Elk Valley Water Quality Plan

Annex L.3

Regional Approach for the Protection of Groundwater

Teck

REGIONAL APPROACH FOR THE PROTECTION OF GROUNDWATER – ELK VALLEY WATER QUALITY PLAN

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1 INTRODUCTION AND PURPOSE OF DOCUMENT

The Environment & Water business unit of SNC-Lavalin Inc. (SNC-Lavalin) has developed this document for Teck Coal Limited (Teck) to accompany the Elk Valley Water Quality Plan (the Plan) as required by the provincial Ministerial Order No. 113 (the Order). The purpose of this document is to provide Teck with an approach to the protection of groundwater in the Elk Valley, as listed in Schedule C, Section B of the Order, summarized below:

Issues to be Addressed in the Plan

Outcomes to be Achieved

7. Environmental management objectives and outcomes for the designated area including the following:

    d. protection of groundwater

The Order, associated Terms of Reference, and pertinent background related to the Order are provided in various chapters in the Plan; as such, no additional background is presented herein. The approach is intended to be regional in scale (i.e., Elk Valley watershed in the Designated Area) and is intended to dovetail with groundwater programs being carried out by Teck Operations as well as the existing management strategies for surface water protection. Furthermore, the approach is intended to be adaptive in nature and will be adjusted as necessary to meet environmental management objectives.

2 REGULATORY UNDERSTANDING AND WATER QUALITY OBJECTIVES

The Order was issued under Section 89 of the *Environmental Management Act* (EMA)[1] with requirements for protection of groundwater. The focus for groundwater protection will be on water quality, which is consistent with the area-based management plan. Water quantity protection will be considered for individual cases as and where necessary in accordance with applicable provincial regulations and guidance (e.g., *Groundwater Protection Regulation* for the construction and maintenance of water wells, *Environmental Assessment Act* for groundwater extraction).

The BC Ministry of Environment (MoE) regulates groundwater quality through the EMA and its associated regulations, including the *Hazardous Waste Regulation* (HWR)[2], *Waste Discharge Regulation* (WDR), and the *Contaminated Sites Regulation* (CSR)[3]. Specific guidance related to protection of groundwater quality for area-based management plans does not appear to be available with the exception of the following document:

- Water and Air Baseline Guidance Document for Mine Proponents and Operators, Ministry of Environment, October 9, 2012 (MoE, 2012).

The above document focuses on baseline study requirements and information considerations necessary for mineral projects for Environmental Assessments; however, components of the document may be used to understand general regulatory expectations for the protection of groundwater. Specifically, Appendix 8 provides hydrogeology rationale and guidance on requirements and expectations for the protection of groundwater quality. A summary of pertinent regulatory expectations in MoE (2012) is summarized below.

By statute, the Crown owns all natural waters in the province, including groundwater, and resource development should be protective of all existing or reasonably expected future uses of groundwater. Protecting the most sensitive potential use preserves options for flexibility for future uses, and unless other evidence is provided, drinking water use and freshwater aquatic life are assumed to be default uses. Drinking water use is default wherever human habitation is possible, unless there is no useable aquifer below or down-gradient of the mine site. Freshwater aquatic life is present in most groundwater discharge areas; however, groundwater discharge from a mine site will not be the only source of water in streams or wetlands, so allowance may be made for naturally occurring processes of mixing, dilution, and aeration. The mining project must not result in a significant adverse impact to groundwater or surface water quality at any time, as defined by the following:

[1] *Environmental Management Act* (EMA), [S.B.C. 2003], c. 53, current to April 9, 2014.
[2] *Hazardous Waste Regulation* (HWR), B.C. Reg. 63/88, including amendments up to B.C. Reg. 63/2009.
[3] *Contaminated Sites Regulation* (CSR), B.C. Reg. 375/96, including amendments up to B.C. Reg. 4/2014.

- Substances in groundwater exceeding the standards set out in the CSR for drinking water use and freshwater aquatic life use. The drinking water standard will not apply to substances for which the background groundwater concentration exceeds the applicable standard; and,
- Substances in surface water exceeding established water quality concentration guidelines (or site-specific objectives) for protection of aquatic life.

Specific water quality objectives for the approach to protection of groundwater for the Plan are described below.

