Factors to Consider in Estimating Oil Sands Plant Decommissioning Costs

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December, 2011

Oil Sands Research and Information Network

Oil Sands Research and Information Network

OSRIN is a university-based, independent organization that compiles, interprets and analyzes available information about returning landscapes and water impacted by oil sands mining to a natural state and provides knowledge to those who can use it to drive breakthrough improvements in reclamation regulations and practices. OSRIN is a project of the University of Alberta's School of Energy and the Environment (SEE). OSRIN was launched with a start-up grant of $4.5 million from Alberta Environment and a $250,000 grant from the Canada School of Energy and Environment Ltd.

OSRIN provides:

- **Governments** with the independent, objective, credible information and analysis required to put appropriate regulatory and policy frameworks in place
- **Media, opinion leaders and the general public** with the facts about oil sands development, its environmental and social impacts, and landscape/water reclamation activities – so that public dialogue and policy is informed by solid evidence
- **Industry** with ready access to an integrated view of research that will help them make and execute reclamation plans – a view that crosses disciplines and organizational boundaries

OSRIN recognizes that much research has been done in these areas by a variety of players over 40 years of oil sands development. OSRIN synthesizes this collective knowledge and presents it in a form that allows others to use it to solve pressing problems. Where we identify knowledge gaps, we seek research partners to help fill them.

Citation

This report may be cited as:

Morton Sr., M., A. Mullick, J. Nelson and W. Thornton, 2011. *Factors to Consider in Estimating Oil Sands Plant Decommissioning Costs*. Oil Sands Research and Information Network, University of Alberta, School of Energy and the Environment, Edmonton, Alberta. OSRIN Report No. TR-16. 62 pp.

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REPORT SUMMARY

This report provides a number of cost estimating factors, common terminology and common practices derived from industrial decommissioning projects, international cost estimating practices and the outcome of a joint university, industry and regulator workshop. The cost estimation factors identified in this report represent common practice in the decommissioning industry and are intended to cover the key cost components for a detailed oil sands plant decommissioning cost estimate. This report also identifies factors that may affect the reliability of the estimates (i.e., the level of uncertainty and therefore an indication of the contingency factors that may need to be applied to the estimate).

Significant factors contributing to a detailed oil sands facility Mine Financial Security Program (MFSP) Liability project cost estimates include:

- Scope Definition
- Assumptions
- Basis of Estimate
- Site Environmental Assessment(s)/Physical Plant/Residual Materials/Hazards
- Shutdown/Isolation/Hazards Removal
- Demolition/Dismantling/Salvage/Recycle
- Remediation/Decontamination
- Risk Analysis
- Long Term Monitoring
- Liability Estimate Revisions

The intent of this document is to supplement the existing guidance on the content of the MFSP Liability value that is in the *Guide to the Mine Financial Security Program*. The report *does not* prescribe what needs to be included at any point in the Approval Holder's MFSP estimate. Included in the report are the things one should consider at some point in the life cycle of the oil sands plant (especially close to the time the Operating Life Deposit is made) and some information on the methodology and accuracy of estimates. Similarly, the intent is not to prescribe when the Approval Holder chooses to include increased detail or accuracy to the estimates – this is the Approval Holder's decision. The report does offer suggestions (e.g., estimate methods, content, and when and why the accuracy of the estimate might be updated, etc.) to assist in developing an estimate.

ACKNOWLEDGEMENTS

The Oil Sands Research and Information Network (OSRIN), School of Energy and the Environment (SEE), University of Alberta provided funding for this project.

OSRIN and WorleyParsons Canada are also grateful to the individuals who provided written comments on the two drafts of the report (David Brand, Mark Kavanagh, Orest Kotelko, Susan McGregor, Lori Neufeld, Taras Pojasok, Thomas Schneider and Kevan van Velzen), and appreciate the input provided by the 30 individuals from government, industry, consultants and academia who attended the Workshop held October 13, 2011 at the University of Alberta.

CAVEAT

Following completion of the final draft report by WorleyParsons and the termination of their contractual responsibilities OSRIN requested and received feedback on the draft final report. OSRIN, at its sole discretion, revised the draft final report to address the comments received.

1 INTRODUCTION

WorleyParsons Canada (WorleyParsons) was retained by the Oil Sands Research and Information Network (OSRIN) to prepare a report to outline the key components that might inform development of a cost estimate for decommissioning of an oil sands processing plant[1] (i.e., suspension, abandonment, remediation – see Figure 1), and the factors that might impact the costs in each project component within those estimates. A draft of this report was discussed by 30 individuals from government, industry, consultants and academia who attended an OSRIN-sponsored Workshop held October 13, 2011 at the University of Alberta. The report was revised based on their feedback and then circulated for comment and the report again revised to reflect the comments received. Key comments from workshop participants (green) and reviewers (blue) are highlighted in this report in call-out boxes.

It is important to note that this report is not a consensus view of the issues related to estimating decommissioning costs for an oil sands processing plant. In fact it is quite evident from the Key Workshop Observations and Key Review Observations that there are significant differences of opinion about cost estimation processes, the level of detail required and the timing of detailed estimates.

Key Review Observation

The decommissioning industry uses terms that are different than those used in MFSP. This report uses the decommissioning terminology but it is important to note that the only terms with regulatory standing are those defined in the *Environmental Protection and Enhancement Act*, the *Conservation and Reclamation Regulation*, the EPEA approval and the *Mine Financial Security Program Standard*.

WorleyParsons staff has extensive experience in the oil sands, coupled with over 20 years of decommissioning experience for non-oil sands facilities, which has been incorporated into this report.

[1] The focus of this report is on estimating decommissioning costs for an oil sands plant. The MFSP also requires similar estimates for other oil sands infrastructure and many of the points raised in this report could also apply to those infrastructure components.

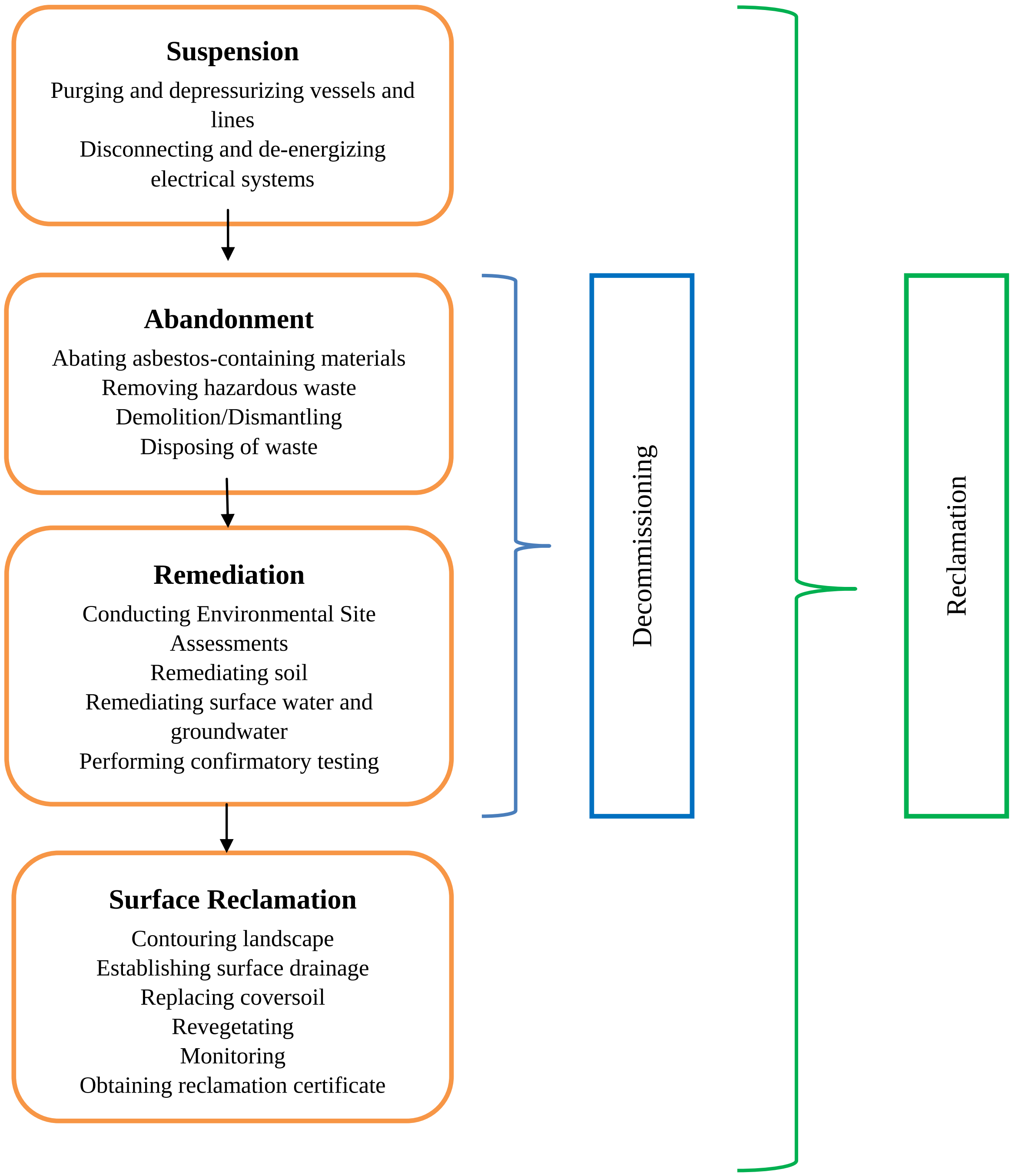

Figure 1. Relationships between Terms Used in This Report

Modified from Alberta Energy and Utilities Board, 1998. Surface Reclamation is not discussed in this report but is addressed in the Mine Financial Security Program.

1.1 Purpose and Scope

Alberta's recently announced Mine Financial Security Program (MFSP) includes a requirement for oil sands mine Approval Holders to estimate the costs to suspend, abandon, remediate and reclaim the processing plant as part of the MFSP Liability value. The purpose of this report is to describe the components that might be included when developing MFSP Liability estimates for the suspension, abandonment and remediation of oil sands processing plant sites in accordance with the requirements stipulated in the MFSP Standard and accompanying Guide (Alberta Environment 2011a,b).

Figure 1 and section 8 provide an overview of the terminology used in this report. Readers are also encouraged to review the glossary in the *Guide to the Mine Financial Security Program* (Alberta Environment 2011b).

1.2 Using This Report

This report provides information as to what a detailed oil sands processing plant decommissioning cost estimate may contain. The report does not recommend that this level of detail be required in the early stages of project development, nor does it suggest that the level of effort to create such a detailed estimate should be expended every year. **OSRIN is a research organization providing information to stakeholders – it does not set provincial regulatory policy; thus this report is not provincial policy.**

The report does note that the level of detail could be expected to increase over time as more information becomes available. The report also notes that the importance of the relative accuracy of the MFSP Liability increases as the Operating Life Deposit becomes payable since this deposit is based on the MFSP Liability value.

Key Review Observation

One could argue that the estimate accuracy is critical only when the full MFSP Liability is required to be secured (i.e., when the Reserve Life Index is less than six years and the Operating Life Deposit is at 100%), not at the start of the Operating Life Deposit payments.

This report focuses on oil sands processing plant decommissioning costs and does not address the following components of the overall MFSP Liability calculation:

- Tailings ponds and tailings disposal areas
- Other infrastructure on the mine site (e.g., maintenance buildings or vehicle maintenance shops)
- Reclamation following decommissioning

Four key principles underlying the MFSP are relevant to the use of this report and were frequently mentioned in the Workshop and in written comments on the draft report:

- The MFSP is **a risk-based approach** to determining when and how much financial security is required – keeping in mind the MFSP design principle that project liabilities are fully offset by a combination of assets (reserves) and financial security, with financial security rising to 100% of liabilities six years prior to the end of mine life. As such the methods to calculate the liability associated with oil sands processing plant decommissioning should reflect the level of risk and the impact to the MFSP security triggers at all stages of plant development.
- The MFSP **relies on existing rules and reports** for other regulatory bodies where available rather than creating new rules. Therefore if existing industry estimating practices are accepted for financial reporting purposes (e.g., under the International Financial Reporting Standards) or are based on common, documented industry practice they are be acceptable for MFSP purposes to the extent they meet MFSP requirements.
- The MFSP was designed to allow for **minimum but critical information** to be reported to the regulators on an annual basis but is **backed up by the ability of the regulators to audit the details** behind the annual information. This audit function is an important tool to allow the regulators to understand the basis for calculations and therefore the rules and practices described in the first bullet.
- The MFSP allows an Approval Holder to elect to pay full cost security in lieu of security based on the four reclamation deposit types. An Approval Holder would likely elect to post full cost security when their MFSP Liability is less than the Base Security Deposit.

