TECK'S COAL BUSINESS UNIT APPLIED RESEARCH AND DEVELOPMENT PROGRAM - A WATERSHED APPROACH

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ABSTRACT

Teck's Coal business unit is embarking on a comprehensive, applied research and development (R&D) initiative that will provide information to support management decisions with respect to mine design changes that will support the objective of maintaining watershed function in perpetuity, at all of Teck's coal mining operations.

The program will involve laboratory, pilot, prototype and commercial scale studies to ensure that results of technology testing are demonstrated and that indicators of watershed function (hydrologic and biogeochemical, in the short term), are established and verified at the dump, mine, and watershed scales.

Projects within the program will be undertaken at all of Teck's operations in the Elk Valley of southeast B.C., and at our Cardinal River Operations in Alberta. The projects are being undertaken in partnership with a team of industry and University-based research scientists and engineers. The program is a multi-year initiative designed to actively support mine planning and closure planning decisions on an ongoing basis through a developed technology transfer process.

The overall applied R&D program is being developed using the US Environmental Protection Agency (EPA) Data Quality Objectives (DQO) process as a guide. The DQO process is used to develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (EPA QA/G-4 2006). Teck is employing the DQO process at various levels to assemble the research program and to clearly link the research to management decisions and mine planning activities.

The applied R&D program is a multi-disciplinary program with a selenium (Se) and watershed focus. It integrates applied research in the areas of biogeochemistry, water balance (hydrology, hydrogeology), landform design and reclamation. Core questions within the program will integrate results to address the broader management decisions which will allow for maintenance of healthy watershed function.

Key Words: Data Quality Objectives, multi-disciplinary, technology, transfer, watershed, selenium

INTRODUCTION

Teck's Coal business unit has committed to developing and implementing designs for new mining facilities as well as managing ongoing operations and legacy sites in a manner that protects watershed health, and other watershed values in the near and long term, both on and off site. Mine planning guidelines are required to achieve these objectives, and development of these guidelines requires a focused research and development (R&D) program. The vision for this program, which commenced in 2012, is a well coordinated and integrated applied R&D program that:

- supports sound management plans, such that mine design changes can be made now to maintain watershed function in perpetuity at all of Teck's coal mining operations
- and generates innovative solutions to watershed issues

The overarching program objectives are 1) to conduct rigorous, independent R & D activities addressing clearly worded hypotheses about mechanisms and rates of water and Se (and other compounds of interest (COI's), including NO_3, SO_4, Fe, Ca, CO_3, organic C, and O_2) movement at the dump, mine and watershed scale and 2) to develop and implement an R&D Synthesis and Technology Transfer process that will ensure timely incorporation of research and development results into mine planning activities. As a result, the Applied R&D program is a key component of Teck's overall Cumulative Effects Water Quality Management Framework, with the relationship described in Figure 1.

