

**DEVELOPMENT AND UTILIZATION OF AN END LAND USE PLAN  
FOR HIGHLAND VALLEY COPPER**

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**ABSTRACT**

At the end of mine life an estimated 6900 hectares of land will have been disturbed at the Highland Valley Copper minesite. The Reclamation Permit for the property requires reclamation to a variety of uses that are compatible with the existing surrounding use. In 1998, a comprehensive End Land Use Plan was developed for the operation that incorporated reclamation work done to date and provided guidance for future reclamation activities. Five land use categories and eight landform units were defined and developed into a conceptual large-scale plan. Detailed planning is now conducted on a site by site basis to achieve the goals of the plan.

The paper describes both the methodology used to develop the plan and how the plan is now used on a daily basis.

**INTRODUCTION**

Mineral exploration and mining activities have been a part of the land use in the Highland Valley area since 1954. To date, mining within the area of Highland Valley Copper's Reclamation Permit M-II has disturbed approximately 6200 hectares. The operation closed indefinitely in May, 1999, due to low metal prices, however, the mine plan envisages a further ten years of mining activity.

In the late 1980's, Highland Valley Copper initiated large-scale reclamation activities. Initial reclamation was based on the recommendations in "Reclamation and Land Use Plan for Lornex Mining Activities Area in Highland Valley" (Runka et al., 1984) and the "Highland Valley Copper Reclamation Plan", (Jones, 1987). In general the land uses recommended in the 1984 and 1987 plans were integrated uses of grazing, non-commercial forestry, and wildlife. To date, 1675 hectares of inactive Lornex, Highmont and Bethlehem mining areas have been returned to productive use through seeding of agronomic grasses and legumes, planting of native shrubs and

trees, and transplanting of aquatic and wetland plant species. In addition, reclamation of aquatic areas has demonstrated their potential for recreational fisheries and wildlife use.

The early land use plans slowly became outdated as more knowledge was gained concerning the capability and productivity potential of different areas of the site. The decision was made in 1997 to develop an updated land use plan. A long range plan was needed to both guide ongoing reclamation activities and assist with evaluation of reclamation success by Highland Valley Copper and regulatory agencies. What resulted is a conceptual, large-scale plan that is actively used to guide reclamation activities. Detailed planning is done on a site by site basis to fit within these concepts. The plan will continue to be updated to reflect changes in the mine plan and as new information is developed about sites' suitability, land capability, plant species sustainability and wildlife use.

## **MINE DEVELOPMENT**

Surface development at the site includes the following activity areas:

**Open Pits.** There are six open pits including the active Lornex and Valley pits and the inactive Jersey/Iona, Heustis, and Highmont East and West Pits. Open pit disturbance at end of mining is expected to total approximately 870 hectares.

**Waste Rock Dumps.** Waste rock dumps flank most open pits on all sides. Total disturbance by dumps is expected to be approximately 2200 hectares.

**Tailings.** There are four tailing impoundments on the site including the active Highland tailings impoundment, and three inactive impoundments at Bethlehem Main, Trojan and Highmont. Total disturbance by tailings is expected to be approximately 2700 hectares.

**Infrastructure.** One active and two inactive plant sites are located on the property. No significant reclamation can begin at the Highland site until mining is completed. At the inactive Bethlehem and Highmont plant sites most of the structures have been dismantled or relocated and a total of 70 hectares have been capped with soil materials and revegetated.

**Watercourses.** Water diversion works have been constructed in several locations to increase volume of water available for the operation and divert flows around active areas. Reestablishment of watercourses or permanent reclamation to new watercourses will not begin until after mining operations have ceased.

**Linear and Associated Disturbances.** Linear disturbances include roads, tailings lines, ditches, exploration paths, natural gas and powerline right-of-ways, a pipeline corridor from the Thompson River and borrow pits. To date disturbance of this type totals 936 hectares. In general, linear disturbances were not included in the conceptual land use plan. Addition plans for reclamation of linear disturbances are being developed to fit within the framework of this conceptual plan.