Key Review Observation

Since the project is in early development stages with limited overall risk of failure, and there is likely limited development of the plant site, when an Approval Holder has elected to pay full cost security the level of detail required for the plant site decommissioning costs would be expected to be low (similar to the observation above about the level of detail needed before the Operating Life Deposit is triggered).

Finally, the report draws information from a wide range of industries in many jurisdictions and may refer to practices that might not be required under legislation or an individual operating approval (for example, the report describes salvage and recycle/reuse practices for materials generated during dismantling). Approval Holders and regulators will need to determine which of the steps described in this report are expected, which are encouraged as best practices, and which are not required.

1.3 Decommissioning and the Mine Financial Security Program

The general regulatory principle of plant site decommissioning in Alberta is that the EPEA Approval Holder is responsible to complete suspension, abandonment, remediation and surface reclamation work to the applicable Provincial and/or Federal guidelines, and to maintain care and custody of the land until a reclamation certificate has been issued. The MFSP is designed so that the Approval Holder will have the financial resources to complete these obligations.

Alberta enacted the MFSP in 2011. The MFSP "provides a responsible balance between protecting the people of Alberta from the costs associated with the liability of coal and oil sands development in the event an Approval Holder cannot meet their obligations…" (Alberta Environment 2011b). Further details of the MFSP are discussed below.

The MFSP details new requirements for Approval Holders when reporting liability estimates, which include enhancing existing documentation and reporting practices (Alberta Environment 2011b). Further aspects of the MFSP are listed below:

- Consistent and transparent methods for calculating closure costs;
- Project liabilities are fully offset by a combination of assets (reserves) and financial security, with financial security rising to 100% of liabilities six years prior to the end of mine life.
- Consistent, objective and conservative methods for determining how much financial security needs to be provided and when – based in part on the calculated closure costs;
- Six years prior to the end of the operation, full financial security for all outstanding abandonment, remediation and surface reclamation must be on deposit with the Government;
- Annual updates on asset and liability information, and annual posting of revised security amounts – based in part on the calculated cost estimates;
- The Chief Executive Officer, Chief Financial Officer, or the Designated Financial Representative of a joint venture, must certify that appropriate procedures were used to determine the value of the MFSP Asset, MFSP Liability and financial security deposit estimates, confirming that the resulting estimate is reasonable; and
- Annual public disclosure of Asset Safety Factor, financial security (total and individual components) and reclamation progress.

As noted in the *Guide to the Mine Financial Security Program* (MFSP Guide; Section 3.1; Alberta Environment 2011b) MFSP Liability is calculated as:

MFSP Liability = Asset Retirement Obligation (ARO) Liability + Other Liability

The description of the contents of an MFSP Liability cost estimate (Alberta Environment 2011b; TIP box on page 20) is consistent with the Association for the Advancement of Cost Engineering International (AACE)[2] expectations for reliable, repeatable and consistent cost estimates.

Applicable Audit Questions in Section 7 of the MFSP Guide (Alberta Environment 2011b) have been incorporated within the Basis of Estimate (BOE) section to provide greater consistency between this report and the MFSP Guide. These include:

a) What professionals signed off on the various MFSP calculations? Were they internal or third-party (to ensure proper representation for estimate discussion)?

b) What technical reports are available to support the MFSP calculations?

c) What contingencies were used to calculate MFSP Liability?

d) What equipment rates were used to calculate MFSP Liability and what proof is there that these rates represent a rate government could obtain?

e) What standards and techniques were used to establish remediation costs and why?

f) What disposal strategies and costs for plant site structures and facilities were used to calculate MFSP Liability?

g) What disposal strategies and costs for wastes and by-products were used to calculate MFSP Liability?

h) Are any roads or other infrastructure components left in place (un-reclaimed)?

i) Are there costs assigned to the treatment of water to ensure water quality criteria for release is met?

j) How much was allocated to the development of a revised reclamation plan?

k) How much was allocated to monitoring and maintenance after final reclamation but prior to final reclamation certification of the site?

2 COST ESTIMATING

2.1 Assumptions

Assumptions are very important and should be captured during the estimating process, for the entire decommissioning project, and for each of the activities that make up the overall

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[2] See http://www.aacei.org/

decommissioning project. Early in facility life, the assumptions concerning means and methods, waste disposal, etc. are likely to be relatively broad and far reaching. Conversely, as end of life approaches the assumptions would become more focused to capture assumed conditions for project execution.

If a key assumption changes, this can significantly impact the estimated cost of the decommissioning project. Assumptions, particularly in light of changing regulatory requirements, may need to be updated as part of the periodic estimate updates to reflect current perspectives.

Detailed decommissioning project assumptions should include:

a) Weather delays

b) Levels/extent of contamination prior to the availability of complete site assessment information

c) Availability of personnel and equipment for the completion of routine or specialized operations

d) End State (the planned final condition/use of the site and/or specific areas)

e) Abandonment and decontamination processes and methods to be used for various aspects of the project

f) Anticipated project timing and staging that forms the basis of the current estimate. Will the plant operations be suspended for a period prior to the start of the decommissioning project? Will the plant be decommissioned in stages with gaps in effort? Will some work be done during plant operations?

g) Roles of other supporting or regulatory organizations

h) Waste disposal pathways for remaining process materials, by-product materials and demolition/dismantling debris

i) Equipment breakdown or availability percentages

j) Typical work day (and if overtime is included within the estimate)

k) Availability of funding and continuity of the decommissioning work

l) Required regulatory documentation for project initiation and project closeout

m) Regulatory drivers and stakeholder approval that are expected

n) Waste Acceptance Criteria (WAC) of the selected waste disposal site(s)

o) Availability, acceptability and sizes of waste transportation containers, trucks, railcars

p) How Asbestos-containing Materials (ACM) and other hazardous building materials may be handled

NOTE: Typically, economic factors such as inflation and interest rates are also captured as assumptions for an internal cost estimate; however, the MFSP requires un-inflated and undiscounted costs, therefore they are not included in the assumptions listed above.

2.2 Environmental Site Assessment (ESA)

Environmental Site Assessments (ESAs) are completed to determine the environmental condition of a site, and are considered a key component of any decommissioning estimate[3]. The following is a brief summary of the types of ESAs that would be expected to be completed as part of the decommissioning process:

- **Phase I ESA**: non-intrusive assessment completed to identify actual and/or potential site contamination; consists of an evaluation of existing information through records review, site visits and interviews (refer to Section 2.2 for further detail);
- **Phase II ESA**: intrusive assessment completed to confirm the presence of, and characterize the potential contaminants of concern identified during the Phase I ESA; consists of the collection of soil, groundwater or surface water samples, may also collect sediment samples and includes a Site Specific Risk Assessment;
- **Phase III ESA**: intrusive assessment, similar to the Phase II ESA, consisting of collecting soil and groundwater or surface water samples; completed to delineate the extent of contaminants identified during the Phase II ESA and collect additional information to assist in remedial planning.

Phase I, II and III ESAs can occur progressively through the life of the facility with the information being used to minimize uncertainties in the MSFP Liability estimate updates. Further details are discussed in Section 4.9.

Key Workshop Observation

Workshop participants noted that Phase II and III assessments are difficult to complete during the operating life of a plant. This is particularly problematic for contamination that may exist below grade and/or under structures.

[3] The *Guide to the Mine Financial Security Program* (Section 3.1, p. 22) notes that remediation should be undertaken as soon as contamination occurs and generally should not be carried to end of life. Where this is possible the remediation costs become an operational cost rather than a component of the MFSP Liability.

2.3 Estimate Types, Methods and Basis of Estimate

2.3.1 *Types of Estimates*

Two types of estimating classification systems that could be applied to meet the MFSP Liability expectations are described below for information, however, the Association for the Advancement of Cost Engineering (AACE) Cost Estimate Classification System will be used for consistent terminology for the remainder of this report.

2.3.1.1 System #1 – AACE Cost Estimate Classification System

One way to identify the level of confidence for an estimate is based on the estimate classification defined in the AACE Cost Estimate Classification System (Association for the Advancement of Cost Engineering 2005). Table 1 provides these estimate classifications.

Table 1. AACE Cost Estimate Classification System.

Cost Estimate Classification	Primary Characteristics	
	Level of Definition (% of Complete Definition)	**Cost Estimating Description (Techniques)**
Class 5, Concept Screening	0% to 2%	Stochastic, most parametric, judgment (parametric, specific analogy, expert opinion, trend analysis)
Class 4, Study or Feasibility	1% to 15%	Various, more parametric (parametric, specific analogy, expert opinion, trend analysis)
Class 3, Preliminary, Budget Authorization	10% to 40%	Various, including combinations (detailed, unit-cost, or activity-based; parametric; specific analogy; expert opinion; trend analysis)
Class 2, Control or Bid/Tender	30% to 70%	Various, more definitive (detailed, unit-cost, or activity-based; expert opinion; learning curve)
Class 1, Check Estimate or Bid/Tender	50% to 100%	Deterministic, most definitive (detailed, unit-cost, or activity-based; completed designs and drawings)

2.3.1.2 System #2 – Canadian Treasury Board Classifications[4]

The estimate class descriptions included below are based on the original Treasury Board definitions for construction planning projects but have been modified slightly to suit decommissioning projects.

Table 2. Canadian Treasury Board Cost Estimate Classification System.

Cost Estimate Classification	**Primary Characteristics**	
	Level of Definition (% of Complete Definition)	**Cost Estimating Description (Techniques)**
Class D Rough Order of Magnitude	1% to 15%	Based upon a statement of requirements, and an outline of potential solutions, this estimate is strictly an indication i.e., rough order of magnitude [ROM] of the final project cost, and should be sufficient to provide an indication of cost and allow for ranking all the options being considered. (i) Various and simple methods of estimate preparation may be employed in preparing this class of estimate. (ii) A significant proportion of these estimates may be in the form of assumptions and allowances. (iii) Where additional information is available it is appropriate to use it in the estimate.
Class C Indicative	5% to 15%	Based on a full description of the preferred option, construction/design experience, and market conditions, this estimate should be sufficient for making the correct investment decision, and obtaining preliminary project approval. Prepared from measured and priced quantities, where possible, and priced parameter quantities, all obtained from the facility information that is available.

[4] See http://www.ciqs.org/docs/EstimateClasses.pdf

Cost Estimate Classification	Primary Characteristics	
	Level of Definition (% of Complete Definition)	Cost Estimating Description (Techniques)
Class B Substantive	20% to 35%	Based on design/preliminary drawings and outline specifications for the project, which includes the designs of all major systems and subsystems and the results of all site/installation investigations, this estimate should provide for the establishment of realistic cost objectives and be sufficient to obtain effective project approval. Majority of estimate prepared from measured and priced quantities obtained from the definitive project scope documents and outline specifications.
Class A Check Estimate or Bid/Tender	95% to 100%	Based on complete working drawings and specifications, and prepared prior to calling competitive tenders, this estimate should be sufficient to allow a detailed reconciliation/ negotiation with any contractors preferred tender. Measured and priced, fully detailed quantities and project scope definition, obtained from the completed project plans and specifications.

Key Workshop Observation

Industry participants in the workshop noted that they have used the "tons of steel" approach to develop preliminary cost estimates equivalent to the Class 5 or Class D estimates noted above. In the "tons of steel" approach, consulting companies divide the total decommissioning costs (suspension, demolition and remediation costs for projects that have been fully decommissioned) by the tons of steel and concrete for those projects. The resulting factor (decommissioning unit costs in $ per ton) can then be applied to an MFSP project to represent the all-in cost to decommission based on the tons of steel and concrete in the MFSP project using a metric based on the major cost item. This approach is acceptable under IFRS rules as it is a reasonable representation of actual expected costs for an event that will take place in the distant future. By the time the last OLD payment is made a more detailed cost estimate, based on actual site conditions, will be needed for IFRS and internal budgeting purposes. The detailed estimate is expected to be close to the "tons of steel" estimate and could very well be lower. Economies of scale (e.g., mob and demob as a percentage of total cost will be lower for these much larger projects, etc.) will tend to result in lower cost under the detailed method.

They felt this approach would be acceptable in the early years of plant operation since the Asset Safety Factor is high enough that even a large difference between estimated and actual liability would not trigger an Asset Safety Factor Deposit (for example, even if the cost estimate were to double).

Regardless of the class system used, cost estimates would be expected to be updated at various stages of the project development cycle. The classes of estimates are based on the overall level of project definition, end use, methodology used in developing the estimate, accuracy range, and preparation effort. As the decommissioning project draws closer to execution, the accuracy level of the estimate would be expected to increase in confidence and detail.

