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# Whitewood Mine closure

**D.D. MacKenzie** *Navus Environmental Inc, Canada*

**K.N. Renkema** *Navus Environmental Inc, Canada*

**D.V. Kuchmak** *TransAlta Corporation, Canada*

**G. Janssen** *Prairie Mines and Royalty Ltd, Canada*

## Abstract

*Transalta's Whitewood Mine is one of three TransAlta*-owned surface coal mines. *It is located north of Lake Wabamun, about 70 kilometres (43 miles) west of Edmonton, Alberta, and has been in operation since 1962. The mine is in the final stages of closure after almost 50 years of operation. To date, approximately 1665 hectares of post-disturbed land has been reclaimed, including one end pit lake, numerous wetland features, woodland/wildlife areas revegetated through assisted natural recovery and in the majority, perennially cropped agricultural lands. A total of 890 hectares of reclaimed land has been certified with another 480 hectares in process with the regulators. The remaining 210 hectares will be reclaimed to include two end pit lakes surrounded by wildlife/wetland habit thus completing the reclamation closure plan.*

*Current challenges for the closure of Whitewood Mine include a topsoil deficit (Parkland forests have very little topsoil) for placement, erosion control around the end pit lakes, weed control, reforestation, shoreline and wildlife habitat revegetation and end land use transfer. Given the lack of topsoil on pre-mined lands, vast areas have been reclaimed using only suitable overburden resulting in the creation of mostly class 3 to 5 agricultural capabilities. Past studies on the mine show the overburden is of good quality and with proper fertilization the crop yields are equivalent to areas reclaimed with topsoil. Reclamation practices have evolved overtime along with regulatory requirements. Proposed adaptive management practices to overcome these challenges are discussed.*

## 1 Introduction

Whitewood Mine was an open pit sub-bituminous coal mine that supplied coal to the Wabamum Thermal Generating Plant. The mine and generating plant are one of three such facilities in Alberta that are owned by the TransAlta Corporation. The Wabamum Thermal Generating Plant was constructed in 1956 and initially used natural gas to generate electricity. Mining began at Whitewood Mine in 1962 and was terminated in March 2010 in conjunction with the shutdown of the generating plant. Mining in east and west directions resulted in the creation of an east pit and two west pits. Mining in the east pit area was completed in 1980 and no coal was removed from the east pit after 1982. Mining in the west pit areas continued until 2010. The mined out area covers nearly 1900 hectares and at its widest point it spans 10 km.

During the mine's operation progressive reclamation was carried out in accordance with regulatory requirements and TransAlta's reclamation goals. As regulations and goals changed over the mine's lifetime reclamation practices had to be continually adapted. Earlier reclamation regulations required little or no soil salvage and placement while more recent reclamation requirements required the salvage of topsoil and the establishment of agriculture land with capabilities that were equivalent or better to the pre-disturbance capabilities. Currently, Whitewood Mine is in the process of abandonment and final reclamation (mine closure).

Whitewood Mine has had many reclamation successes in the past; however, as the mine nears closure there is a lack of salvaged material, yet, an end pit lake, surrounding wildland and productive agriculture land must be created. Past reclamation techniques used at Whitewood Mine are presented to provide context for the final reclamation plans. A description of the final reclamation plans shows how reclamation techniques will be adapted to conditions at Whitewood Mine. Information regarding Whitewood Mine was obtained from Whitewood Mine Annual Reports (TransAlta Corporation, 1983–2009) unless noted.

**Figure 1 Aerial imagery of Whitewood Mine in 2009. The mined area is outlined in white, two proposed end pit lakes are shaded black on the left side of the image and East Pit Lake is located on the right side of the image**

# 2 Site description

Whitewood Mine is located north of Lake Wabamun, about 70 kilometres (43 miles) west of Edmonton, Alberta (53° 35' N 114° 32 W). The mine is located within the White (agricultural) Zone of Alberta, and reclamation goals, until currently, were primarily orientated toward the re-establishment of agricultural capability (vs. forestry or wildlife habitat).

