Oil Sands Remediation – What's the (end) Point?

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ABSTRACT

Remediation professionals need some basic information to develop a remediation strategy, implementation plan and schedule, and cost estimate. The information needs include an understanding of: the current and proposed land use; the compounds of potential concern (COPCs); the natural levels and variability of COPCs in the environment; and, the guidelines (endpoints) to be applied.

It is assumed that oil sands process-affected water and contaminated soils arising from mineable oil sands development may eventually require remediation. While we have a reasonably good understanding of the proposed land use (a self-sustaining, locally-common boreal forest), there is some uncertainty about the COPCs and considerable uncertainty around the endpoints to be used.

Notwithstanding this uncertainty there has been considerable work undertaken to develop remediation options, especially for oil sands process-affected water. Additional work has been done to characterize the natural levels in the environment of some COPCs, and to monitor and model fate and behaviour some COPCs.

This paper will review some of the reasons for, and issues arising from, the uncertainty around COPCs and endpoints. The conclusion from this review is that remediation professionals, regulators, industry and stakeholders must begin discussions to resolve the uncertainty so that appropriate guidelines can be set and research and demonstration efforts can be better focused on solving the "real" problem.

1 INTRODUCTION

It is assumed that oil sands process-affected water may eventually require some form and level of remediation to allow for release to the natural environment, specifically the Athabasca River (Oil Sands Water Release Technical Working Group 1996). Similarly, it is assumed that some form and level of remediation will be required for contaminated soils arising from oil sands processing, at the very least on the plant site area, to allow for subsequent reclamation (Morton et al. 2011).

Although there has been considerable effort into developing remediation options and techniques, especially for process-affected water, this work has been done in the absence of any clear agreed upon remediation guidelines (endpoints). While this research may assist in development of appropriate remediation guidelines, there is considerable risk that the work may not be as effective as it would be if there were clearly defined and accepted end points. In the worst case, erroneous conclusions and recommendations may lead to unwise investments in technology-based solutions and wasted time, effort and resources.

This paper focuses on remediation related to mineable oil sands developments. Some of the issues may also apply to in-situ developments, however the current approach to applying the Upstream Oil and Gas Reclamation and Remediation Program principles to in-situ sites may provide more certainty surrounding remediation guidelines (Alberta Environment and Sustainable Resource Development n.d. (a)).

1.1 Terminology

For the purposes of this paper we have adopted the following definitions. That there may be very different interpretations of these terms amongst parties interested in the subject of oil sands remediation. When embarking on any discussions about guidelines, policies, research or demonstrations it is therefore imperative to develop a common set of terminology to avoid misunderstandings.

Guideline – A numerical concentration or narrative statement recommended to support and maintain a designated use. Guidelines are formally adopted as regulatory tools by provincial and/or federal government. The *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* are an example (Alberta Environment 2010a). In this paper, the term *endpoint* is synonymous with *guideline*.

Remediation – The removal, reduction, or neutralization of substances, wastes or hazardous material from a site so as to prevent or minimize any adverse effects on the environment now or in the future. Remediation may include: source removal, physical removal of contaminated groundwater and/or soil, natural attenuation, degradation by micro-organisms or neutralization with chemicals that react with the contaminants to form benign substances (Alberta Environment and Sustainable Resource Development n.d. (b)). In this paper the term *treatment* is synonymous with *remediation*, however some parties make a strong distinction between the two terms, particularly when it comes to process-affected water and oil sands tailings. One of the reasons for making this distinction is the belief that *remediation* implies an environmental problem that requires correction while *treatment* implies proactive efforts to prevent a problem.

Tier 1 Guidelines – the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (Alberta Environment 2010a).

2 BASIC REQUIREMENTS FOR A REMEDIATION PLAN

Remediation professionals need some basic information to develop a remediation strategy, implementation plan and schedule, and cost estimate. The information needs include an understanding of: the current and proposed land use; the compounds of potential concern (COPCs); the natural levels and variability of COPCs in the environment; and, the guidelines (endpoints) to be applied.

2.1 What is the Problem?

Before getting into the details of a remediation plan we first have to decide if there is problem that requires remediation and, if so, we need to clearly define the problem. Given all of the negative press surrounding oil sands, and more specifically tailings and process-affected water, it may seem obvious that remediation will be required. However, for a variety of reasons, some of which are described in section 4, this should not be taken as a consensus view and will require discussion.