Key Workshop Observation

No matter how the estimates are developed the workshop participants agreed that the Approval Holder will have to be able to explain the basis of the estimate and provide rationale why the methodology is acceptable. Some of the reasons might include acceptability to the financial reporting regulator (e.g., IFRS rules).

Figure 2 is provided as a graphic illustration of the process of the life of the facility. The left edge of the figure represents the estimate for a facility early in its operating life, then shows the expectation of some movement from a Class 5 and 4 estimate as the facility shutdown approaches toward a Class 3 or 2 and moving to Class 2 or 1 during last years of site operations, represented at the right edge of the figure.

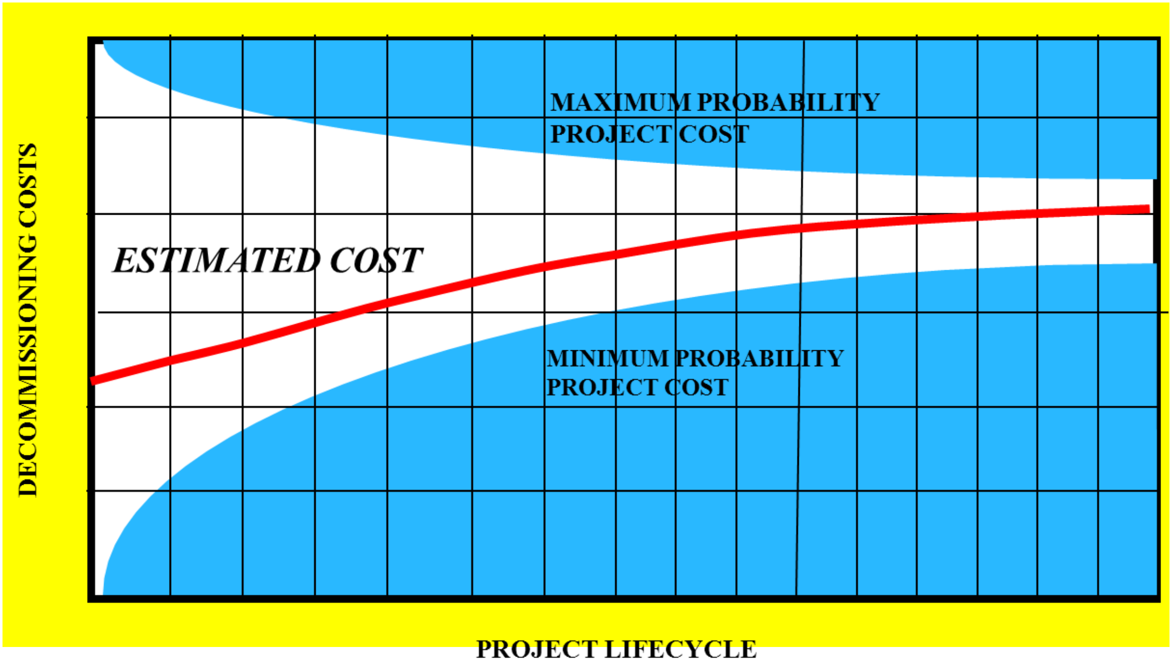

Figure 2. Estimated Cost and Accuracy Profile through Facility Life.

Key Workshop Observation

Workshop participants noted that the x-axis on Figure 2 could represent time, the Asset Safety Factor or the inverse of the Reserve Life Index (i.e., running highest to lowest from left to right).

Key Review Observation

The red line in Figure 1 is more likely to be shaped like a set of stairs with a long flat value for the early years (increased or decreased with major changes to the plant) and then major step changes in the value as the first Operating Life Deposit is paid and again at the last payment, and then decreasing as decommissioning occurs. The early stage estimate would likely be at a Level 5 with the steps resulting in increasing levels of estimate accuracy such that a Level 1 estimate would be prepared for the final ORD payment. The contingency values associated with the steps would change in the opposite direction (higher to start and reduced as estimate accuracy increases).

2.3.2 *Basis of Estimates (BOE)*

A Basis of Estimate (BOE) commonly contains the type of information noted in Table 3. The information can provide a complete BOE to strengthen the foundation of the estimate and addresses a number of potential MFSP audit questions. The information can be provided at any estimate level or classification. It is the amount and level of detail within the document that would be expected to increase as the estimate becomes more precise. The AACE guidance for BOE is shown in Table 3.

Table 3. Content for a BOE Document

Attribute of BOE	Content Expectations for each section
Purpose	Provides a concise description for the project cost estimate and establishes when in the plant life the estimate was prepared – i.e., what the relative knowledge level is concerning the site conditions at the time of the MFSP Liability estimate.
Decommissioning Strategy	Unless negotiated specifically with the regulators, the assumed decommissioning strategy is an orderly shutdown of the facilities followed by demolition/dismantling to meet the regulated end land use. Questions to consider in this stage include: Will the plant be decommissioned in stages with gaps in the schedule? Will some work be done during plant operations?
Project Scope Description	The project scope description (including a Work Breakdown Structure [WBS] similar to that shown here) should provide detail for the main elements of the WBS for each major segment or phase of the project. Major pieces of equipment should be identified as well as the primary trades to be involved.
Inventory	Create a list of what is in estimate and what is not; this list would be improved with each annual update. Sometimes called an *asset inventory* this would more appropriately be called a *liability inventory* in MFSP terms.
Hazardous Materials and Asbestos Inventory	Identify hazardous material and asbestos waste streams specifically in the estimate and that studies/work be done as part of updates to better quantify any uncertainties in the inventory and related cost estimate.
Resource List and Rates	Include a separate resource list and independent, third party contractor rates used for the MFSP estimate. This would allow for ease of comparison between estimates and for audit purposes. MSFP Audit Questions: What equipment rates were used to calculate MFSP Liability and what proof is there that these rates represent a rate government could obtain?

Attribute of BOE	Content Expectations for each section
Estimating Methodology	The methodology should indicate the primary estimating method used to prepare the cost estimate.
Estimate Classification	Identify the estimate classification, including any rationale or justification for the selection of the estimate classification.
Design Basis	Design basis can provide the types and status of engineering design deliverables used to prepare the estimate and any design assumptions, which may include a checklist and/or a list of engineering drawings used.
Environmental Site Assessments	A three phase approach for ESA's can be performed to identify physical, residual, and hazardous materials through the life of the facility. These assessments can form the basis for contaminant remediation estimates to be included in the MFSP Liability amount. Appropriate methodology should be confirmed with the regulator. MSFP Audit Questions: What standards and techniques were used to establish remediation costs and why? What disposal strategies and costs for plant site structures and facilities were used to calculate MFSP Liability? What disposal strategies and costs for wastes and by-products were used to calculate MFSP Liability? Are there costs assigned to the treatment of water to ensure water quality criteria for release is met?
Planning Basis	Planning basis can document the project management, engineering, design, procurement, and decommissioning approaches. Contracting or resource strategies are often included, such as work week, work hours per day, equipment, and the overall project schedule and key milestones.
Cost Basis	Cost basis, tied closely to the estimating methodology, can provide the methods and sources for pricing material, labor, and subcontracting. MSFP Audit Question: What equipment rates were used to calculate MFSP Liability and what proof is there that these rates represent a rate government could obtain?
Allowances	Allowances can document the common allowances for take-offs, overbuy, design, weather delays, congestion, etc.

Attribute of BOE	Content Expectations for each section
Assumptions	Assumptions can include all other assumptions that have not been included in previous sections. See Section 2.1 of this report for typical types of assumptions that may be included within an estimate.
Exclusions	Exclusions can be listed for costs that have not been included in the estimate. Project tailings ponds and tailings disposal areas are not part of the oil sands processing plant estimate, nor is reclamation following decommissioning[5]; however soil contamination within the plant boundary is included.
Exceptions	Exceptions can provide any anomalies or variances to the Approval Holder's standard estimating practices, including any major deviations. MSFP Audit Question: Are any roads or other infrastructure components left in place (un-reclaimed)?
Risks and Opportunities	Risk and opportunities can provide the process by which risks were assessed and identify the risks and opportunities for the project, especially for high risks or opportunities (a risk register can be referenced during this stage).
Contingencies	The method of determining contingencies should be identified, either by estimator experience, or by Monte Carlo-based Risk Analyses for P50 or P80 Confidence Levels. AACE has two recommended practice documents discussing Contingency estimating using range estimating (RP 41R-08 2008) and expected value (RP 44R-08 2009). Contingencies should identify any uncertainty, variability or inadequacies in the project scope definition, estimating methods, data, unforeseen events, and should provide the contingency amount and confidence level. MSFP Audit Question: What contingencies were used to calculate MFSP Liability?
Management Reserve	Management reserve can provide an allowance for unanticipated changes in scope that could be encountered.
Reconciliation	Reconciliation can provide a discussion and evaluation of any major differences in the current estimate and the previously prepared estimate.
Benchmarking	Benchmark the estimated costs against other similar or equivalent projects to verify the reasonableness of the estimate.

[5] Note however that they are part of the overall MFSP Liability estimate.

Attribute of BOE	Content Expectations for each section
Estimate Quality Assurance	Quality Assurance documents any estimate reviews that have taken place, comments provided, and actions taken. Typically, three reviews are performed; (1) At the outset to orient the estimating team; (2) Midway through the estimating effort to assess progress and resolve problems; and (3) Near the end of the effort prior to delivery of the estimate to check results and verify the reasonableness of the estimate. Estimate validators should be independent from the personnel performing the estimate.
Estimating Team	Identify the estimating team as part of the estimate development, including their roles and responsibilities. MSFP Audit Question: What professionals signed off on the various MFSP calculations? Were they internal or third-party?
Attachments	Make any attachments that provide supporting documentation readily available, such as rate tables, asset inventories, etc. They could also include reference documents, letters and communications, and benchmark comparison documents. MSFP Audit Question: What technical reports are available to support the MFSP calculations?

2.3.3 *Possible Content for an Estimate Work Breakdown Structure*

Figure 3 provides an example of a work breakdown structure (WBS), which is a combination of items from the Energy Resources Conservation Board (ERCB) Directive 001 *Requirements for Site-Specific Liability Assessments*, which includes Form 001-A, *Suspension and Abandonment Cost Estimate Report* (Alberta Energy and Utilities Board 2005), and Section 3.1 of the *Guide to the Mine Financial Security Program* (Alberta Environment 2011b).

1. Suspension

1.1 Facility Suspension (purge vessels, flow lines – gas and liquid free)
1.2 Facility Preparation (electrical/instrumental disconnect)
1.3 Phase II (and where possible Phase III) Environmental Site Assessment

2. Abandonment

2.1 Asbestos Abatement
- Asbestos – piping insulation
- Asbestos – building insulation

2.2 Hazardous Materials Removal
2.3 Demolition/Dismantling
- Equipment Removal or Demolition
- Vessel Removal or Demolition
- Concrete Demolition
- Structural and Building Demolition/Dismantling

Aboveground Piping Demolition/Dismantling
Belowground Facilities (piping/tanks)
2.4 Asset Recovery (NOT in MFSP Liability Calculation, but an important part of any project estimate)
2.5 Remediation
Remedial Action and/or Risk Management Plan Development
Underground Structure Removal (if / where required) that could not be completed as part of the Demolition/Dismantling phase of the project
Soil Remediation
Groundwater Remediation

3. Transportation and Disposal

3.1 Disposal Cost – Class I Landfill
3.2 Disposal Cost – Class II Landfill
3.3 Disposal Cost – Class III Landfill
3.4 Disposal Cost – NORM Disposal
3.5 Disposal Cost – AEW Licensed Incineration
3.6 Liquids Disposal (from Facility Suspension)
3.7 Disposal Cost – Removal or approved disposal of byproducts such as sulfur, coke, bottom ash or fly ash
3.8 Treatment of contaminated soils and water
3.9 Waste Material Processing
Sorting and Sizing Cost
Transportation and Loading Costs

4. Project Management

4.1 Project Management Services
Planning and Reporting to AEW
4.2 Project Engineering and Supporting Services
4.3 Site Administrative and Care & Maintenance Costs until reclamation certificate is issued (supervision, safety, utilities, trailers, taxes, lease payments, Employers Costs, insurance, etc.)
4.4 Mobilization and demobilization of equipment
4.5 Post project monitoring water, soil until reclamation certificate is issued

5. Surface Reclamation*

**Reclamation is included for completeness, but is outside the scope of this report*

Figure 3. Example of Decommissioning Project WBS.

2.3.4 *Possible Liability Estimate Review and Update Strategy*

MFSP Liability estimates are to be updated annually (Alberta Environment 2011a). While a full re-estimate of the plant decommissioning costs on an annual basis prior to the onset of the Operating Life Deposit payments is probably not expected, warranted, or needed there are very good reasons for periodic, in-depth reviews and updates for the estimate throughout the life of the facility (and especially during the Operating Life Deposit payment years).