The climate is characterised by a mean summer temperature of 18.5°C, a mean winter temperature of –12.1°C and a total mean precipitation of 333 mm. Prior to mining, the Whitewood Mine area consisted of low lying peatland and upland forests of deciduous and coniferous trees. Scattered fields used for pasture or to grow forage crops were also present; however, agriculture was limited by short growing seasons, poorly drained soils and poor soil texture. The topography was nearly level to gently sloped (0 to 9%), and two lakes (Whitewood Lake and Lake A) were located on the west half of the present day mine.

Soils in the area consisted of orthic gray luvisols, orthic humic gleysols and humic luvic gleysols with pockets of organic soils. Typical topsoil textures varied from gravelly loamy sand or silty loam over a loam or clay loam till. The approximate average depth of the topsoil was 0.20 m. Under the surficial deposits was a glacial till that consisted of silt and clay with some pebbles with rare occurrences of cobbles and boulders. It had an average approximate depth of 4 m. Sands and gravels at the base of the glacial deposits are pre-glacial in origin although some reworking during glaciations may have occurred. There is approximately 3 m of this material. The parent materials are generally non-sodic. The overburden overlying the coal zone is from the Paskapoo formation and is characterised by fine to coarse grained sandstones. The overburden is non alkaline and non-sodic, making spoil material suitable for reclamation material, and its thickness ranges from 10–28 m. Six coal seams are mined varying in thickness from <1 m to almost 4 m. Combined the seams can have a total thickness of 16 m (Northwest Corporation, 2009). Interburden thickness can range from 1–10 m.

The agricultural capability of the Whitewood mine area represents the underlying productive capacity of the land based on the quality of the soils, topography and drainage and local climatic conditions. Increasing slope angle/or complexity of slopes decrease the land's capability to support agriculture. The presence of stones, low organic matter content of overburden, hard-pan layers and poor drainage also limit agricultural capability. Pre-mine land capability ranges from Class 2 (moderate limitations for agriculture) through

Class 7 (no agricultural capability) (for a description of agriculture classes refer to Agriculture and Agri-Food Canada, 2008; Leskiw, 1993). Currently, land surrounding the mine is used for agriculture, annual crops, forage crops and pasture, and small patches of trembling aspen and spruce forest remain between fields. East Pit Lake and surrounding areas are used for recreational purposes.

# 3 Reclamation regulations and certificates

Reclamation requirements for Whitewood Mine were improved over its years of operation. Prior to 1983, topsoil was not salvaged, between 1983 and 1991 topsoil salvage was required if it was deeper than 15 cm, and all topsoil was salvaged after 1991. Topsoil was required to be placed on all areas disturbed between 1983 and 1991 to a depth of 0.15 m. For areas disturbed between 1992 and 1997 topsoil was required to be placed at a depth of 0.2 m, and after 2002, it was to be placed at a depth of 0.15 m for all class 2 and 3 agriculture lands. Topsoil replacement depth requirements varied between 1997 and 2002 as the land had to be reclaimed to meet predetermined agriculture capabilities. For areas where topsoil was replaced, it had to be put back over at least 1 m of subsoil or suitable spoil; soil that has a good, fair or poor rating according to the Soil Quality Criteria Relative to Disturbance and Reclamation (Soil Quality Criteria Working Group, 1987) document which provides rating categories for soil physical and chemical parameters such as texture, structure, consistence, pH, sodium adsorption ratio (SAR), and electrical conductivity (EC). Additionally, reclaimed land must have equivalent or better land capability than the pre-disturbed land capability. For example, a certain percentage of the land must have class 2, 3, 4, 5, 6 and 7 capabilities based on pre-disturbance data.

# 4 Reclamation

To date 1665 hectares of the 1875 hectares disturbed by mining have been reclaimed. Approximately 890 hectares of reclaimed land has already received reclamation certificates and another 480 hectares is in the review process for reclamation certification. The reclaimed areas include agriculture, wetlands, woodland/wildlife areas and an end pit lake. See Figure 1 for an aerial image of Whitewood Mine. Reclamation has improved the agricultural capability compared to pre-disturbance capabilities, to date there is an increase in class 2 and 3 agricultural soil capabilities on reclaimed land (Table 1). Reclaimed areas provide excellent habitat for wildlife and an increase in wildlife was noted in the area. Species including white-tailed deer, mule deer, moose, elk, ruffed grouse, ducks, geese, woodpeckers and song birds are commonly seen throughout the mine. Partnering with the Alberta Fish & Game Association's Wildlife Trust Fund, in 1997 TransAlta donated East Pit Lake and the surrounding reclaimed land to help create a 335 hectare reserve dedicated to wildlife habitat conservation, education and recreation. TransAlta has also sold 233 hectares of agricultural land for private ownership.

