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Memorandum

To: Ryan Herbert (Minto Explorations Ltd.)

From: Jim Theriault, Jim Harrington, Scott Keesey (Alexco Environmental Group, Ltd.)

Monique Haakensen, (Contango Strategies Ltd.)

Date: February 26, 2016

Re: **Re-evaluation of Candidate Passive Treatment Technologies for Minto Mine Closure**

1 INTRODUCTION

Passive treatment of mining impacted waters (MIW) in closure and post-closure is being evaluated for the Minto Mine. The Reclamation and Closure Plan (RCP) for the site proposes a transition from active to passive water treatment, and research has been underway to refine performance expectations for the technologies most likely to be successful at the site. These include constructed wetland treatment systems, bioreactors, and in-pit batch biological treatment of MIW. These technologies were previously selected in connection with preparation of RCP v4.0 (Phase IV Mine Plan), based on a methodical evaluation of appropriate technologies for the site.

This memo reviews the decision-making process that was employed to identify the preferred passive treatment technologies and also presents the results of a recent re-evaluation of potential passive treatment technologies that could be effectively incorporated into the new Phase V/VI Minto RCP. It also documents the technologies and best practices that have been incorporated into the reclamation design that ultimately have resulted in the water quality that can be treated by the passive or semi-passive technologies proposed. This includes a number of types of mitigation measures which prevent constituents from becoming part of the MIW, which ultimately results in a minimization of treatment requirements. These prevention technologies are listed in Table 1, and include:

- Administrative controls,
- Backfilling and subaqueous disposal,
- Capping, covers, and grading,

- Diversionary structures,
- Excavation and disposal of solid mine waste,
- Re-use and reprocessing technologies.

These technologies will each be incorporated into closure planning to varying degrees, but will not be considered in the current evaluation of candidate passive treatment technologies. Together the incorporation of these "best practices" result in MIW that will be amenable to passive treatment.

The reasons for this re-evaluation of passive treatment technologies include:

- The technologies were last formally evaluated in connection with the Minto Phase IV mine closure plan. This proposed Phase V/VI Mine Plan has a revised configuration and some changed conditions;
- The YESAB evaluation of the Phase V/VI mine and closure plans contains guidance on how passive treatment should be evaluated and implemented (see Section 3);
- Minto Exploration Ltd (Minto) has committed to work collaboratively with Selkirk First Nation (SFN) on Closure Planning and water quality issues and to seek opportunities for involvement of SFN in both closure implementation and long-term care and maintenance; and
- The process can be used to foster a collaborative approach to optimization of the mine closure configuration. This is consistent with the recognition that Minto mine is in SFN traditional territory and will ultimately be returned to the SFN upon cessation of the mining and full, successful implementation of the RCP.

Specifically, the information presented in this memo is intended to be consistent with "Step 1 – Confirm Technologies" as outlined in an associated memo "Framework for Development of Minto Closure Water Quality Objectives" (August 5, 2015), and incorporates subsequent feedback from SFN related to the proposed process.

As described in the WQO Framework memo, scoping level work to date suggests that there is a good potential that some aqueous constituent load reductions from the site can be expected with passive treatment, but it is possible that these measures will not result in achieving a non-degradation target in lower Minto Creek. Minto is committed, in consultation with SFN, to exerting the best effort possible in refining a reasonable and practical passive treatment plan for Minto. In turn, objectives that are reflective of this plan and protect aquatic resources in lower Minto Creek will also be developed in consultation with SFN.

Minto recognizes the importance of evaluating the achievability of meeting non-degradation targets as outlined in the recent Water Licence Amendment. Minto, with the support of Alexco Environmental Group (AEG), has completed some additional analysis regarding the achievement of non-degradation targets. This analysis (results provided separately) suggest that although some aqueous constituents may reasonably be expected to meet a non-degradation concentration post-closure, many key constituents will not. As a result, the steps and evaluation in this framework remain focused on the key parameters considered previously, and also includes the parameters identified for water quality objectives in the revised Water Use Licence (operational water quality objectives, see section 3.1 below).

Given this introductory information, Section 2 of this memorandum presents background of how the passive treatment technologies proposed in previous versions of the Minto RCP came to be selected, and outlines the ongoing work being undertaken to provide site-specific proof of concept and develop the design basis. Given the changes in the mine plan and closure configuration for the proposed Phase V/VI mine expansion and our improved understanding of contaminant removal mechanisms that have been gained through the ongoing reclamation research program, this document also presents a framework for evaluating the relevance and applicability of a full range of potential passive treatment technologies.

Section 3 of this document then presents the updated ranking and evaluation of the various potential passive treatment technologies and identifies the passive (and semi-passive) treatment technologies that are proposed for consideration in closure planning at the Minto Mine Site. Section 4 identifies how the findings are proposed to be utilized, as next steps.

2 PREVIOUS WORK ON PASSIVE TREATMENT TECHNOLOGY SELECTION

A process for the identification and evaluation of the full range of passive treatment technologies that could potentially be incorporated into closure planning at the Minto Mine site was formally initiated in late 2012, in connection with the preparation of RCP v4.0. The work was initially presented to SFN in the associated preliminary FMEA workshop (January 2013). Prior to this formal process being undertaken, identification of potential passive treatment technologies was incorporated into closure planning at a conceptual level.

At that time, there was already substantial information available with respect to both observed and predicted water quality across the mine site and the anticipated long-term geochemical evolution of MIW. The need for a more formalized approach to identifying potential passive treatment technologies was recognized and the process was initiated in connection with early planning for the RCP v4.0. The framework utilized in the 2012/13 evaluations is outlined below in section 2.1, and is followed by brief summaries of the 2012/13 findings in sections 2.2 and 2.3 respectively.

2.1 FRAMEWORK FOR TECHNOLOGY EVALUATION

The options evaluation for closure reclamation technologies for the RCP v4.0 was based, in large measure, on the Interstate Technology and Regulatory Council (ITRC) mine waste treatment technology selection process, which is described in detail on the ITRC website: http://www.itrcweb.org/miningwaste-guidance/technology_overviews.htm

The ITRC is a public-private coalition and the technical material is developed by teams composed of environmental professionals, including state and federal environmental regulators, federal agency representatives, industry experts, community stakeholders, and academia. This site is continually updated and serves as an aggregator of best practice and innovative emerging treatment technologies and provides relevant case studies to support the design process. The ITRC mine waste technology selection process is recognized as a world class resource for on the topics of innovative mine reclamation and treatment technologies. As such, it was selected to use as the primary tool for identifying and evaluating potential treatment technologies.

The ITRC web-based resources on mine waste treatment technology selection process are designed to help regulators, consultants, industry, and stakeholders in selecting an applicable technology, or suite of technologies, which can be used to remediate mining sites. Through a series of questions, decision trees guide users to a set of treatment technologies that may be applicable to a particular site situation. Each technology is described, along with a summary of the applicability, advantages, limitations, performance, stakeholder and regulatory considerations, and lessons learned. Each technology overview links to case studies where the technology has been implemented.

The decision tree for identifying potential treatment options for mitigating mining impacted groundwater and surface water is presented in Appendix A.

2.2 2012 Passive Treatment Options Assessment

The 2012 Options Assessment considered the ability of various treatment technologies to treat observed and predicted water quality emanating from seeps at the South West Dump (SWD) and monitoring point W37, immediately downgradient of the dry stacked tailings storage area (DSTSF). The technology evaluation focused on treatment technologies that could address mining impacted water (MIW) as either surface water or groundwater flow.

The 2012 Options Assessment ranked the technologies in a semi-quantitative matrix, using a variety of metrics including:

- Ability to address main contaminants of potential concern (CoPCs; e.g., Cu, Cd, Se),
- Ability to operate in the climate and seasonality of water at Minto,
- Requirement for addition of chemical reagents,
- Ability to operate without constant power source,
- Successful track record in similar conditions,
- Opportunities to engage stakeholders,
- Long-term operational requirements,
- Long-term maintenance requirements, and
- Aesthetics.

The 4 short-listed technologies identified in the 2012 evaluation were: 1) constructed wetland treatment systems (CWTS), 2) biochemical reactors (BCR), 3) permeable reactive barriers (PRB), and 4) in-pit chemical precipitation treatment. Some of these technologies were further evaluated for potential applicability at Minto through the reclamation research program (refer to Section 2.4) to further refine the identification of the most promising passive treatment technologies for incorporation into long-term closure planning.