Major actions that could have a noticeable impact to the estimate (such as equipment upgrades or changes, process changes, major upsets or accidents (such as a fire), significant regulatory changes or court decisions to name a few examples) are required by IFRS to be included in the estimate and therefore would show up in the next MFSP Annual Report.

In general, more detailed/accurate estimates are warranted when the Operating Life Deposit (OLD) is paid since payments are based on the MFSP Liability value. However, there were differences of opinion about whether the detailed estimates should be made at the first OLD payment or at the last one. In the early life of a project, before the OLD payments are triggered, lower estimate accuracy may be adequate for an Approval Holder with an Asset Safety Factor (ASF) value greater than three because it would take a significant error in the estimate to cause the Asset Safety Factor Deposit to be triggered.

Key Workshop Observation

It is important to note that significant changes to reported ASF values may generate questions from the public, regulators and the Auditor General.

Key Review Observation

One could argue that the estimate accuracy is critical only when the full MFSP Liability is required to be secured (i.e., when the Reserve Life Index is less than six years and the Operating Life Deposit is at 100%), not at the start of the Operating Life Deposit payments.

2.4 Estimating Needs, Expertise, Information and Tools

When estimates are developed, the team members should have specific expertise and experience in the major aspects of the project as required by IFRS. This can increase both the confidence level and accuracy of the estimate. A team for a detailed MFSP Liability estimating project could include: Project Manager, Estimator(s), Quantity surveyor(s), subject matter experts (SMEs) with representation from, as a minimum, industry operations and industrial decommissioning, Quality Assurance Manager/Engineer, Health and Safety representative, and a technical editor.

Available information concerning not only construction and normal operations, but upset and accident reports, should be gathered to best describe the condition of the facility as part of the Phase I or II ESA. Each of these types of information may affect the means and methods and waste streams to be expected from the decommissioning effort and can thus impact the cost estimate as well.

Different corporate estimating tools and processes may be considered from those used for operations and construction. Selection of the right tools can facilitate the ease of conducting unique MFSP Liability detailed cost estimates, but can also:

a) Help to maintain the MFSP Liability/decommissioning estimate configuration control between update cycles;

b) Allow for alternative analysis without significant rework of the estimate;

c) Be capable of direct export to financial and scheduling software.

Other supporting tools that can add credibility to any estimate are publications that define industry norms for productivity such as:

a) RSMeans Building Construction Cost Data (updated annually)

b) Alberta Roadbuilders handbook

c) Richardson's Construction Estimating (EOS Group 2011)

Application of any of these standards requires a knowledgeable estimator and SME(s) to ensure proper application.

3 BACKGROUND FACILITY AND PLANT INFORMATION REQUIRED FOR COST ESTIMATING

3.1 Overview of a Typical Oil Sands Plant

The following list illustrates the major components, structures and processes that could be included within the scope of an oil sands processing plant cost estimate. While recognizing that not every site will include every component, structure or process listed below, this list is provided as a general reference of major equipment and facilities types that may be encountered[6]. Additionally, this list may be used to demonstrate the level of detail for an equipment listing required in a Class 5 estimate. The equipment list could be updated as more details are added over the life of the facility.

- Receiving facilities/structures that accept ore from the mine
  - Ore receiving and storage (surge pile(s))
- Extraction Plant
  - Sands and rock separation
  - Steam and water application

[6] Note this list does not include other building infrastructure that is not part of the oil sands processing plant such as maintenance buildings or vehicle maintenance shops. These are covered under the Mine Financial Security Program but are not addressed in this report.

- Slurry and clean sands separation
- Bitumen separation from slurry (decant or centrifuge)
- Bitumen/water separation
- Sand and water to tailings ponds (tailing ponds are specifically excluded from the scope of this report)

- Upgrading Plant
  - Crude Unit, both atmospheric and vacuum units, with Diluent Recovery
  - Primary Upgrade:
    - Coker Furnace/Drum/Fractionator with gas recovery and coke handling equipment, or
    - Reactor/Steam and Methane Reformer Hydrogen Plant/Fractionator with gas recovery equipment
  - Secondary Upgrade for sulfur, ammonia and product separation
  - Sulfur Plant containing recovery units, amine units, sour water strippers, flairs and sulfur product holding areas
  - Sulphur and coke storage and disposal areas
- Tankage
  - Bitumen storage from the extraction plant prior to upgrade
  - Product storage prior to shipment
  - Diluent storage
  - Fuel and other chemical storage
- Utilities
  - Cogeneration Facilities that utilize waste heat and waste gas from the upgrade plant for power generation for use on the site (applicable for those locations where the Approval Holder has the responsibility)
  - Transmission lines
  - Substations
- Shipping Facility and Pipeline
  - Pumping facilities located within the facility boundary
  - Pipelines located within the facility boundary
- Roads, culverts, bridges, laydown areas and construction stockpile sites located within the facility boundary.

- Any other plants and related components for which the Approval Holder has taken on MFSP decommissioning responsibility

Key Workshop Observation

Workshop participants noted that it is important to recognize that there will be significant differences in equipment between a plant that includes an upgrader to produce synthetic crude oil and one that produces bitumen.

3.2 Site Information Review and Reconnaissance

Prior to developing a detailed MFSP Liability cost estimate, the team should possess a thorough knowledge of site conditions to understand the potential issues that can affect the cost estimate. The site information review and reconnaissance can be completed through a detailed Phase I ESA. Part of the annual or periodic cost estimate updates can be to review and update assumptions and information gathered during the initial Phase I ESA. However, it is recognized that until the final facility shutdown, changes to the estimated extent of contamination are expected due to upset or accidents at the facility, ongoing remediation efforts or incomplete characterization (e.g., under buildings).

The purpose of the Phase I ESA is to help determine past and present operational practices and processes, help generate equipment lists, compile a detailed list of waste streams, areas of potential environmental concern (APEC's), contaminants of potential concern (COPC's), any distinguishing physical features for the site, etc.

The Phase I ESA can be completed in general accordance with the Canadian Standards Association (CSA) standard Z768-01(CSA R2006) for conducting Phase I ESAs, and at a minimum should include:

a) Review of current land use, and intended end land use, of the site and adjacent areas to identify potential environmental effects on the site;

b) Review of geological, hydrogeological, and hydrological information for the site and surrounding areas;

c) Review of historical information (including aerial photographs, maps, historical records, listings and documents, existing environmental reports, and any other pertinent available third-party information) for the site, occupants and surrounding area;

d) Review of past and present operational practices including equipment used on site, waste streams, emergency response plans, as-built drawings (refer to Section 3.4 for further detail), etc.;

e) Inspection of the site should include, but not be limited to, APECs, topography, natural resources, habitat, surface water drainage patterns, fill materials and debris, surface staining, type and condition of vegetation, evidence of storage tanks (above and below ground), chemical storage areas, wells, utilities, physical infrastructure, preliminary identification of site hazards and/or access issues, etc. (refer to Section 3.2 for further detail);

f) Records of spills, contamination, cleanup activities, replacements to the original design, and operating difficulties resulting in conditions changed from the original design;

g) Interview(s) with a representative(s) of the current landowner of the site, site operators, government agents, community stakeholders, adjacent site owners, etc. with regard to the site history;

h) Review of any historical, heritage or archaeological values associated with or in close proximity to the site, which were identified during the Environmental Impact Assessment (EIA);

i) Review of regulatory requirements and any commitments made during the application review and approval process.

3.3 Facility Condition and Age

Physical age of the facilities can provide significant "state of the industry" information to the estimator. For instance, any industrial facility built prior to the early 1980's can be expected to have significant friable asbestos insulation that must be managed, if progressive removal of these materials has not been completed. The same type of facility, built in the late 1990's or later could be expected to have significantly less or no friable asbestos.

The conditions of facilities at shutdown will have an impact on the MFSP Liability costs and should be considered. A reasonable assumption may be that a terminal shutdown occurs that flushes caustic or acidic operating liquids or removes bulk process or addition chemicals/materials prior to the operator securing equipment for the last time. If this does not occur, (i.e., shutdown occurs due to a rapid change in the site requirements or an immediate shutdown order), these hazardous or caustic or acidic materials could remain in the systems for many months or years, may damage the systems to an unknown extent prior to decommissioning or as a minimum must be removed and disposed of prior to demolition/dismantling.

Good site and system configuration management should document the as-left condition (preferably deactivated and ready for demolition/dismantling). If the as-left condition is not documented, and the plant is left idle for an extended period, this can introduce hazards into the suspension and abandonment processes and cause delays, which could have been minimized early on.

3.4 As-Built Drawings

As noted above, understanding the rigor of the process for drawing configuration management during site operation is an important item for cost estimating and eventual decommissioning of the site. Drawings that are not available or more critically, available but not a reliable source of information, can introduce significant unknowns into both the cost estimating and the work process planning. This being said, not all drawing types are equal when developing the estimate or work plans. Possible drawing types and their potential use in the cost estimating process are listed in Table 4. Note that items considered critically important are bolded in the Use column.

Table 4. As-Built Drawing/Information Type

Drawing/ Information Type	Use in Cost Estimating or Work Planning Efforts
Civil/Structural	**Subsurface concrete structures and foundations, steel pilings,** concrete placement specifications containing concrete strength and reinforcing information. Overall quantity takeoffs for parametric estimates (e.g., m^2/m^3 of building, m^2 of siding) or reach requirements for demolition/dismantling equipment. Gross values for recycle steel or concrete demolition.
Electrical Distribution	**Equipment/building/area isolation in work planning** and design support for re-power areas or building power during project work.
Electrical Instrumentation	Marginal value in either cost estimating and decommissioning planning.
Liquid Systems	**Isolation of pressure systems prior to demolition/dismantling.**
Facility Equipment and General Arrangement drawings by floor or area	Layout of the facility work areas, access to equipment hatches, doorways, material handling routes, sizes of equipment, areas of walls and floors for concrete or steel quantity estimation, and determination of removed equipment staging areas.
Iso-metric system drawings	Marginal value, possibly used when draining critical systems.
Site Plans	Used in overall site/project design and waste handling planning.
Bill of Materials	Overall site or building or system content, useful in parametric estimates or bottom up estimates for removal of a certain material e.g., m^2 of asbestos siding for a given building. Valuable for determining lengths of piping, conduit, cable trays, etc.

4 FACTORS TO CONSIDER WHEN PREPARING A DETAILED COST ESTIMATE

4.1 Scope Definition and Activity Identification

Good project management practices generally require that a clear scope be established and that intermediate steps to achieve that scope be defined. End points (as used here) are the intermediate steps and end state is the site condition at the end of the project. Refer to Section 2.3.3 for a suggested WBS, which can assist with scope definition.

4.1.1 *Defining Material Volumes*

Most operating facilities maintain an active asset and hazardous material inventory in some format for various financial or regulatory reasons. These existing inventories can be used as a basis for scope definition for the MSFP Liability estimate. These inventories, in some cases, already include enough information for Class 4 or 5 estimate and may require minimal further work to support higher classifications of estimate.

4.1.2 *Defining System and Structure Endpoints – Activity Identification*

Decommissioning end points for system, structure and space, may generally be made early in the plant life for *major* classes of systems, structures and spaces, and then established for *each* system, structure and space as part of the definitive project planning phase. Once established, this can become the scope list that forms the basis for implementation schedules and sequencing.

4.1.3 *Defining the Project End State*

The decommissioning project end state should be established via assumptions early in the facility life/early cost estimating efforts. As plant shutdown nears, more specific end states may be defined (even if still only assumptions), and discussed with the regulators.

The project end state is generally a regulatory driven condition, which can be negotiated (i.e., risk-based guidelines) for the plant site. Some specific items of importance when the end state is defined are as follows:

a) Final condition of any plant buildings, structures or manmade improvements such as roads, drainage ditches and culverts, etc., which includes their individual final endstates (i.e., slab on-grade, removed 1m below ground surface, or left in-place);

b) Acceptable levels of contaminants of concern that may remain in soil or groundwater (considering planned end land use);

c) Ground level grades and contours (considering planned end land use and re-establishment of surface drainage).

4.2 Suspension and Abandonment Planning

Experienced facility staff can provide expert information on existing conditions and operations. Using solid expertise and experience incorporating lessons learned from other projects will help develop even the conceptual planning to produce required safety, environmental, technical, cost and schedule documentation.