2.1 Water Quality Objectives

The main focus for protection of groundwater quality will be the constituents in the Order: selenium, cadmium, nitrate, and sulphate. However, it is noted that the approach is structured to be adaptive in nature and as such should be able to consider additional constituents if necessary. The water quality objectives for each of the constituents in the Order will include existing or reasonably expected uses of groundwater for drinking water and freshwater aquatic life, but will also include irrigation, livestock watering as they are considered existing uses in the Elk Valley.

Based on guidance from MoE (2012), values from CSR standards for drinking water, irrigation and livestock watering will be used as default objectives for future protection of groundwater quality. Actual values have not been provided in this document as they are subject to change over time. For example, the drinking water guideline for selenium is currently being reviewed by Health Canada and an increase in the value from 10 µg/L to 50 µg/L is being considered. We understand that once Health Canada makes changes to drinking water guidelines, there is the potential for the MoE to adopt the same value for the provincial guideline and standard.

For freshwater aquatic life, we note Teck have been developing site-specific ecologically protective values for nitrate, sulphate, selenium and cadmium. The methodology for the development of these values is provided in the Plan and will be considered in the approach for protection of groundwater quality for freshwater aquatic life. This is considered appropriate as groundwater CSR Standards typically account for a dilution factor of 10 (i.e., Standards are 10x higher than the surface water quality guideline).

3 CURRENT GROUNDWATER UNDERSTANDING AND MONITORING

The level of current understanding of groundwater conditions is discussed below.

3.1 Groundwater Understanding and Objectives at Operational Sites and Applied R&D Projects

Various Operations in the Elk Valley are at different levels of understanding groundwater conditions. Groundwater monitoring wells and some networks exist at or in the vicinity of each Operation. These monitoring wells and networks have been developed for different purposes. Examples of programs where monitoring wells were completed are: Environmental Assessment as part of permitting, research and development purposes; water supply assessment; geotechnical investigations; environmental investigation of various potential contaminant source areas; and, risk assessment. In addition to assessment through monitoring wells, groundwater discharge areas (i.e., springs/seeps) have also been investigated at a number of Operations which also provides a level of understanding of groundwater conditions.

Operations and the Applied Research and Development (R&D) group have recently or are currently developing groundwater monitoring networks and monitoring programs to improve understanding of groundwater at an operational level. The stage of program development for each Operation is different; however, we understand the common overall objectives of each operational groundwater program are to:

- Characterize the groundwater resource; and,
- Identify (and if necessary quantify) impacts to groundwater from mining-related activities.

3.2 Regional Groundwater Understanding and Objectives

An understanding of regional groundwater conditions has been developed from a recent drinking water evaluation and sampling program (Annex L.2 to the Plan), the objectives of which were to:

- identify drinking water supplies in the Elk Valley that may be susceptible to mine influenced water and potentially contain elevated concentrations of Order constituents (cadmium, nitrate, selenium, and sulphate); and,
- evaluate whether concentrations of Order constituents exceed applicable drinking water quality guidelines through completion of a drinking water supply sampling campaign.

Relating to regional understanding, the following were concluded:

- Selenium (and sulphate at one location) was the only constituent identified with concentrations exceeding current drinking water guidelines;
- Two general transport pathways for selenium in groundwater were identified:
  - Source release to upland groundwater: Groundwater transport is expected to occur in the vicinity of and hydraulically down-gradient from the respective Operations; and,
  - Surface water recharge, specifically from the Elk River, to groundwater.
- Shallow groundwater (i.e., < 15 m bgs) in the Elk River floodplain has a higher degree of hydraulic connectivity to the Elk River than deep groundwater and as such, greater potential to be influenced by elevated concentrations of mining-related constituents in the Elk River;
- Shallow groundwater in floodplain areas hydraulically down-gradient of a meander may receive a higher component of surface water recharge; and
- Surface water recharge to groundwater appears to be higher where river gradients are higher, typically after confluences with major tributaries.

The main limitations of the study surrounded limited data on the source release to groundwater transport pathway; lack of seasonal water quality information; and, reliance upon drinking water wells and points-of-diversion for representing groundwater conditions.

3.3 Preliminary Regional Conceptual Hydrogeological Model

A preliminary hydrogeological conceptual model for the Elk Valley is described below and was developed based on information from the drinking water study, brief review of existing conceptual models and published literature, and corporate experience in the Elk Valley. A regional hydrogeological conceptual model is envisioned to be an important component in the regional approach to protection of groundwater.