2.3 JANUARY 2013 PRELIMINARY FAILURE MODE AND EFFECTS ANALYSIS (FMEA)

The ITRC mine waste treatment technology selection process (web based decision tree) was presented at the January 2013 Preliminary Failure Mode Effects Analysis (FMEA) workshop along with the rationale by which the most promising passive treatment technologies were identified (i.e., CWTSs, BCRs, PRBs, and pit lake treatment). The potential application of these passive treatment technologies was then brainstormed in the context of evaluating a range of closure scenarios:

Scenario 1 – a source control focus in which emphasis would be placed on installing high quality, low permeability covers and subaqueous disposal of PAG waste rock to limit contaminant loading at the source.

Scenario 2 – referred to as a treatment focus (active and passive), considering minimal covers and source term control but heavy emphasis on treating all MIW before it leaves the site.

Scenario 3 – a hybrid closure scenario that relied on moderate covers (using readily available cover materials and industry practices for grading and revegetation) and incorporation of passive treatment technologies (with active treatment as contingency) to further improve water quality and decrease contaminant loads leaving the site.

Scenario 3 was ultimately endorsed and closure concepts including revegetated soil covers and passive treatment technologies were further developed in the Phase IV RCP.

It should be noted that subsequent to the 2013 FMEA, the site-wide geochemical modeling inputs were updated with new information and resulted in greatly improved estimated closure water quality relative to the working assumptions at the time of the 2013 FMEA.

2.4 PASSIVE TREATMENT RECLAMATION RESEARCH PLAN (RRP)

The results of the initial passive treatment technology evaluation, and subsequent feedback from the January 2013 FMEA workshop, were further considered by Minto and subject matter experts from AEG and Contango to develop a robust reclamation research plan for passive water treatment (RRP). The goal of the ongoing RRP is to enable, within the site-specific context of the Minto project, the determination of 1) proof of concept of each technology, 2) the anticipated treatment potential and 3) the design parameters required for more detailed design and costing of the proposed passive treatment technologies at closure.

The RRP for passive water treatment was initiated in 2013 and was designed to focus on CWTS and BCRs. The passive treatment RRP was designed to provide additional insight into innovative ways in which CWTS and/or BCRs could be applied at site, and potential to be combined as a treatment train to provide maximum flexibility for a wide range of potential closure scenarios. Studies to evaluate the potential for batch treatment of pit-lakes (i.e., limnocorral trials) were already underway as that study had been initiated in the fall of 2012 (discussed below). Although permeable reactive barriers were initially identified as a potentially promising technology, they were not specifically evaluated through the RRP due to the anticipated challenging subsurface conditions (discontinuous permafrost) and limited areas of potential applicability. However, it was recognized that the proposed research into BCRs could provide relevant information to the potential applications and benefits of PRBs in a closure context.

The passive water treatment RRP included dedicated site visits with associated field and laboratory testing programs to provide preliminary characterization of potential treatment areas (Contango 2014a). Additionally, locally available borrow sources were sought out for substrates and vegetation that could be incorporated in passive treatment design. The initial field program identified areas where natural attenuation and treatment of MIW are already naturally occurring on-site and provided additional insight into potential treatment mechanisms. The approach being used to design the passive water treatment systems involves a phased approach, starting with off-site pilot-scale testing and optimization (at Contango's facilities in Saskatoon). The pilot-scale trials (medium-size trials in large barrels) included different combinations of soils/substrate and vegetation to allow for selection and optimization of the best design for the Minto site (Contango 2014b). The systems were designed to provide specific insights into the biogeochemical process-driven steps. The pilot-scale tests were fully instrumented, monitored regularly, and subjected to a variety of potential site conditions and water quality scenarios. The pilot-scale tests were run in a controlled facility, allowing for accurate evaluation of how different aspects affect the performance of the systems (e.g., nitrate, water depth) without the influence of other external and confounding factors. At the end of pilot-scale CWTS testing, additional organic material (straw and hay) were added to the wetland cells converting them to a hybrid CWTS/bioreactor. This provided a preliminary proof of concept for the feasibility of a semi-passive hybrid CWTS/bioreactor as a contingency option. The results of the pilot-scale testing were used to further optimize the design, and enabled refinement of sizing and set design, performance, and timeline expectations for the scale-up to a larger demonstration-scale treatment wetland to be constructed at Minto.

In the fall of 2014, an on-site demonstration-scale CWTS was constructed on the Minto Site to evaluate the effectiveness for treating actual MIW. The demonstration-scale system is constructed as four cells (two systems in parallel, each made of two cells in a series). The demonstration-scale CWTS has been progressing through commissioning as expected based on the pilot-scale testing, and is beginning to treat water (Contango, 2015; Capstone Mining, 2015).

Concurrently, dedicated research into the potential effectiveness of bioreactors has been undertaken at Yukon College both in lab facilities and at the Minto site. Lab-based testing utilized synthetic effluent to examine metals removal in sulphate-reducing conditions; these results are documented in Janin and

Harrington (2014). On site testing provided water from W37 to a series of reactors which utilized wood chips, ethanol, or wood biochar as substrates with gravel. Removal of selenium, copper, and nitrogen compounds was evaluated over a 2+ month operating window, and showed effective removal for both selenium and copper, and no detrimental effects to nitrogen compounds.

Limnocorral studies were undertaken prior to the development of the RRP and so it was not necessary to include additional pit-lake treatment studies as part of the RRP. In brief, to evaluate the potential for batch treating open-pit water, limnocorral studies were initiated in the Main Pit at Minto in October 2012 and ran through to the spring of 2013. The trials evaluated the feasibility and effectiveness of batch treating pit-lake water by addition of select carbon sources (sugars, alcohols and wood chips) to create reducing conditions (i.e., negative oxidation-reduction potential) that would in turn facilitate the precipitation of metals as sulphides and selenium as elemental selenium. Initial limnocorral tests provided promising results for metals treatment. If selected as a technology to pursue for implementation, additional research would be required to further develop the site-specific approach for batch treatment of the pit-lake water at Minto.

The passive water treatment RRP was initially designed to address the anticipated closure water quality conditions of the Phase IV mine plan. The proposed Phase V/VI Mine Plan contemplates changes to both the closure water conveyance network and to potential sources of contaminant loading. Consequently, the range of potential passive treatment technologies that might be applicable to the updated mine configuration will be evaluated anew.

3 UPDATED EVALUATION OF POTENTIAL PASSIVE TREATMENT TECHNOLOGIES

The Decision Document issued following the YESAA Screening of the Minto Mine Phase V/VI Expansion project proposal provided the following guidance for the development of closure WQOs:

> *#33. …Non-degradation (compared to historical background quality) of Minto Creek water quality shall provide the basis for the development of water quality objectives for the closure period. However, if non-degradation cannot be achieved using reasonable and practical passive treatment mitigations, then the closure objective shall be guided by what can be practically achieved (as long as the objectives are below the effects levels for aquatic resources with sufficient contingency). Determination of "reasonable" and "practical" mitigations must take into account the expected or actual site performance of a given mitigation, and the cost of the mitigation (both initial cost and long-term maintenance cost) compared to the expected contaminant reductions.*

This memo is designed to identify which particular technologies are considered as a ‘reasonable and practical’ basis of a long-term site-specific passive water treatment implementation strategy in the context of the Minto site. What is considered ‘reasonable and practical’ will depend on site-specific considerations and expectations of long-term operational and maintenance activities. For the purposes of evaluating and refining technology selections for passive water treatment and the Minto site, ‘reasonable and practical’ has been defined as having the following criteria:

- Operationally passive:
  - Self-sustaining in the long-term (e.g. minimal need for electricity or chemical addition)
  - Minimal ongoing operational oversight required
  - Does not require active decommissioning activities
- Minimizes long-term maintenance:
  - Able to naturalize, with only periodic and limited maintenance requirements
  - Most maintenance can be performed manually (i.e., does not require heavy equipment)
  - No routine addition of substrates or organics

In this context, it is recognized that even passive treatment technologies will require some operation and maintenance during commissioning. Moreover, several technologies under evaluation can span between passive to active, depending on their approach to implementation. For technologies that may be implemented in different forms, only the most passive options are being considered as priority options in terms of being 'reasonable and practical' for the Minto site.

An updated reclamation and closure plan (RCP) was prepared for the Phase V/VI expansion. A Failure Modes and Effects Assessment (FMEA) workshop, attended by representatives from MEL, YG and SFN, was conducted in the summer and fall of 2014 to evaluate the latest iteration of the RCP (v5.1). The FMEA identified potential risks associated with closure water quality and also identified a need to address the topic of defining "reasonable and practical" passive treatment technologies to assist with the development of closure WQOs.

