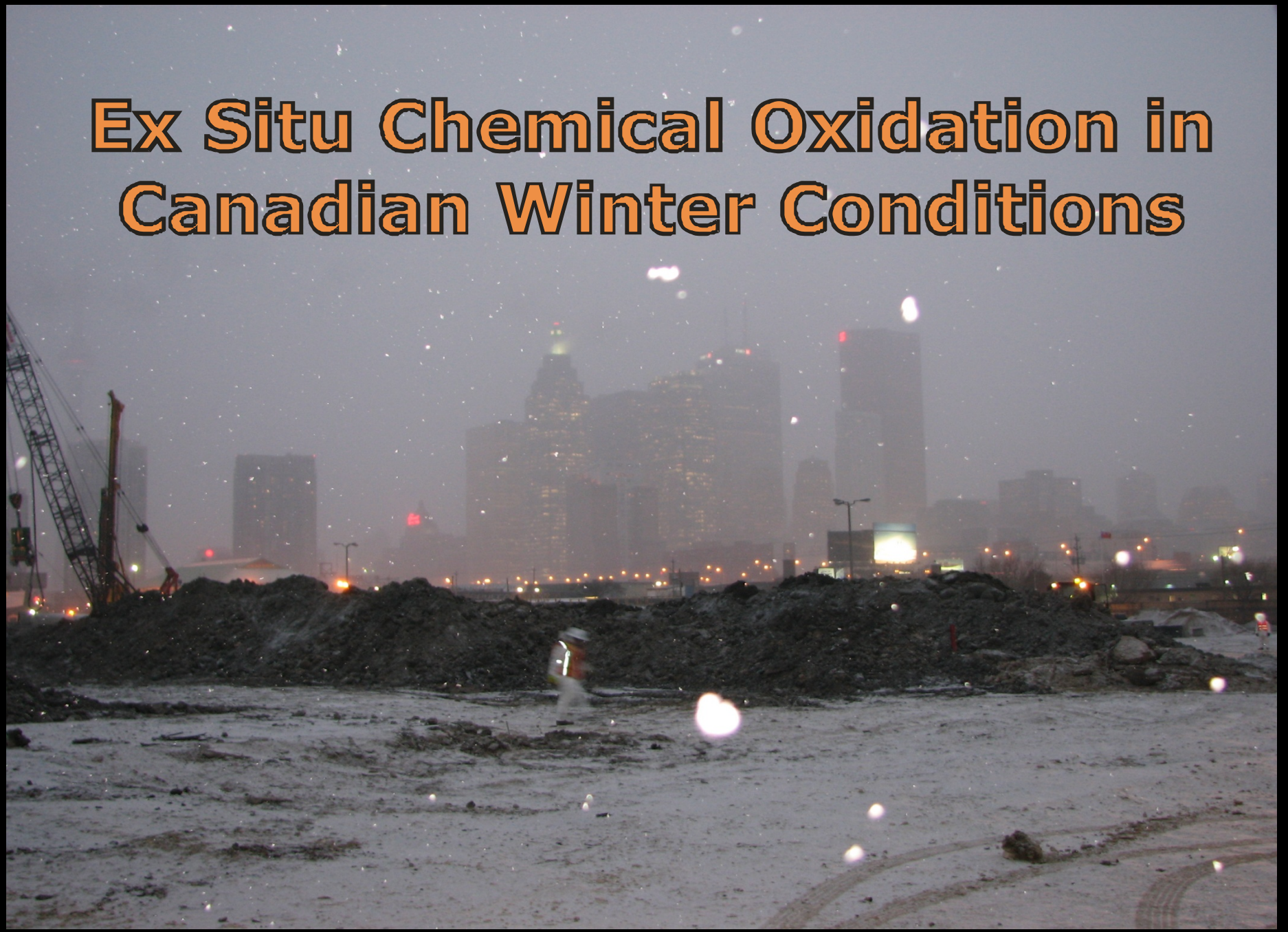
Ex Situ Chemical Oxidation in Canadian Winter Conditions

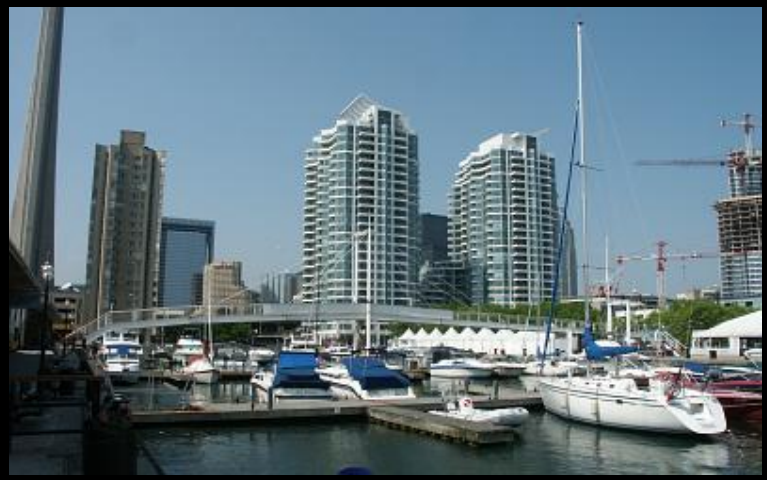


Project Background

- Re-development of the Toronto Harbour front has been on-going for many years.
- This waterfront site was previously occupied by a two storey building housing a film studio and commercial parking lot.
- The site was re-developed by the Toronto Economic Development Corporation (TEDCO) as an entertainment centre at an estimated cost of $130 million dollars.
- The proposed building design is aiming for Gold Certification under the Leadership in Energy & Environmental Design (LEEDS).