Specific items that should be addressed include:

1. Project Scoping/Planning Documents – to assist in defining end points and end state;
    a. End Point Development as needed for site, facility and systems as input to the Scoping documents.
    b. Perform cost benefit analysis for concepts.
    c. Note that at least the Phase I ESA should be completed so that accurate information is included in the regulatory documents as needed.
    d. Investigate innovative approaches for minimizing costs, streamlining processes and achieving closure status that fully decreases hazards to the environment and reduces long-term liability.
2. Execution Plans – to define sequencing and support requirements;
3. Health and Safety Plans – to identify, mitigate or eliminate potential health and safety risks associated with the project;
4. Waste Management, disposal and recycle requirements and strategies;
5. Regulatory requirements, permits and interfacing to develop a remedial action plan;
6. Strategic Long-Range Plans – Prioritization and sequencing schemes, strategies and approaches that may include updates of corporate risk-based prioritization and sequencing with the change in status planned for this individual site.

Near the end of facility operation, dedicated planning and engineering services should be assigned to the project to progress the conceptual planning efforts into: (1) definitive/executable sub-projects; (2) definitive cost estimates; (3) prioritized schedules prior to the facility shutdown; and (4) the start of work.

4.3 Environmental, Health and Safety Hazard Identification

Drawing on various scientific models, operational disciplines and operational history will help estimate the environmental, health and safety (EHS) risks that exist or can develop with time, during site operation. Early risk identification, proactive stewardship and operational management may reduce future EHS risks as well as remedial obligations. Conversely, if poor operations, accidents, and releases routinely occur during plant operations, the expected environmental, health and safety issues during decommissioning would likely result in increased costs and schedule delays. These changes may be best reflected in periodic updates to MFSP Liability cost estimates by reviewing operational history since the last estimate in an attempt to estimate expected changes.

While ROM estimates (Classes 5 and 4) for liability management and future year planning are quite acceptable, the Phase II and III ESA results are generally critical in developing definitive project costs and schedule, and should be factored into re-estimates as the facility end of life approaches.

Within a few years of plant shutdown, the results of the Phase I and II ESAs and available or partial Phase III ESA data should be input to a conceptual EHS document to formulate specific assumptions regarding EHS controls during suspension, abandonment, remediation and waste management activities.

Further, the results of the ESAs could be used to identify the potential EHS risks, and develop risk mitigation measures and controls in the project execution documents, the work control documents and the sub-contraction documents.

4.4 Suspension of Operations

The activities and operations required to ensure the safe and secure condition of a site when production activities have ceased and/or while receivership/resale of all or parts of the project takes place is defined as "suspension" in the MSFP. This includes activities and operations to maintain the care and custody of a site while abandonment, remediation and surface reclamation activities are undertaken.

Key Workshop Observation

Industry participants in the workshop noted that there are varying industry practices in terms of accounting for suspensions costs – some companies include it in operations costs while others include it in decommissioning costs. The participants agreed at the workshop that for MFSP purposes the suspensions costs should be considered as part of the overall MFSP Liability estimate.

4.5 Mobilization and Project Setup

Mobilization for decommissioning is typically a phased operation that can fall generally into the three subsections below. Early in facility life, an allowance or ROM for the entire "mobilization" may be acceptable, but should be expected to be more specific as the schedule progresses from planning, to suspension and decommissioning activities.

4.5.1 *Early Mobilization*

Professional and technical staff may be mobilized to the project site in the later stages of terminal shut down operations for decommissioning planning and ESA work. Likely only personnel will be mobilized at this point and may occupy existing office space; this is expected to be the least noticeable and lowest cost mobilization.

4.5.2 *Suspension and Abandonment Mobilization*

Salvage, scrap and hazardous material removal contractors would be mobilized at the start of the project work. Depending on the subcontracting scheme and schedules for each type of work, the Approval Holder may provide office, shop and locker/sanitary facilities for these groups, but most likely each subcontractor will require some mobile office or facilities.

Equipment mobilization at this phase of the project may be expected to provide protective enclosures (e.g., ventilated enclosures for asbestos or lead paint removal) and scaffolding or mobile platforms would likely be mobilized to support this work scope as well.

The largest and most visible mobilization will likely be the demolition/dismantling, recycle and remediation contracts. Many pieces of large demolition/dismantling and transport equipment would be expected and new roads or access paths potentially requiring establishment. Support facilities will include office, living, and shop facilities. Needs in this area may be for a larger work force than during site operations and should be anticipated, either by assumptions that existing facilities are used and or that some new facilities could be needed.

MFSP estimates *do not* include or take credit for the potential salvage value of materials that can be realized. However, for the basis of estimate, it is still considered important to identify in the overall decommissioning plan if salvage/scrap/resale is to occur (this would be considered for execution purposes). See a further discussion of this topic in Section 4.12.3.

Provision for handling salvageable materials can take a number of forms based on the Approval Holder's direction: (1) the material handed over to the salvage contractor for removal and disposition, from which the contractor receives all the resale benefit, (2) the demolition/ dismantling contractor removes the equipment and places it in a central repository for the recycle/scrap contractor to remove and keep the proceeds to recover their transportation and handling costs; (3) any of the above where the recycle/scrap contractor returns a portion of the value to the Approval Holder.

The choices made in this area may depend on the value of recycle/scrap at the time of the estimate, keeping in mind that the assumed process could change over the life of the facility. However, these credits are not considered in the final estimate as these values may change over time due to volatility of markets, and the liability needs to be included, regardless of potential salvage value.

4.6 Hazardous Material Removal

Removal of hazardous materials such as naturally occurring radioactive materials (NORMs), lead, mercury, asbestos, transite[7], circuit boards (if not permissible in the demolition/dismantling waste stream) should be completed prior to demolition/dismantling to ensure that a given waste stream is not compromised.

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[7] See Wikipedia definition at http://en.wikipedia.org/wiki/Transite

Class 5 and 4 cost estimates may use bulk unit rates for the gross mass, volume or area of a particular hazardous material (such as from the construction bill of material) while the expectation for later, more accurate estimates, would be to use a measure of actual mass, volume or area as the basis of estimate. In addition, the later more refined estimates would be expected to address removal means and methods and material location with more detail as uncertainties are minimized and or removal processes become better defined.

For instance, a Class 5 estimate notes that 750 m^2 of transite siding is included in the structure and a unit rate for transite removal is included with all the transite on the site. But a Class 2 estimate would be expected to address that one-half the transite in this structure is greater than 10 m in the air and will require a special man lift and crane to reach above the switchyard on the east side, or that this switchyard is out of service and removed prior to transite removal, thus allowing normal removal in this problematic area.

4.7 Deactivation – Within the Suspension Phase

An output of an end point development process can include a list of system and structure deactivation/suspension activities that are deemed necessary to be completed to proceed to demolition/dismantling of the system or structure. The actual timing and end state decision is generally made outside the decommissioning planning efforts based on corporate, regulatory, stakeholder and other criteria.

Once made however, this decision can act as a trigger for the following actions:

- Implement or construct a "Continue Operations Project" to allow other processes on the site to remain operational. Installation and commissioning of the new systems or equipment (such as a major re-route and downsizing of the electrical system to support the project only) should be integrated into the project schedule to ensure replacement equipment or systems are in fully operational condition before impacts to original shared equipment are planned in the project;
- Terminal draining of water and other liquid systems; drain machinery oils for reuse or recycle; drain water systems as needed to prevent unwanted spills or leakage. Note that draining potable, fire protection and raw water systems may not be needed since the impact of a spill is negligible. In the same manner, however, if an unused potable water tank were to freeze, leak or damage a main access road, draining that system is needed to prevent the damage – not because of the hazards associated with the liquid;
- Removal of bulk operational chemicals and products that may be sold or used at other operational plants, or may have to be disposed of accordingly – such as boiler chemicals, sulphur, ammonia, water treatment chemicals, consumables, specialty tools and spare parts from warehouses or maintenance facilities;

- Rack out breakers for all but needed support equipment and infrastructure. This is a quick, easy and safe way to de-energize large portions of the site and small equipment that will not operate again.
    - If the early electrical isolation / system shrinkage allows de-energizing some polychlorinated biphenyls (PCB) transformers these should be removed to eliminate that potential hazard early in the process;
    - Alternatively – one could physically remove breakers as long as the breaker cover may be shut following removal and people remain safe from energized breaker bars in the cabinet.

Removal of high value salvage items and some scrap could be performed at this point if hand removal is warranted. Generally demolition/dismantling equipment removal of scrap materials is much cheaper and safer than hand removal, but many extenuating situations have been observed where hand removal is required (e.g., brass, copper, aluminum scrap) inside a steel or concrete enclosure that would be extensively damaged or lost in the demolition/dismantling process. Circuit boards with precious metals, even if allowable in the waste stream, may be valuable enough to warrant hand removal.

The removal of site utilities and process connections to other structures, including electrical, potable water, fire protection, sewers, storm drains, etc., should be accomplished in this phase of the project. The final step in the operations suspension phase would be to complete a multi-discipline inspection of the structure with the purpose of declaring/certifying the site or structures do in fact meet the pre-planned end points.

Deactivating the site, structure, or system, and/or installing a temporary electrical system to support continued work is a large project decision with scope, cost and schedule impacts that should be considered. Scope and timing of the isolation efforts are very fluid and can change from site to site based on needs, project schedules for follow up work and work conditions in a facility when all but construction power is removed.

Certification of "demolition/dismantling-ready" should include waste management review of the remaining structure to ensure that waste streams are not compromised by questions asked later (e.g., removal of questionable materials from the structure is usually much easier than from a rubble pile). Adjustments should be made to the demolition/dismantling subcontract scope documents to reflect "as left" conditions for the demolition/dismantling preparation phase. The award of the demolition/dismantling subcontract should be scheduled so that the subcontractor is being mobilized to participate in demolition/dismantling-ready inspections.

As in hazardous waste removal, suspension and demolition/dismantling preparations would include an allowance for each major utility or process system to be isolated with little specificity as to means and methods in a Class 5 or 4 estimates. By contrast, a Class 2 or 1 estimate could include a design and contractor estimate to isolate and or re-route a steam header that is still needed for one more season.

4.8 Demolition and Dismantling – Within the Abandonment Phase

This discussion is broken into three major sections, since all are considered critically important to cost estimating and successful project execution. Each section should be addressed, regardless of the level of estimate, with more and more detail with time, for improved estimate accuracy.

4.8.1 *Project Management and Oversight of Subcontractor(s)*

The Approval Holder should maintain a presence on the site of the decommissioning work through the very end of the project for oversight purposes. Regardless of how much or how little the Approval Holder desires to transfer the decommissioning implementation risks to a single or multiple subcontractors, the Approval Holder maintains overall responsibility and so should maintain a notable presence on the site. Specific Approval Holder actions can include:

- Award of demolition/dismantling and remediation subcontracts;
- Provision of onsite staff to include Project Manager (PM), safety, and project scheduling support. This staffing may also include financial oversight from off site;
- Provision of environmental and or waste management representation should be considered based on the site and contracts in place to, as a minimum, audit or monitor subcontractor implementation of waste disposal and environmental requirements for the project.

4.8.2 *Project Subcontractor Execution and Management of Work*

The demolition/dismantling and remediation subcontractor(s) are expected to mobilize and staff the project with suitably qualified and experienced personnel and have appropriate equipment available to maintain progress to safely implement the project work. This staff and equipment is expected to include:

- Project management and appropriate numbers for safety oversight, field engineering, demolition/dismantling supervision, and waste management, salvage, and transportation to implement the project;
- Appropriate numbers and mix of demolition/dismantling personnel and demolition/dismantling, size reduction, and waste handling equipment to implement the project. This may include significant heavy equipment with excavator mounted hammers and shears and/or craft personnel that torch-cut materials to size for disposal;
- Provisions for specialty demolition/dismantling expertise, such as explosives for extremely heavy concrete or high reach excavators and operations for demolition/dismantling more than approximately 15 m high. Special design may be, and special equipment is always, required for structures greater than about 20 m high.

4.9 Contaminant Assessment for Remediation

In addition to the MFSP Liabilities associated with decommissioning surface and subsurface infrastructure, the Approval Holder must take into account liabilities associated with remediation of contaminated soil and groundwater that may exist on and underneath the plant site footprint. Until such time as plume delineation is completed, the scope of the liability estimate should be defined based on known and assumed site and subsurface information. Remediation estimates rely heavily upon Phase I, II and III ESA data. Therefore as the amount of assessment data increases, the level of accuracy of remediation estimates often increases as well.

Concentrations of contaminants of concern in the soil and groundwater should be compared with various AEW or Canadian Council Ministers of the Environment (CCME) guidelines. However, at a minimum, analytical data should be compared against background data and the *Alberta Tier 1 Soil and Groundwater Remediation Guidelines* (Alberta Environment 2010a), regardless of whether any site-specific guidelines are developed (see below).