It was recognized at that time that a complete reassessment of the full range of potential passive treatment technologies was warranted, to ensure that any changing site conditions and/or emergent technologies were factored into the potential passive water treatment technology selection. A re-visiting of relevant site conditions was undertaken (Section 3.1) and the ITRC Process was then re-applied (Sections 3.2 – 3.5).

3.1 SUMMARY OF SITE CONDITIONS RELEVANT TO TREATMENT TECHNOLOGY EVALUATION

The following section briefly summarizes the specific site conditions that are directly relevant to closure planning and passive water treatment planning at the Minto mine site:

- Remote: The site is relatively remote. Accessing the site requires crossing the Yukon River via barge / ice dam or flying in via plane or helicopter. Once the closure plan is fully implemented, the airstrip would be decommissioned and barge service discontinued. Remobilization of heavy equipment would require temporary remobilization of the barge.

- Climate: The site is located in the sub-arctic ecoregion and experiences extreme cold during the winter months and a pronounced spring freshet.

- Contaminant Sources: The primary sources of ongoing contaminant loading in closure include waste rock dumps, dry stacked tailings, historic ore and concentrate stockpile areas and pit walls. Of these potential contaminant sources, the Southwest Dump and Drystack Tailings (DSTSF) account for the majority of predicted contaminant loads. The associated seepage from these contaminant sources has been monitored for years and the observed contaminant loadings add a significant degree of confidence to water quality predications.

- Site Configuration: The site is essentially confined to a single watershed which progressively constricts to a single point of discharge downgradient of the DSTSF (current spillway through the Water Storage Pond Dam). The majority of mining impacted water upgradient of the DSTSF is routed through completed open-pits (which provide flood attenuation and additional residence time).

- Natural Attenuation: Significant reduction in contaminant loading is observed in the “wetland” area adjacent to sampling point W15. The observed contaminant load reduction in this flooded, natural area provides strong evidence that naturalized wetlands have the potential to provide ongoing passive treatment to mining impacted waters on site.

- Timing of Contaminant Flux: Evaluation of flow and concentration profiles from the mine has shown that peak flows typically occur in April and May, and that the metals loading distribution follows flow.

- Contaminants of Potential Concern: Aqueous metal and metalloid concentrations in site seepage and runoff are the primary focus of planned load reduction through passive treatment, as N-species (NH4, NO3 and NO2) concentrations are not anticipated to persist in post-closure conditions as they are a product of active operational blasting activities, and decay relatively quickly after these activities cease. The remaining COPCs identified in the current water use licence as parameters for which there is an operational water quality objective are:

    - Aluminum
    - Arsenic
    - Cadmium
    - Chromium
    - Copper
    - Iron
    - Lead
    - Molybdenum
    - Nickel
    - Silver
    - Selenium
    - Zinc

  These are the contaminants of focus for the ongoing evaluation of passive treatment options at Minto.

3.2 Review of the ITRC Mine Waste Treatment Technology Decision Framework

The ITRC mine waste treatment technology decision framework currently includes a total of 22 potential technologies (prevention and treatment) that could be applied to mitigate and/or treat mining impacted surface water and ground water. The list of technologies is reviewed and updated frequently by the ITRC and is comprehensive, spanning operational life and mine closure, and includes both passive and active technologies.

The list of potential treatment technologies includes several active treatment technologies that do not meet the initial screening criteria (Section 2.1) of requiring no consistent power supply and a need to have low or no operation and long-term maintenance requirements. The active treatment technologies eliminated include: electrocoagulation, electrokinetics, ion exchange, and pressure driven membrane separation (e.g., reverse osmosis).

3.3 Additional Resources Considered

In addition to the ITRC decision framework referenced above, the following resources were also reviewed to ensure that all relevant passive treatment technologies have been considered:

1) Mine Environment Neutral Drainage guidance documents: http://mend-nedem.org/guidance-documents/
2) GARD guide: http://www.gardguide.com/
3) Alberta Environment published a review report titled "Evaluation of Treatment Options to Reduce Water-Borne Selenium at Coal Mines in West-Central Alberta".
4) CH2M Hill prepared a review report for North American Metals Council titled "Review of Available Technologies for the Removal of Selenium from Water"
5) Golder prepared a review report for Teck titled "Literature Review of Treatment Technologies to Remove Selenium from Mining Influenced Water".
6) MSE prepared a report for US EPA and Department of Energy titled "Selenium Treatment/Removal Alternatives Demonstration Project".

3.4 Long List Of Potential Passive Treatment Technologies

The long list of potential MIW mitigation methods/technologies is presented in Table 1. This table addresses each technology at a high level, provides general comments about the applicability of each technology to Phase V/VI closure planning, the current status of evaluation of the technology or approach, and how that technology could potentially fit into Minto-specific closure planning.

As noted in Section 1, six (6) of the seventeen (17) long-listed methods/technologies are already incorporated in the existing designs of Minto Mine closure. In addition, six (6) are considered not relevant to site conditions at Minto (aeration treatment systems, anoxic limestone drains, chemical stabilization, in situ biological treatment, passivation technologies, and phytotechnologies). The rationale for these decisions is provided in the attached tables. This leaves five (5) passive treatment technologies that are considered relevant in the context of identifying "reasonable and practical passive treatment" as defined in the Decision Document. These are:

- Constructed wetland treatment systems;
- Biochemical reactors;
- Permeable reactive barriers;
- In situ treatment of open pits (chemical precipitation through sulphate reduction); and
- In situ treatment of open pits (enhanced biological treatment using algae to sequester metals).

These five (5) treatment technologies are considered further as "short listed" potential passive treatment technologies.

3.5 SHORT LIST OF POTENTIAL PASSIVE TREATMENT TECHNOLOGIES

The short list of potential passive treatment technologies is outlined in Table 2. This list has been maintained intentionally broad in recognition that many of these technologies are "variations on a theme" and can be tailored and/or subject to further optimization in an integrated closure scenario.

Of the five (5) technologies that made the short-list, only one (1) has been identified as a primary passive treatment technology in the Minto Mine closure context – CWTSs. This is primarily based on the level of site-specific research that has been conducted at the Minto site, and the technologies' 'readiness' for advanced design- level integration into the current closure planning.

Four (4) additional technologies are presented as candidate contingency passive treatment technologies – BCRs, PRBs, and two variations of in-situ batch treatment in open pits. Batch treatment of open-pits is subdivided into sulphate reducing batch treatment (which removes metals by precipitation as sulphides) and enhanced biological treatment (which removes metal by algae sequestration which then sinks to the base of the pit). These measures can be considered at a 'contingency' plan level of integration into current closure planning at the Minto site, but would require further site-specific experimentation to be able to refine performance expectations.

4 PROPOSED PATH FORWARD

This document should serve as a foundation for the further development and refinement of:

1. Closure Water Quality Objectives – This technical briefing document is a reference for the ongoing collaborative work underway in the Closure WQO development. The next step (Step 2 – Develop Configuration Options) of the framework is underway, and preparations are being made for Step 3 (Select Configuration and Implementation Strategy); and
2. Refinement of the RCP v6.0 Reclamation Research Plan – this document in combination with outcomes of the WQO Framework will advise the intent and content of the research programs that will continue at the Minto Site.