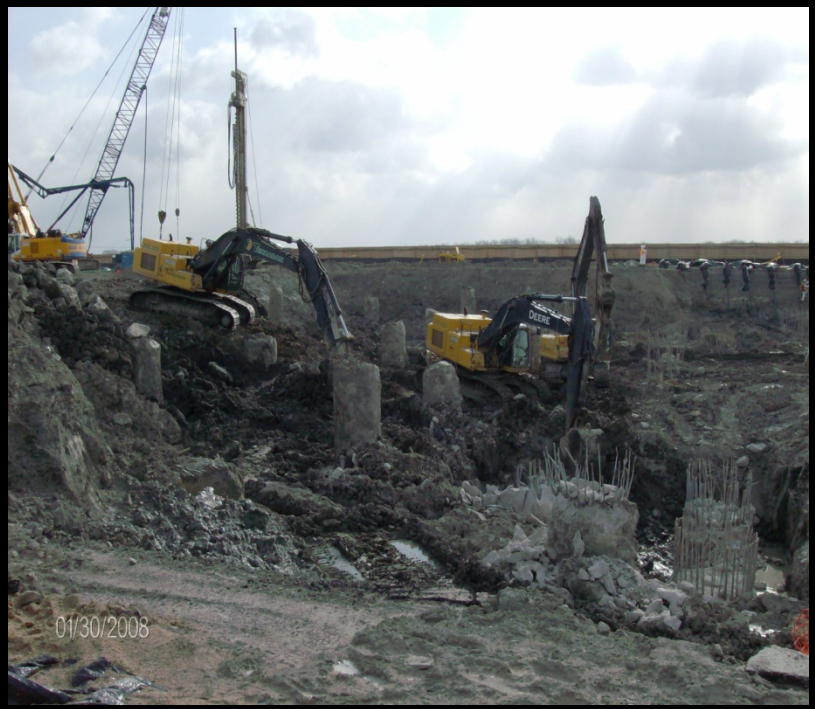
Project Background

- Extensive environmental site assessments were conducted for this site and the surrounding lands. The area of the site and surrounding lands were backfilled over many years to permit expansion of the Harbourfront.
- Contaminates of concern at the site were identified as localized areas of PAHs and PHCs.
- Previous site assessments delineated 18,000 to 20,000 tonnes of impacted soil.
- Initial estimates forecast the project to begin by December 2007 but the project did not start until Jan. 2008 as winter conditions were settling into Toronto.



Top: Queens Quay 1993
Bottom: Queens Quay 2003

Project Background



- Remediation of the site was to be conducted in conjunction with the excavation of soils in preparation of the new building's construction.
- Various remediation technologies were considered by the stakeholders and their consultants.
- Modified Fenton's chemical oxidation was selected for ex-situ remediation of the excavated soils due to the speed of remediation and lower costs.

Modified Fenton Chemistry (MFC)

defined as:

$$H_2O_2 + Fe^{+2} \rightarrow Fe^{+3} + OH^- + OH\bullet$$

$$2CaO_2 + 2H^+ \rightarrow Ca^{2+}(aq) + 2\,H_2O_2$$

$$H_2O_2 + OH^- \rightarrow H_2O + HOO^-$$

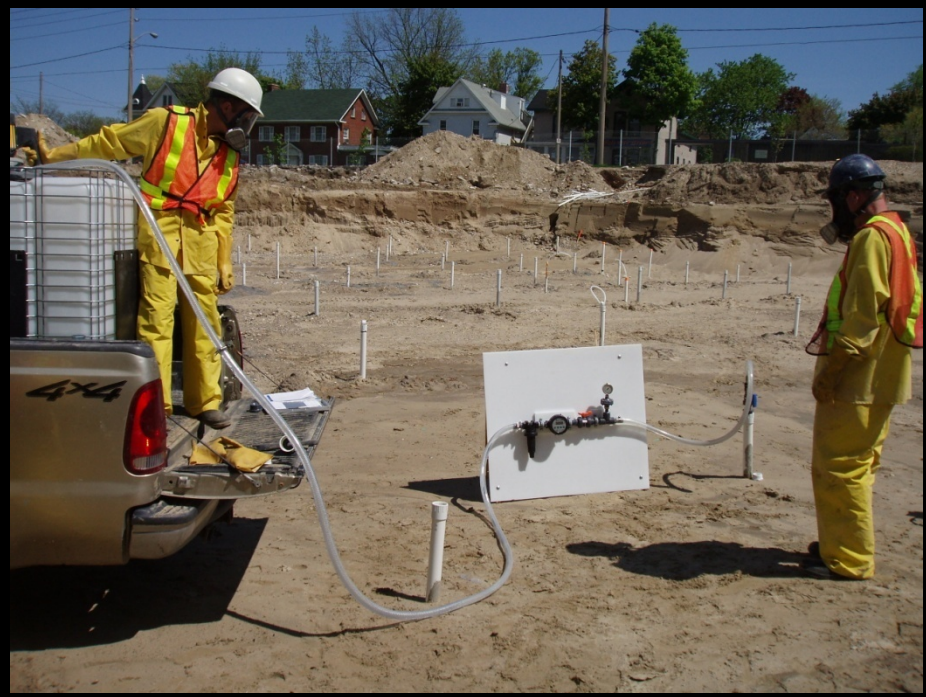
$$2\,H_2O_2 \rightarrow 2H_2O + O_2$$

Modified Fenton Chemistry (MFC)

- MFC ex-situ methodologies were employed to make soil conditions acceptable for treatment in cold weather conditions through chemical formulations changes.

- Controlled oxidation generates oxygenated organic molecules that degrade to simple acids and alcohols which aid in the desorption of co-contaminates from soil. This process greatly aids the oxidation process by bringing the contaminates into solution and susceptible to chemical oxidation.

- Green technology, un-reacted hydrogen peroxide decomposes to molecular oxygen and water. Combined with the bio-nutrient compounds used in the oxidation product phase to control the oxidation reaction rates, bioremediation is stimulated to polish the job.