**Table 1 Pre-disturbance and reclaimed agriculture land capability classes from 1983–2010 at Whitewood Mine***

| Land Capability Class | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Pre-disturbance* | 39 | 395 | 220 | 172 | 28 | 236 |
| Reclaimed* | 69 | 649 | 201 | 84 | 54 | 33 |
| Future Reclaim** | 0 | 0 | 0 | 90 | 70 | 70 |

*Excludes 809 hectares reclaimed prior to 1983.

**Based on the 2009 Whitewood Mine No. 1757 License Extension Application (TransAlta Corporation, 1983–2009).

## 4.1 Dryland areas

Reclamation was carried out progressively as mining advanced. Topsoil (A horizon) was the main reclamation material salvaged; however, lake bottom sediments have been salvaged for use as an amendment. Spoil piles were levelled and contoured and topsoil was spread, if available. Spoil materials were used as both subsoil and topsoil on areas that did not have topsoil replaced. Wastes, including flyash and baghouse dust, coal fines and washbay sludge, were buried a minimum of 1.0 m below the surface of the recontoured spoil. A seed bed was prepared on topsoil or suitable spoil materials by discing and harrowing the soil and removing rocks and trash. The majority of the land was prepared for agriculture use. Agriculture lands were seeded with alfalfa and various tame forages along with a cover crop of oats. Species with extensive root systems were selected to maximise soil organic matter accumulation. In the past fertilizer was applied twice a year based on soil nutrient analyses, then reduced to an annual application. Weeds were controlled through a combination of mechanical and chemical methods. After land had been cropped with perennial species for several years, local farmers were allowed to cultivate the reclaimed land and seed annual crops. Several monitoring programs were used to monitor productivity on reclaimed lands: crop yield data was collected and compared to nearby fields and measurements of topsoil depth, structure and texture were obtained to determine preliminary agriculture capability classes. Select areas were revegetated with forest and wetland species, most of these areas revegetated through natural recovery.

## 4.2 East pit lake

Beginning in 1980 an area in the east pit was contoured into a moderate to strongly rolling landscape. East Pit Lake reached the predicted surface elevation for the year of 2000 in 1992 (Table 2). East Pit Lake is primarily maintained by groundwater and the predicted inflow from groundwater was 130 $m^3$/day (TransAlta Corporation, 1993). Water outputs are primarily from evaporation.

**Table 2 Morphometrical parameters for East Pit Lake, West Pit Lake and Whitewood Lake**

| Parameter | East Pit Lake* | West Pit Lake** | Whitewood Lake*** |
|---|---|---|---|
| Surface elevation (masl) | 772 | 775 | 775.5 |
| Max length (m) | 1,210 | 3,000 | 1,676 |
| Max depth (m) | 10 | 20 | 20 |
| Mean depth (m) | 3.3 | 4.2 | 4.7 |
| Mean width (m) | 155 | 130 | 160 |
| Volume in lake ($m^3$) | 624,280 | 2,737,000 | 1,923,000 |
| Surface area ($m^2$) | 187,175 | 421,000 | 288,000 |
| Shoreline length (m) | 4,180 | 8,000 | 4,163 |
| Litoral area ($m^2$) | 64,000 | 140,000 | 84,000 |

masl - meters above sea level.
* Based on the Reclamation Certificate Application East Pit Lake - Whitewood Mine Volume 1 (TransAlta Corporation, 1993).
** Based on written communication (Kuchmak, 2011).
*** Based on the 2009 Whitewood Mine No. 1757 License Extension Application (TransAlta Corporation, 1983–2009).

