2017 British Columbia Mine Reclamation Awards

September 19, 2018, Williams Lake British Columbia

INTRODUCTION

Good evening everyone and welcome. For those of you that don't know me, my name is Jennifer McConnachie and I am the Manager of Mine Reclamation with the British Columbia Ministry of Energy, Mines, and Petroleum Resources. I am also the Chair of the Awards Sub-Committee of the Technical and Research Committee on Reclamation. And it is my job tonight to present the Annual BC Mine Reclamation Awards.

The TRCR established the Annual Jake McDonald BC Mine Reclamation Award, shortly after mine reclamation legislation was enacted in BC. As many of you know, BC has long been a leader in this area. This award is named for Jake McDonald, a former Senior Reclamation Inspector, and pioneering practitioner with the BC Ministry of Energy and Mines. In addition to the jade award, the committee can also recognize excellence in reclamation through category awards for metal mining, coal mining, sand and gravel operations, quarries, industrial mineral mines, placer mining, mineral exploration and coal exploration.

The awards may recognize work of various scopes and may be the result of a group effort or a single person's activities. These awards are assessed by the awards sub-committee based on:

- quality in research,
- innovation in techniques,
- quality of work undertaken,
- extent of land reclaimed, and,
- work of a high standard that has been conducted over a number of years.

I would like to acknowledge the thoughtful deliberations of other committee members in the nomination evaluation process, including Lauchlan Fraser, with Thompson Rivers University, Alan Gibson, with the Ministry of Environment and Climate Change Strategy, Jonathan Buchanan, with the Association for Mineral Exploration of BC, Ben Chalmers with the Mining

Association of Canada, and Tania Demchuk, with the Ministry of Energy, Mines and Petroleum Resources. I am pleased to report that we reached consensus, and all of the award decisions were unanimous.

To remind everyone, last year, due to the wildfires affecting much of the Cariboo region, the symposium was cancelled and no awards were presented. This year I will be presenting 2 awards. The previous symposium, which was also the 40th anniversary of the TRCR, had only one nomination, but the committee felt that nomination deserving of the jade award. Before presenting this year's awards, I will present the keeper trophy for the 2015 winner of the British Columbia Jake McDonald Mine Reclamation Award.

KEEPER TROPHY - 2015 JAKE MCDONALD MINE RECLAMATION AWARD

The winner was Thompson Creek Metals Company Inc. for outstanding reclamation achievements at the Mount Milligan Mine.

The Mount Milligan Copper-Gold mine is located halfway between Mackenzie and Fort St. James, in central BC, approximately 150 km northwest of Prince George. The Project underwent several separate phases of mine planning and feasibility assessment over a 15 year period prior to development, including two separate environmental assessment processes.

During those reviews, and in response to concerns from First Nations, regulators and other stakeholders, the original 1993 mine design was significantly modified to reduce the mine footprint by more than 1300 hectares; a roughly 48% reduction in mine footprint. The major mine plan changes included the relocation of the tailings storage facility as well as the realignment of the tailings dams to avoid key fish habitat. It also confined most of the mining activities and associated infrastructure to a very tight footprint within the King Richard Creek watershed. Although the modified mine design resulted in many positive changes for the project, the project was still going to impact approximately 9.5 hectares of stream habitat due to construction activities, which would result in the alteration of the natural flow regime. The

development of an extensive fish habitat mitigation and compensation plan was required to address this impact.

The compensation measures developed for the mine focussed on minimizing and mitigating habitat alterations and losses for rainbow trout, in particular for overwintering habitat, in the Rainbow Creek watershed. Thus, a key component of the habitat compensation plan was the construction of three large overwintering ponds, creating roughly 3 ha of new habitat. The ponds were designed to be hydrostatically connected to Rainbow Creek, but also at the same time, to be continually recharged by upslope streams and upwelling groundwater.

The overwintering ponds were constructed between 2012 and 2014. Each pond was sized to maximize the amount of overwintering habitat that could be created within the floodplain. Inlet waters to the ponds were directed over cobble cascades to aerate the water year-round, significantly adding to the winter oxygen levels. Outlets to the ponds were designed to promote trout passage, both at low flow and during flood conditions, and substrates were placed to provide habitat for insects, amphibians and juvenile fish.

