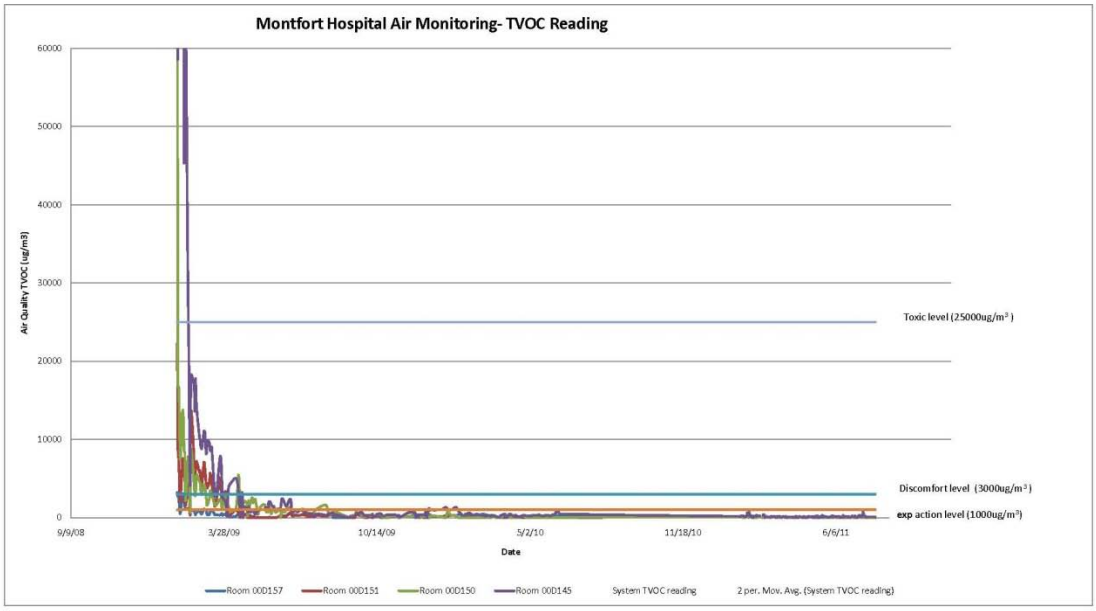

Figure 3 - Graph of Total Volatile Organic Compounds (TVOC) concentrations within the hospital. Significant reductions in TVOC concentrations were achieved after the implementation of the MPE system.

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Ottawa, April 10th, 2013

To whom it may concern,

Five months post occupation of our new 125,000 square foot Ambulatory Care wing, which also houses the Canadian Forces Health Services Centre, a major oil spill occurred resulting in 22,000 liters of oil under this brand new building. The Hospital was still in the midst of its complex redevelopment project, 1½ years away from overall substantial completion. Exp, as part of our development project team, immediately became involved in the emergency responses required and in developing and implementing a remediation strategy. This was a complex project and patient and staff safety was our primary concern. Potential impact on our neighbors to the South and East of the Hospital was also a major concern, especially since the neighboring community was not on city water, but relied on wells. Exp, under the leadership of Dan McNicoll, was one of the key players in the interdisciplinary approach required to manage this project. Their technical expertise was well recognized and respected but their collaborative approach with other stakeholders really made them stand out. They were very sensitive to stakeholders' concerns, be it with the administrative and medical staff working in the area where the wells were installed, or those of the neighboring community. Regular reporting to both the Hospital and the community ensured a transparent process.

The Hospital is very appreciative of their technical and overall leadership. The situation is now under control, without having an impact on public, patient and staff safety.

Sincerely,

Kathy O'Neill
Vice President
Planning and Support Services