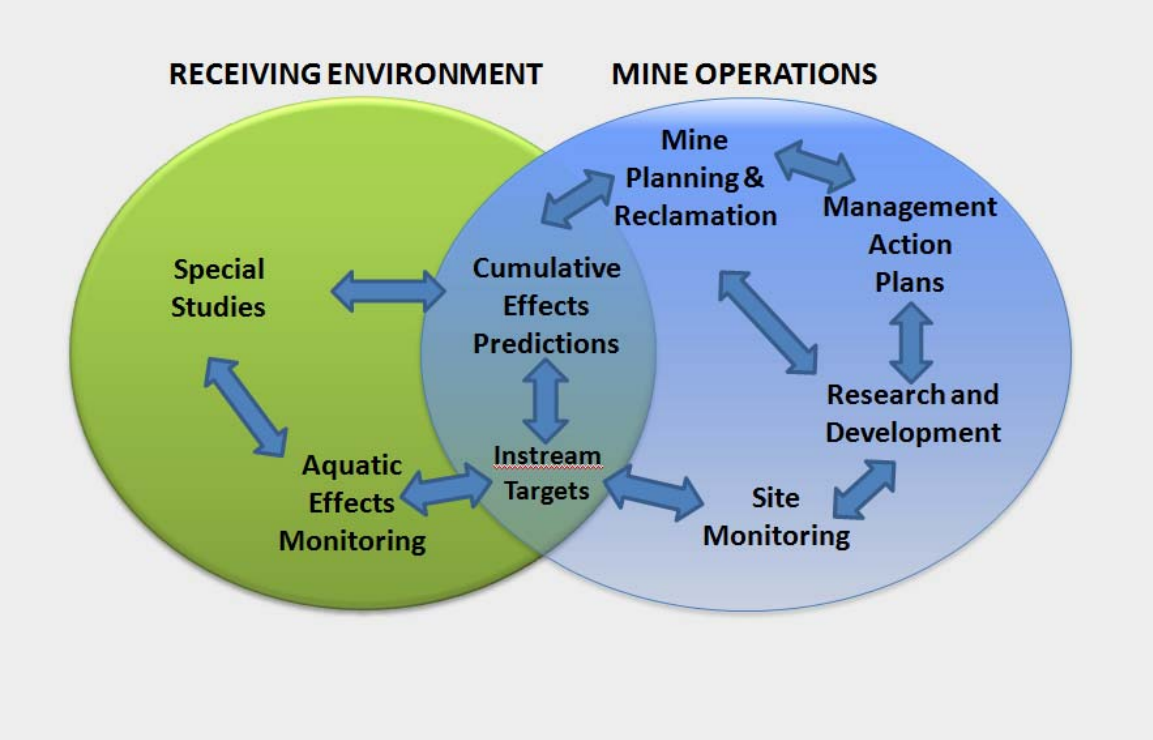

Figure 1. Teck Coal's Cumulative Effects Water Quality Management Framework

DATA QUALITY OBJECTIVES (DQO) PROCESS

The overall Applied R&D Program is selenium (Se) and watershed focused and is being developed using the United States Environmental Protection Agency (US EPA) DQO process as a guide. The DQO process was developed by the US EPA to "develop performance and acceptance criteria (or data quality objectives) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions" (EPA QA/G-4 2006).

The DQO process has well-established management and scientific elements that explicitly link data collection projects/studies to information needs identified for making management decisions with tolerable (agreed upon) levels of certainty/uncertainty. The DQO process is completed as a team and facilitates mutual understanding and agreement on what decisions must be made, the key scientific questions that must be answered, and what it will take to reduce the uncertainty when making the decision. It is a "front-end" process to identify a path from clearly describing the management decisions at hand and posing the questions to be addressed, through design and completion of studies, to technology transfer of the Applied R&D project findings into operational activities. This process can be used at any level of decision making from program-level or management-level questions down to specific project- or study-level scientific questions. Teck is employing the DQO process as a guide at the various levels to assemble the research program and to clearly link the research to management decisions and mine planning activities.

The DQO process is a 7 step process for the systematic planning of a program or project. The steps are:

1. Define the problem: so that the focus of the program or study(s) will be clear and unambiguous. Identify leaders and members of the planning team/decision makers, develop the conceptual model, and determine resources
2. Identify the goals of the program (high level) or project (individual study): State how data will be used in meeting objectives and solving the problem; identify study questions, define outcomes, prioritize.
3. Identify information inputs: Identify data and information needed to answer program or project questions or produce estimates
4. Define the boundaries of the study: Specify the target population and characteristics of interest, define spatial and temporal limits, scale of inference
5. Develop the analytic approach: Define the parameter of interest, specify the type of inference, and develop the logic for drawing conclusions from findings (decision type problem or estimation type problem)
6. Specify the performance or acceptance criteria (Tolerable Limits on Decision Rules) Specify the decision maker's acceptable limits on decision errors, which are used to establish appropriate performance goals for limiting uncertainty in the data.
7. Develop the detailed plan for obtaining data

FOCAL RESEARCH AREAS

Through various group sessions in 2011, the first 5 questions and original 5 focal research areas were identified. In June of 2012, a multi-stakeholder group in British Columbia helped to refine

and expand these focal research areas. The original 5 focal research areas, for which projects commenced in 2012, are included in the newly expanded list.

1. "How can new waste rock dumps (unsaturated or saturated) be designed to lower the amounts of selenium (and other compounds of interest) to the lowest level feasible? How do we evaluate legacy dump performance? What criteria do we use to assess legacy dumps? How do we manage these dumps to minimize release of constituents of interest?" These are directly linked to original Focal Research Area 1: Ex-pit waste rock dump design and management: new and legacy landforms.

2. "How do water management processes affect releases of constituents of interest? How can Teck maximize the effectiveness of water management/minimize releases?" These link to original Focal Research Area 2: Water balances to aid in water management decisions.

3. "How do rock drains affect release of Se and other constituents of interest?" This revised question links directly to original Focal Research Area 3: Rock drain design and use.

4. "How effective are designed saturated zones in managing releases of selenium and other constituents of interest, and what are their implications for overall water management?" These questions link to original Focal Research Area 4: Saturated zone design and operation.

5. How do reclamation options affect release of Se (and other constituents of interest)? How do they perform in meeting the other reclamation objectives and what, if any, are the trade-offs between potentially competing goals? These are unchanged from the original question and the original Focal Research Area 5: Reclamation and Se management.

6. What is the effectiveness of explosives (nitrates) management on minimizing release of nitrates? What are follow-on effects to water treatment/Se release?

7. What advances in Se treatment/emergent Se technologies should be implemented at pilot or commercial scale?

8. How can mine developed water bodies (end-of-pit or other) be used to manage releases of constituents of concern?

It is important to note that these focal questions/focal research areas are not in a priority order, they are simply numbered for ease of reference. The questions each have specific scientific and engineering questions within them which are also being developed using a DQO process as a guide.

SELENIUM AND WATERSHED FOCUS

The research program to address these questions is multi-disciplinary and watershed oriented to ensure that the overall *program* (comprised of many projects) and its participants integrate ideas

across study areas and scientific disciplines to arrive at multiple lines of evidence to inform mine design. Although Se is a specific focus, the intent of the program is to address Se as well as other and other compounds of interest (COI's), including NO_3, SO_4, Fe, Ca, CO_3, organic C, and O_2as their behaviours, and ultimately effects, are inter-related.