Any discussion of the need for remediation immediately generates a chicken-and-egg debate – without guidelines you can't pinpoint the problem and if you don't believe there is a problem there is no need for guidelines. The best place to start the discussion about whether or not remediation is required is found in the definition of remediation in section 1.1: *so as to prevent or minimize any adverse effects on the environment now or in the future*. Will one or more of the Compounds of Potential Concern (COPC) cause an adverse effect on the environment? If so, some form of remediation will be required to *prevent or minimize* the effect. If a guideline exists for the COPC then we can develop a plan to meet the guideline. If no guideline exists we can search for an appropriate (and agreed upon) surrogate and use that to develop the plan. Failing either of these approaches, we need to develop a guideline for the COPC.

2.2 Land Use

The reclamation objective for oil sands mines is described in the *Environmental Protection and Enhancement Act* approvals as (Alberta Environment 2011a, s. 6.2.1, Total E&P Canada Ltd. Joslyn North – emphasis added):

> *The approval holder shall reclaim the land so that the reclaimed soils and landforms are capable of supporting self-sustaining, locally common* ***boreal forest*** *ecosystems,* ***regardless of the end land use****.*

The Tier 1 Guidelines define five generic land uses that determine the applicable the numeric values to use (Alberta Environment 2010a, s. 3.2): natural areas, agricultural, residential/ parkland, commercial and industrial. The Guidelines indicate that forested land will fall into the natural areas class. However it is also reasonable to assume that there may be recreational use of reclaimed lands (Greystone and Westwind Resources Group Ltd. 2003) and therefore the residential/parkland class may apply. One cannot rule out the potential for commercial or industrial use of land for small areas such as the plant sites as well (Jones and Forrest 2010); however the reclamation objective noted above would seem to suggest application of the natural areas guidelines should be used regardless of the end land use.

Therefore one of the initial points of discussion will be to agree upon the appropriate land use to apply. In any case, care will be required to ensure that Aboriginal traditional use of the reclaimed land, regardless of the assigned class, is considered in establishing the appropriate guideline (Buffalo et al. 2011).

2.3 Compounds of Potential Concern (COPCs)

Once we know the land use we need to know which Compounds of Potential Concern (COPC) we are remediating. Characterization of oil sands tailings (e.g., BGC Engineering Inc. 2010), process-affected water (e.g., Allen 2008a) and overburden (e.g., Devenny 2010) suggest that the principle COPCs are likely be hydrocarbons (e.g., Thomas 2011), salts (e.g., Kessler et al. 2010) and metals (e.g., Mahdavi et al. 2012).

One group of hydrocarbons that have received considerable attention is naphthenic acids (e.g., Eickhoff et al. 2010), although there is lively debate on what exactly is encompassed by this label. Fedorak et al. (2010) have recommended adopting a new term – *oil sands tailings water acid-extractable organics* – to distinguish these compounds from traditional naphthenic acids. The debate and related uncertainty creates considerable difficulty in determining what COPC will require a guideline and how one would establish agreed upon measurement techniques to develop remediation plans and prove compliance.

2.4 COPCs in the Environment

One option for remediation in Alberta is to modify the Tier 1 Guidelines by accounting for natural background levels of the Compound of Potential Concern (Alberta Environment 2010b). Research and characterization work has been done to understand naturally occurring levels of hydrocarbons (e.g., Fleming et al. 2012, Leskiw 2005, RAMP 2011 Implementation Team 2012, Visser 2008), salts (e.g., Close et al. 2007, Lieffers 1984, Purdy et al. 2005) and metals (e.g., Allan and Jackson 1977, Lutz and Hendzel 1977).

The data arising from this work will need to be factored in to development of remediation plans and may help to focus efforts in developing guidelines for COPCs such as oil sands tailings water acid-extractable organics.

2.5 Applicable Guidelines

Once we know what COPCs are an issue we can look to existing guidelines to determine what the endpoints for the remediation plan will be. Guo (2010), for example, has provided analytical results for process-affected water and compared them to a variety of guidelines. Western Resource Solutions (2003) reviewed potential water quality guideline values for chemicals of concern in the lower Athabasca River.