The water quality was monitored annually and was found to be suitable habitat for a variety of invertebrates and capable of supporting sport fishing. East Pit Lake is a moderately hard, well-buffered water body that is resistant to rapid or dramatic changes in pH. Based on the 1993 reclamation certificate application for East Pit Lake, the pH of the water was slightly alkaline (7.4 to 8.1), EC ranged from 340 to 548 µs/cm. Dissolved oxygen in the fall ranged from 8.83 to 10.32 mg/l with water temperatures of 13 to 16 °C. East Pit Lake was stocked with Rainbow Trout and aquatic invertebrate populations established naturally. East Pit Lake is a popular fishing spot that attracts many visitors throughout the year and it provides excellent wildlife habitat and many species occupy the area.

No topsoil was placed around East Pit Lake and the levelled spoil consisted of a mix of till and lacustrine sediments, sandstone, gravel, coal imbedded in mud and siltstone, peat and other organic materials. The area surrounding East Pit Lake was seeded in 1988 with a shoreline grass mix consisting of orchard grass, brome, meadow fescue and white clover and areas away from the shoreline were seeded with creeping red fescue, crested wheatgrass and white clover. Trees and shrubs were planted in 1989. Species included willow, trembling aspen, balsam poplar, jack pine, white spruce, chokecherry, dogwood and green ash. A survey in 1991 indicated that the survival of many of the planted woody species was low due to competition from grasses and weed species; however, the natural regeneration of balsam and poplar and willows was vigorous. Much of the herbaceous vegetation consisted of native and non-native grass and clover species.

A reclamation certificate was obtained for East Pit Lake in 1994. Currently, East Pit Lake is a popular sport fishing location and used by many local residents.

# 5 Reclamation research

Whitewood Mine conducted several research programs to determine the agriculture productivity on land reclaimed without topsoil and develop methods to increase soil organic matter on these areas. Cereal and hay crops were grown on mine spoil (no topsoil) and on areas where 0.20 m of topsoil was placed over mine spoil. The plots were treated with four different fertilizer rates. Results indicated that forage yields on plots without topsoil and plots with topsoil were similar. Cereal crop yields (barley) on plots with topsoil were higher than on plots without topsoil. When fertilizer was applied, regardless of the application rate, yields were comparable on the plots without topsoil and plots with topsoil. Trials conducted to develop seed mixes and crop rotation guidelines that would increase the organic matter content determined that barley yields could be sustained with below average fertilizer rates when barley is rotated with alfalfa due to the ability of alfalfa to fix nitrogen (refer to the 1986 & 1987 Whitewood Mine Annual Reports) (TransAlta Corporation, 1983–2009).

The results of these programs helped Whitewood Mine develop seed mixes and fertilization practices that were economical and maximised the productivity of land reclaimed without topsoil. Typical practices were to seed alfalfa and apply fertilizer based on soil nutrient analysis. Land reclaimed at Whitewood Mine without topsoil has been as productive as land reclaimed with topsoil.

Establishing forest vegetation at Whitewood Mine was challenging as it is surrounded by agriculture land which facilitates the spread of weeds and non-native plant seeds. Beginning in 1979 TransAlta partnered with the Stony Plain Fish and Game Association, Alberta Environment and Alberta Agriculture to create a wildlife habitat improvement area. The area was seeded to alfalfa and forage grasses, and between 1976 and 1983 several thousand native shrub and trees were planted. In 1988 results showed that survival of many of the planted trees, white spruce, Manitoba maple, Siberian elm and lilac, was less than 25%; however, deer and grouse spotting increased significantly. Additional, tree and shrub trials were conducted between 1982 and 1988. Various tree and shrub propagules were grown in a greenhouse and then outplanted. Their establishment success, ability to control weeds and microsite improvement were all parameters examined. Several shrub species had survival greater than 70% including Saskatoon berry, wolfwillow and prickly rose (refer to the 1988 Whitewood Mine Annual Report) (TransAlta Corporation, 1983–2009).

# 6 Mine closure and challenges

## 6.1 Land use

Whitewood Mine is located adjacent to a major highway (20,000 vehicles/day) and within close proximity to the city of Edmonton, Alberta. The reclaimed land is in high demand by private (residential/agricultural) landowners, the local municipality and recreational users. TransAlta has been under both public and local government pressure to reclaim disturbed land at Whitewood Mine so that is able to sustain intense agriculture and recreational use. Special features such as a beach area and boat launches will also be added.