The remediation guidelines identify a three-tiered system of contaminated site management as the Approval Holder proceeds from initial site assessment to regulatory closure. The three options are (Alberta Environment 2010a,b):

- Tier 1 – general remediation guidelines
- Tier 2 – site-specific remediation guidelines based on modification of Tier 1 guidelines
- Exposure Control – risk management through exposure barriers or administrative controls based on site-specific risk assessment

Regulatory closure is only available for sites managed to meet Tier 1 and 2 remediation guidelines (Alberta Environment 2010a) and therefore these should form the basis for the decommissioning cost estimate.

Key Review Observation

If an Approval Holder wishes to base their decommissioning cost estimate on an Exposure Control closure status they should discuss this with Alberta Environment and Water.

The identification of soil and groundwater contamination is generally determined through the execution of a Phase II ESA, which should be completed in general accordance with CSA Standard Z769-00 (CSA R2008).

4.9.1 *Selection of Applicable Criteria*

4.9.1.1 Alberta Tier 1

The Tier 1 Soil and Groundwater Remediation Guidelines are generic assessment and remediation guidelines, which have been developed using conservative generic scenarios. These scenarios incorporate the various receptors requiring protection, exposure pathways and a set of parameters that allow for a reasonably conservative prediction of risk at sites throughout Alberta (Alberta Environment 2010a). Where site conditions result in a more sensitive scenario, a Tier 2 approach is required. The addition of exposure pathways is also possible at a Tier 1 level; however, the removal of pathways that may not be applicable at a site is not permitted. The appropriate generic scenario for a site is determined based on its land use and soil texture.

Land Use

For the purpose of implementing guidelines, AEW defined five generic land uses: Natural Areas, Agricultural Lands, Residential/Parkland, Commercial Land Use and Industrial Land Use. Assessors must determine the full range of uses allowed under the applicable zoning bylaw when determining the appropriate end land use for Tier 1 application. For most oil sands sites in Alberta, the Natural Areas land use would be applicable. However, if none of the generic land uses are applicable, a site-specific Tier 2 approach will be required (Alberta Environment 2010b).

Soil Particle Size

The Alberta Soil and Groundwater Remediation guidelines for Alberta Tier 1 assessment are available for two soil types, coarse and fine. These soils are defined as having a median grain size greater or less than 75 microns, respectively (Alberta Environment 2010a).

Key Workshop Observation

Workshop participants noted potential difficulty in predicting current and future remediation costs because of uncertainties in how the hydrocarbon and salt guidelines would be applied to oil sands mines. Further work is required to clarify the guidelines that will be applied.

4.9.1.2 Alberta Tier 2

Tier 2 guidelines are based upon modifications to the Tier 1 guidelines and may include exposure pathway elimination and/or guideline recalculation by adjusting the Tier 1 models using site-specific values for certain parameters (Alberta Environment 2010a,b). These site-specific standards require authorization by the AEW Director prior to implementation (Alberta Environment 2010b).

There are several conditions where Tier 1 guidelines are not applicable to a site and Tier 2 guidelines must be used (Alberta Environment 2010b). In these situations, site conditions would violate one or more of the assumptions used in the Tier 1 modeling or where exposure conditions or receptors are more sensitive than the generic scenario. In addition, site-specific remediation standards are used if there is no soil quality standard for a particular substance at a site.

4.10 Contaminant Remediation

Soil and groundwater remediation often comprise a large portion of the overall liability associated with decommissioning a facility. Issues affecting the cost of soil remediation can differ significantly from those for groundwater remediation. Therefore, once an area or areas on site have been identified as requiring remediation, and any interfering structures have been removed, an evaluation of remediation alternatives and remediation recommendations should be completed. As a first step, the site information is generally reviewed, which can include:

- A review of historical data, contaminant conditions (e.g., type, level of contamination, lateral and vertical extent) and site conditions (e.g., geology, hydrogeology etc.) that influence migration, potential exposure scenarios, and existing site features (e.g., utilities, roads and physical structures);
- Determination of receptors of concern;
- Assessment of potential risks. Risk assessment, either qualitative or quantitative, is used to define the ultimate implications of the impact on the site and surrounding property. Applicable risks include, expectations of First Nations and other stakeholders, site logistics, human health, ecological, economic, public relations, personal and corporate liability;
- Establishing remedial objectives for the site, considering provincial and federal policy, regulatory requirements, financial and time constraints, public pressure, and/or valid ecological concerns. It is anticipated that the overall remedial objectives incorporate stakeholder input to ensure that the options selected meet the requirements of all of the potentially affected parties.

Remedial alternatives are then identified, and generally will fall into the following categories:

- No action
- Monitoring only
- Containment, control and/or isolation of the impacts
- Off-site disposal of impacted material
- In-situ treatment of impacted material
- Ex-situ treatment of impacted material

Using technical, social, regulatory and economic analysis, the possible remediation alternatives are evaluated and compared. Cost-effective alternatives capable of achieving the remediation goals are evaluated against their economic and social impact, including factors such as: compliance with remediation targets, timeframe, public acceptance, complexity, cost/benefit, liability, etc. If warranted, lab or field pilot studies are conducted to determine feasibility. The value of conducting these studies and pilot tests are weighed against the available budget and time required. If significant cost savings can be achieved or if uncertainties can be reduced to tolerable levels, then treatability studies would be warranted.

A remediation recommendation is provided upon completion of the remediation options analysis, and if required, a detailed remediation action plan (RAP) for the site. The remediation recommendation could include the approximate implementation costs and schedule and any additional post-remediation monitoring or data verification.

A more detailed RAP may be expected to include:

- Details of the overall site location and delineated horizontal and vertical locations of contamination presented in maps, cross-sections and other graphic representations;
- Details of all remediation strategies which were considered for managing contamination associated with a site;
- Details of the remediation strategy selected to ensure compliance with the applicable regulatory standards;
- Details regarding any contaminants, the concentration and volume of impacted material remaining on-site or to be relocated;
- An estimated schedule and approximate timeline for the remediation;
- Details of the known regulatory requirements applicable to the remediation, including any permits or authorizations required;
- Proposed confirmatory sampling and analysis program during and after remediation process;
- Measures and controls to ensure the ongoing management of any remaining in-situ impacts;
- Details of any public consultation, including review of the RAP, which has occurred or which is proposed during remediation; and
- A Class 3 cost estimate.

Should the selected remediation option include a risk-based approach, the RAP may also include:

- Reasoning for the risk-based approach;
- Methodology for human health and ecological risk assessment to ensure compliance with risk-based remediation standards;

- Identification of potential environmental impacts of any contaminants during the remediation process, including the potential for the release of contaminants and their associated receptors;
- Procedures, including monitoring, designed to mitigate any of the potential impacts identified, including the potential for the release of any contaminants to their associated receptors;
- Description of testing and monitoring requirements for evaluation of the risk management program.

4.11 Remediation Verification

Verification sampling of the remediated areas/materials should be undertaken to ensure effective remediation. Thorough documentation including verification data should be sufficient to demonstrate that the objectives and remediation criteria have been met.

The verification sampling plan should include the contaminants of concern that will be analyzed, the sampling protocol, which should include an estimate of number of samples that will be submitted for laboratory analyses, and a quality assurance/quality control (QA/QC) plan. The verification sampling plan will rely heavily upon the results of the Phase I, II and III ESAs.

How the verification data will be used may also affect the number of samples required. The expectation of confidence level (95% versus 80%) could easily double the overall number of samples collected and/or analyzed. Likewise, comparing the sample results to Tier 1 guidelines may require fewer samples, while a risk-based fate and transport model may demand a greater number of samples.

4.12 Waste Management and Disposal / Asset Recovery

4.12.1 *By-products*

The two main waste by-products at an oil sands processing plant are sulphur and coke. Produced sulphur is a commodity by-product, and is either temporarily stored on-site (blocked) for future shipment or shipped directly to other users. At older oil sands facilities, historic practices for coke disposal included burial on site, typically within the mined area. Current practices generally include coke disposal into tailings ponds or tailings disposal areas. A Phase I ESA would be required to determine historic coke handling practices. Subsequently, a remediation plan would have to be developed and approved by the regulator, which may include in-place abandonment of existing buried coke. Liability associated with the decommissioning of the tailings ponds are outside of the scope of this report.

Oil sands processing plants with upgrading facilities may have a wastewater stream that is stored within an effluent pond. The wastewater may include ammonia, hydrogen sulphide, naphtha, etc. The remediation plan developed for the plant site would have to include provisions for wastewater disposal, and decommissioning and reclaiming of any holding ponds on site.

4.12.2 *Waste Handling During Demolition/Dismantling*

Approval Holders or subcontractors may handle the size-reduced waste from the demolition/dismantling site to disposition point, but the requirements are similar and should be addressed in any level of estimate. Factors to consider include:

- Appropriate demolition/dismantling site loading equipment (both number of pieces and type of equipment) should be closely matched to the demolition/dismantling waste generation rate to ensure proper movement of waste, debris and salvage materials away from the demolition/dismantling zone;
- Salvage preparation actions are expected to include needed size reduction for transport as well as a potentially significant segregation and verification effort to ensure carbon steel/aluminum/brass/stainless steel segregation is managed properly;
- Appropriate number and size of transport vehicles from demolition/dismantling site to disposition site to ensure proper movement of waste, debris and salvage materials away from the demolition/dismantling zone;
- Disposal or disposition site daily acceptance capacity is matched with the waste generation rate. Include salvage transportation or the planning for cost, schedule impacts for double handling materials.

Waste handling and disposal is typically one of the most costly demolition/dismantling activities and components of decommissioning estimates. Therefore, one alternative to packaging, transporting, and disposal of waste materials has been disposal onsite in pits or void spaces in the below-ground levels of these facilities and plants.

> **Key Workshop Observation**
>
> Workshop participants noted that disposal of all or a part of plant site materials within the mine pit is not an uncommon practice. Further work is required to clarify the guidelines that will be applied and the level of public acceptance of such a strategy.

4.12.3 *Asset Recover, Recycling and Scrap Markets*

MFSP liability estimates are not to include financial credit for sale of recycle or scrap materials. This section is provided only for completeness of the description of the overall Abandonment Project content.

To reduce the amount of waste being disposed of in landfills, to promote green initiatives, and develop safe-work protocols, the decommissioning plan of a facility should consider including a survey/inventory of salvageable, recyclable, hazardous waste, and non-hazardous waste materials. The plan should consider how to safely and properly handle, store, transport and dispose/recycle these types of materials. Consideration should be given to dismantling of facilities as opposed to demolition, where feasible, to divert waste from landfills. All handling of wastes should be in accordance with the *Waste Control Regulation* (Government of Alberta 1996).

Salvageable materials primarily include, but not limited to, ferrous and non-ferrous metals and materials and equipment (e.g., HVAC systems, mechanical, electrical, office equipment, and scrap steel) that can be re-used or sold either by the Approval Holder or the contractor. An agreement regarding salvage should be established between the Approval Holder and the contractor. In some instances the amount of return on salvaged material can offset some of the cost of the decommissioning project. There are a number of scrap metal vendors/recycle companies throughout Alberta and neighboring provinces that will purchase scrap metals for resale or recycling. These facilities can be contacted for current pricing, and transportation methods. Some of these companies may accept other recyclable materials (batteries, waste oils, etc.). However, the large volumes of material and their location in relation to these recycling companies may not make it feasible to recycle. An option, feasibility and cost benefit analyses for disposing of these materials should be completed. The recyclable waste handling strategy should then be discussed with, and approved by regulators prior to implementation.

There are also a number of local and provincial recycling opportunities that can be taken advantage of during a decommissioning project (http://environment.alberta.ca/02638.html). Recyclable materials include but not limited to paper, electronics, tires, used oil, batteries, and building materials.

4.13 Care and Maintenance Including Monitoring

Care and maintenance of the remaining industrial support complex will likely be required after suspension of operations. Care and maintenance should be planned for the following types of equipment/structures and cessation of those actions as noted below:

- Electrical and heating systems until the equipment/structure is taken to a deactivated condition for demolition/dismantling or removal;
- Ventilation systems as required for habitability and atmosphere controls until not required;
- Fire protection system and portions thereof until approval for isolation/removal is granted;
- Required or desired industrial security systems or equipment or staff;
- Communications systems (phones, public address, radios, computer network) on a graded removal basis as needed for site emergency response, decommissioning operations, site remediation.
- Other site administrative costs (supervision, safety, utilities, trailers, taxes, lease payments, Employers Costs, insurance, etc.) must be budgeted for from the start of the suspension work up until the time that a reclamation certificate is issued.

On-going soil and groundwater monitoring after the site has been decommissioned will likely need to be accounted for depending on the remediation action and/or risk management plan. This likelihood is also noted in Section 3 of the MFSP Standard (Alberta Environment 2011a): "It is recognized that activities required for suspending, abandoning, remediating and surface reclaiming the site will continue to occur after the mine ceases to operate, and that a period of monitoring may be required prior to reclamation certification on any given piece of land."