Intuitively, given the likely COPCs, province-wide guidelines issued by Alberta Environment and Sustainable Resource Development such as the Tier 1 or 2 Guidelines (Alberta Environment 2010 a,b) and the Salt Contamination Assessment & Remediation Guidelines (Alberta Environment 2001) should be applicable to the mineable oil sands. However this belief may not be universally held and thus will require dialog between government, industry and stakeholders.

Given the extensive interest in oil sands tailings water acid-extractable organics, and their uniqueness to the sector, it seems likely that one or more guideline values specific to the mineable oil sands may be required to supplement the Tier 1 Guidelines (Gosselin et al. 2010).

3 RESEARCH

Notwithstanding the uncertainty around applicable guidelines there has been considerable work undertaken to develop remediation options, especially for oil sands process-affected water. Additional work has been done to:

- develop analytical methods for oil sands tailings water acid-extractable organics
- characterize the natural levels in the environment of some COPCs (see section 2.5)
- monitor and model fate and behaviour some COPCs, and
- assess environmental effects and toxicity of various COPCs.

3.1 Treating Process-Affected Water

Significant effort is devoted to identifying technologies, or suites of technologies, that can be used to treat (remediate) process-affected water (e.g., Allen 2008b, Guo 2010, Sobkowicz 2012). The two primary goals for this work are: to ensure the appropriate water quality is available for use in the extraction or utilities plants; and, to provide water of sufficient quality that it could be discharged to the environment. Work has focused on removing suspended sediments (fine tailings) through use of filters (e.g., Banerjee 1984, Peng et al. 2004) and various additives such as polymers (e.g., Alamgir 2011, Wang 2011), removing toxicity (e.g., Liang et al. 2011, Small et al. 2012) and harnessing biological processes in-situ in tailings ponds (e.g., Quagraine et al. 2005), in wetlands and water bodies (e.g., Armstrong et al. 2009, Bishay 1998, Headley et al. 2010) or through use of bioreactors (e.g., Huang 2011).

3.2 Analytical Methods

Considerable effort has been made to develop more precise analytical tools to better characterize the suite of chemicals in oil sands tailings water acid-extractable organics (e.g., Zhao et al. 2012). Work has also been done to develop field-based sensors (e.g., Taschuk et al. 2010). Improved characterization will set the stage for additional work to determine the fractions that are creating adverse effects and therefore help direct researchers to appropriate remediation strategies.

3.3 Monitoring and Modelling

Efforts to understand the fate and behaviour of COPCs, especially oil sands tailings water acid-extractable organics, will support development of appropriate remediation guidelines (e.g., Armstrong et al. 2009, Clemente and Fedorak 2005, Eickhoff et al. 2010, Gane et al. 2011). Monitoring and modelling work, focused on understanding how and where COPCs may move, will also help (e.g., Evans and Talbot 2012, Frank et al. 2010, Gibson et al. 2011, Hunter 2001, Tompkins 2009).

3.4 Environmental Effects and Toxicity

A number of studies have evaluated the environmental effects and toxicity of COPCs (e.g., Cruz-Martinez and Smits 2012, Gentes et al. 2007, Gupta 2009, Rogers 2003, Sprague et al. 1978, Verbeek 1994, Warith 1983). Nelson et al. (1993) described the role of toxicity testing in the evaluation of reclamation options. These studies can help inform guidelines development by identifying adverse effects levels.

4 WHAT IS HOLDING US BACK?

Oil sands have been mined and processed for 45 years so why is there any lack of clarity on the guidelines that would be applicable for remediation? As noted below, there are several reasons for this. Notwithstanding the merits of these reasons, deferral of the discussions necessary to set out the remediation guidelines is simply postponing the inevitable. The worst thing that could happen would be to wait until there is an application made to discharge process-affected water and then have to scramble to set guidelines.

Far Future Problem

For most of the last 45 years it has been assumed that any remediation arising from plant site decommissioning or discharge of process-affected waters would not happen for many years and therefore effort should be spent on more immediate issues. Notwithstanding the closure and reclamation of Suncor's Pond 1A (now called Wapisiw Lookout), the industry's first tailings pond (Christian 2011), the closure of plant sites is still deemed to be a far future activity (Morton et al. 2011).