5 REFERENCES

Janin A, Harrington J. 2014. Performances of lab-scale anaerobic bioreactors at low temperature using Yukon native microorganisms. Proceedings submitted for the Mine Water Solution in Extreme Environments, April 2015, Vancouver, BC

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TABLE 1
FULL LIST - ITRC MINE WASTE MITIGATION TECHNOLOGIES (PREVENTION AND TREATMENT)
RE-EVALUATION IN CONNECTION WITH PHASE V/VI RCP

TECHNOLOGY	CATEGORY (TREATMENT OR PREVENTATION)	BASIC DESCRIPTION	POTENTIAL APPLICABILITY FOR MINTO CLOSURE	STATUS OF EVALUATION	CLOSURE ROLE
Administrative and Engineering Controls	Prevention. (Already Incorporated in Closure Planning)	Administrative controls (ACs) are nonengineered instruments intended to minimize the potential for human exposure to contamination by limiting land or resource use. Engineering controls (ECs). ECs are physical controls put into place to prevent human and ecological exposure to contamination. Several other technologies listed in this table (e.g., capping, covers and grading; diversionary structures; backfilling and subaqueous disposal) also fall within the broad EC category.	Incorporated into all aspects of closure planning.	Key concerns were flagged in connection with ongoing planning and consultation, and most recently in connection with the Closure FMEA. Incorporated into AMP.	Incorporated into AMP as well as monitoring and maintenance planning. Does not play a role in the evaluation of "reasonable and practical" passive treatment.
Aeration Treatment Systems	Treatment of anoxic or high BOD waters. (Not Relevant)	Aeration involves the mechanical introduction of oxygen into the MIW stream through a variety of techniques with the goal of oxidizing specific dissolved metals species into less soluble forms. Aeration can use gravity and/or mechanical devices to increase the concentration of dissolved oxygen in MIW, promoting oxidation of ammonia, and metals and metalloids such as iron, manganese and arsenic. Some other metals species may also bind to the iron or manganese.	The elements treated by aeration are not relevant to the MIW at Minto. Generally not relevant to Minto unless BCRs or PRBs create a high BOD in outflow water, aeration could be incorporated (gravity flow) to reoxygenate water for receiving environment. Aeration could potentially play a role in oxygenating low oxygen waters to support aquatic ecosystem health.	The role of aeration will be considered in the context of the water chemistry and constituents needing removal from the water, in connection with water conveyance along primary ditches and adjacent to passive treatment zones.	Will be evaluated if needed downstream of BCRs or PRBs to reoxygenate waters. Design principles are well understood. No requirement for specific field trials.
Anoxic Limestone Drains	Treatment of acidic water. Semi-passive. Finite life-span. (Not relevant based on current/predicted water quality)	Anoxic limestone drains (ALDs) are passive treatment systems that can be used to treat the acidity of mine-influenced water (MIW) under specific geochemical conditions. ALDs consist of a buried bed of limestone ($CaCO_3$) engineered to intercept anoxic, acidic MIW and add alkalinity through dissolution of the limestone.	Not relevant to treatment of Minto MIW as the seepage is circumneutral. The technology is well understood by the closure design team and could be incorporated if acidic condiitons develop.	Not appropriate as a key technology for Minto (based on our understanding of the site wide geochemistry), but this technology is well understood by the design team and will be incorporated in the design of passive treatment systems if conditions warrant.	Not currently planned.
Backfilling and Subaqueous Disposal	Prevention. (Already incorporated in closure planning)	In its most basic form subaqueous disposal involves removal of surface material and placing it underground and/or under water, thus eliminating direct contact exposures. It is typically applied to sulfide-containing solid mine wastes to reduce oxidation of the wastes, thus limiting acid generation and/or neutral metals release. It has also been used to dispose of non-acid-generating solid mine wastes through backfilling.	This is being incorporate in the closure planning with tailings and ARD/ML waste rock being deposited in completed open pits which will flood and submerge the mine waste at closure	Saturation of PAG waste rock has always been a part of closure planning at Minto. Minto's Water Use Licence also contains specific language that requires that potentially reactive waste rock associated with the Phase V/VI mine expansion will remain saturated in perpetuity under closure conditions and requires further evaluation of maximizing the backfilling of tailings and mine waste in exhausted open-pits and mine workings.	Mine plan currently being revised to optimize backfilling and subaqueous disposal - consistent with WUL requirements. The implications of subaqueous disposal are already incorporated in WQ modeling and further optimization is not part of current discussion of additional "reasonable and practical" passive treatment technologies for developing closure WQOs.
Biochemical Reactors (BCRs)	Treatment. Semi-passive. Finite life-span. (Proposed in existing closure planning. Re-evaluated as a contingency technology due to finite life span)	Biochemical reactors (BCRs) treat mining-influenced water (MIW) by using microorganisms to transform contaminants and to increase alkalinity in the treated water. The most commonly used BCRs for treating MIW are operated anaerobically (no oxygen) and are also called "sulfate-reducing" bioreactors. The microbial process of sulfate reduction produces sulfide and bicarbonate within the reactor, allowing the target metals such as cadmium, copper, nickel, lead, and zinc in MIW to precipitate as metal sulfides at pH values above 5.0. Biological selenium reduction (treatment) also occurs under these conditions. The bicarbonate produced through sulphate reduction promotes an increase in pH and will promote the removal of some metals as carbonates such as $FeCO_3$ and $ZnCO_3$ under the appropriate conditions.	This technology is semi-passive, requiring periodic maintenance (e.g., injection of carbon source and/or periodic replenishment of porous media). As such, their applicability is considered to be limited to early in the closure period (i.e., PC1) after which time the BCR would no longer be maintained. The exhausted BCR would either be decommissioned or left in place in a geochemically stable condition. They could be installed as stand-alone treatment features (potentially to treat concentrated seepage at the toes of waste rock dumps or the DSTSF), but more likely in connection with a CWTS, where the CWTS would perform treatment once the BCR is no longer effective.	BCRs are being evaluated in connection with the ongoing RRP in coordination with Yukon College.	This research is being conducted in connection with the RRP. This is a semi-passive technology that could be employed early in the mine closure process with the intension that the system would be left and cease to be maintained beyond an initial operational period. This technology is considered as a contingency passive treatment technologiy for closure at Minto.

TABLE 1
FULL LIST - ITRC MINE WASTE MITIGATION TECHNOLOGIES (PREVENTION AND TREATMENT)
RE-EVALUATION IN CONNECTION WITH PHASE V/VI RCP

