The Groundwater Vector in the Reclaimed Oil Sand Mining Landscape: Learnings from the Operational Phase

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Abstract

During oil sands mining, significant volumes of liquid tailings are generated and retained in large tailings ponds. This process-affected (PA) water is toxic to aquatic organisms and so its release to the surrounding environment is limited. However, where PA water has escaped tailings pond containment an opportunity is provided to assess the fate of toxicants as they migrate through the groundwater pathway or vector.

In general, expansion of oil sands mining in NE Alberta is encountering more surficial sandy aquifers which are susceptible to transport of contaminants to nearby aquatic systems. One can expect that more of these shallow aquifers will be impacted by PA water, especially where external tailings ponds are located nearby. Not only are these aquifers important reservoirs of water in the reclaimed landscape, but they represent pathways or vectors for contaminants to surficial aquatic systems. When considering water within the reclamation landscape, should the groundwater vector be minimized, or does it present natural attenuation benefits for protection of surface waters? A number of groundwater studies, with lab and modeling support, were undertaken within the operational phases of oil sands mining and present an opportunity to anticipate the challenge or opportunity provided by the groundwater pathway (MacKinnon et al., 2005; Gervais and Barker, 2005; Oiffer et al., 2009; Yashuda et al., in press; Ferguson et al., 2009).

Most petroleum hydrocarbons retained in PA water within tailings ponds and dykes are attenuated before significant migration in groundwater. The major remaining toxicant is a complex mixture of naphthenic acids (NAs). NAs are non-volatile, hydrophilic, alkyl-substituted acyclic and cyclicaliphatic carboxylic acids. These are naturally occurring, but are concentrated in the PA water during extraction of oil. A number of field studies, generally supported by

laboratory and modeling work, suggest that NAs are mobile and persistent in shallow groundwater of the oil sands mining area. Therefore, little attenuation, beyond dispersive dilution, can be anticipated along the groundwater vector in the reclaimed landscape.

While PA-impacted groundwater usually contains little trace metals, there is concern that the mildly anaerobic PA-impacted groundwater plumes may leach toxic metals from the aquifer material. It is possible that such groundwater plumes would leach inorganics after lengthy exposure times over long (> 1 km) pathways and so could attain undesirable levels of Se, As, etc. However, studies of current plumes show little accumulation of such toxic constituents in groundwater plumes.

Groundwater studies continue, emphasizing the natural attenuation of NAs, mobilization of metals, etc. as well as remediation methods that might be considered during the transition from operational to reclamation phases of oil sands mining. To date, there is little evidence that deliberately directing tailings water through groundwater pathways holds additional opportunity for toxicity attenuation. Studies to date also suggest that the groundwater pathway is unlikely to induce significant leaching of toxic materials from the shallow sand aquifers in the oil sands mining area. Ongoing research continues to improve our understanding of the groundwater vector, but these learnings need to be conveyed to reclamation planners as they optimize reclamation designs.

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