Some of the innovative reclamation techniques used during the work included the collection of the original surface organic mat, preserving it through the construction phase, and then immediately placing it back over exposed areas. The natural seed bank and native roots of willow, scrub birch, rose and other local plants that were already in situ were then able to successfully revegetate the area.

To provide additional habitat, whole trees, including roots and branches were anchored into the pond floor and placed around the perimeter. While providing habitat for fish, these trees are also meant to provide habitat to aquatic insects, including several blue-listed dragon flies that inhabit the area. Snags were also "planted" at an angle over the water, providing perching habitat for birds.

The ponds were constructed in partnership with Duz Cho Logging, which is owned by the McLeod Lake Indian Band. The company is well-regarded for its high standards for safety and

for its quality workmanship, and several of the reclamation design aspects came directly from the expertise of the Duz Cho management and crews.

Effectiveness monitoring of the overwintering ponds confirms that all ponds are functioning as intended. Critical winter oxygen levels are maintained and fish presence in each pond has been confirmed. Vegetation on the pond edges had greater than 80% survival after two seasons and inlets and outlets of the ponds also remain stable and passable by fish year-round. Duck, geese, grebes and sandpipers have been observed using the ponds for nesting. Osprey have also been observed to be utilizing the inverted snags and have built a nest at the site.

The work to date at Mount Milligan, highlights that successful reclamation doesn't just happen at the end of mine life – it starts early in the planning process, and sets a stage for future success. Thompson Creek Metals was recognized for their exemplary efforts to significantly reduce the impacts to fish habitat at the Mount Milligan Mine through proactive mine planning. The company is also recognized for its research, planning and holistic approach to implementing the habitat mitigation and compensation works for the project. The positive relationship and strong partnership with the McLeod Lake Indian Band is noteworthy and also serves as an example to others.

Wes Chingee (Environmental Technician and member of the McLeod Lake Indian Band) and Daphne Hall (Environmental Advisor), both with Thompson Creek Metals Company Inc., accepted the 2015 Jake McDonald Mine Reclamation Award for the Mount Milligan Mine, and I would now like to call upon them to come forward and accept the keeper trophy.

2017 COAL MINING RECLAMATION AWARD

The award for outstanding achievement for reclamation at a coal mine is presented to Teck Coal Ltd. for their work to reclaim Horseshoe Ridge at Line Creek Operations.

Line Creek is an active coal mine located between Sparwood and Elkford BC. Mining in the Horseshoe Ridge area occurred between 1997 and 2012. The development consisted of 3 Pits and 62 Million bank cubic meters of rock placed in spoils. Original reclamation began in 2005 at the south and upper reaches of the Horseshoe Ridge spoils using the reclamation approaches that were implemented by Teck Coal at all of the Elk Valley operations at that time. These traditional approaches were focussed on achieving broad objectives of wildlife habitat and moderate yield forestry using predominantly agronomic legumes and grasses.

Since then Teck Coal has made a fundamental shift in reclamation and end land use planning approaches. This transition gained traction in 2011 when the company committed to achieving a Net Positive Impact on Biodiversity for their mining operations. In order to define the criteria for meeting the NPI goals, the company engaged with local communities, the Ktunaxa Nation, regulatory agencies and other interested parties and conducted arduous office-based exercises to backcast the pre-mining ecosystems and land uses. The new approach is intended to model natural, local, and relevant ecosystems and develop reclamation prescriptions that will establish ecological trajectories that will mimic the natural ecosystems that are targeted. With this approach, it is acknowledged that land uses will change as ecosystems change and provide different functions over time.

The Horseshoe Ridge area, comprising about 100 ha, provided the opportunity to practically test the new approach. The reclamation efforts required a coordinated approach between the reclamation team and equipment operators to get it right. Prescriptions were prepared with the best information available at the time, with no agronomic species included. In fact, there were species selected that not many people have used previously on mine sites, such as Mountain Sorrel. The prescriptions were implemented on the lower lifts of the spoil complex in 2012.

In areas that had already undergone reclamation activities, in fill planting was used in attempts to transition the previous approaches to the new standards. In previously reclaimed areas, the ground was reworked and prepared with the new techniques and new prescriptions supportive of the new end land use plan.

