RECLAMATION OF ABANDONED MICA, FELDSPAR, AND KAOLIN SURFACE MINES AND ASSOCIATED TAILINGS DISPOSAL SITES IN WESTERN NORTH CAROLINA[1]

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Abstract. Sedimentation from abandoned mica, feldspar, and kaolin surface mines has filled Davy Crockett Lake at Greeneville, Tennessee and is impacting municipal water supplies, and the Tennessee Valley Authority's (TVA's) Douglas Reservoir.

In 1980, TVA; local, State, and Federal agencies; the mining industry; and landowners began work to reclaim these erosive sites. To date, 239 hectares (590 acres) have been reclaimed.

INTRODUCTION

In Western North Carolina industrial minerals (mica, feldspar, and kaolin) have been surface mined since the turn of the century. Products from these mines are used nationwide. North Carolina provides more than half of the nation's mica for such varied uses as electrical insulators, joint cement, plastics, roofing paper, and decorative "snow sparkles." North Carolina has also long held a similar lead in the mining of feldspar for porcelain bathroom fixtures and ceramic glazes. The State has also been one of the world's principal sources of kaolin for speciality china, refractory ceramics for high temperature scientific and industrial applications, synthetic rubber, paints, and cosmetics. About half of the world's kaolin is now used for fillers and coating for paper (TVA 1981A).

These minerals are the most economic and actively mined minerals in North Carolina and are mined through area and/or contour-type surface mining methods. In terms of tonnage, dollar values, and acreage, these minerals are no match for the surface coal mines in other States; however, when their abandoned mines and associated tailings disposal sites were compared on an environmental basis, they were identified as the major contributor to one of the 10 most critical water quality problems in the Tennessee river watershed (Clark et al, 1980).

In the 1960s, State water quality regulations required processing plants to install treatment systems to remove solids from the wastewater discharges from their ore washing and flotation processes. The easiest place and cheapest way to dispose of the untold cubic meters of sand-like tailings was along the riverbanks in this mountainous region.

The environmental problems associated with the abandoned mines and tailings disposal sites are numerous. The major problem is erosion and subsequent siltation of streams and rivers. Siltation is continually upsetting the aquatic community by burying plants and animals, altering feeding and spawning habitats, and suffocating fish by coating their gills. In a study conducted by the North Carolina Department of Natural Resources and Community Development (Duda and Penrose, 1980), the benthic macroinvertebrate population found in the North Toe River indicated severe biological damage caused by the sediment.

Silt has constricted the flood-channeling capacity of area streams and has been eliminating flood-storage capacity behind Nolichucky Dam (Davy Crockett Lake). In August 1972, the average annual filling rate for Davy Crockett Lake was 332,656 cubic meters (272 acre-feet). Generating equipment at Nolichucky Dam suffered excessive wear from the abrasive grit carried in the water and required frequent repairs. This, along with the fact that 86 percent of the original storage capacity had been lost to silt, was a major factor in TVA's decision to cease electrical power generation. So in August 1972, Nolichucky Dam stopped generating hydroelectricity and the reservoir and adjacent area became an environmental education center and waterfowl sanctuary.

Douglas Dam, a multi-purpose TVA project located on the French Broad River 134 kilometers (83 miles) below Nolichucky Dam, is now losing

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storage capacity to silt at an annual rate of 2.5 million cubic meters (2,000 acre-feet) which is approximately three times higher than other major tributary reservoirs in the TVA system. There are two public water supplies drawn from the Nolichucky River; at Greeneville (Nolichucky River kilometer 92.1 (57.2 mile)), and Jonesboro, Tennessee (Nolichucky River kilometer 139.9 (86.9 mile)). These water supplies experience problems with covering over and clogging of intake pipes and the abrasive nature of silt causes premature wear on plant equipment.

Only mine and tailings disposals created before July 1 of 1971 are considered abandoned since mines started after this date must be reclaimed in accordance with the provision of North Carolina's Mining Act. Additionally, in 1973, North Carolina enacted the Sedimentation Pollution Control Act governing offsite siltation problems associated with land disturbance. While such laws were enacted no provisions were included to pay for corrective reclamation of past mining.