## **RECLAMATION OBLIGATIONS AND EXEMPTIONS**

### Reclamation Obligations

Highland Valley Copper's reclamation obligations are specified in Reclamation Permit M-II. The Permit identifies requirements to reclaim land to a variety of uses, which include grazing, non-commercial forestry, wildlife, and agriculture and water storage. To achieve these goals, the reclamation objectives at Highland Valley Copper are as follows:

- Develop a self-sustaining vegetation cover using a combination of agricultural and native species to achieve specific land use objectives for the various types of disturbed areas;
- Achieve a level of productivity on the reclaimed mine land equal to that which existed prior to mining on an average property basis; and,
- Meet the water quality guidelines as set out by the Environment Protection Branch of the British Columbia Ministry of Environment, Lands and Parks.

In addition to the requirements specified in the Reclamation Permit, Highland Valley Copper has the obligation to provide a replacement recreational lake in compensation for Little Divide Lake which was utilized for sport fishing prior to mining disturbance.

### Reclamation Exemptions

Areas of the Bethlehem site were developed before the enactment of reclamation legislation in 1969 and are specified in the Reclamation permit as being exempt. As well, the permit exempts 5 percent of the surface area of the other Bethlehem dumps and 15 percent of the surface area of the final dump slope faces at Lornex.

## **RECLAMATION POTENTIAL OF MINE WASTE**

While developing the End Land Use Plan consideration had to be made of the different types of disturbances which require varying reclamation treatment. Each waste material has different physical or chemical characteristics, some of which constrain plant production. In addition, varying site conditions, such as slope or aspect, further limit revegetation options. Finally, significant elevation and climatic differences occur between mining areas resulting in necessary variations in revegetation prescriptions. The growing season is short, averaging only 20 freeze free days in the higher locations. Precipitation during the growing season is generally low, an important consideration given the low water holding capacities of the waste material.

## **PLAN DEVELOPMENT PROCESS**

CE Jones and Associates, the primary reclamation consultant for Highland Valley Copper, was engaged to develop the plan in conjunction with mine staff. A number of essential principles were established to guide the development of the plan.

- A conceptual, large scale planning process would be used. Detailed planning would be done later to achieve the goals of the conceptual plan.
- The plan was to incorporate reclamation work done to date. Massive reworking of previously reclaimed sites was unacceptable. Ultimately however, the final plan did require some reworking to establish wildlife travel corridors.
- The Land Use Plan would be driven by the Mine Plan. Within reasonable limitations, the final topography would be determined by what was the most effective way to mine the ore body.

Once the basic categories of use and appropriate landform units had been established, the development of the plan proceeded on two fronts. Descriptive text was developed to define the different categories of use, and reclamation prescriptions were written to compile the best available knowledge of appropriate reclamation techniques for the different areas of the site. The actual layout of plan was developed using orthographic images of the site, mine plans showing ultimate dump and pond layouts, field visits and considerable debate.

Early versions of the plan were reviewed with regulators from several Ministries on a number of occasions with their comments being incorporated into the plan. More comprehensive stakeholder involvement will be a part of future planning as the mine moves closer to a permanent closure. The final plan was presented to and subsequently approved by the South Central Mine Development Review Committee in 1998.

## CATEGORIES OF USE /LND LANDFORM UNITS

An important component of the End Land Use Plan is the utilization of the concepts of "Categories of Use" and "Landform Units". Five principal categories of land use were identified early in the planning process. The categories:

Agriculture	Wildlife	Mixed Use
Aquatic	Recreation	

are described below. Other optional uses are briefly discussed at the end of the section.

Eight landform units were developed:

Cropland	Grassland	Shrubland
Mixed Forest	Wetland	Shallow Pond
Lake	Reservoir	

Reclamation prescriptions were then established for each unit. Some landform units are found in only one category of use while others appear in several categories.

### Suitable Post Mining Land Uses

The Reclamation Permit cites requirements for reclaiming land to a variety of uses that are compatible with the existing, surrounding use. These uses may include grazing, non-commercial forestry, wildlife, agriculture and water storage. In addition to the reclamation potential of the waste materials which limits land use options for certain sites and materials, allocation of disturbed land to a certain post-mining use requires consideration of the present use adjacent to the mining property.

**Agriculture.** Livestock grazing in the Highland Valley existed before mining and presently continues in the surrounding areas during the summer months. A number of operators hold grazing licences within the range units that border the mine site.