TECHNOLOGY	CATEGORY (TREATMENT OR PREVENTATION)	BASIC DESCRIPTION	POTENTIAL APPLICABILITY FOR MINTO CLOSURE	STATUS OF EVALUATION	CLOSURE ROLE
Capping, Covers and Grading	Prevention. (Already incorporated in closure planning)	Capping or covering of solid mining waste is an effective and proven treatment technology. Installation of a cap or cover on solid mining waste can reduce or eliminate erosion, fugitive dust emissions, and infiltration of water to prevent the migration of contaminants. Caps or covers eliminate direct exposure to solid mining waste by creating a physical barrier that prevents direct contact with the contaminants.	All mine waste will be capped with an isolating soil cover and revegetated to facilitate the naturalization of the site at closure and a return to self-sustaining conditions that are consistent with land use planning goals.	An evaluation of the full potential range of cover designs was completed by SRK in connection with closure planning and preparation of RCP v4.0. The evaluation concluded that the only cover material available in sufficient quantities for use as cover material is overburden from the stripping of the open-pits and mine infrastructure foundations.	All mine waste will be appropriately graded and covered with a minimum 0.5m of revegetated, isolating soil cover. The HGW portion of the SWD will be capped with a very low permeability BGM cover. The anticipated cover performance is already incorporated in the water quality modeling and is not being considered further in the current context of defining additional "reasonable and practical" passive treatment technologies.
Chemical Precipitation (e.g., In-Pit)	Treatment. Passive or Semi-passive if in-pit settling is designed rather than active filtration/removal of precipitates. (Addressed as a contigency treatment technology in current closure planning in the context of in-situ treatment of water in open pits)	Chemical precipitation is a conventional technology used to treat mining-influenced water (MIW), including acid mine drainage, neutral drainage, and pit lake water. Chemical precipitation processes involve the addition of chemical reagents, followed by the separation of the precipitated solids from the cleaned water. Typically, the separation occurs in a clarifier, although separation by filtration or with ceramic or other membranes is also possible. Chemical precipitation can also be used in pit lakes or other water bodies, in which case the precipitated solids can simply settle and remain in the bottom of the pool.	Potential for significant role as contingency for treating Area 2 Pit water quality. Potential for carbon loading to turn the pit water reducing (encouraging sulphate reduction) and precipitate metals (e.g. Cu, Cd) as sulphides, and reduce SeIV and SeVI to elemental selenium (Se0) which would all settle to the pit bottom. This treatment technology overlaps with In-Situ Treatment of Pit Lakes (below).	Limnocoral trials were completed over the fall/winter of 2013/14. Evaluation to date has focused on creating sulphate reducing conditions to precipitate metals as sulphides (with an emphasis on treatment of Se). Batch treatment of Open-Pits is incorporated in the RRP. Limnocoral trials have confirmed the presence of selenium reducing bacteria and provided proof of concept. Currently considered a contingency treatment technology. The potential application of enhanced biological treatment (algae precipitation) is relatively well understood based on the Grum Pit trials at Faro.	Preliminary limnocoral trials in main pit provided proof of concept. Additional study (limnocoral) will likely be undertaken as Area 2 Pit begins to fill towards the end of the mine life. It is anticipated that batch treatment of Area 2 Pit will remain a contingency plan for closure. No requirement for additional study at this time.
Chemical Stabilization, Phosphate and Biosolids Treatment	Prevention. (Not practical at Minto)	Chemical phosphate treatments have used a variety of phosphate species, but phosphoric acid has been demonstrated to be the most effective. Organic sources of phosphate such as biosolids or composted animal wastes have also been used to stabilize, reclaim, and revegetate barren mine and mill wastes.	Not considered at the Minto Site due to a lack of readily available, cost effective source materials. Other, more appropriate treatment options are readily available.	Not considered for application at Minto.	Not applicable. Dropped from further consideration.
Constructed Wetland Treatment Systems (CWTS)	Treatment. Passive or Semi-passive. Can be designed for long-term, perpetual treatment. (Proposed in existing closure planning)	Constructed treatment wetlands are man-made biologically active vegetated systems that are characterized by saturated soil conditions and at least periodic surface or near-surface water designed specifically to treat contaminants in surface water, groundwater, or waste streams. The wetlands can be designed to operate either aerobically, or anaerobically, depending on the water treatment requirements. The CWTS can be operated as part of a treatment train (e.g., after BCR or in pit treatment).	Several areas are currently being considered. The most significant area is immediately downgradient of the DSTSF and MVFE (treating W37 seepage) and the area around W15. The area around W15 is already functioning as a natural treatment wetland. Evaluations are ongoing for ways to further enhance treatment peformance. Open pit overflow (i.e., Pit 2) is also being considered for treatment.	One of the primary passive treatment technologies being evaluated for Minto. Described in detail in the Reclamation Research Plan. Detailed pilot-scale trials specific to Minto have already demonstrated proof of concept and anticipated removal rates for CoCs for a given surface area, as well as developped the preliminary design considerations. Minto is currently operating an on-site demonstration CWTS to optimize design and refine full-scale sizing requirements.	Will be incorporate into long-term treatment of MIW. Next step is to confirm specific areas for implementation on the mine plan (closure configuration) and confirm available footprint and anticipated outflow water quality based on removal rates (developed from demonstration scale wetland), inflow water quality, and flow rates.
Diversionary Structures	Prevention. (Included in existing closure planning)	Diversionary structures are designed to prevent clean water from becoming MIW by coming into contact with mining solid waste (net acid-producing materials) and/or to divert MIW to treatment or collection systems and away from sensitive environments. Diversionary structures can be used to reduce the volume of, or exposure to, MIW that may present risks to human or ecological receptors and also to prevent/reduce erosion.	Incorporated where possible to both protect mine closure infrastructure and minimize contact of clean water with mine waste. Examples include the Tailings Diversion Ditch and the various primary and secondary water conveyance ditches.	Diversionary structures are already designed for the currently anticipated Phase V/VI closure configuration.	Incorporated in closure planning as appropriate. Concepts are well understood and there is no requirement for additional research in connection with the development of WQOs.

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RE-EVALUATION IN CONNECTION WITH PHASE V/VI RCP

TECHNOLOGY	CATEGORY (TREATMENT OR PREVENTATION)	BASIC DESCRIPTION	POTENTIAL APPLICABILITY FOR MINTO CLOSURE	STATUS OF EVALUATION	CLOSURE ROLE
Excavation and Disposal of Solid Mine Waste	Prevention. (Included in existing closure planning. Largely duplication of Backfilling/ Subaqueous disposal category)	Soil, sediment, or tailings can be removed so that the remaining contaminant concentrations meet a risk-based cleanup level or removed to a certain depth or areal extent so that the clean backfill placed on top of the remaining contamination creates a physical barrier preventing direct contact with the contaminants.	This is already incorporated into closure planning to the degree practicable in the form of excavating pockets of contamination (e.g., areas around concentrate piles or Pelley bone-yard) and dispolsal in engineered landfills or with other reactive mine wastes as appropriate. Application to larger volumes of contaminated mine wastes (e.g. waste rock) is generally covered under backfilling and subaqueous disposal of mine waste (described above) and is a specific requirement within the most recent WUL conditions.	Mine plan is currently being updated to ensure consistency with the WUL requirements. PAG rock that is excavated during the next mine phase will be stored in areas that will be saturated under closure conditions.	This is already incorporated in closure planning ("good practice").
In-situ Biological Treatment	Treatment. Semi-passive. Finite life-span. (Not relevant as defined herein, although partially overlaps with the category chemical precipitation)	In situ biological source treatment consists of isolating the source of mining-influenced water (MIW) through the establishment of an in situ biological layer on exposed metal sulfide surfaces. This is typically accomplished through the injection of inoculum (e.g., wastewater effluent) and substrate into the subsurface material. The in situ biological source treatment can achieve satisfactory results without the cost of excavation and material handling.	Not specifically considered for Minto – although this technology is closely related to BCRs and CWTS which are considered more appropriate technologies for closure application at Minto.	No specific research has been completed. Not specifically considered for closure applications at Minto.	No. Not considered for closure application at Minto.
In Situ treatment of Mine Pools and Pit Lakes	Treatment. Passive or Semi-passive. Can have long-lasting effects, depending on source water and pit characteristics. (Proposed as contingency measure in existing closure planning)	The technology consists of the injection or placement of substances, including (as appropriate) alkaline materials and organic carbon substrate, with nutrients directly into the mine pool or pit lake to neutralize the MIW and to produce anaerobic conditions to precipitate metals in place. Injection of a carbon source such as molasses or alcohol with nutrients and sometimes an alkaline source, such as lime, can create conditions favorable to the precipitation of dissolved metals in place.	Treatment of pit lakes is being evaluated at Minto and is a part of the ongoing RRP. The mine pools are not anticipated to require any treatment. A variation on a theme, which has not been previously discussed for Minto, is encouraging algal growth (through the addition of fertilizer/nutrients) which would scavenge metals and precipitate to the bottom of the pit (e.g., Similar to Grum Pit trials at Faro). Potential challenges with this include potential bioaccumulation of Se as it is taken up by algae; therefore this technology could likely only be considered in combination with initial sulphate reduction to first remove Se from the water column. Enhansed algal growth could be used to maintain treatment conditions semi-passively.	Limnocoral trials were completed over the fall/winter of 2013/14. Evaluation to date has focused on creating sulphate reducing conditions to precipitate metals as sulphides (with an emphasis on treatment of Se). Batch treatment of Open-Pits is incorporated in the RRP. Limnocoral trials have confirmed the presence of selenium reducing bacteria and provided proof of concept. Currently considered a contingency treatment technology. The potential application of enhanced biological treatment (algae precipitation) is relatively well understood based on the Grum Pit trials at Faro.	In-situ treatment of pit lakes (specifically the Area 2 Pit) is being considered as a contingency measure for closure .
Passivation Technologies	Prevention. (Considered not relevant / not practical at Minto)	Technology involves chemically producing coatings on reactive mine waste to limit metals mobility. Typical solutions include use of phosphates and silica. Treatment of acid-generating rock with permanganate and magnesium oxides at a high pH (>12) is a patented process. All passivated surfaces still have reactive rock below the surface, and oxidations will return once that passivation layer is removed. Thus, whether passivation is a viable option depends on time, other environmental conditions, and treatment efficiency requirement.	Not specifically considered in closure planning to date. May have application for treatment of pit walls in the event that ML from exposed surfaces proves problematic in the long-term. Geochemical modelling to dateprovides a high degree of confidence that metal leaching from exposed pit walls at closure is unlikely to be problematic. Passivation technologies typically produce inconsistent and relatively short duration reduction in contaminant loading.	Additional primary research would be required in advance of any large scale trials.	Not explicitely considered in the current RCP.
Permeable Reactive Barrier (PRB)	Treatment. Semi-passive. Finite life-span. (Proposed in existing closure planning. Re-evaluated as contingency treatment technology due to finite life-span and limited applicability in a Minto specific closure context)	In the broadest sense, a permeable reactive barrier (PRB) is a continuous, in situ permeable treatment zone designed to intercept and remediate a contaminant plume. The treatment zone may be created directly using reactive materials such as iron or indirectly using materials designed to stimulate secondary processes, such as by adding carbon substrate and nutrients to enhance microbial activity.	PRBs could potentially be incorporated in very specific applications, as part of a passive treatment train, in areas where space is limited and the potential exists to passively intercept mining impacted groundwater (e.g. immediately downgradient of the DSTSF.	The RRP research into bioreactors and CWTSs, while not explicity directed towards the design of PRBs, provides significant insight into the design and operation of PRBs (i.e., hydraulic, geochemical and microbial characteristics) in a Minto closure context.	This is considered a variation on a theme similar to BCR. Recognized that PRB would likely be used as part of a treatment train rather than as a stand-alone technology.

