Groundwater Metals Contamination and Construction Dewatering: Challenges and Effective Solutions

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Re-development of port land, previously occupied by Western Stevedoring's (Western) terminal in North Vancouver, BC to the G3 Terminal Vancouver (G3TV) grain export terminus (the Site) required management of historical contamination. A pre-development environmental investigation identified concentrations of copper, zinc and cadmium in groundwater above the Groundwater Quality Guidelines for Federal Contaminated Sites. This metal contamination was believed to be migrating from an industrial property to the east and was diffuse and irregularly distributed (Figure 1). Source removal was not possible, however the groundwater contamination was delineated on the Site and not migrating from the Site to sensitive receptors.

The groundwater contamination coincided with a proposed excavation required to construct facilities for offloading and receiving grain arriving by rail (referred to as the Rail Receiving Pit). Construction required excavation below the water table, dewatering, and disposal of groundwater to the Lynn Creek estuary. The concentrations of cadmium, copper and zinc in groundwater were above the BC and Canada Water Quality Guidelines (WQGs) for marine and estuarine aquatic life.

This situation highlights a common problem faced by developers. The metal contamination in groundwater at the Site was shown to attenuate to below the WQGs along the groundwater flow path by processes including dilution/dispersion, precipitation and adsorption before discharging to the marine environment. Extraction of this groundwater for construction dewatering eliminates the natural attenuation processes and creates a water disposal issue.

Dewatering and construction of the Rail Receiving Pit was further confounded by the very high permeability of the soil which comprised coarse grained alluvial sand and gravel deposits. Preliminary estimates indicated 3000 gallons per minute (gpm) of groundwater needed to be pumped to ensure dry construction conditions. G3TV proposed to mitigate the high flow volumes by installing a control density slurry mix (CDSM) soil cement cofferdam to isolate the excavation (Figure 1). Seepage rates through the CDSM soil cement cofferdam were predicted to be 100 gpm. Since the location and geometry of the source of the contamination was unknown and metal contamination on the Site was dispersed and irregular, the concentration of metals in groundwater seeping into the Rail Receiving pit was uncertain. To create a comprehensive risk mitigation strategy and monitoring plan, as well as manage the potential cost of treatment, this data gap needed to be filled.

PGL designed a pumping test to represent groundwater with sporadic metal contamination draining into this excavation. It was initially conceptualized that the pumping well extraction rate would be several times higher than the seepage rate to create a capture zone equivalent to the size of the excavation. Design challenges included:

- Representing a 1200 m^2 excavation by a single pumping well;
- Placement of the pumping well to avoid utilities and Site construction activities;
- Direct discharge of pumped groundwater to the Lynn Creek estuary was not possible as it had to be assumed the groundwater was contaminated;
- Discharge of water to the sanitary sewer was capped at 130 gpm because of capacity issue and the high iron content of groundwater; and
- Groundwater levels were strongly influenced by tidal fluctuations.

Disposal of groundwater into the sanitary sewer was deemed the only feasible option for the pumping test and presented an additional design challenge of representing seepage water quality with a pumping well extraction rate of only 130 gpm.

The extraction well was placed at north edge of the proposed excavation where the worst-case metals contamination on the Site was measured but where non-contaminated groundwater was also documented to the west and south (Figure 1). As the pumping rate was low, the pumping duration had to be as long as possible to maximize the capture zone. A 96-hour pumping test was completed. Concentrations of metals in groundwater and water levels in monitoring wells were measured frequently. A tracer was deployed in a cross-gradient monitoring well to improve characterization of the capture zone given the noise created by large tidal fluctuations.

During the pumping test, cadmium, copper and zinc concentrations remained elevated in extracted groundwater and unacceptable for direct discharge. Tracer data indicated the capture zone was drawing water from both contaminated and uncontaminated areas, and therefore the pumping test was likely representative of expected groundwater seepage through the CDSM soil cement cofferdam. It was concluded that copper, cadmium and zinc concentrations in groundwater extracted from the Rail Receiving Pit would remain elevated above the WQGs over the course of construction and treatment would be required prior to discharge of groundwater to the Lynn Creek estuary.

The CDSM soil cement cofferdam was installed in spring 2017. A metals treatment system was designed based on the water quality documented during the pumping test and comprised a metals precipitation process with flocculation, settling and sand filtration. The system began pumping seepage water in July 2017 and will continue until approximately May 2018. Influent water quality to the treatment system is tested regularly and concentrations of copper, cadmium and zinc have been consistently elevated above the WQGs as predicted by the pumping test. Learnings from this work were: if contaminants with respect to any standard or guideline remain in place prior to construction, it must be assumed there is a risk and strong mitigation plans to minimize risk are required. A key part of the success was Western and G3TV cooperation. While this did present contractual challenges, they were out-weighed by the strong commitment of all parties to environmental protection.

Figure 1: Site plan with key features. Scale and locations are approximate.