The monitoring requirements will likely change with time, as contaminant sources are removed or remediated, or verification sampling results indicates that a reduced frequency or cessation of sampling is warranted. The monitoring plan should be reviewed regularly and should be provided, along with results, to the regulators for review, comment or approval.

4.14 Other Factors and Considerations

The following sections discuss other potential factors and considerations in completing a decommissioning liability estimate.

4.14.1 *Stakeholder and First Nations' Expectations*

The term "stakeholders" is used to refer to all those who are affected by, and have the ability to affect, the Approval Holder's business. They include employees and shareholders; residents and business operators in the communities where the Approval Holder operates; local, provincial and federal regulatory agencies; non-government organizations; academics; and other interested parties.

Approval Holders should consider including stakeholders, including First Nations' communities, as early as possible in project planning. Early contact, communication and relationship building are essential for understanding stakeholder interests and concerns, and for incorporating mutually beneficial accommodations into early-stage project planning, which in turn affects the long-term decommissioning strategy.

Key elements to consider in effective stakeholder engagement include:

- Initiating and having ongoing communication with stakeholders, including regular feedback and review sessions with stakeholders to monitor progress;
- Ensuring issues and concerns are addressed formally;
- Providing a communications channel between stakeholders and the project team; and
- Obtaining input into decommissioning plans as part of the ongoing regulatory process to promote awareness of the process, timing, and plans.

4.14.2 *Project Duration*

Decommissioning of oil sands plants will most likely be multi-year projects. This project duration will affect the cost and therefore should be included in the detailed estimate. Project duration cost impacts are primarily related to the following:

1. There is an optimal point at which the project management, safety, project controls and engineering support supplied by the Approval Holder is "right sized" for the level of activity on the project. Straying from this optimal point increases cost by either carrying too much project labour and facilities loads for the current field activities or causing delays in the field work due to lack of these support efforts.
2. Delays due to lack of planning, accidents or subcontracting efforts being inadequate or out of sync can prevent proceeding through the entire project with work stoppage. Any of these types of delay could mean incurring stand-by time and associated costs with little or no project progress. While these costs may only appear in a contingency line item, these kinds of delays would be expected to be more prevalent if inadequate project planning efforts are applied on the front end, terminal shutdown or project design phases that should occur in the last few years of site operation.

It is also important to note that delays in the decommissioning phase can create delays in the overall site reclamation plans, therefore potentially affecting the overall costs.

4.14.3 *Uncertainties and Contingency*

Uncertainties generally fall into categories as follows:

1. Uncertainties – Known unknowns are elements such as the exact hourly cost of labor or fuel when the project is initiated. These elements are usually covered by the choice of a reasonable value and then documenting that choice in the basis of estimate. Funds to cover these uncertainties may best take the form of an allowance within the estimate;
2. Uncertainties – Unknown unknowns are elements that cannot be reasonably estimated regardless of assumptions. Making an assumption and then estimating weather delays based on the seasonal rain, snow or temperature extremes is a common practice and would not be considered in this category. Rather, the unknown unknowns would be the delays that result from a 100 year flood that would significantly affect the project. This category of item could possibly best be articulated in the project risk assessment/risk management plan which could assess an impact (cost and schedule) and likelihood, then address the potential impact to the total project through that mechanism.

In general, the total project contingency should be established based on the overall risk matrix for the project that may be established during early estimating efforts and carried forward through definitive planning and then maintained throughout the project implementation.

1. Contingency (funds) – are that amount of funds included in the overall MFSP Liability value to cover project risks that may be realized during implementation. During facility operations prior to project, the amount of contingency may be established relative to the overall uncertainty in the estimate. The means of estimating the contingency using Monte Carlo Risk Analyses has gained more support in recent years. Many estimating companies are using this approach, and some government and industry groups are recognizing risk-based contingency estimates as a good approach. This allows a probabilistic analysis/insight into the uncertainty drivers and the range of costs that could affect the project. This approach also shows that removing uncertainties over the course of the facility life time can lower the needed contingency. Therefore, the higher the uncertainty in the estimate, the higher the contingency values;
2. Contingency (schedule) – The critical path for a project can be established and managed to ensure that the project is being executed in as efficient a process as possible. As the technical risk and duration of a project increase, schedule contingency can be established to address some of the risk mitigation actions falling short and adverse impact to the project schedule resulting.

5 FACTORS TO CONSIDER WHEN COMPARING SIMILAR COST ESTIMATES AND ANALYSIS

MFSP provides for government audits of the MFSP Annual Report submissions and the data underlying them. One of the tools available to the regulators to help determine which estimates to audit is a comparison of the various Approval Holder MFSP Liability estimates. Once an audit is underway, the regulator will also be comparing audit results with those of past audits. Therefore there is a need to understand the factors that might create differences in these estimates.

Each of the key factors affecting estimates was assessed using the qualitative criteria in Table 5. The criteria are based on subjective determinations and evaluation of the relative impact levels of the factor to scope, cost estimate, and schedule, as they are inter-related and form the BOE. Additionally, factors of impact to the environment and risk acceptance were also considered as they can impact both the estimated cost and confidence levels of those estimates. The evaluation criteria were used to make the range determinations in Table 6, which provides a qualitative analysis of the range of impacts to the total liability estimate for each factor noted in Section 3 and Section 4[8].

Table 5. Evaluation Criteria.

Level	Criteria
L	Little to no impact to project, scope impact doesn't require significant changes to work documentation, cost is impacted <10% (+ or -), schedule impact < 1 week, no adverse impact to volumes of waste or risk.
L-M	Minor impact to project, scope may require some changes, but objectives can be achieved, cost is impacted + /- 10% to 20%, schedule impact 1 to 4 weeks, may result in an increase in waste volumes by 10%, however, no direct impact to volumes, requires acceptance of low or moderate risks.
M	Moderate impact to project, scope changes required that impact both cost and schedule, cost is impacted + /- 20% to 30%, schedule impact 4 to 8 weeks, waste volumes may increase by 10% to 20%, however, strong possibility of direct environmental impact if not contained, requires acceptance of medium-level risks which necessitate mitigations actions to be implemented.
M-H	Medium to major impact to project, scope changes required that impact both cost and schedule baseline, cost is impacted + /- 20% to 40%, schedule impact 8 to 12 weeks, waste volumes may increase by 20% to 25%, will required increased disposal costs, requires mitigation actions for identified risks to be implemented and contingency funding used.
H	Major to critical impact to project, project stops while project scope is re-evaluated and requires change to approved remediation strategy, including consultation and approval from all stakeholders, cost is impacted + /->40%, schedule impact > 3 months, significant increase in waste volumes > 25%, requires multiple mitigations actions to address specific and multiple risks.

It is important to consider each factor when estimating the MFSP Liability of an oil sands plant as even relatively low impact items can compound with other factors and increase the costs over time. In addition, unknown factors that occur over time may impact more than one factor, so it is important to review them frequently, as in some cases this can more than double the cost of the MFSP Liability cost. There also may be some cases where opportunities for cost savings can be realized.

[8] Table 6 is based on an assumed comparison of cost estimates between oil sands plants in Fort McMurray. Comparisons to a cost estimate for an upgrader in Edmonton, or to another type of industrial facility would likely have different ratings.

Table 6. Cost Estimating Factors Sensitivity Table.

Factors		Range of Impact: Low	Low-Med	Med	Med-High	High	Additional Considerations
Facility	**Type**	L	L-M	M			Impact ranges based on the production components and equipment that are used in the oil sands plant; for example there is a cost difference between decommissioning a plant that includes an upgrader to synthetic crude oil in comparison to a bitumen only plant.
Facility	**Size**		L-M	M	M-H		The size of a facility/plant is impacted at certain thresholds of size. Many of the older sites have larger plants/footprint while the newer plants are smaller and therefore it has less of an impact.
Facility	**Age / History**		L-M	M	M-H		Early oil sands plants were constructed in the 1970s – 1990s. New plants, and new facilities on older sites, are being constructed. Earlier facilities would be expected to contain more hazardous building materials such as asbestos, and would likely have more widespread soil and/or groundwater impacts given the longer operating lifespan of the facility, and historical operational practices. Events that have occurred throughout a facility/plant history may also impact its cost if the event is significant enough to create major contamination that has not yet been remediated.
Facility	**Location**	L	L-M				All current oil sands mine-based plants are located in Northern Alberta and as such are all equally impacted by any logistics concerns.
Estimate	**Type**	L					The estimate type definitions specifically address the expected accuracy. By agreement that a particular level of estimate is required at a point in plant life, the impacts are fixed for that classification – if the estimate is executed properly.

	Factors	Range of Impact					Additional Considerations
		Low	Low-Med	Med	Med-High	High	
Project	**Basis**		L-M	M	M-H		The detail within the Basis of Estimate provides the best indication of pedigree or reliability of the estimate. A detailed, well organized basis of estimate leads to confidence in the detail of the estimate.
Project	**Duration**		L-M	M	M-H		Within reason, a shorter project will have less impact of duration errors due to carrying the hotel loads of the project. A 10% increase in a 24 month project is only half of the cost of the same 10% increase in a 48 month project in terms of hotel loads.
Project	**End State**	L	L-M	M	M-H	H	Remediating a site from an industrial land-use to a natural land-use does not double the cost, but may be an x10 factor; however, if regulations require the same end state, then the impact will be the same for all plants and operators.
Knowledge	**Known Hazards**		L-M	M	M-H		An estimate must be based on the known hazards at the time. The degree of confidence in knowing these hazards will directly impact the resultant cost estimate. Errors in knowing the right information would be expected to be a greater impact that estimating how to mitigate the hazards if site expertise is not engaged in the estimating process.
Knowledge	**Environmental Site Assessments**		L-M	M	M-H		As ESA data become more prevalent and reliable, the accuracy of the MFSP Liability estimate is expected to be refined accordingly; therefore, the impact is related to the availability and use of data.
Suspension, Abandonment, Remediation	**Mobilization**	L	L-M	M			This is expected to be a very small value when compared to the total MFSP Liability costs.
Suspension, Abandonment, Remediation	**Suspension - Hazardous Material Removal**		L-M	M	M-H		These are expected to be relatively small values when compared to the total MFSP Liability costs, but may adversely impact demolition/dismantling and waste management costs if done poorly or significant hazardous items are missed that slow or shutdown the demolition/dismantling/waste management work.
Suspension, Abandonment, Remediation	**Suspension - Deactivation**	L	L-M				

	Factors	Range of Impact					Additional Considerations
		Low	Low-Med	Med	Med-High	High	
	Abandonment - Demolition/Dismantling		L-M	M	M-H		Traditional (mechanical) vs. surgical (deconstruction) vs. controlled explosive demolition can have a range of impacts to cost and schedule, both positive and negative.
	Abandonment - Remediation			M	M-H	H	Estimating the costs for remediation is highly dependent on the level of intrusive assessment completed prior to remediation. Intrusive investigations are also often limited by surface and subsurface infrastructure during plant operation. If widespread groundwater contamination is present, on-going remediation and monitoring can escalate costs.
	Verification	L					This is expected to have little impact when compared to the total MFSP Liability costs.
	Waste Management/Disposal		L-M	M	M-H	H	A high level of uncertainty exists with feasible and acceptable disposal options for high volume waste, including potentially recyclable materials.
Other Factors	**Regulatory Requirements**	L	L-M	M			The regulatory requirements are fairly standard, with clear expectations if the proponent can meet Tier 1 guidelines. However, if site-specific risk-based guidelines, risk management or novel approaches to remediation are required the regulatory approval process may increase in length, thus impacting the schedule.
Other Factors	**Long-Term Monitoring**	L	L-M	M	M-H	H	The costs associated with long-term monitoring are highly dependent on environmental management and stewardship completed during the operation of the plant. If widespread groundwater plumes exist underneath the plant site footprint, that were not adequately assessed and therefore managed because of accessibility issues, long-term monitoring may have a larger impact on MFSP Liability costs and schedule.