In 2013 and 2014, approximately 250,000 seedlings were planted, including 34 different native and culturally important species, several of which neither Teck nor their partner nurseries had experience propagating or planting in the past. In 2016, the site was overseeded with a low competition, native grass seed mix to assist with developing structure and increasing species diversity.

Preliminary results from monitoring conducted using the new Vegetation Quality Assessment approach that compares vegetation communities establishing in reclamation units to relevant natural benchmarks, indicates that the approach is working. I believe Teck will be sharing the details of the VQA method with the mine reclamation community in the near future.

The nomination cited that the success of the Horseshoe Ridge project could not have occurred without the passion, dedication, drive and energy that Teck, the Ktunaxa Nation, regulatory agencies and local community groups committed in support of a concerted shift away from the practices in mine reclamation previously conducted in the Elk Valley. The site is one of the best examples of reclamation in the Elk Valley coal mines currently, and it illustrates the fundamental role that detailed ecosystem-based planning has in successful mine reclamation.

I now wish to call upon **Warn Franklin (Environmental Superintendent)** with Teck's Coal Ltd. to please come forward and accept the award for outstanding Coal Mine Reclamation for the reclamation of Horseshoe Ridge at Line Creek Operations.

ANNUAL BRITISH COLUMBIA JAKE MCDONALD MINE RECLAMATION AWARD

On behalf of the Technical and Research Committee on Reclamation, I am very pleased to announce that the recipient of the 2017 British Columbia Jake McDonald Mine Reclamation Award is Teck Highland Valley Partnership for outstanding reclamation achievements at Highland Valley Copper.

The Highland Valley Copper mine is located approximately 17 km west of Logan Lake BC. Mining in the area started in 1962 and continues to present day. In the early 1990s, HVC began to assess the potential of its tailings ponds and pit lakes to simultaneously function as aquatic habitat and as passive water treatment facilities. The resulting progressive reclamation of the Bethlehem, Trojan, and Highmont tailings ponds, and the Heustis, Iona, and Jersey pit lakes that has occurred over 20+ years demonstrates that Highland Valley Copper is a global leader in this area of mine reclamation science. It is for their work in reclamation research and biomonitoring with the goal of achieving productive end land uses and improving water quality for aquatic mine facilities that we are recognizing Highland Valley Copper today.

Transforming a tailings pond or a pit lake into productive habitat AND a bioreactor is a complex process that requires a great deal of time, patience and resources to cultivate the right ecological conditions and functions. The efforts made to keep working to fine tune the reclamation recipes, so to speak, illustrates a strong commitment to find innovative solutions to reclaim these challenging mine components.

The dual function of these systems requires a constant supply of biologically and chemically active particulates to interact with dissolved metals in the water column. Adsorption of metals onto algae and bacteria is an important form of metal removal, storing metals in the sediments as the cells die. In addition to metal removal, accumulation of these organic sediments is essential to support biological processes..

At HVC, bacterial colonization of tailings sediments began without assistance once suitable water quality conditions were achieved. However, substrates and plants from established ponds

and water bodies were added as ingredients to accelerate the process. Filamentous algae enclosed in netting were introduced to help provide organic carbon to the aquatic system. As organic sediments developed, sulphate reducing bacteria began to establish in the anoxic zone within the sediments, resulting in the formation of a sink for aqueous metals through biochemical reactions.

Zooplankton and invertebrate species were also infused using a screened bucket, as well as through introduced plants and hay bales which had been soaked in adjacent water bodies. Plant species were added using root frames, seed dispersal and transplantation of the upper sediments from established plant beds in nearby water bodies. While the plants did not always survive the transfer, root fragments and seed banks in the sediments generated new plants.

Riparian vegetation was established around the tailings ponds through planting of willow and cottonwood live stakes and living logs, as well as plug planting of tree and shrub species. Trials demonstrated that the most successful method for live staking was to plant stakes as soon as the tailings thawed in the spring. Additional riparian vegetation was planted in the fall, during low water levels. This program included the placement of 20 cm by 20 cm plugs of sedges, reeds and cattails dug out of donor wetlands, and cattail seed heads pressed directly into the exposed tailings.