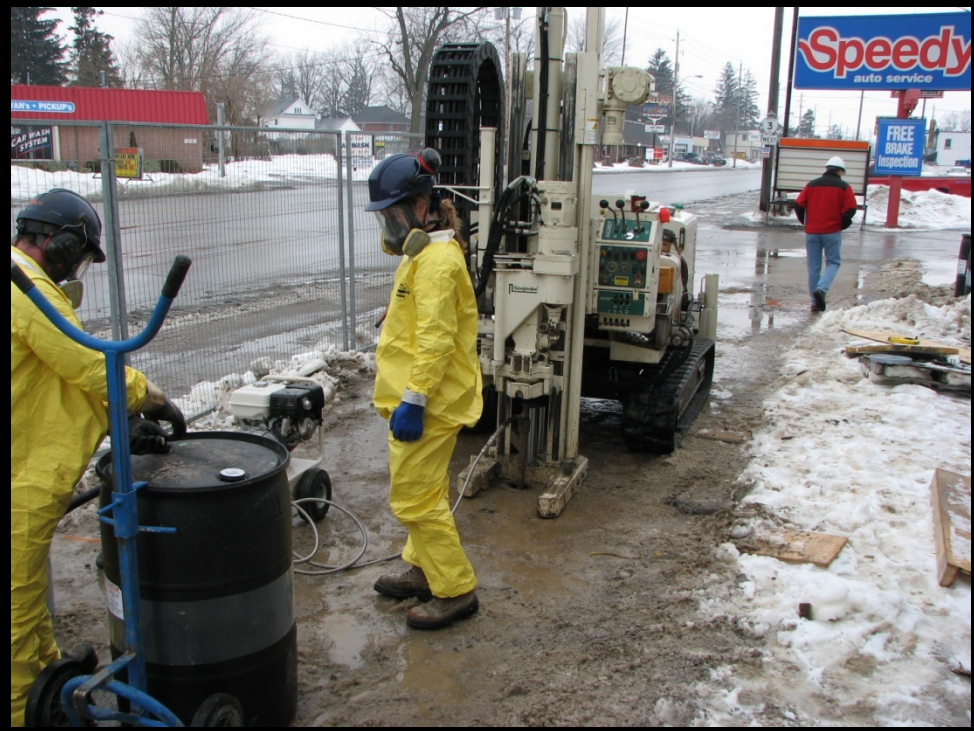


OXYTEK

Modified Fenton Chemistry (MFC)

- MFC is particularly effective for treating high contamination concentrations in saturated and unsaturated zones. Chlorinated compounds are particularly vulnerable to halogen / hydroxyl substitution reactions of this process and no vinyl chloride is produced.

- BTEX, chlorinated solvents, pesticides, fungicides, etc. are fragmented and converted to oxygenated compounds during the oxidation phase. Bioremediation of these bi-products occurs very quickly there after.



OXYTEK

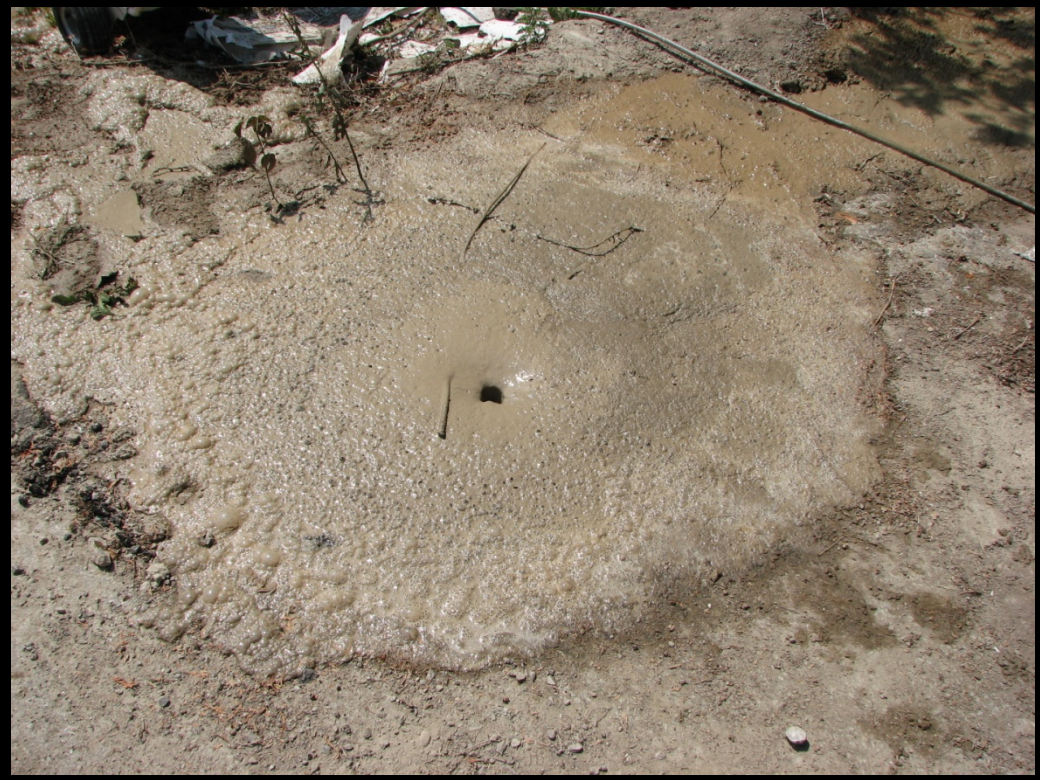
Modified Fenton Chemistry (MFC)

- When following Health and Safety guidelines, the reactions are controlled to avoid excessive heat, off-gassing and pH changes. The process is hydrogen peroxide based.