Re-establishing summer cattle use on the site requires the development of open or semi-open forage areas with access to a suitable water supply. The sites reclaimed to date have exhibited substantial forage productivity capable of supporting summer grazing. In general, lower elevation dumps are suitable for early summer and fall grazing, with higher elevation dumps being suitable for mid-summer grazing. At this time, Highmont tailings has

not been designated for grazing use as the impact of the molybdenum concentrations in Highmont forage on grazing live stock has not been adequately determined.

Conflicts between cattle grazing and moose wintering in the area became an important parameter in the planning process. Adequate range for both agriculture and wildlife uses were accommodated in the end land use plan for the Valley areas. Competition can be limited by restricting cattle use of the Valley areas after mid September and fencing to restrict cattle access to critical moose habitat.

In addition to summer forage, establishing a hay base on the property would be supportive of a future cattle operation. Highland tailings pond is the most suitable for this use due to the potential availability of water for irrigation, flat topography, and valley bottom location with a desirable climate for growing hay.

**Wildlife.** Information concerning wildlife use in the surrounding area is limited. Land capability for optimum ungulate habitat is restricted by poor distribution of landforms and rooting zone depth due to shallow soils over bedrock. Summer use offsite is believed to be at higher elevations in both the Bethlehem and Highmont areas. Aerial surveys have identified significant moose numbers wintering on the south facing slopes of the Bethlehem area, lower elevation forested areas of Lornex, and lower elevation semi-open Valley areas. Providing adequate cover in corridors on the mine site for ungulate travel from summer to winter areas was considered a critical end land use component.

Mule deer currently access most areas of the property during spring through fall months. Summer use by moose is more commonly observed on portions of Highmont tailings, Highmont dumps, and Bethlehem dumps. The waste rock dumps on Lomex, Bethlehem and Highmont are suitable for summer browse for ungulate use. Browse islands, identified as "shrublands" in the plan are foraging areas patterned to provide sufficient escape cover for deer movement. Line of site breaks (woody debris, rock piles, topography changes) will be utilized to provide additional escape cover.

**Mixed Use - Agriculture and Wildlife.** Substantial portions of the Bethlehem, Lornex and Highmont waste dump areas are designated as mixed use for wildlife and livestock grazing. This occurs particularly on summer range areas where conflicts between cattle and mule deer are expected to be low. Open "grasslands" are interspersed with "shrublands" at a ratio considered to be suitable for mule deer: approximately 60 percent grasslands to 40 percent shrublands.

**Aquatic.** Current production of waterfowl in areas surrounding the mine property is severely restricted due to limited wetland development. Undisturbed lakes have been classed as having moderately low capability for waterfowl due to marsh edge and water depth limitations.

Development of nesting and feeding areas is planned for lowland areas surrounding Trojan, Bethlehem and Highmont tailings impoundments. Both "wetlands" and "shallow pond" units are planned for lowland areas around the Highland tailings pond, however the final topography in this area is less certain.

Various lakes in the surrounding area have been utilized over the years for sport fishing and canoeing. Highland Valley Copper has the obligation to develop a replacement lake in compensation for a lake drained during the development of the Valley Pit. Establishment of aquatic vegetation and a recreational fisheries resource has been initiated at Trojan tailings and the Heustis and Highmont East pits.

The Lornex, Valley, Highmont West, Jersey and Iona pits are designated as "reservoirs" of water. Insufficient littoral zones in these pits suggest that the development of productive lakes is unlikely. The potential for utilizing water stored in the Highland tailings pond for the production of electrical power or irrigation water in the Thompson valley is a consideration through an existing pipeline to the Thompson River. The quality of water stored in these sites and its suitability for irrigation or other uses will be considered.

**Recreation.** Other than sports fisheries, other outdoor recreation pursuits within the general vicinity orient towards hunting, snowmobiling and cross-country skiing. These recreational uses were not specifically addressed in this plan, but neither were they limited by the present reclamation goals. Additional considerations of post-mining recreational uses of the reclaimed land will occur during the development of a Post-Mining Access Management Plan.

### Landform Units

The following section provides descriptions of the landform units identified in the plan. General reclamation prescriptions for achieving the vegetation cover and productivity desired for each unit is explained. Reclamation prescriptions will be modified over time as further information is gained from ongoing reclamation research projects and the evolving performance of previously reclaimed areas.