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RE-EVALUATION IN CONNECTION WITH PHASE V/VI RCP

TECHNOLOGY	CATEGORY (TREATMENT OR PREVENTATION)	BASIC DESCRIPTION	POTENTIAL APPLICABILITY FOR MINTO CLOSURE	STATUS OF EVALUATION	CLOSURE ROLE
Phytotechnologies	Prevention. (Not relevant in WQO context)	Phytotechnologies use plants to remediate various media impacted with different types of contaminants. Phytotechnologies can be applied to address certain issues associated with mining solid wastes and mining-impacted waters. There are six basic phytoremediation mechanisms that can be used to clean up mining-contaminated sites: phytosequestration, rhizodegradation, phytohydraulics, phytoextraction, phytodegradation, and phytovolatilization	All mining waste will be covered with a minimum 0.5m of clear overburden and revegetated. Consideration of specific phytotechnologies, such as phytosequestration and phytohydraulics may be warranted in specific, small scale applications, such as seepage zones, but generally in the context of protection of wildlife and the prevention of metal uptake by plants that could be detrimental to wildlife that consumes those plants (i.e., not to remediate metals in soil).	Not specifically evaluated as a primary reclamation technology for Minto but understanding of the topic (phytosequestration, rhizodegradation, phytohydraulics, phytoextraction, phytodegradation and phytovolatilization) is incorporated in a general sense within the revegetation evaluations.	Consideration of specific phytotechnologies, such as phytosequestration and phytohydraulics may be warranted in specific, small scale applications such as seepage/wet zones – but generally in the context of protection of wildlife and the prevention of metal uptake by plants that could be detrimental to wildlife that consumes those plants.
Re-Use and Reprocess (R^2) Technologies	Prevention. (Incorporated in existing closure planning)	Re-use consists of using problematic mine waste either directly or following reprocessing or other treatment as a beneficial product that is environmentally safe in its re-used form. Reprocessing consists of subjecting mine waste to physical or chemical processes designed to extract minerals or other waste components for beneficial use, rendering the waste material suitable for other beneficial use or environmentally safe disposal on the mine site.	Marginally economic waste rock will be processed as economically feasible. The site is remote site has limited potential for re-use (e.g., use of clean waste rock as rip-rap in streams has proven prohibitively challenging). The WUL specifically prohibits mine waste from being transported off-site.	Optimal reprocessing of marginal waste rock is incorporated in the MWROMP. No further evaluation planned.	Further optimization is not considered. Topic included for completeness.

TABLE 2
SHORT LIST - ITRC PASSIVE TREATMENT TECHNOLOGIES
RE-EVALUATION IN CONNECTION WITH PHASE V/VI RCP

TREATMENT TECHNOLOGY	Status of Evaluation	Steps to Advance	Site Considerations; Reasonable/Practical	Potential Areas of Application	Opportunities for SFN Participation	Key Documents
Primary Passive Treatment Technologies [1]						
Constructed Wetland Treatment System (CWTS)	Highly advanced as documented in the RRP. A field scale CWTS is currently in operation at the Mine Site with the option of converting to a hybrid CWTS/BCR as a contingency. The flooded area around W!5 has also been evaluated in the context of natural attenuation of contaminant loading that is already occuring (in a non-engineered setting) and the potential for enhanced natural attenuation through further optimization and plant species and improved routing of flows.	This is the primary passive treatment technologies being evaluated for Minto. Described in detail in the Reclamation Research Plan. Potential to be converted to a semi-passive BCR if needed as a contingency. Potential sites have been identified and predicted water quality will be refined as data continues to be produced form the on-site demosntration CWTS. Steps 2 and 3 of the "framework for developing Minto closure WQOs" will involve identifying potential sites for incorporating CWTSs (alone or as part of treatment train) under closure conditions.	This is considered both reasonable and practical at the Minto Site and is summarized in Contango (2014a, 2014b and 2015)	Anywhere MIW surface water can be routed through a relatively flat area of sufficient size to accomodate a treatment cell. Whenever possible, should be installed as multiple systems at water sources to reduce loads at the source. A primary area under consideration is immediately downgradient of DSTSF and MVFE. Additionally, the wetland in the W15 area is already naturally functioning in many respects to treat water and could be further enhanced at closure.	Sourcing wetland vegetation. Producing elements of substrate (e.g. wood chips, straw). Construction of the CWTS and monitoring and maintenance during commissioning.	RRP, CWTS site assessmet, CWTS pilot-scale testing, CWTS field-scale construction documents.
Contingency Passive Treatment Technologies [2]						
Biochemical Reactor (BCR)	Somewhat advanced as documented in the RRP. A small-scale BCR is currently in place on site under the design of Yukon College.	Further on-site investigations of seepage sources (quality, variability, flow rates, seasonality) should be undertaken to inform further in-situ research, including demonstration scale reactors. This research would further inform the feasibility of the use of BCRs in the closure planning at Minto.	This technology is semi-passive, requiring periodic maintenance (e.g., injection of carbon source and/or periodic replenishment of porous media). As such, their applicability is considered to be limited to early in the closure period (i.e., PC1) after which time it would no longer be maintained and would be isolated and remain buried in geochemically stable condition. BCRs could be installed as stand-alone treatment features, but more likely in connection with a CWTS, where the CWTS would perform treatment once the BCR is no longer effective. Because BCR are only semi-passive and shorter life span than CWTS, they are most practical to apply as a secondary option where insufficient footprint is available for a CWTS, or concentrations are higher than could be treated by a CWTS. This will need to be evaluated against findings for CWTS feasibility	These are being evaluated in connection with the ongoing RRP and evaluation of CWTS (i.e., to determine which sites would have sufficient area for effective CWTS treatment, and which would need to consider a bioreactor for treatment in a smaller footprint). Potential exists to turn area below the MVFE into a BCR by injecting carbon source to generate sulphate reducing conditions. Still at conceptual level - considered contingency application. If this is done, the CWTS design at that location may need to be revisited as water chemistry will have different treatment requirements (e.g., BOD)	Producing elements of porous media/substrate (e.g. wood chips, granular…). Participation in the construction, monitoring and maintenance during commissioning, and ongoing operation, monitoring, and maintenance.	RRP
Permeable Reactive Barrier (PRB)	This is considered a variation on a theme similar to BCR. It is being evaluated in connection with the RRP. Recognized that PRB would likely be used as part of a treatment train rather than as a stand-alone technology.	Focused review of subsurface information would be required prior to any detailed planning associated with PRBs.	Practical only where groundwater plume is identified and constrained into a groundwater source area that can be channelled.	Best suited where space is limited and groundwater must be passively intercepted/treated - such as immediately downgradient of DSTSF and MVFE.	Sourcing organics for permeable media. Monitoring of operational performance.	RCP v4.0. RRP
In-Situ Treatment of Open Pit (Chemical Precipitation through sulphate reduction)	Limnocoral evaluation has provided proof of concept - suitable for establishing anticipated removal rates of CoCs and required dosing with carbon sources.	Initial limnocoral trials in 2013/2014 have provided proof of concept. Additional trials may be completed as the Area 2 Pit begins to fill during the later stages of Phase V/VI operations.	Proof of concept demonstrated in Main Pit limnocorral trials. Would require mobilization of reagents and equipment for each implementations. Potential application in both Main Pit and Area 2 Pits.	Batch treatment of Open-Pits is incorporated in the RRP. Limnocoral trials have confirmed the presence of selenium reducing bacteria and provided proof of concept. Currently considered a contingency (semi)passive treatment technology.	Monitoring of pit water quality for trends in water quality that would warrant the implementation of batch treatment.	Limnocoral trials
In-Situ Treatment of Open-Pit (Enhanced biological Treatment using algae to sequester metals)	Has not been formally evaluated at this time. Risks identified with potential amplification of Se toxicity as algae could potentially make Se more bioavailable.	Internal discussion. Review the available data from the Grum Pit treatment trials at Faro (program overseen by Lorax). Research implications for Se removal.	Contimant load reduction has been demonstrated at similar sites (e.g., Faro Mine, Grum Pit).	Area 2 Pit. Contingency treatment technology. Would likely only be implemented in combination with batch treatment to drive sulphate reduction to remove Se.	Monitoring of pit water quality for trends in water quality that would warrant the implementation of batch treatment. Application of fertilizer/nutrients to promote algae growth.	Grum treatment evaluations from Faro (additional literature review warranted)