The multi-disciplinary, watershed frame of reference for the Applied R&D program also provides for and demands:

- ✓ rigorous examination of assumptions in each discipline,
- ✓ collaborative identification of components of, and processes in, mine-affected watersheds requiring reconstruction or re-establishment for watershed functionality, resilience and ecological health
- ✓ synergies in discoveries/innovation,
- ✓ synergies in project resources and
- ✓ integration of results from multiple of scales of investigations (lab-scale, waste dump scale, multiple watershed scale)

Projects within the Applied R&D program will be undertaken at all of Teck's facilities in the Elk Valley and at Cardinal River, with activities underway in 2012 at Line Creek (LCO), Fording River (FRO), Elkview (EVO), Greenhills (GHO) and Cardinal River (CRO). The program will involve laboratory, pilot, prototype and commercial scale studies to ensure that results of technology testing are demonstrated and that indicators of watershed function (hydrologic and biogeochemical, in the short term), are established and verified at the dump, mine, and watershed scales. The projects are being undertaken in partnership with a team of industry and University-based research scientists and engineers. 2012 is the first year of programming under the Applied R&D umbrella and research projects have commenced in partnership with The University of Saskatchewan, McMaster University and Montana State University.

TECHNOLOGY SYNTHESIS AND TRANSFER

The applied R&D program is an integral part of an iterative adaptive management process, with the Technology synthesis and transfer step being a key component receiving substantial focus. The process is depicted in Figure 2.

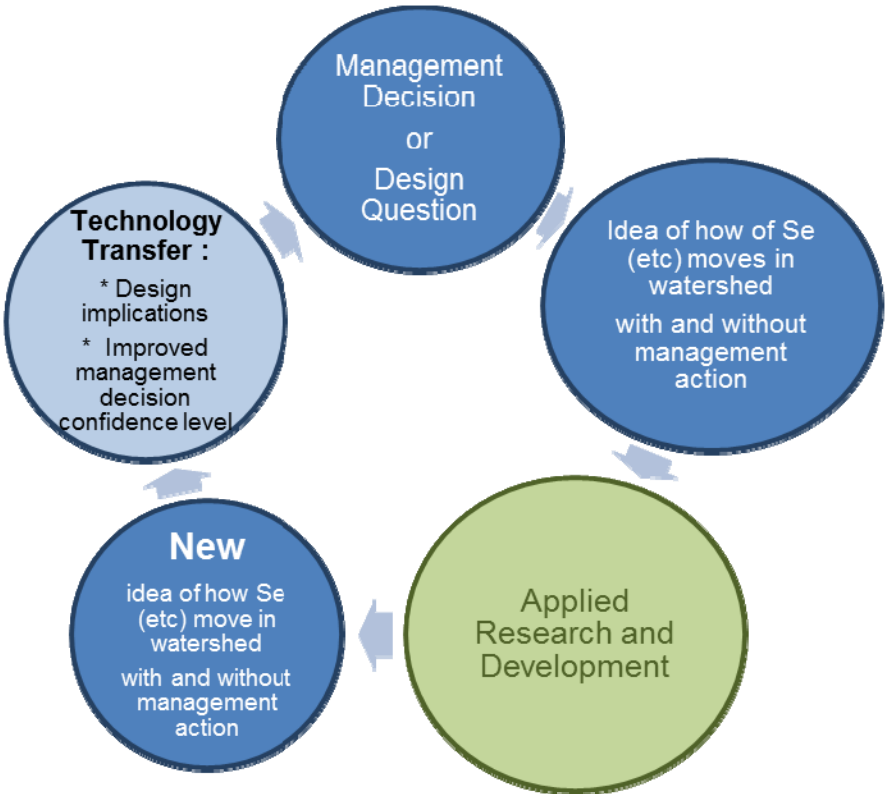

Figure 2. How R&D informs management decisions- the critical Technology Transfer step.

Technology transfer from applied watershed research to mine design recommendations must involve synthesis of research results from each of the research projects, weighing of results from one discipline in light of those found from other disciplines and then arriving at an integrated recommendation. This process of synthesizing results from multiple research projects from a range of scientific disciplines is central to developing confident design recommendations that can be broadly endorsed. Development and implementation of a process for technology transfer is a core focus of the Applied R&D program.

CONCLUSION

Teck has embarked upon on an integrated, applied research and development program that a) supports development of sound management plans, such that mine design changes can be made now to maintain watershed function in perpetuity, at all of Teck's coal mining operations, and b) generates innovative solutions to watershed issues. The overall applied R&D Program has a Se and watershed focus and is being developed using the US EPA (Environmental Protection Agency) DQO (Data Quality Objectives) process as a guide. The program is a multi- year, multi-disciplinary initiative designed to address the scientific and engineering uncertainties underlaying several key questions identified by various groups through the use of the DQO process as a guide. Research projects to advance understanding in the first 5 focal research areas commenced in

2012. Along with the research activities, development of a robust process for research synthesis and technology transfer is also underway.

REFERENCES

United States Environmental Protection Agency, 2006, Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4) 111 pages.