BOISSEVAIN RECLAMATION PROJECT

A MULTIDISCIPLINARY APPROACH TO ABANDONED MINELAND RECLAMATION[1/]

Edward M. Tackett[2/]
Soil Scientist, CPSS
Commonwealth Technology, Inc.
2520 Regency Road, Suite 104
Lexington, KY 40503

Abstract.--A team of scientists and engineers was employed to design reclamation measures on an abandoned mineland project in northwestern Virginia. The project area consisted of coal refuse stored in randomly placed piles and in the floodplain of a local stream. An environmental assessment of the site identified the potential hazards from flooding and refuse sliding, erosion, and aesthetics as major problems. Reclamation alternatives were formulated along with environmental impacts and cost estimates. The reclamation alternative chosen included regrading the refuse piles into safe configurations, removing refuse in and along Laurel Fork, installing permanent drainage features, and revegetation of the existing refuse material. Conventional construction equipment and methods were used in the earthwork phase of the project. Revegetation included heavy application of lime and fertilizers based on refuse sample analyses. White pine (Pinus strobus) and autumn olive (Elaeagnus umbellata) seedlings were hand planted on the reclaimed outslopes. After one year of growth, total vegetative cover was about 50% with approximately 60% tree seedling survival. Scattered areas throughout the project area required maintenance revegetation treatments, partly because of a very dry spring and summer. Four years after reclamation, approximately 80% cover had been achieved with good survival and growth in the autumn olive seedling and poor results with white pine seedlings. The success of the project was due to an effective assessment of the problem and the formulation and implementation of a cost-effective, workable plan.

Additional Key Words: coal refuse, revegetation, white pine, autumn olive, Virginia.

INTRODUCTION

Since the Surface Mining Control and Reclamation Act of 1977 was enacted, government agencies and the private sector have cooperated to rehabilitate several thousand acres of useless or abandoned land. Commonwealth Technology, Inc. has employed a multidisciplinary approach to design reclamation measures on many abandoned mineland projects in Kentucky, Ohio, Virginia, and West Virginia in the past 7 years. Design engineers, soil scientists, geologists, hydrologists, and biologists offer unique insight into abandoned mineland problems sometimes overlooked. This paper reports on one such project administered by the Commonwealth of Virginia, Division of Mined Land Reclamation. The

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2/ Edward M. Tackett is a Soil Scientist, Commonwealth Technology, Inc., Lexington, Kentucky.

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site, as shown in Figure 1, was located in northwestern Virginia near the community of Boissevain which was constructed in the early 1900's when the Pocahontas No. 3 Coal Seam was mined. In the 1970's, much of the refuse was removed for reprocessing and the remaining waste was spread along the banks of Laurel Fork, the major tributary flowing through Boissevain. Additional placement of refuse occurred in one of the small hollows on site. Primary goals of the project were to reduce the potential for flooding along Laurel Fork, reduce sediment production from unvegetated areas, and to improve the site aesthetically.

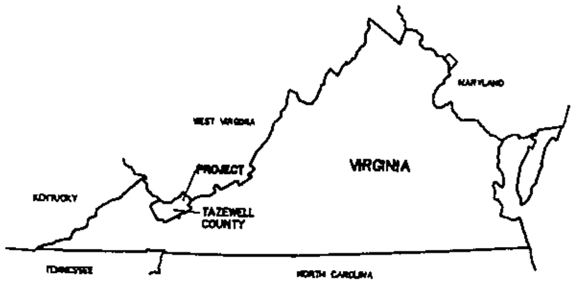

Figure 1. -- Boissevain Reclamation Project site.

PROBLEM ASSESSMENT

In order to determine the impacts of the refuse dump on the environment, a team of professionals of various disciplines was assembled to investigate the problem. The team included design engineers, a biologist/hydrologist, a geologist, a soil scientist/forester, and a field survey crew.

Surface water runoff from the project is received by Laurel Fork, a tributary of the Bluestone River. Laurel Fork is a second-order stream which drains 6.5 mi at the project site. The project site is shown in Figure 2. Forestland is the major land use in the basin. Domestic sewage discharge from local residents also flows into Laurel Fork throughout its reaches. Five surface water stations were monitored to assess background water quality. The stations included an upstream station for control as well as four sites affected by the refuse dump. The results indicated an increase in iron, manganese, and suspended solids at the stations receiving runoff from the refuse site. Two of the stations, one upstream and one affected by the refuse, were sampled for aquatic biology. The Simpson Diversity Index (Brower and Zar, 1977), which is a ratio of population species to population numbers, was determined to be 0.48 and 0.58 at one upstream station and one downstream station. monitoring stations. A second-order stream, such as Laurel Fork, could be expected to have a macroinvertebrate diversity value in the 0.7-1.0 range. At the time of the aquatic survey, streamflow was low and no significant runoff from the refuse dump was occurring. After further investigations, it was determined that the flat stream gradient evident at both sampling sites was partially due to placement of refuse in and along Laurel Fork causing pool conditions upstream of the site. The stagnant conditions created by the siltation from the area, partially blocking culverts on Laurel Fork, in combination with the input of domestic sewage were the chief causes of low stream fauna diversity.