However it is interesting to note that:

- In 1968, government entertained a request from Suncor (then Great Canadian Oil Sands) to discharge tailings pond water to the Athabasca River (Alberta Health, Environmental Health Services Division 1968); and
- In 1996, government and industry developed a document outlining the scope of work needed to evaluate the acceptability of releasing process-affected waters to the environment in recognition that applications for release would eventually be submitted (Oil Sands Water Release Technical Working Group 1996).

Don’t Want to be First

There is understandable reluctance to be the first to propose an action (e.g., an application for discharge of process-affected water) that would start the discussions necessary to identify the application of existing guidelines or to develop new guidelines.

Zero Discharge Policy

There is a wide-spread belief in the existence of a government policy for zero discharge of process-affected water from oil sands sites. Whether or not such a policy exists[1], the mere fact that people believe one does is potentially hindering consideration of options.

Guidelines Already Known – No They Aren’t

Some people believe the existing province-wide guidelines apply and therefore there is no need for a discussion.

Others believe the province-wide guidelines don’t apply because oil sands are a special case and, since everyone would see that, there is no need for a discussion.

Don’t Want to Know What the Guidelines Might Be

Clarity on the applicable guidelines would potentially confirm contamination exists and must be addressed, start to narrow the potential options to address contamination, and set the stage for better delineation of financial liabilities that would have to be reflected in financial statements (Schneider 2010) and reclamation security estimates (Alberta Environment 2011b).

Natural Remediation

If degradation of COPCs below levels that cause an adverse effect will occur without aggressive intervention no remediation will be required. Early work in the 1980s showed that process-affected waters would degrade over one to five years once the ongoing inputs of fresh tailings was stopped (e.g., Boerger 1985, MacKinnon and Boerger 1986). Other work has focused on the microbially-mediated degradation of hydrocarbons in the tailings ponds (e.g., Herman et al. 1993, Siddique et al. 2006) and the receiving environment (e.g., Biryukova et al. 2007, Headley et al. 2002).

[1] For the record, the authors believe that there is no formal government zero-discharge policy.

Remediation Plans Provided by Regulator

One could argue that the regulator has already identified the appropriate remediation technology to be applied for oil sands mined land and therefore there is no need for guidelines. For example, the Total Joslyn North approval provides the following direction for a variety of substrates, some of which could reasonably be expected to contain COPCs (Alberta Environment 2011a, s. 6.3.7):

> The approval holder shall cap the following materials and locations with a minimum average depth of 1.0 m of tailings sand or suitable overburden prior to placement of reclamation material as per subsections 6.3.8 through 6.3.14, unless otherwise authorized in writing by the Director:
>
> a) impervious conditions such as rock;
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> b) lean oil sand;
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> c) reject from the oil sands conditioning and transport system;
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> d) dried fine tailings;
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> e) thickened tailings;
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> f) froth treatment tailings;
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> g) clearwater overburden; and
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> h) the processing plant areas.

5 CONCLUSIONS

There is currently a lack of clarity on the remediation guidelines that should be applied to mineable oil sands developments. Deferral of the discussions necessary to set out the remediation guidelines is simply postponing the inevitable. Given the extensive interest in oil sands tailings water acid-extractable organics, and their uniqueness to the sector, it seems likely that one or more guideline values specific to the mineable oil sands may be required to supplement the Tier 1 Guidelines.

The worst thing that could happen would be to wait until there is an application made to discharge process-affected water and then have to scramble to set guidelines.

6 A PATH FORWARD

What is evident from the above discussion is that it is time to begin the discussions on the policies and guidelines that will apply to oil sands mining and processing operations. This will not be an easy task nor will it be quick. However the task is made somewhat simpler because of the extensive preliminary work that has already been done in the areas of COPC characterization, background levels, analytical methods, toxicity and environmental effects, and treatment methods and efficacy.

It is recommended that an umbrella government/industry Steering Committee be struck to develop oil sands remediation guidelines and/or confirm the applicability of existing guidelines. The Steering Committee would oversee the technical work of government/industry/academia/ stakeholder subcommittees dealing with soil remediation guidelines and process-affected water remediation guidelines. An initial step could be a workshop to surface issues, knowledge, gaps and recommendations. The workshop could also help identify key players to populate the technical subcommittees.

Once the guidelines are developed they should be communicated broadly to inform stakeholders and demonstrate that the regulators and industry are addressing this key environmental issue.

This work could also be informed by, and help inform, the federal/provincial regional monitoring program (Government of Canada and Government of Alberta 2012).

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