On August 3 of 1977, Congress enacted The Surface Mining Control and Reclamation Act, Public Law 95-87, which created program funding under Title IV, for the reclamation of abandoned coal mine lands. Although provisions were included for the reclamation of other noncoal minerals lands, the supporting fund is linked to fees on active coal mining, none of which is taking place in North Carolina. Consequently, there is little to no opportunity under this law to alleviate problems associated with past unregulated surface mining for noncoal minerals in North Carolina.

To deal with the problem, a cooperative Abandoned Mine Land Reclamation Committee was formed in 1979. The committee is composed of representatives from Avery, Mitchell, and Yancey Counties; Soil and Water Conservation Districts; North Carolina Department of Natural Resources and Community Development; Region D Council of Governments; U.S. Soil Conservation Service (SCS); landowners; local citizens; mining companies; and TVA. This paper reports on cooperative efforts in correcting the environmental problems associated with these lands and restoring productive uses.

PROJECT ADMINISTRATION

The project was a cooperative Federal/State/landowner effort. From 1980-85 TVA provided $415,000 through its Regional Water Management Program and expertise through its Land Reclamation Program to reclaim the lands causing offsite environmental problems. TVA contracted with the North Carolina Forest Service and private contractors to carry out certain work. Throughout project implementation, TVA sought and obtained financial and in-kind contributions from local, State, and Federal agencies; the mining industry; and landowners.

Sixty-six landowners signed agreements with TVA authorizing reclamation and protection of the reclaimed site for five years. The estimated value of their contributions, along with the mining industry was about $72,000. Example of contributions include heavy equipment operation, construction materials, storage facilities, and hand labor for tree planting.

The State provided limited funding and tree seedlings, while the SCS designed earth sediment structures and provided experimental seed mixtures. Through the cooperative committee "grassroots" support for the project was established that resulted in passage of a State Bill in 1984 to provide funding for abandoned mine land reclamation in the three-county area, based on local matching funds.

PROJECT AREA

The abandoned mine lands are primarily clustered in the North Carolina mountains of Avery, Mitchell, and Yancey Counties. These sites drain into the North and South Toe Rivers, which with the Cane River form the Nolichucky River.

The tri-county area lies within the Blue Ridge physiographic province, a division of the Appalachian Highlands. This region covers about 760 square kilometers (300 square miles); 19 kilometers wide and 40 kilometers in length.

The topography is rolling to mountainous, and the elevation ranges from 610 to 1,830 meters (2,000 to 6,000 feet). The climate is characterized by cold winters and mild summers, with a monthly mean temperature range from 18 degrees (C) (33 degrees (F)) in January to 37 degrees (66 degrees (F)) in July. Annual precipitation fluctuates between 178 centimeters (70 inches) on the mountaintops to 127 centimeters (50 inches) in the valleys.

The major vegetative cover-type existing on these minesites before mining was forests. Several forest cover-types and variations occur in this region as noted by the Society of American Foresters (SAF, 1980). This is very characteristic of the Blue Ridge Mountains.

INVENTORY OF SITES

A cooperative TVA/SCS/State ground survey was conducted of each minesite to determine the overall magnitude of environmental problems. The survey showed that 590 hectares (1,456 acres) were disturbed before North Carolina's Mining (Reclamation) Act of 1971 was passed. Of this total, 195 hectares (481 acres) had been adequately reclaimed by nature, 156 hectares (385 acres) had been remined and reclaimed by mining companies, and 239 hectares (590 acres) were in need of reclamation. The 239 hectares (590 acres) comprise 103 minesites and are spread out over three mountainous counties: Avery 34 hectares (3 sites); Mitchell 93 hectares (49 sites); and Yancey 112 hectares (51 sites). Priorities were assigned for each site based on environmental and treatment needs.

CHARACTERISTICS OF MINE SPOIL AND TAILINGS

The soils located on these lands prior to mining were naturally of low fertility due to slope position. However, because of the mining methods employed, no soil structure existed on the abandoned minesites. The sites were mined with only one objective in mind: to get the minerals out as economically as possible. Therefore, no topsoil or overburden segregation was attempted, and what little soil existed either washed away through erosion or was hauled away with the ore to be processed.