The Elk and Fording Rivers exist within former glacial valleys carved into bedrock with the majority of surficial deposits present at the base of the Elk Valley. Regionally, two general groundwater hydrogeological settings appear to be present: upland groundwater consisting of groundwater on the adjacent mountain slopes and lowland (e.g., floodplain groundwater), consisting of groundwater present in the valley bottoms.

3.3.1 Upland Groundwater Occurrence and Flow Regime

Slopes of the adjacent mountains are considered to consist of unconsolidated surficial deposits (primarily colluvium) overlying sedimentary bedrock; however, some terraces comprising glacial-related deposits are present. A number of tributary creeks, some ephemeral, exist on the valley slopes. The difference in permeability and hydraulic conductivity between surficial deposits and bedrock may be relatively significant and, as such precipitation (rainfall and snow melt) in the tributary catchments recharges surficial aquifers and discharges into the creeks with limited interaction with the underlying bedrock. Therefore, tributaries would be considered 'gaining' systems (i.e., receiving discharge from groundwater); however, where tributaries flow across thicker, generally unsaturated terraces, surface water recharge to groundwater may be occurring. It is noted that some larger tributaries with more incised valleys may have a deeper component of groundwater that does not daylight.

Groundwater occurrence and flow in bedrock likely occurs along fractures, faults and joints within the bedrock and discharge from bedrock would typically only be from outcropping or sub-cropping of groundwater-bearing fracture or fault zones. Where the Mist Mountain Formation is present, groundwater within bedrock would be generally perched on low permeability coal seams which can control the regional bedrock groundwater flow regime.

3.3.2 Elk River Floodplain (Lowland) Groundwater Occurrence and Flow Regime

In the Elk River floodplain, unconsolidated lithology consists of variable deposits of cobbles, gravel, sand and gravel, sand, silt, clay and till. The expected depositional environment in the floodplain would be alluvial or fluvial, including overbank deposits, overlying deposits of glacial, glaciofluvial and glaciolacustrine origin.

Upstream of the confluence with the Fording River the valley gradient is irregular, and downstream the gradient is more typical of an alluvial slope due to increased river discharge. Geomorphology of the Elk River is a wandering gravel-bed which represents an intermediate condition between meandering and braided rivers (Northwest Hydraulic Consultants, 2006). Groundwater-surface water interactions in wandering rivers can be relatively complex and are highly influenced by local morphology and river gradient, permeability of the underlying materials and seasonality (Driscoll, 1995). Depending on the presence of confining layers, deeper groundwater may not interact with either shallow groundwater or surface water.

Shallow groundwater in a floodplain is typically unconfined. Groundwater flow direction is typically parallel or sub-parallel to the valley as the river provides continuous recharge to the underlying sediments. In steep river valleys such as the Elk River Valley, additional recharge can result from upland tributaries and as such, mounding of the groundwater table in the vicinity of the alluvial fan of the tributary would be expected. Where meanders are

oriented perpendicular or semi-perpendicular to the predominant groundwater flow direction (i.e., down-valley), groundwater recharge or discharge may occur. These interactions will likely depend on the elevation of the river vs. adjacent groundwater which may be locally affected by river morphology.

3.3.3 Potential Sources, Transport Pathways and Uses for Groundwater

Based on the drinking water evaluation and sampling program, two main groundwater transport pathways for mine-related constituents were identified, listed below in relation to the preliminary conceptual model:

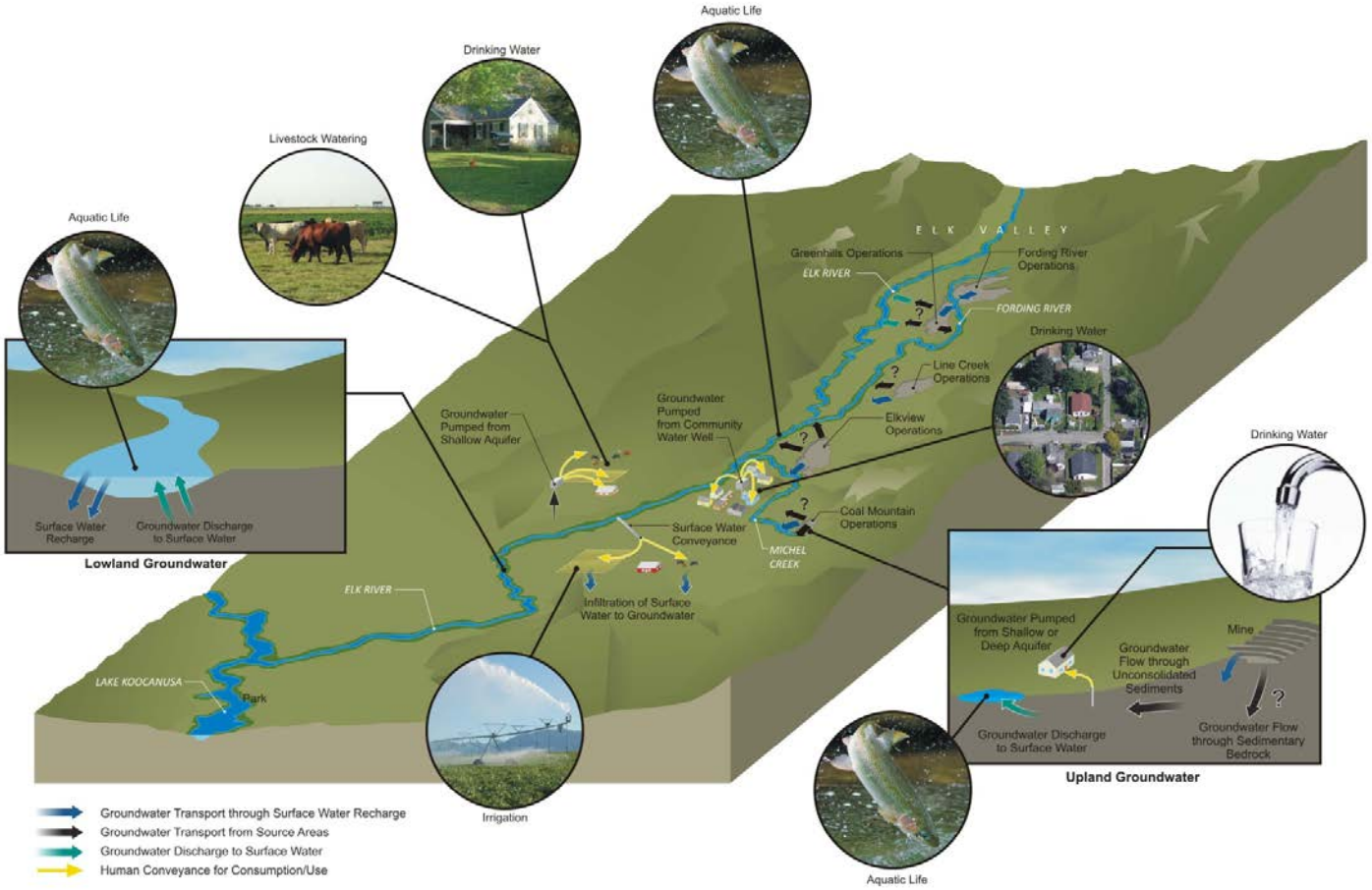
- **Source release to groundwater:** Groundwater transport from source areas would be expected to occur in the vicinity of and hydraulically down-gradient from respective Operations. In general, the majority of mining Operations exist in the upland setting, with tributaries of the Elk and Fording Rivers flowing into the main stems of those rivers. Groundwater transport of mine-related constituents in tributary catchments in the upland setting would be expected to discharge to surface water unless the valley was highly incised. It is noted that components of certain Operations do exist in the lowland setting (i.e., Elk or Fording floodplains) which may result in transport of mine-related constituents in the floodplain; and,
- **Surface water recharge to groundwater:** where constituents are present in surface water, transport of mine-related constituents to groundwater through surface water recharge is expected. Concentrations of mine constituents would therefore be related to surface water concentrations (current and historical) where a hydraulic connection is present.

Current and future uses of groundwater in the Elk Valley are considered to be as follows:

- Human – protection of groundwater for drinking water, irrigation
- Livestock – protection of groundwater for livestock watering
- Aquatic Life and Wildlife – protection of groundwater for discharge to aquatic environments.

Figure 1 below presents a conceptual drawing of the general hydrogeological settings (i.e., upland vs. lowland) groundwater transport pathways, and water uses in the Elk Valley.