**Cropland.** A cropland unit has been allocated to the lowest elevation tailings site, Highland tailings, where climatic, topographic and ground, (soil), conditions for cultivation are most favourable. The mapped unit encompasses approximately 1000 hectares. Irrigation of the unit for hay production is probable due to abundant water availability and installed pumping facilities.

Reclamation prescriptions to achieve production of perennial grasses and legumes on Highland tailings will be based on experience gained from reclamation work on Bethlehem tailings. Revegetation of the Bethlehem tailings area is almost complete with the site sustaining a non-irrigated cover of predominantly pubescent wheatgrass, timothy, orchardgrass, bluegrass, red fescue and alfalfa. Initial revegetation efforts of the tailings will require application of high phosphate fertilizer and drill seeding of forage species. Where wind erosion is a serious concern, asphalt emulsion may be applied after seeding to provide stability until vegetation is established. Alternative reclamation practices including organic amendments, such as biosolids and wood chips, to aid in erosion control and provide nutrient additions will continue to be utilized where appropriate.

Fencing around the perimeter of the site will be required to limit animal grazing during summer months and to contain cattle during the fall grazing period.

**Grassland.** Open grassland units will be established on upland sites on both waste rock dumps and on tailings that are relatively dry and well drained. The primary use of the grassland units is livestock grazing. Grazing use is likely to occur in conjunction with the adjacent Crown range between mid May and mid September. Some wildlife use will also occur, particularly on forest edges where wildlife such as mule deer will venture out onto grasslands for foraging. Other species, such as moles, voles, mice and marmots, will colonize the grasslands utilizing the vegetation as both cover and forage. Predator species such as coyotes, hawks and owls will hunt for prey inhabiting these areas.

The vegetation community will consist of legume and grass species. The longevity of legumes is likely to be limited by grazing impacts. Over time, these units will be composed primarily of drought tolerant species such as crested wheatgrass, red fescue and pubescent wheatgrass. Establishment of islands of native shrub species in the grasslands will help to promote diversity of plant cover and animal use.

In areas designated for wildlife use only, cattle will be excluded by fencing. Grassland units where cattle are excluded are planned for locations where the wildlife values in the adjacent area is high, or where the suitability of forage with high molybdenum concentrations for cattle grazing has yet to be demonstrated.



**Shrubland.** Shrubland units will be established on both waste rock dump and tailings areas. The primary use of the shrubland units is wildlife. The shrublands will provide a source of browse for ungulates, plus some thermal and visual cover for small mammals, game birds and songbirds.

In locating and spacing the shrublands, consideration was given to the typical movement patterns of mule deer and moose. The wildlife travel routes utilize a variety of features which will provide cover for security for wildlife as they travel through an area: undisturbed areas, terrain features such as gullies, pit walls, and benches, berms, swales, wood debris piles, and planted shrublands. Shrublands at Highland Valley Copper are planted as distinct, shrub dominated communities, decreasing the competition with forage species and improving shrub survival. Candidate species are selected for the different areas of the minesite due to variations in material types, soil moisture conditions, aspect, and elevation. Shrub selection also considers the requirements of the wildlife using the different areas. Species commonly used in the reclamation program include aspen, balsam, poplar, willow, rose, saskatoon, sage and others.

**Mixed Forest.** Mixed forest units will be established in areas where travel by wildlife, particularly moose, is required. Typically, this land use unit will consist of wide, densely planted areas of trees and shrubs located in corridors across sections of the minesite.

Deciduous shrubs and trees will provide browse, plus visual and thermal cover in summer. Coniferous trees such as lodgepole pine, Douglas Fir and Interior Spruce at higher elevations, will provide visual and thermal cover and are particularly important for moose wintering areas in Valley and portions of Bethlehem. In order to encourage moose utilization, the width of corridors will range from 100 to 300 metres, depending on corridor length and site topography as recommended by the Ministry of Environment, Wildlife Branch. In general, longer corridors will be wider.

**Wetland.** The wetland units are vegetated lowland areas surrounding shallow ponds and lakes. The vegetation community will consist of grass, forb and shrub species. Due to the mixture of vegetation units established and the presence of water, wetland areas will be utilized by a variety of wildlife.