The mine is currently in various stages of abandonment and final reclamation. Challenges that must be overcome during the closure of Whitewood Mine include a topsoil deficit (due to the lack of salvaged topsoil) for placement on the remainder of the reclamation area, meeting the required land capability classes and weed control. In addition, the creation of two end pit lakes is planned and will require erosion control, weed control, reforestation and shoreline and wildlife habitat revegetation. It is expected that all reclamation will be completed and certified by 2024.

## 6.2 Topsoil replacement and erosion

Overcoming a lack of topsoil is a challenge to the closure of Whitewood Mine; however, in past reclamation at Whitewood Mine, it has been demonstrated that spoil can be used to create productive agricultural land providing there is a certain level of maintenance (i.e. fertilizer and nitrogen fixing plants). On the remainder of the land to be reclaimed, topsoil is only required to be placed on class 2 and 3 agriculture land that was disturbed after 2002. Also to be considered in topsoil placement is the requirement for the final land capabilities to be equivalent or better than the pre-mine capabilities. Approximately 30% of the land will need to be reclaimed to class 2 and 3 capabilities and will require topsoil; therefore, the remaining topsoil stockpiles will be spread on lands that have contours and subsoil characteristics that will ensure class 2 and 3 capabilities are achieved. Agriculture land that does not receive topsoil will need to be managed so that the productivity of the spoil is maximised. As done in the past, species such as alfalfa that increase soil organic matter will be planted and fertilized. Fertilizer applications on land surrounding end pit lakes will be limited to the first few years of plant establishment to reduce potential eutrophication problems in the future.

Erosion on moderate and steep slopes is expected and if not controlled after spoil piles are levelled, the erosion could impact water quality within the two end pit lakes. Additionally, erosion could slow down the revegetation processes. There are various methods that can be used to control erosion (e.g. engineered, cover crops, coarse woody debris). Economical methods for controlling erosion include seeding annual and perennial cover crops of herbaceous plants. Hydroseeding may be required on areas that have very steep slopes. On forested, wildland or riparian areas, the use of coarse woody debris or mounding may be employed.

## 6.3 Weed control

Weeds must be controlled on reclaimed land in accordance with the Alberta Weed Control Act and Weed Control Regulation (Government of Alberta, 2008). Tansy, Canada thistle, perennial sow thistle and scentless chamomile are common on unlevelled spoil piles and initially on reclaimed areas. These weeds are extremely difficult to control and require continual weed management at the early stages of reclamation to prevent their spread. Weed control around riparian areas and treed areas is increasingly complex as mechanical and chemical control of weeds reduces the survivability of trees and shrubs and there are restrictions to using herbicides near water bodies.

An integrated weed management program will be used to control weeds. The spread of weeds will be reduced by reducing the amount of bare ground available for emergence by establishing permanent grass/forage cover soon after recontouring. The seed mix for the natural areas will need to consist of non competitive species. Planting only trees at the onset of revegetation could result in a plant community highly susceptible to weeds and erosion. Increasing tree planting densities will more quickly result in a canopy cover and could help reduce weed competition. The grass cover will need to be carefully monitored and mowed prior to the flowering of the weeds to prevent the spread of seeds. Litter that accumulates on the ground after mowing will reduce future weed invasion and help build organic matter within the surface soil. It is essential that the forage is not baled within the first few years for these reasons. Spot spraying or weed picking will likely need to be implemented for areas that are heavily infested with weeds.