Figure 1: Conceptual Hydrogeological Settings, Groundwater Transport Pathways and Use



4 APPROACH TO PROTECTION OF GROUNDWATER

Teck is currently planning and/or implementing management strategies for the reduction and/or mitigation of Order constituents in surface water. These measures, or a combination thereof, are anticipated to comprise the main management strategies for protection of groundwater. The following outlines the general proposed approach to protecting groundwater quality as part of the Plan:

- identification of areas and related groundwater protection objectives where current or future mitigation and management strategies may be necessary from a regional groundwater quality perspective. Existing strategies for mitigation of constituents in surface water will be evaluated in relation to protection of groundwater for identified areas;
- if necessary, development of a framework for regional monitoring to measure performance against groundwater protection objectives and for providing regular updates to stakeholders, where applicable. A monitoring program may also provide a baseline to form the basis for assessing the effectiveness of a variety of mitigation measures that have been completed to date or are implemented as part of the Plan; and,
- if necessary, development of supplemental management strategies based on the regional understanding. Any supplemental management strategy would dovetail with operational groundwater programs.

The last two components are considered part of Teck's adaptive management strategy, which is a systematic process for reviewing and adjusting the Plan to ensure objectives are being met. Additional details on the approach and steps are provided below.

4.1 Evaluation of Existing Management Strategies for Groundwater Protection

Existing management strategies and applicable strategies related to protection of groundwater may include: source reduction measures; ecological risk assessment for protection of aquatic life in river main stems; and human health risk assessment for the protection of human health. The first component of the approach for protection of groundwater would be to evaluate these strategies in relation to the current understanding of regional groundwater conditions and protection objectives.

Work completed to date has provided an initial understanding of the how existing management strategies will address the protection of groundwater required in the Order. For example, the preliminary hydrogeological conceptual model identified two transport pathways for mine-related constituents, listed below with general areas and potential existing management strategies:

1) Source release to groundwater, where areas/aquifers hydraulically down-gradient of identified source areas may require protection. Conceptually, these areas/aquifers could exist in both upland and lowland hydrogeological settings. At present, the respective Operations are assessing source transport pathways within and adjacent to their property boundaries to improve understanding of groundwater at an operational (local) level. Results of these programs will be used to help improve Teck's understanding of local groundwater in relation to potential mitigation scenarios; and,

2) Surface water recharge to groundwater, where areas/aquifers are subject to surface water losing water to ground and recharging groundwater. Conceptually, these areas typically exist in the floodplain environment, but may also be present in elevated alluvial terraces where tributaries may recharge groundwater. Existing mitigation and management strategies for surface water are anticipated to be applicable to the surface water transport pathway based on the drinking water evaluation, and will also reduce concentrations in groundwater in locations where surface water infiltrates to ground or recharges groundwater (e.g., losing tributaries).

To provide technical rationale for evaluation of existing management strategies for regional protection of groundwater, a technically-based and scientifically defensible understanding of regional groundwater conditions is necessary. As such, the preliminary conceptual site model will be expanded upon using existing data and available information from operational sites, Applied R&D program and other resources to develop a regional hydrogeological conceptual model. Areas and/or aquifers could be grouped on a regional scale based on transport pathways and water uses for evaluation to existing management strategies.

4.1.1 Regional Groundwater Synthesis and Management Strategy Evaluation Report

As mentioned above, the first and main component of the approach for protection of groundwater would be to evaluate regional groundwater conditions and protection objectives in the context of existing mitigation and management strategies. This would be achieved through a groundwater synthesis report which would identify and summarize areas and/or aquifers that may require protection or consideration of adaptive management steps, along with related water quality objectives. Where areas are identified as potentially requiring additional consideration, an evaluation of the appropriate management strategies will be performed.

At present, the respective Operations and Applied Research and Design (R&D) programs are assessing source transport pathways within and adjacent to Teck's property boundaries. These programs are in their infancy and protection objectives and/or monitoring points for areas hydraulically down-gradient may not have been developed. The synthesis would dovetail with groundwater programs being developed at each of the Operations

and/or Applied R&D programs. Offsite information and conceptual models from operational groundwater monitoring programs, the R&D program and the regional drinking water study would be combined as well as existing groundwater information from other resources, if available. The following two scenarios are envisioned as a result of the synthesis:

- Offsite (i.e., outside of operational property boundaries) areas where groundwater contains elevated concentrations of constituents above protection objectives which warrants further evaluation and triggers for adaptive management; and
- Offsite areas where groundwater does not contain elevated concentrations of constituents, but may be vulnerable to future impacts based on hydrogeological setting, anticipated geochemical changes, or changes to upslope source areas and flow regimes.