Once plants, invertebrates and fish species had established, specialized habitat features were developed for each of the three ponds. These features included spawning channels, side channels, nesting islands or boxes, shelter belts, and shade rafts.

The results are that Trojan pond now supports a self-sustaining rainbow trout fishery AND acts as a bioreactor to reduce metals in the water column, including molybdenum and copper. Waterfowl use of the reclaimed Bethlehem pond has increased steadily since 2011. And the Highmont pond provides significant waterfowl and shorebird habitat. Reclamation monitoring programs have found that the ponds are used by over 20 animal species, 150 bird species, amphibians and more.

Converting pit lakes into bioreactors is similar, but the different morphology means different problems to solve and ingredients to add. This work has included correcting nutrient imbalances in the water column, addition of B vitamins, and increasing habitat complexity. Learnings from the tailings pond work informed methods used in the pit lakes, specifically the need for colonization of the ponds by bacteria and algae to support the development of a functional system. Fertilizer was added to stimulate algal blooms, the accumulation of organic sediments and adsorption of metals. Initial results suggest that large algal blooms, such as the first bloom that occurred in the Iona pit, can remove between 3 to 10 % of the dissolved molybdenum and 4 to 25 % of the dissolved copper from the surface water layer.

Similar methods to those used for the tailings ponds were used to colonize the flooded pits with bacteria, algae, aquatic plants, and invertebrate species. The resultant pit lakes were stocked with kokanee and rainbow trout. Monitoring has identified the importance of B vitamins in the development of benthic algae. HVC has trialed a number of methods to introduce B vitamins and stimulate algal growth, including induced artificial upwelling of bacteria and vitamin-rich bottom water, addition of organic amendments and compost, expansion of substrates where algae and bacteria grow together using rafts, reefs and aquatic plant beds, and diversifying available habitats.

In order to create a control for comparison, the Jersey pit has not been fertilized since 2000. As a result, the main factors controlling metal concentrations are inflowing surface and subsurface drainage and evaporation, rather than biochemical mechanisms. Total copper and molybdenum concentrations in Jersey exceed guidelines with an increasing trend. In contrast, a semi-permanent anaerobic layer has developed in the shallower and warmer Heustis pit lake, which hosts sulphate reducing bacteria that can remove metals. Since 2011, there has been a decreasing trend in copper, molybdenum, phosphorus and nitrogen concentrations in the Heustis pit.

The Iona pit is deep enough to form a non-mixing bottom layer and is seen as a proxy to how the Valley and Lornex pits will act when these are reclaimed at the end of mine life. The anaerobic zone within the non-mixing layer is expanding and becoming increasingly anoxic. Most of the biochemical metal removal occurs within the upper 10 meters and includes statistically

significant removal of copper, molybdenum, magnesium, silica, sulphate and calcium, particularly during annual ice free algal blooms where the dramatic changes in surface water chemistry also include decreases in nitrate, phosphate, sodium, calcium, silica and potassium. The Iona pit was not fertilized between 2011 and 2016 to study the rate of decline in productivity. Study results indicate that the decline was slower than expected; however continued fertilizer addition is needed to maintain productivity.

Importantly, the ongoing monitoring that has occurred over the past 20 years has not detected biomagnification of metals through the food chains developed in the water bodies and surrounding riparian areas.

The work conducted at Highland Valley Copper to date demonstrates that tailings pond and pit reclamation can simultaneously achieve desired functions of aquatic habitat and passive water treatment facilities, by harnessing natural processes and establishing native species. This research to develop recipes intended to enhance the capability of these post-mining aquatic features is not only important for HVC in their endeavour to achieve successful reclamation, but also will help the mining industry as a whole learn to do the same.

It is now my distinct pleasure to call upon **Jaimie Dickson (Environmental Supervisor)** with Teck Highland Valley Copper Partnership to please come forward and accept the 2017 British Columbia Jake McDonald Mine Reclamation Award for Highland Valley Copper.

CLOSING

That concludes the award presentations for this year. On behalf of the TRCR, I would like to congratulate the winners. And I also want to recognize all of the companies and individuals that are so committed and involved with mine reclamation throughout the province. We look forward to seeing you next year.