Wetland revegetation efforts have begun on the Bethlehem, Trojan and Highmont tailings ponds. Species selected are palatable for a variety of wildlife species and are chosen for their cover value. Collection of plant materials for propagation and transplanting is conducted from on-site and near-site sources. To enhance vegetation establishment and growth, fertilizer is periodically applied.

**Shallow Pond.** This land unit consists of small water bodies of shallow depth generally surrounded by wetlands. Depending on the degree of aquatic vegetation establishment and the presence of aquatic Invertebrates, these sites could be utilized by waterfowl for feeding with the surrounding vegetated areas providing forage, cover, and nesting habitat.

Establishment of aquatic vegetation has been initiated in ponds on Bethlehem and Highmont tailings. Wire mesh is used to construct vegetation mats for transplanting from on-site sources to receiving pond bottoms. To enhance vegetation establishment and growth, nutrient levels in water are periodically monitored and when necessary, fertilization is conducted. The success of vegetation establishment in the shallow ponds is dependent on the final or stable water level of the ponds, which is currently unknown.

**Lake.** This unit consists of deeper water bodies that have the potential for sustaining aquatic vegetation and fish populations. Lakes are proposed for Trojan and Highland tailings and the Heustis and Highmont East pits. Lakes may contain shallow areas and may be surrounded by wetlands. With established aquatic vegetation and the presence of aquatic vertebrates/invertebrates, waterfowl will use the shallows for feeding with the surrounding vegetated areas providing forage, cover and nesting habitat. As with shallow ponds, the lake units will provide habitat for small mammals and be a source of drinking water for a variety of wildlife species and livestock.

Hatchery fry were used to stock Trojan tailings in 1993 and 1994. A spawning channel installed in 1995 has resulted in a large trout population that is being used to stock other water bodies on the site.

**Reservoir.** This unit consists of deep water bodies which will be established as a result: of pit flooding. The potential for these water bodies to sustain a viable fish population is unknown and will depend on the ultimate water level, extent of littoral zone and water quality. Stored water may be of use for irrigation or livestock watering depending on post-mining water quality.

## **PLAN COMPONENTS AND DAILY USE**

The Plan is composed of two components, text and maps. The text describes the elements of the plan in detail along with the reclamation prescriptions required to achieve the land use goals. While the text is an essential part of the plan, it is the maps that have come to be used the most.

The maps were developed using Highland Valley Copper's GIS system. Plan components, including areas of completed reclamation, were superimposed onto an orthographic image of the mine site and surrounding area. Map sets ranging from 11x18 inch detailed segments used for detailed field planning to 8 x 6 foot murals were

generated. The maps are referred to daily for discussions and decisions covering many topics including the required thickness and quality of capping material in different areas, seed selection and planting requirements. As the mine engineering group develop details of the final topography for various parts of the site, detailed planning is done to incorporate the goals of the end land use plan. When possible, priority is being given to the creation of the Mixed Forest corridors as these are a new feature and the reclamation prescription for this unit is still being refined.

## **ONGOING AND FUTURE PLANNING ACTIVITY**

Following the completion of the plan in 1998, detailed planning has begun for specific aspects of minesite decommissioning. As a part of this process, an entirely new potential use was identified for the pit lakes designated in the plan as reservoirs. Highland Valley Copper is currently investigating the feasibility of leasing the pit lakes for an aquaculture operation to raise salmon fry.

Future development and updating of the post-mining management plans will be conducted with appropriate stakeholders. This will included the development of:

- Access Management Plans in preparation for road deactivation and post-mining recreational uses;
- Water Management Plans to guide watercourse reconstruction, reservoir deactivation, irrigation water supply and waterhole installations for cattle and wildlife management; and,
- Cattle Management Plans to guide fencing activities.

As required in the Reclamation Permit the End Land Use Plan will be completely updated in early 2003 to reflect the knowledge learned from ongoing research and operational results.

## **REFERENCES**

Jones, C.E. 1987. Highland Valley Copper Reclamation Plan

Runka, G.G., C.E. Jones, and R.B. McTavish. 1984. Reclamation and Land Use Plan, Lornex Mining Activities Area, Highland Valley Copper. Volumes I and II.