Existing management strategies would be evaluated with respect to these scenarios. Where possible, the evaluation would be dovetailed with specific management strategies for each Operation to minimize effort and avoid duplication. Current and anticipated future groundwater conditions would be assessed based on changes to mining activities and water quality improvements resulting from mitigative actions currently being undertaken or planned in the future.

The main outcome of the evaluation would be to understand the impact of existing management strategies to areas that require protection of groundwater. Uncertainties or data gaps in the regional understanding of groundwater conditions may exist that may limit evaluation and would need to be addressed. This would be managed as part of the adaptive management process and potential steps may include:

- Coordination with operations and R&D to address data gaps within site boundaries through adjustments to site groundwater monitoring programs, with input into the adjustments provided by the responsible authority coordinating regional monitoring activities. Since each operational facility is at differing stages of monitoring program development and execution, filling of data gaps may occur over a period of several years as investigation activities are completed; and,
- For data gaps beyond site boundaries, supplemental assessment may occur and would be guided by the adaptive management process through consideration and development of appropriate triggers. Potential work that may be considered consist of: additional desktop study; reconnaissance seep/spring sampling; assessment of known groundwater discharge areas in surface water, regional geochemical isotopic studies, or intrusive investigation (e.g., drilling of monitoring wells).

To address potential timing issues while ensuring appropriate protection measures are in place, a regional groundwater monitoring and management program may be developed that would include a framework for routinely incorporating new information and reviewing the status of data gaps along with updating stakeholders accordingly. This would be part of the adaptive management process, and further described below.

4.2 Adaptive Management: Development of Groundwater Monitoring and Management Program

As per an adaptive management approach, a potential second component of the approach may consist of the development of a groundwater monitoring and management program, if required. The synthesis report is anticipated to inform requirements for regional groundwater monitoring; however, some concepts are provided in the discussion below.

Groundwater monitoring and management plans at each of the operational facilities are in differing stages of development and execution. At present, a regional groundwater monitoring and sampling program is in place at locations in the Elk Valley where selenium concentrations exceeded drinking water quality as outlined in the groundwater summary report. Components of existing programs may be combined into a regional groundwater monitoring management program, if necessary.

A regional monitoring program may provide a framework for monitoring to measure performance against groundwater protection objectives and for providing regular updates to stakeholders, where applicable. In addition, it may also provide baseline information to form the basis for assessing the effectiveness of mitigation measures implemented as part of the Plan. Any monitoring program would be part of Teck's adaptive management strategy and would likely outline contingency actions and monitoring triggers that may require further mitigation actions.

4.3 Adaptive Management: Development of Supplemental Management Strategies

As per an adaptive management approach, a potential third component of the approach would be the consideration and development of supplemental mitigation actions and management strategies, if required. In general, planned or completed mitigation actions to achieve other outcomes outlined in the Order (e.g., protection of aquatic ecosystem health, protection of human health) are anticipated to reduce constituent concentrations in groundwater and address groundwater protection requirements. However, additional actions and management strategies may be required solely for the protection of groundwater, and/or protection of receptors utilizing groundwater.

Based on information in the synthesis report, supplemental mitigation actions and management strategies may be identified for both short-term and long-term protection. Any supplemental management strategy would be adaptive in nature as ongoing monitoring, groundwater information, and/or water quality objectives may change over time. Additional actions and management strategies are anticipated to occur through assessment and execution of the groundwater monitoring and management plans at each of the operational facilities currently in progress. If areas are identified where immediate action is warranted to protect groundwater and certain receptors, an approach for protection will be prepared on a case-by-case basis at the operational level, and will outline operational and/or institutional actions necessary to protect groundwater.

4.4 Summary

In summary, the phased approach to protection of groundwater is to use an adaptive management process to:

- evaluate existing management strategies in the context of regional groundwater protection;
- if necessary based on the evaluation of existing information, implement an adaptive monitoring and management program to:
  - track groundwater quality and improvements over time; and,
  - provide a framework for providing regular updates to stakeholders;
- if required based on evaluation of existing data and implementation of a monitoring and management plan, develop potential supplemental management strategies.

The approach to protection of groundwater will be a holistic approach that will integrate with other management plans, and ensure objectives for protection of groundwater are met.