The remaining spoil is characterized as sandy in texture, highly erosive, resisting compaction, extremely low in moisture-holding capacity, and having a tendency to absorb and retain heat. The spoil material can be considered as parent material just beginning the normal process of soil formation. The material is practically devoid of organic matter. Because of these harsh conditions, most abandoned mines have not revegetated naturally, even where primary invader species are present near the disturbed area.

The tailings disposal sites are composed of waste material from the ore washing and flotation processes. This material is best described as a fine whitish like sand with little to no ability to support vegetation without employing a proper reclamation scheme. Because of its sandy texture, it can be classified as extremely erosive.

Several spoil samples were randomly collected from the minesites and disposal dumps to determine the presence of elements either toxic or essential for plant growth. Analysis indicated spoil pH ranged from 4.8 to 5.9, while pH of the waste piles varied from 5.2 to 7.7. To meet soil test nutrient requirements for ground cover establishment, 392 kilograms (350 pounds per acre) of 19-19-19 high analysis fertilizer and 112 kilograms (100 pounds per acre) of concentrated superphosphate were applied per hectare. Since pH was generally within acceptable limits for vegetation establishment, minimal liming was conducted on selected sites (2,240 to 3,360 kilograms per hectare - 2,000 to 3,000 pounds per acre).

RECLAMATION TECHNIQUES

The reclamation approach of this project is based on a successful pilot demonstration conducted in 1981 at four sites totaling 17 hectares (41 acres) (TVA, 1981B). The objective of this pilot work was to demonstrate cost effective reclamation through cooperative Federal/State/landowner effort and to demonstrate degrees of reclamation--that is, the level of work (and costs) necessary to correct problems of surface water flow and active erosion in order to minimize environmental impacts, return land productivity, and enhance overall aesthetic values. The levels of reclamation range from minimum revegetation efforts to intensive water control, site preparation, and revegetation work. The associated costs of these treatments varied accordingly from $726 to $3,792 per hectare ($294 to $1,536 per acre) (Muncy, 1981).

Water and Sediment Control

To properly control rainfall runoff, numerous proven reclamation methods were utilized. These included constructing water bars, diversion and drainage ditches, and waterways. Also employed were soil bioengineering and riprapping techniques.

Sediment control was accomplished through perforated drop inlet earth sediment basins, rock sediment basins, silt fences, and check dams. Check dams were constructed from logs, rock, burlap bags, and hay bales. Erosion control netting was secured in unstable, highly erosion-prone areas.

Grading and Site Preparation

Grading was conducted on selected sites to open up access roads, to eliminate rills and gullies, to bury debris, to cover nonfertile material, to create gentle slopes, to establish proper surface water drainage patterns, and to prepare seedbeds. Site preparation activities included disking, dragging, tracking in with bulldozers, and taking advantage of freezing and thawing periods.

Revegetation

The most effective method of erosion control and soil stabilization is the establishment of vegetation. The new vegetation also improves visual qualities of mined areas and usually is an important step in returning the mined land to productive use (Vogel, 1981).

Considering these lands were primarily covered by forests prior to mining, reforestation techniques were employed to return them to productive forest and wildlife uses. This consisted of establishing herbaceous ground cover for immediate erosion control, and planting trees having long-term stabilization and commercial values, along with shrubs beneficial to wildlife. Under this approach, soil erosion is controlled, the land is restored to productive capabilities, and esthetics are improved.

Different seed mixtures of grasses and legumes were used concurrent with the planting of trees to provide cover over the denuded minesites. This tree-herbaceous combination is possible because of the amount of rainfall received is over 127 centimeters (50 inches) annually.

Grasses and Legumes

The grass and legume species selected are proven species for establishing cover for erosion control in mined land reclamation, aiding retention of soil moisture and building up organic material in the spoil. Quick cover species were mixed with permanent species to ensure optimum benefits of revegetation. Also, the nitrogen produced by the legumes will lengthen the stand life of cool-season grasses and will increase the vigor of warm-season grasses.