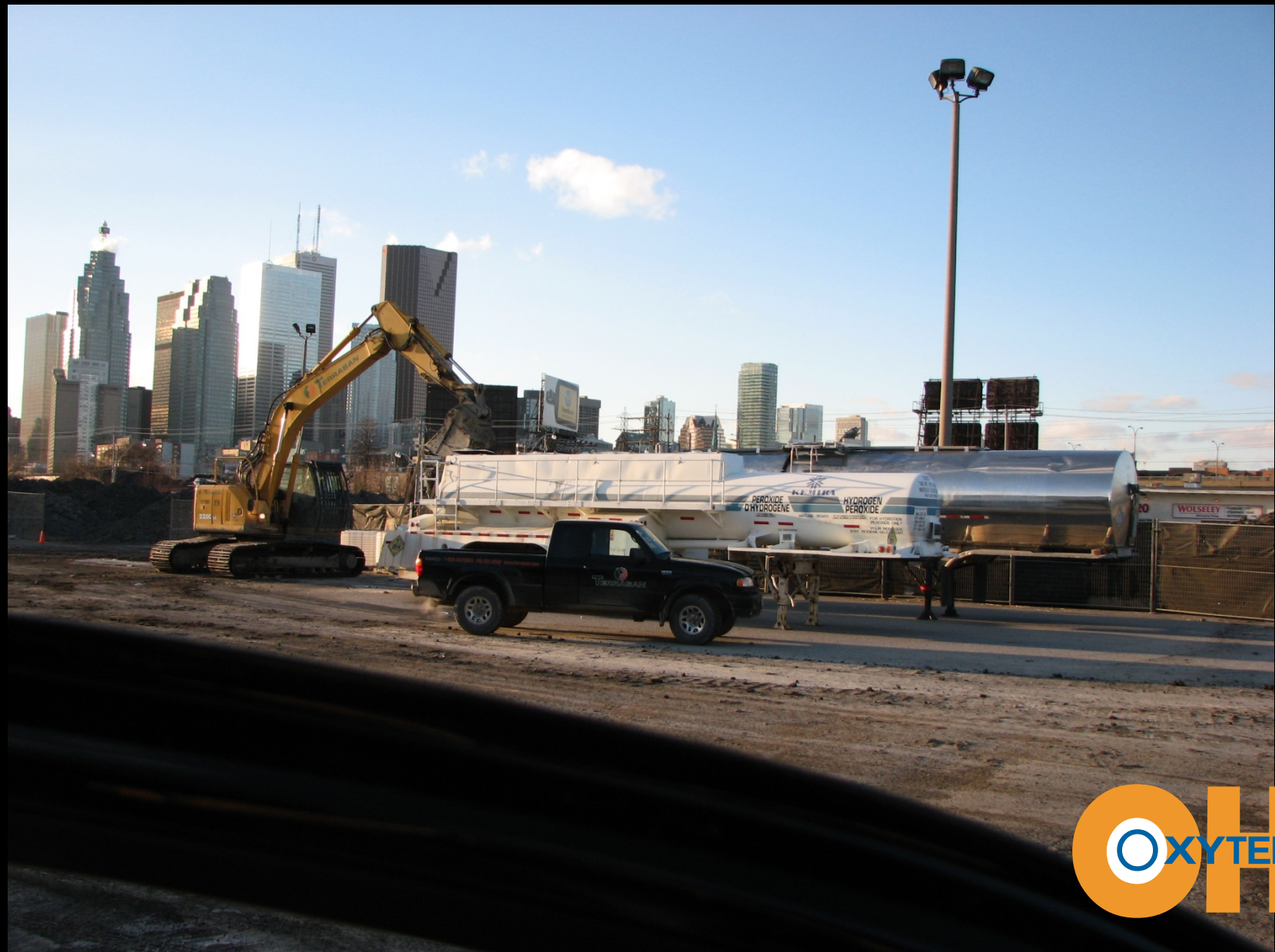
- During oxidation, any product not consumed as a chemical oxidizer is converted to molecular oxygen. When combined with the bio-nutrient compounds used in the oxidation phase to control the oxidation reaction, bioremediation polishes the job.

Modified Fenton Chemistry (MFC)

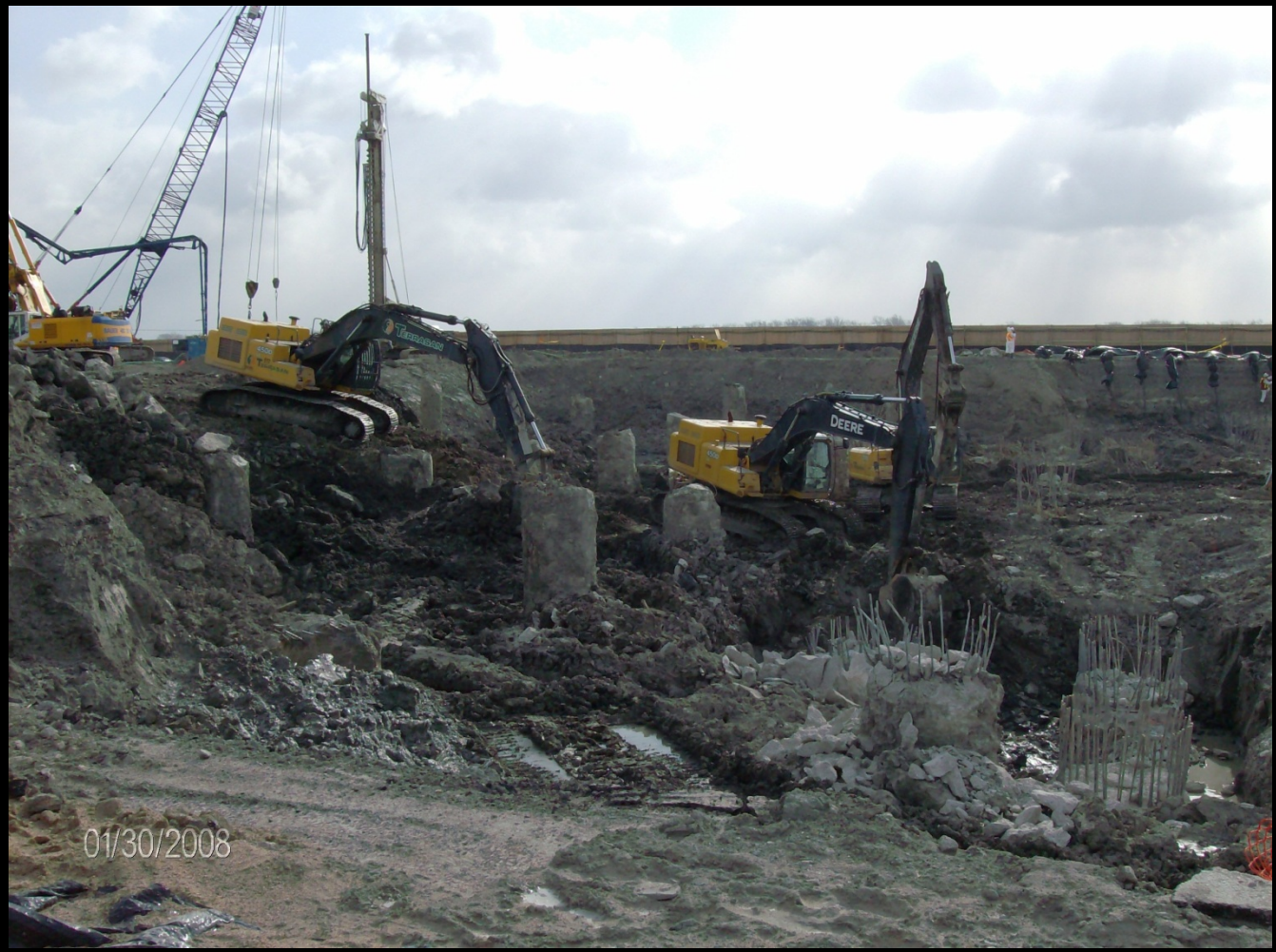
- The MFC process is cost effective, maintenance free and quick.
- The success of MFC is knowing how to modify the chemical reactions based on the site conditions.
- The oxidant must be formulated for controlled activations via reagents and other compounds determined by site conditions and temperatures.