		Range of Impact					
	Factors	Low	Low-Med	Med	Med-High	High	Additional Considerations
	Stakeholders	L	L-M	M	M-H	H	Stakeholder engagement and positive stakeholder relations from initial project inception and approval is required to minimize the potential financial and scheduling impacts to the MFSP Liability cost estimate, and ultimately decommissioning implementation. If the proponent has a history of contentious relations with stakeholders, cost and schedule can be significantly impacted.
	Risk Management and Uncertainties			M	M-H	H	Many projects fail to recognize and/or manage the risks. Each risk comes with a cost, which can range from small to large, to mitigate the risk and/or to address the risk if realized. Poor risk management or putting an inappropriate cost for the level of risk in the estimate can have a wide-range of impacts.
	Lessons Implemented from earlier projects	L	L-M	M	M-H	H	A very wide range of impacts is possible, based on the experience of the planning and execution organization. Commitment to use operating staff with no decommissioning experience eliminates site learning curve concerns but maintains a workforce without decommissioning experience; conversely hiring industry expertise maximizes the decommissioning experience, but slows initial work while site conditions are incorporated into work processes.
	Early Suspension / Abandonment		L-M	M	M-H		Early suspension / abandonment activities typically have the ability to reduce long-term monitoring costs and/or the cost of decommissioning due to simple financial factors such as inflation, degradation, and interest; however, regulations and cost of business (labor and materials) may also increase.
	Transition from Operations to Suspension / Abandonment Activities			M			Applicable primarily to suspension work and then only if implementation is planned to be completed by the operations staff. Site management leadership to ensure staff remains productive until the very end of the project.

Factors		Range of Impact					Additional Considerations
		Low	Low-Med	Med	Med-High	High	
	Experience		L-M	M	M-H	H	Prior experience with decommissioning projects is critical to many aspects of the project beyond just cost. Proper scoping, planning, estimating, and performance of the work, including lessons learned from previous projects, can have a range of impacts, depending on the project.
	Recycling/Salvage Value	L					Recycling and/or salvage opportunities can reduce the costs of the project or help recoup some of the costs. However, these cost savings are not to be included in the MFSP.

6 CONCLUSIONS

This report provides information to industry, regulator and auditing groups with a common frame of reference for detailed MFSP estimates pertaining to oil sands processing plants. The preparation efforts, written comments and the one day University of Alberta workshop were all designed to ensure that views of a broad cross section were considered to make the information provide most useful to all.

As noted within the report, the scope / accuracy / methods / content of the individual estimates are to be determined by the Approval Holder with due consideration for the MFSP requirements. The level of detail for the estimates should factor in the MFSP design principle that project liabilities are fully offset by a combination of assets (reserves) and financial security, with financial security rising to 100% of liabilities six years prior to the end of mine life. Using the information contained in this report will allow some common language in discussing the background of the MFSP estimates.

One important common element that came out of this effort is noted below – but again – the details are to be determined by the Approval Holder of each facility. In general, there is an expectation that more detailed/accurate estimates are warranted to ensure the appropriate Operating Life Deposit (OLD) are paid since the OLD is based on the MFSP Liability amount. However, there were differences of opinion as to whether this meant detailed estimates were required at the start of OLD payments or at the last OLD payment. In the early life of a project, before the OLD payments are triggered, lower estimate accuracy may be adequate for an Approval Holder with an Asset Safety Factor (ASF) value greater than three because it would take a significant error in the estimate to cause the Asset Safety Factor Deposit to be triggered.

The ideas, principles, much of the terminology, and overall guidance discussed in this document may be applied to other industrial facilities throughout Canada or the world. Prudent and consistent end of life asset management / decommissioning cost estimates that get more attention and greater accuracy as end of life gets closer make good business sense, regardless of any regulatory driver or expectation.

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8 GLOSSARY OF TERMS AND ACRONYMS

8.1 Terms

See Figure 1 for the relationships between terms used in this report. Readers should also refer to the Glossary in the Guide to the Mine Financial Security Program (Alberta Environment 2011b).

Abandonment

That phase of the project that includes hazardous materials and asbestos abatement, removal of above grade structures to -1m and asset recovery. Suspension (before Abandonment) and Remediation and Reclamation (after Abandonment) are not included.

Allowance

An acceptable reduction in the quantity, quality or value of an asset.

ARO Liability

The undiscounted and un-escalated estimated cost required to settle the suspension, abandonment, remediation and reclamation obligation for the MFSP site. This amount may be reported in the notes to the financial statements under Canadian Institute of Chartered Accountants (CICA) disclosure requirements for ARO. Since the amount is undiscounted and un-escalated, it is generally larger than the actual ARO figure on the balance sheet. This number includes all the appropriate suspension, remediation and reclamation activities that form part of the abandonment process.

Asset Retirement Obligation (ARO)

A legal obligation associated with the retirement of a tangible asset that a company is required to settle as a result of an existing or enacted law, statute, ordinance, or written or oral contract or by a legal construction of a contract under the doctrine of promissory estoppel. For MFSP, the asset retirement obligation includes the costs to address life cycle financial security obligations of a project, which are suspension, abandonment, remediation, surface reclamation and care and custody prior to land certification. This definition is based on the principles and concepts presented in the CICA Handbook Section 3110 – Asset Retirement Obligations (CICA 2011). The information provided in the MFSP would be considered a basis on which to further understand the term, Asset Retirement Obligations, despite any future accounting changes in Canada and/or the United States. It is important to note in this definition that the term Asset Retirement Obligation may cease to exist in financial reporting circles after the adoption of International Financial Reporting Standards (IFRS). There is no specific requirement under IFRS to use a specific term to describe the liability for this type of activity, but the term ARO will continue to be used in this document.

Approval Holder

The company that holds the *Environmental Protection and Enhancement Act* approval. The Approval Holder has all of the reporting and financial security obligations under MFSP.

Decommissioning

The combination of the steps taken in the Abandonment and Remediation phases of project closure (see Figure 1).

Demolition/Dismantling

Destruction of structures as part of the overall decommissioning process. Destruction may be undertaken by machines (dismantling) or explosives (demolition) – machines offer greater precision and are important when the structures, or parts of them, have salvage value. Dismantling may also be called *deconstruction*.

End of Life

Generally this term refers to the date mining and/or production ceases on the site, but it could also mean the date the final reclamation certificate is issued. However, for the purposes of this report and the assessment of MFSP Liability, a more critical date is when the Approval Holder's Reserve Life Index falls below 15 which is the trigger for payment of the Operating Life Deposit. This date is critical because the amount of the Operating Life Deposit is based on the MFSP Liability and therefore a more accurate estimate of total liability is required.

End Land Use

The land use that will occur after decommissioning and reclamation. The desired/required end land use will determine the appropriate end state and the remediation objectives for the site.

End Point

The pre-determined condition of a system, space or facility that is defined, completed and documented to allow the project or process to proceed to the next phase (e.g., Hydrogen plant systems are purged and vented to atmosphere prior to the start of any demolition/dismantling of the system or facility).

End State

The pre-determined end condition of a piece of real estate, with or without structures and or utilities; that point at which the decommissioning project is complete; i.e., the plant site will be clear of all hazardous chemicals (above local background), all structures and manmade improvements removed to grade (or minus 1 metre), and appropriate contours restored.

Liability Assessment

Assessments conducted by the Approval Holder to estimate the cost to suspend, abandon, remediate and reclaim a site.

Project Closure

The sum of all the steps taken to close an oil sands processing plant, including Suspension, Abandonment, Remediation and Surface Reclamation (see Figure 1).

This is also called *Reclamation*.

Recycle/Scrap

In general, recycle (or salvage) is the careful removal of equipment to preserve its functional ability, such as diesel-generators, large pumps, large valve, etc.

Scrap is usually metallic materials that will be melted down and reused in some new form.

Remediation

The removal, reduction, or neutralization of substances, wastes or hazardous material from a site that is planned or performed to prevent or minimize any adverse effects on the environment now or in the future.

Remediation should be managed on a progressive basis wherever possible, and must be managed immediately when an adverse effect is occurring.

Remediation may also be called *decontamination*.

Suspension

The activities and operations required to ensure the safe and secure condition of a site when production activities have ceased and/or while receivership/resale of all or parts of the project takes place. This includes activities and operations to maintain the care and custody of a site while abandonment and surface reclamation activities are undertaken.

Suspension and Demolition/Dismantling Prep

Actions designed and implemented, as part of the Suspension phase of the project, after terminal shutdown to prepare for a care and maintenance period which may be weeks, months or years. If no care and maintenance period is planned suspension actions are taken to prepare for safe hands-on equipment removal (for re-use or salvage) or to provide for safe/compliant demolition/dismantling work (e.g., if lead or asbestos cable sheathing is used in a facility and is unacceptable to the demolition/dismantling regulations or waste disposal facility criteria – that cabling must be de-energized and removed as part of the Suspension – hazardous waste removal phase on the project).

Take-off

A list of the materials, by type and measure (volume, length, weight), in a structure.

Terminal Shutdown

Those final, pre-defined operations that use existing site equipment, operations staff and procedures that have been designed to leave the site systems and equipment in the optimal condition for suspension / abandonment work.

"Tons of Steel" Approach

In the "tons of steel" approach, consulting companies divide the total decommissioning costs (suspension, demolition and remediation costs for projects that have been fully decommissioned) by the tons of steel and concrete for those projects. The resulting factor (decommissioning unit costs in $ per ton) can then be applied to an MFSP project to represent the all-in cost to decommission based on the tons of steel and concrete in the MFSP project using a metric based on the major cost item. This approach is acceptable under IFRS rules as it is a reasonable representation of actual expected costs for an event that will take place in the distant future. By the time the last OLD payment is made a more detailed cost estimate, based on actual site conditions, will be needed for IFRS and internal budgeting purposes. The detailed estimate is expected to be close to the "tons of steel" estimate and could very well be lower. Economies of scale (e.g., mob and demob as a percentage of total cost will be lower for these much larger projects, etc.) will tend to result in lower cost under the detailed method.

8.2 Acronyms

AACE	Association for the Advancement of Cost Engineering
ACM	Asbestos-containing Materials
AEW	Alberta Environment and Water
APEC	Area of potential environmental concern
ARO	Asset retirement obligations
ASF	Asset Safety Factor
BOE	Basis of estimate
C&M	Care and Maintenance
CAEAL	Canadian Association for Environmental Analytical Laboratories
CICA	Canadian Institute of Chartered Accountants
COPC	Contaminants of potential concern

CCME	Canadian Council Ministers of the Environment
CSA	Canadian Standards Association
EC	electrical conductivity
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EPEA	*Environmental Protection and Enhancement Act*
ERCB	Energy Resources Conservation Board
ESA	Environmental Site Assessment
ESA Phase I	Non-intrusive ESA
ESA Phase II	Intrusive ESA
ESA Phase III	Delineation intrusive ESA
EUB	Alberta Energy and Utilities Board
IFRS	International Financial Reporting Standards
M	Metre
MFSP	Mine Financial Security Program
NORMs	Naturally occurring radioactive materials
OSRIN	Oil Sands Research and Information Network
OLD	Operating Life Deposit
PCB	Polychlorinated biphenyl
PM	Project Manager
QA/QC	Quality Assurance/Quality Control
RAP	Remedial action plan
ROM	Rough order of magnitude
SAR	sodium adsorption ratio
SEE	School of Energy and the Environment
SME	Subject matter experts
WAC	Waste Acceptance Criteria
WBS	Work breakdown structure

9 LIST OF OSRIN REPORTS

OSRIN reports are available on the University of Alberta's Education & Research Archive at https://era.library.ualberta.ca/public/view/community/uuid:81b7dcc7-78f7-4adf-a703-6688b82090f5. The Technical Report (TR) series documents results of OSRIN funded projects. The Staff Reports series represent work done by OSRIN staff.

9.1 Technical Reports

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Chapman, K.J. and S.B. Das, 2010. *Survey of Albertans' Value Drivers Regarding Oil Sands Development and Reclamation*. OSRIN Report TR-3. 13 pp.

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Kindzierski, W., J. Jin and M. Gamal El-Din, 2011. *Plain Language Explanation of Human Health Risk Assessment*. OSRIN Report TR-14. 37 pp.

Welham, C. and B. Seely, 2011. *Oil Sands Terrestrial Habitat and Risk Modelling for Disturbance and Reclamation – Phase II Report*. OSRIN Report No. TR-15. 93 pp.

9.2 Staff Reports

OSRIN, 2010. *Glossary of Terms and Acronyms used in Oil Sands Mining, Processing and Environmental Management*. OSRIN Report No. SR-1. 102 pp.

OSRIN, 2010. *OSRIN Writer's Style Guide*. OSRIN Report No. SR-2. 22 pp.

OSRIN, 2010. *OSRIN Annual Report: 2009/2010*. OSRIN Report No. SR-3. 27 pp.

OSRIN, 2010. *Guide to OSRIN Research Grants and Services Agreements - June 2011 Update*. OSRIN Report No. SR-4. 21 pp.

OSRIN, 2011. *Summary of OSRIN Projects – November 2011 Update*. OSRIN Report No. SR-5. 42 pp.

OSRIN, 2011. *OSRIN Annual Report: 2010/11*. OSRIN Report No. SR-6. 34 pp.

OSRIN, 2011. *OSRIN's Design and Implementation Strategy*. OSRIN Report No. SR-7. 10 pp.