The major seed mixture used consisted of weeping lovegrass (Eragrostis curvula (Schrad.) Nees), sericea lespedeza (Lespedeza cuneata (Dum.) G. Don), KY-31 tall fescue (Festuca arundinacea Shreb.), and white clover (Trifolium repens L.). This mixture provided excellent cover.

Weeping lovegrass was selected as the quick cover component, due to the warm nature and sandy texture of the spoils. Sericea lespedeza and KY-31 fescue were selected because they provided long-term or permanent cover that required little or no maintenance. White clover provided a needed diversity of species and wildlife habitat and forage.

Since the sericea lespedeza component became established relatively slow, it gave concurrently planted woody stem vegetation an early opportunity to become established. Also, it appeared to benefit eastern white pine (Pinus strobus L.) growth and vigor.

Other grasses and legumes such as perennial ryegrass (Lolium perenne L.), annual ryegrass (Lolium multiforum Lam.), Korean (Lespedeza stipulacea Maxim.) and kobe lespedeza (Lespedeza striata var. Kobe), yellow sweetclover (Melilotus officinalis Lam.), deertonque (Panicum clandestinum L.), and redtop (Agrostis gigantia Roth) were successfully established. A mixture of orchardgrass (Dactylis glomerata L.), red clover (Trifolium pratense L.), and perennial ryegrass provided an excellent forage/hay crop after the first growing season on a site where the landowner voluntarily regraded seven hectares back into stable pastureland (Figures 1 and 2).

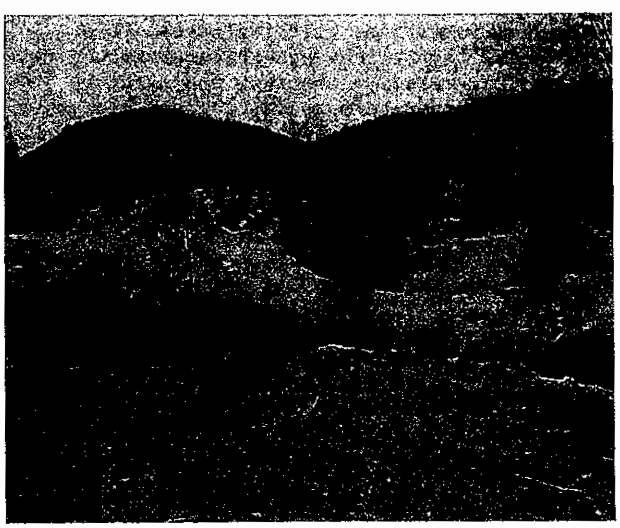

Figure 1.--Abandoned mica minesite before reclamation (looking northeast), March 1982.

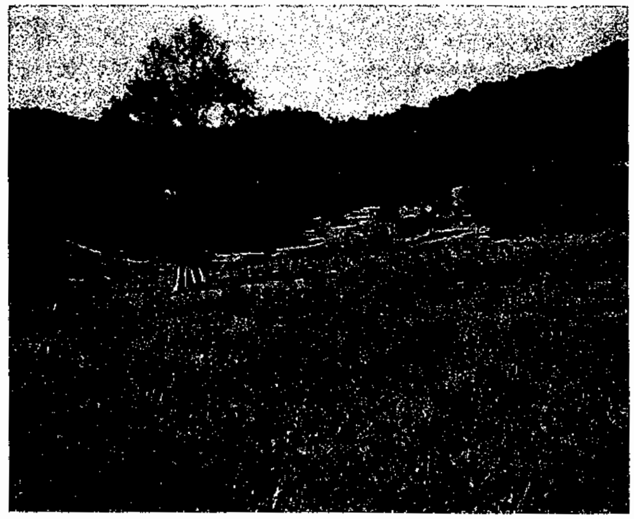

Figure 2.--Abandoned mica minesite after reclamation (looking southwest), July 1983.