MFC Remedial Methodology

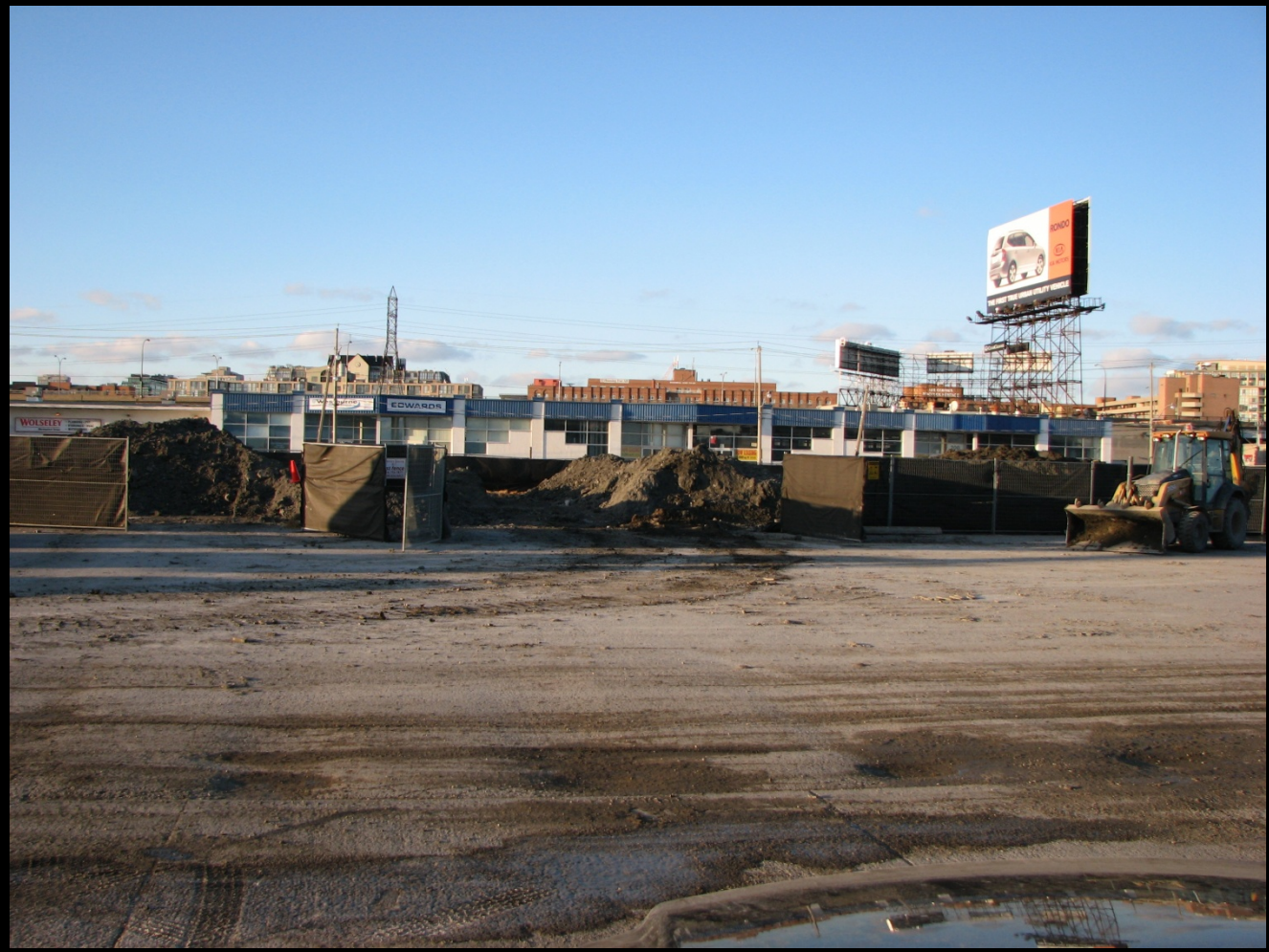


MFC Remedial Methodology



Soils to 3.6 m were excavated across the entire site.