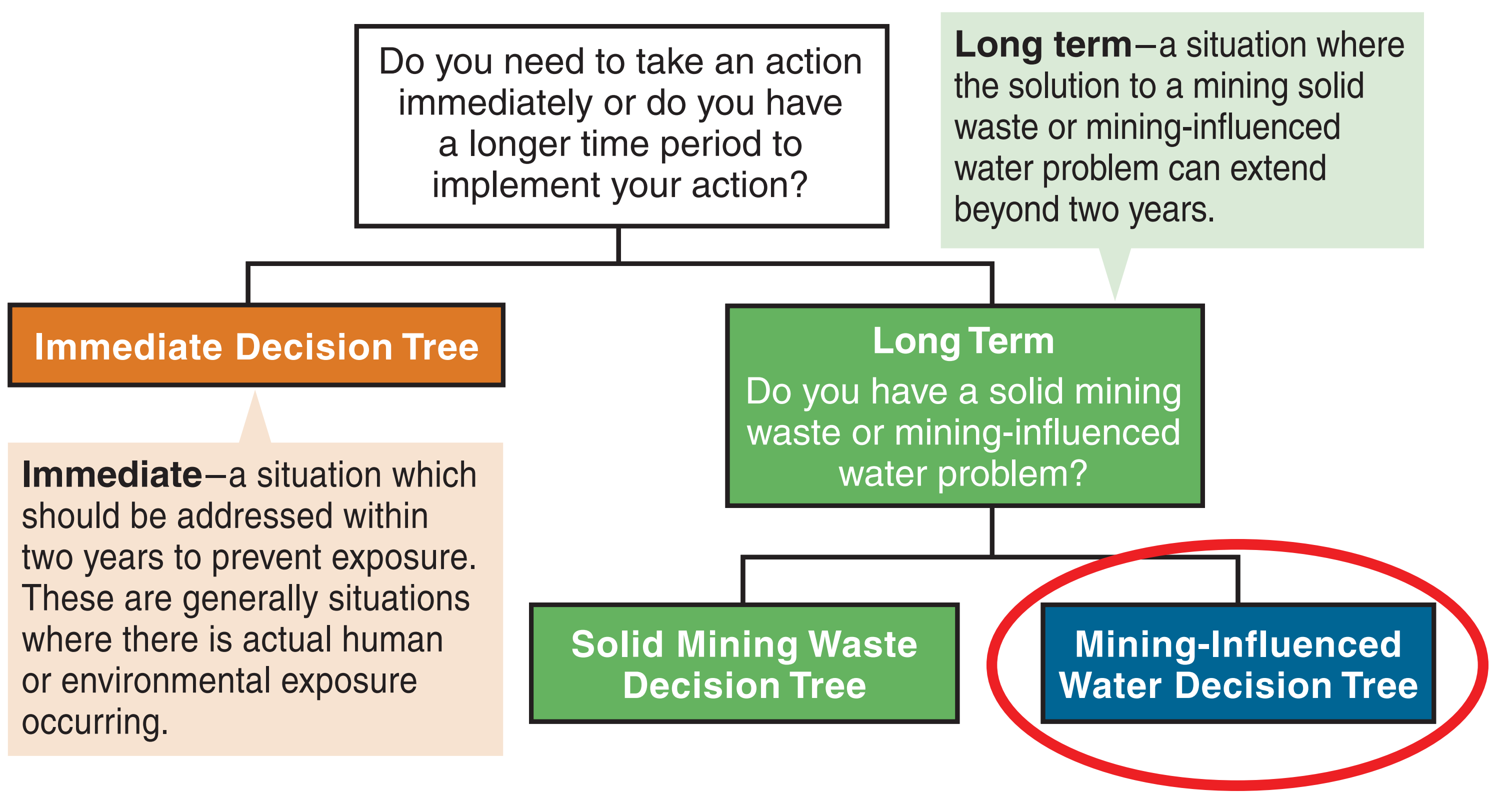
Notes:
1 This technology is considered the most appropriate for evaluation under "Steps 2 and 3" of the Framework for Developing Minto Closure WQO.
2 These technologies are considered "Contingency" passive treatment technologies.

Decision Tree

The Decision Tree has been designed to guide users to a set of treatment technologies that may be useful in managing a particular mine waste site. The user is presented with a series of questions. By answering the questions, the user is directed towards appropriate treatment technologies. Because of the size and complexity of most mine waste sites, there are generally a variety of environmental problems to be addressed. Those problems may include contaminated groundwater, contaminated residential yards, large areas of mine waste, or contaminated surface waters. The user should go through the decision tree separately for each issue to be addressed.

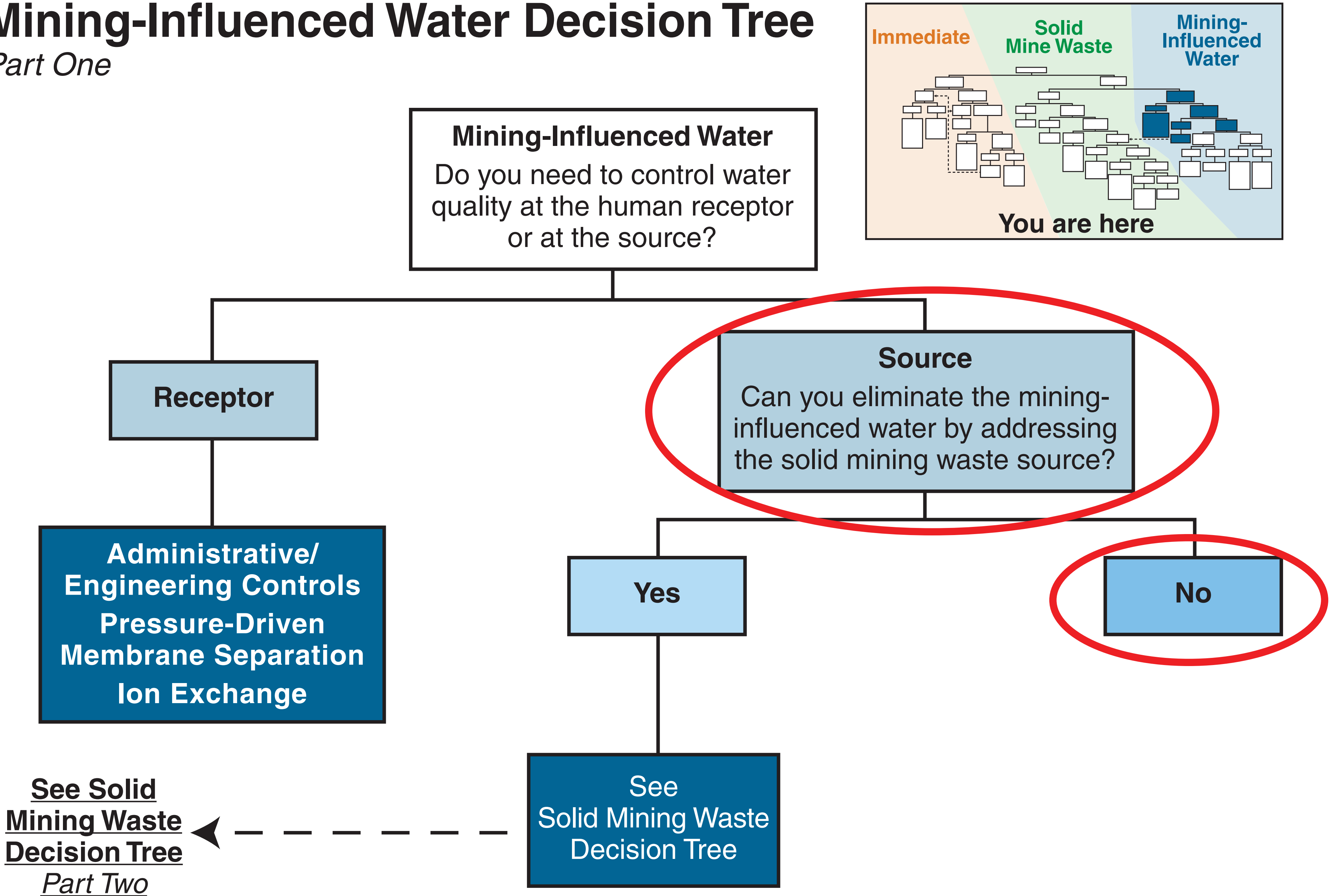
At the end of each string of questions in the decision tree is a list of treatment technologies. Clicking on that list will take users to Technology Overviews where they will learn more about the applicability of specific technologies and supporting case studies.