Test plots of hulled and unhulled caucasian bluestem (Bothriochloa caucasica (Trin.), C. E. Hubb), big bluestem (Andropogon gerardi Vitm.) and switchgrass (Panicum virgatum L.) were not successful where hand seeded and hydro-fertilized and mulched. However, where these native species along with Indiangrass (Sorghastrum nutans L. Nash) were hydroseeded in appropriate mixtures, they became well established, with switchgrass and big bluestem dominating the stands. Both blackwell and kanlon cultivars of switchgrass did well on the hydroseeded sites. These mixtures appeared to provide a diversity of species similar to that in some natural grassland areas. Large numbers of eastern cottontail rabbits (Sylvilagus floridanus) were observed utilizing these tall stands of grasses for habitat; however, adjacent clumps of autumn olive (Elaeagnus umbellata Thunb.) were heavily damaged by browsing rabbits. Some of the autumn olive shrubs were killed from complete bark girdling.

Seeding was accomplished by broadcasting methods including hand cyclone seeders, hydroseeders, and aerial application with a sling bucket helicopter system (TVA, 1984). Hand seeding and hydroseeding were conducted on accessible areas. Since numerous small sites were spread out over the three mountainous counties, aerial seeding was the only practical and environmentally acceptable way to reach these sites. The haul routes used during mining were no longer passable. Building new access roads would have been expensive, but more importantly, it would have caused more environmental damage than would have been corrected by stabilizing the minesites. All seeding methods proved cost-effective within the respective uses.

Mulches

On accessible sites, mulching was conducted to alter the surface microclimate, help conserve soil moisture during the seeding establishment period, and to protect the seed, fertilizer, and soil. This was especially important with these spoils since the overburden material possesses little physical structure, even where the area was regraded and mixed with better material. Organic matter is generally low or nonexistent, causing the spoil material to crust over after a rain and to dry out very rapidly. Also, because of the constant and intense exposure to the sun, the soils have high surface temperatures, making mulching necessary in the late spring and summer months to protect the seed and young plants.

Several types of mulch materials were used to meet various site needs. These included hay, hydro-mulches (with and without tackifers) and excelsior backed erosion control netting. No one material can be classified as the most effective because they all provided different but effective benefits.

Woody Vegetation

The revegetation plans identified sub-sites of mines and matched them with suitable tree and shrub species. For example, the species planting arrangement on one minesite consisted of eastern white pine on the flats and better spoils, black locust (Robinia pseudoacacia L.) on the steep slopes, European black alder (Alnus glutinosa L. Gaertn.) in low, moist areas, bristly locust (Robinia fertilis Ashe) in severe gullies, contour borders of shrub lespedeza (Lespedeza bicolor Turcz.) around the edge and autumn olive in small clumps. This methodology recognized species site requirements and promoted diversity, a basic principal in developing wildlife habitat.

Woody stem seedlings were planted by hand with dibble bars and hoedads because of the steep terrain and the generally scattered and small minesites. In the droughty, erosive spoils, seedlings were planted deeper than normal to improve early survival and growth.

Under the reclamation project 262,356 trees and 68,912 shruhs were planted. Eastern white pine accounted for 179,161, black locust 68,431, autumn olive 55,392, European black alder 14,764, shrub lespedeza 13,300, and bristly locust 220.

ACREAGE RECLAIMED AND ASSOCIATED COSTS

From October 1980 through September 1985, 239 hectares (590 acres) were reclaimed under this cooperative reclamation project. Total costs and in-kind services rendered are identified at $487,000. These costs include actual on-the-ground and associated administrative expenditures. Average cost per hectare is $2,038 ($825 per acre).

IN CONCLUSION

This reclamation project successfully treated 239 hectares (590 acres) of highly erosive mica, feldspar, and kaolin surface mines and associated tailings disposal sites in western North Carolina. These mines and their tailings were identified as the major contributor to one of the ten most critical water quality problems in the Tennessee River Basin.

The project demonstrates cost-effective techniques applicable in controlling soil erosion and returning abandoned mine lands to productive uses through cooperative Federal/State/landowner efforts. Reclamation of these derelict lands aids in watershed protection, enhances wildlife habitat, increases recreational opportunities (hunting), improves visual qualities, and restores productive capabilities such as ornamental crops, pastureland and timber and christmas tree production.

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