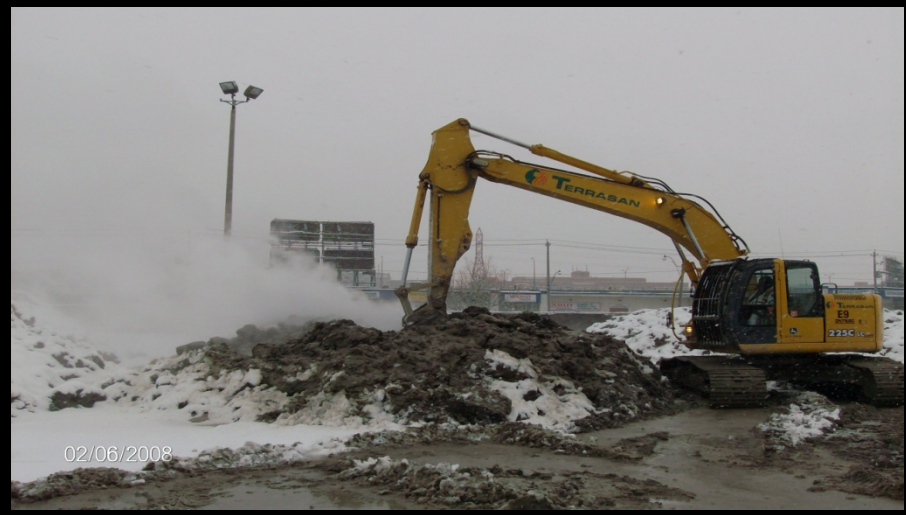
MFC Remedial Methodology

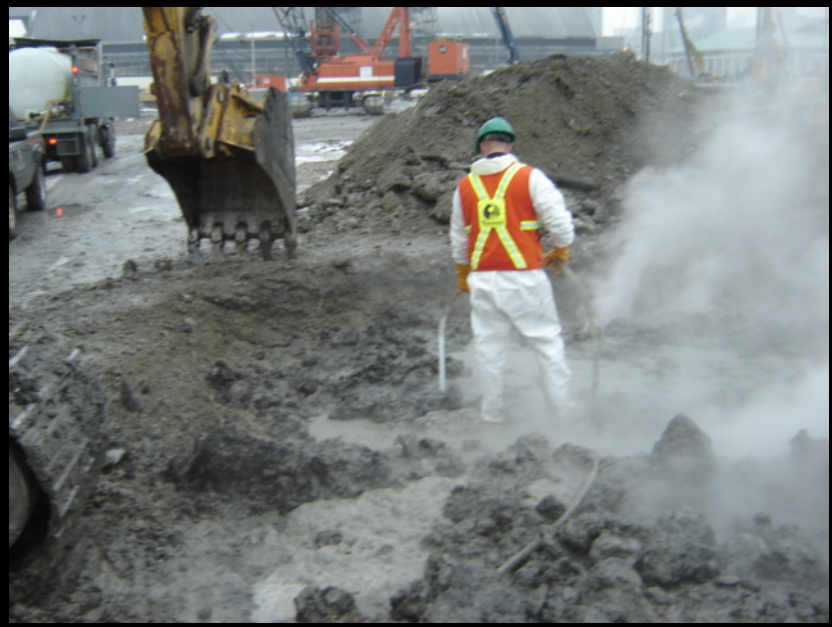


The excavated soils were stockpiled in 500 metric tonne windrows.

MFC Remedial Methodology

MFC was applied to the soil stockpiles using conventional excavators to mix the oxidants into the soil stockpiles.