Mining Waste Team Decision Tree—Initial Questions



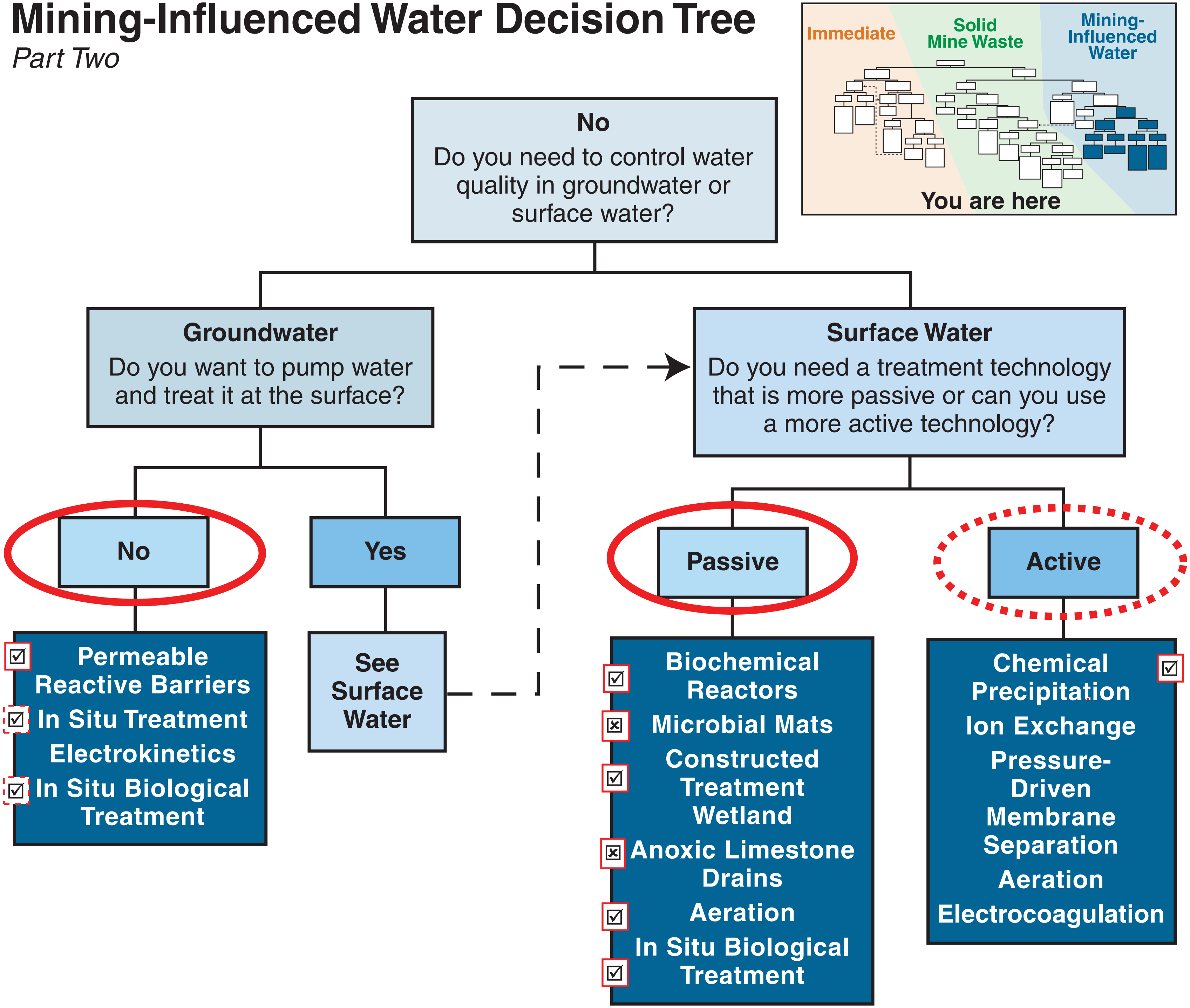
Mining-Influenced Water Decision Tree

Part One



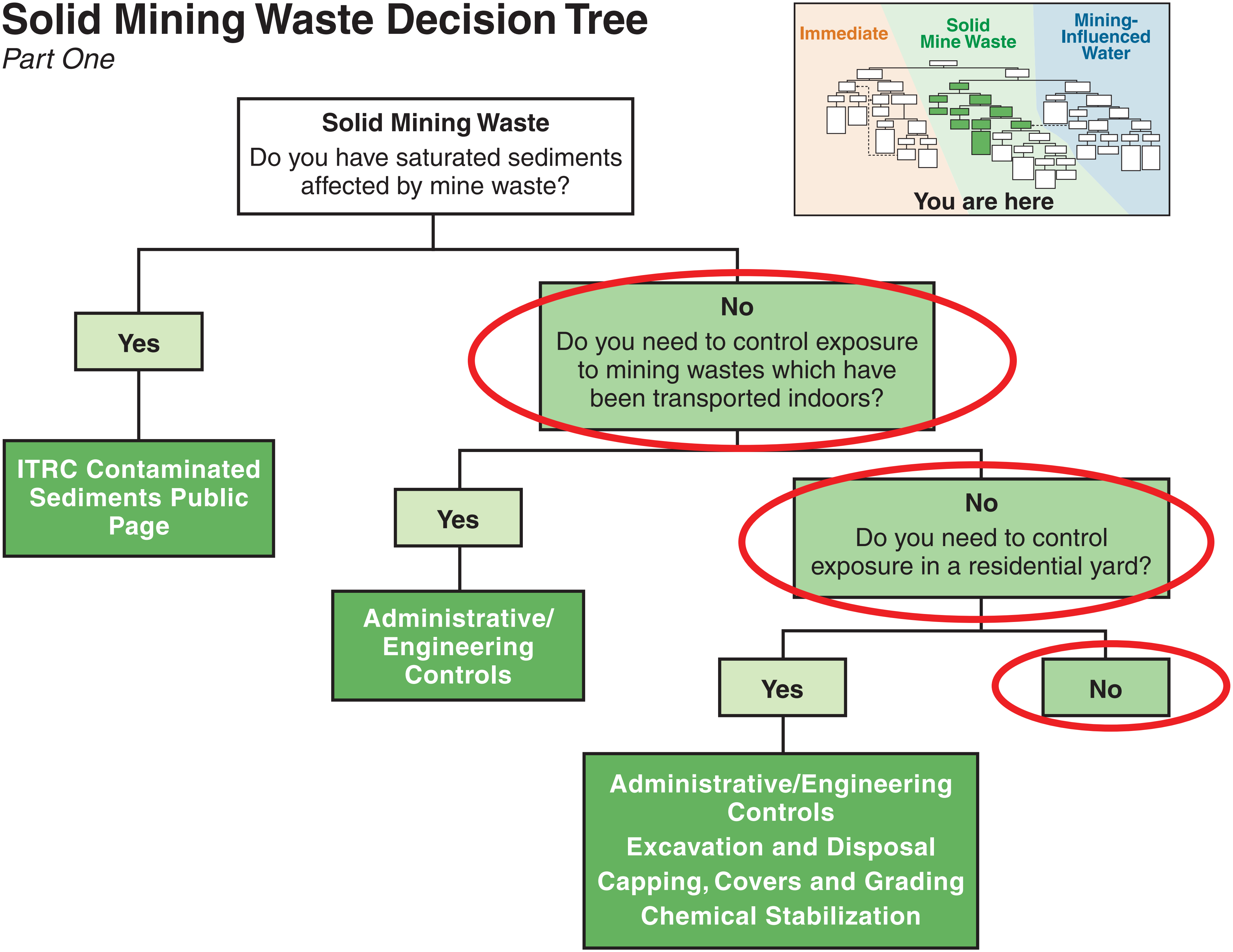
Mining-Influenced Water Decision Tree

Part Two



Solid Mining Waste Decision Tree

Part One



Solid Mining Waste Decision Tree

Part Two