## 6.4 End pit lakes, reforestation and wildlife habitat

The west pit area at Whitewood Mine will be developed into two end pit lakes. Morphometrical data for the two end pit lakes are presented in Table 2. The lakes are intended to be used for recreational purposes and support aquatic and wildlife habitat. The design criteria for the end pit lakes consider the existing post-mine topographic constraints, public safety, recreational potential, erosion protection and developing a put and take fishery with the potential to be a self-sustaining fishery. Lake shore slopes are constructed to be geotechnically stable, non-erodible to both surface runoff and wave action, safe for public recreational use and easily vegetated. Shoreline slopes will range between 14 and 33%. Underwater slopes will be approximately 10%. Estimated total inputs-outputs for the Whitewood Lake and West Pit Lake during the lake filling period is 434 $m^3$/day and 644 $m^3$/day, respectfully (Kuchmak, 2011, written comm.). Filing of the Whitewood and West Pit Lakes is estimated to take 10 and 7 years, respectively. There are no constructed inlet channels for surface flow to the lake and the lake level after the filling period will be primarily maintained by groundwater. The predominant outflow will be from evaporation and the projected maximum lake level fluctuation is less than 1.0 m.

Surrounding the lake will be a riparian zone and forest stand. Establishing a riparian zone and forest stand with native species will be the largest challenges as experienced during the creation of East Pit Lake. To help establish a diverse plant community surrounding the end pit lakes, TransAlta has transported freshly salvaged wetland soil containing vegetation propagules from the adjacent Highvale Mine. Costs were reduced by backhauling the donor material as a part of TransAlta's gravel pit operation at Whitewood Mine.

Forest revegetation within an agroecosystem is typically more expensive than revegetating to perennial forages due to higher costs for seed/transplanting and weed control. Additionally, longer timeframes are typically required for forests to establish to a sustainable point. TransAlta will utilise local sources of seed and vegetative propagules (collectively defined as propagules) to help support native self sustaining plant communities; use of local sources of propagules is anticipated to reduce long term costs by reducing maintenance costs. Native plant seedlings and cuttings may be obtained from local nurseries; however, the use of local on-site propagules ensures they are adapted to local environmental conditions. Cutting and seed collections will be utilised for establishing common woody plant stock for planting in the future. Donor soil containing viable propagules of species that are not commercially available will be spread to enhance biodiversity. Sources include several old forest topsoil windrows within the mine. Fresh forest topsoil may be collected from TransAlta's nearby Highvale mine for use as a propagule source; however, the logistics will determine the feasibility of this method. Donor soils will be distributed in islands to encourage seed dispersal of native seeds on adjacent areas that lack native seeds.

Several hectares surrounding the end pit lakes will have trees and shrubs planted in fall 2011 and spring and fall 2012. A combination of good site selection and planting fast growing species (aspen, balsam poplar, willow and red osier dogwood) at high densities will help control the spread of weeds. Cover crops may be planted to help stabilise the soil for erosion and weed control, the cover crop species selected will be compatible with the future tree crop. An alternative planting regime involving establishing a complete cover of perennial species, followed by dessication and subsequent planting may be necessary if noxious weeds spread out of control or erosion persists. Once an adequate ground cover of litter has established, herbaceous species will be desiccated with a non residual herbicide. The built up of litter will conserve moisture helping aid in the establishment and growth of planted trees and shrubs, and reduce the amount of exposed ground available for weed seed germination.

Shrubs species selected for planting will have the following characteristics: fast growing, nitrogen fixing and berry production. Fast growing shrubs will help control weeds and help control erosion. Shrub species that are capable of nitrogen fixing capabilities (e.g. alder or Canada buffalo berry) are important in achieving a sustainable plant community. Shrubs that produce edible berries (e.g. pin cherry, wild red raspberry) will provide a source of food for wildlife. Some shrubs may require planting at a later date when a canopy cover has developed.

# 7 Conclusions

Through its 50 year lifespan, mining and reclamation activities at Whitewood Mine have had to adapt and evolve to changes in government regulations and the public's expectations. Issues dealt with included a lack of topsoil for reclamation and the use of suitable spoil as topsoil. Cultivating species that increased soil organic matter content helped overcome the lack of topsoil. Establishing native forest species on reclaimed land surrounded by agriculture land required overcoming the competition from grasses and weeds. Nevertheless, several hundred hectares of productive agriculture land has been reclaimed and certified. An end pit lake (East Pit Lake) and surrounding natural area capable of supporting wildlife as well as recreational use has also been created. The reclamation experience from previous reclamation combined with the ability to adapt reclamation techniques to new challenges will be vital in the final reclamation and creation of two new end-pit lakes.

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