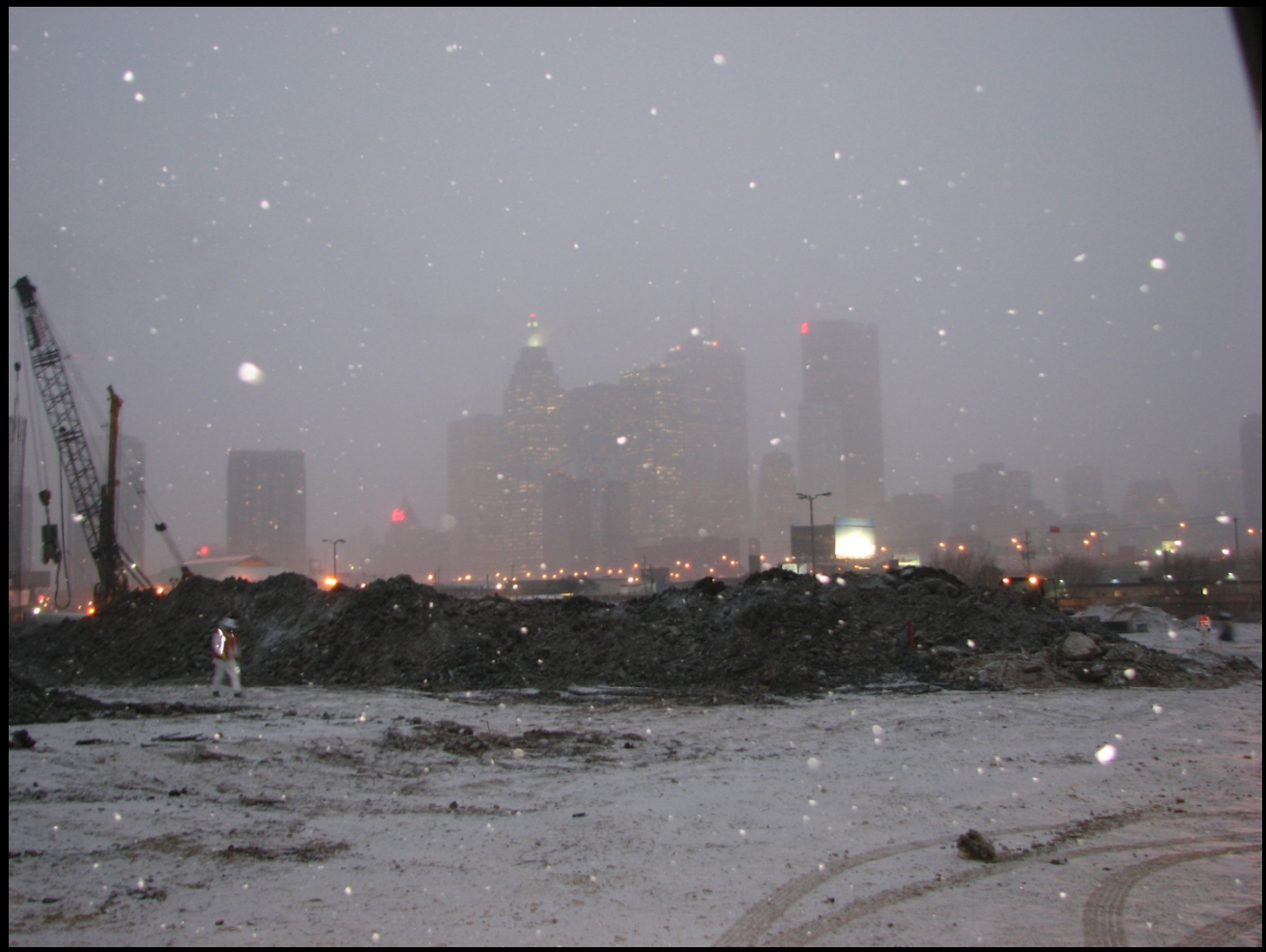




MFC Remedial Methodology

Treated soils had 72 hours of residence time prior to final confirmatory sampling and testing.

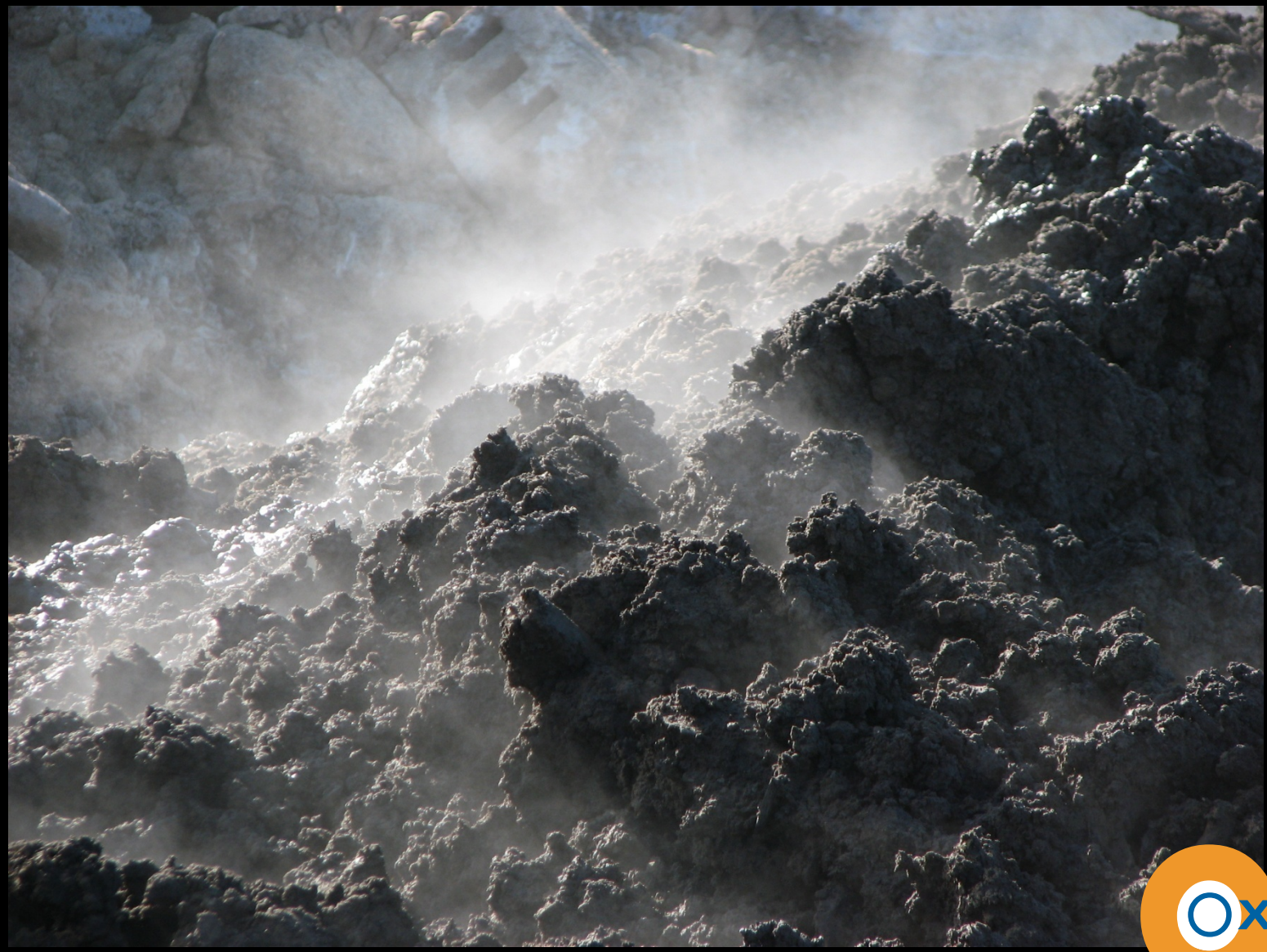
MFC Remedial Methodology



Harsh Canadian winter conditions persisted during January and February 2008 with average temperatures at -10ºC.

Flash freezing occurred with 3 to 4 hours.

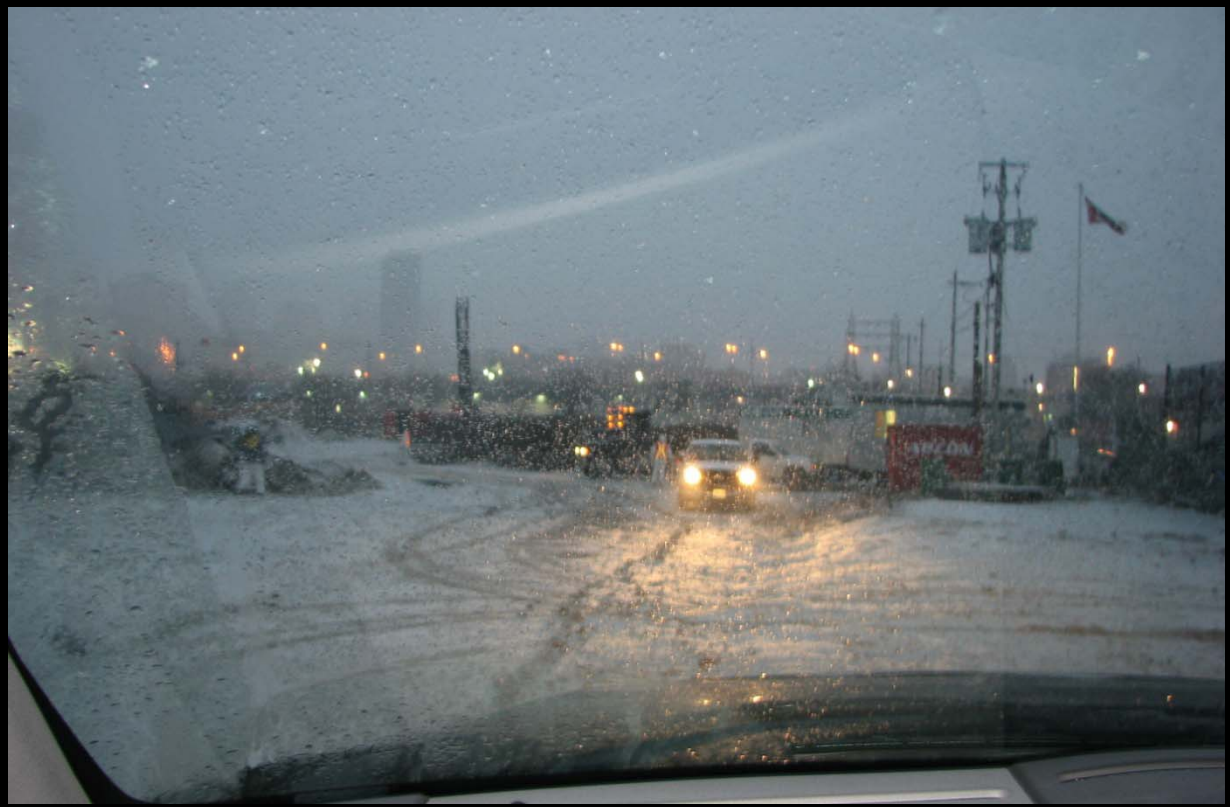
MFC Remedial Methodology



MFC was further modified to compensate for the sub-zero Canadian winter conditions.

MFC Remedial Methodology

Analytical test results confirmed that 98.6% of the treated soils achieved Ontario Ministry of the Environment (MOE) Regulation 153, Table 3 criteria for industrial / commercial land use criteria. Treated soils were shipped to stakeholders property near this site for future construction and development use.



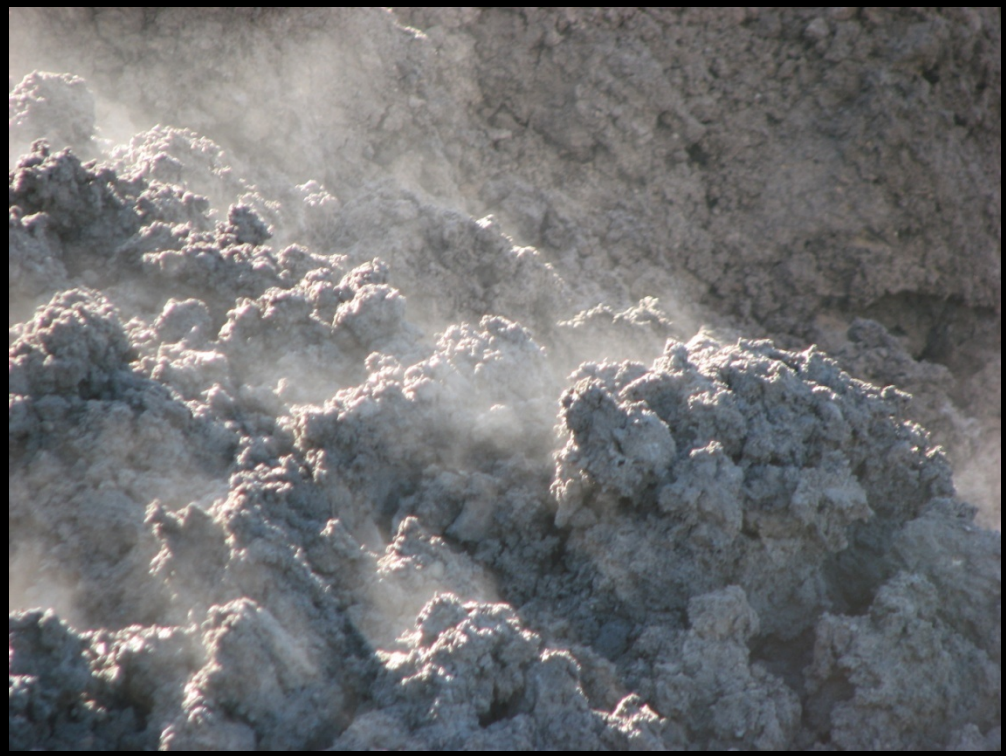
Representative Soil Concentrations Pre-Treatment and Post-Treatment

(reported in parts per million (ppm))

Parameter	Pre-Treatment	Post-Treatment
F2 PHC	860	< 150
F3 PHC	6,500	< 1,200
F4 PHC	7,700	< 150
Benzo(a)pyrene	7.9	< 1.9

Ministry of the Environment, Regulation 153, Table 3, industrial / commercial land use.

MFC Remedial Methodology



- A total of 30,000 tonnes of soil impacted with PHCs and PAHs were remediated using MFC.
- No special equipment was required with this process, only conventional backhoes and excavators.
- TEDCO saved several millions of dollars utilizing ex-situ MFC versus standard landfill practices.
- All stakeholders' time schedules and budget expectations were met.

MFC Remedial Methodology

This project demonstrated that chemical oxidation of contaminated soils can be successfully completed in sub-zero winter conditions, when the technology is adjusted to meet the climatic conditions.