A survey of ground water users in the vicinity of the project area revealed that most residents used the public water upstream provided by the community of Boissevain. Three residents near the project utilized a spring for domestic water. Analysis of a sample from the spring indicated favorable water quality with no apparent effects from the refuse dump. The environmental assessment team also examined land use patterns, vegetation communities, and wildlife inhabitants in the project area. Most of the land in the area is forested, especially the hillsides and upland areas. The valley bottoms contain the roads, railroads, and residential and commercial development. The forestland is second-growth complex of climax and subclimax communities with oak-hickory forest-type dominating. No rare or endangered vegetative species were observed in the project area. A less significant effect of the refuse dump was the reduction of forestland and associated wildlife habitat at the project site.

In the project area, the exposed strata outcropping were from the Lee Formation. The Pocahontas Coal No. 3, the source of the project refuse, lies at the base of the formation and has also been described as part of what has been called the Pocahontas Formation. Structurally, the refuse area was situated on the northern side of a structural boundary marked by a fault line that roughly parallels Laurel Fork and has been called the Abbs Valley Fault. To the north of this fault, the strata are under the influence of the Dry Fork anticline. This feature has resulted in a mild southeasterly dip of most strata although localized anomalies exist where dip may vary significantly. To the south of the fault, the Abbs Valley anticline is a major feature. At the southern edge of the project area, the strata have been folded and truncated as a result of tectonic activity and erosion.

The existence of faulting coupled with anticlines on both the north and south has the effect of concentrating ground water flow along the Laurel Fork watershed. Movement is downdip toward the fault from the Dry Fork anticline and the folding and inclination of strata along the southern edge of the area provide additional ground water flow at this site. A drainage feature was constructed during mining operations on the Pocahontas No. 3 Coal Seam to discharge ground water. Failures or blockage of this drainage facility could result in significant increase in the water table level along Laurel Fork.

The naturally occurring soils of the project area are the residual soils of the uplands - Wellston and Muskingum series; and the alluvial soils such as Dunning, Pope, Philo, Atkins, Huntington, Linside, and Melvin (Southwest Virginia 208 Planning Agency, 1978). The remaining soils at the site are the minesoils, which consist of weathered refuse material alone, mixed with the naturally occurring soils. The minesoil was black to dark brown with iron-staining on coarse fragments which ranged from 1 cm to 12 cm in diameter. Composite samples of the refuse (minesoil) were collected and analyzed for acid-base parameters and metal composition. Samples of topsoil from the forested area adjacent

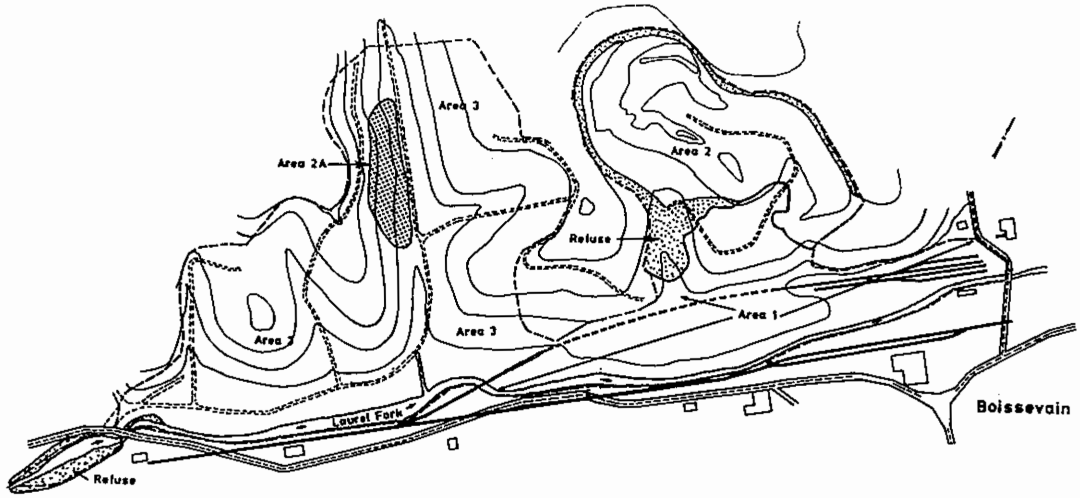

Figure 2. -- Project area showing existing refuse placement.

to the site were also collected and analyzed as potential borrow material. The results of the analysis revealed near neutral minesoil with high reserve acidity. A lime requirement of 14 to 18 tons/acre was indicated by the analysis to neutralize the reserve potential acidity. The borrow area topsoil was slightly acidic, requiring approximately 6.5 tons of lime/acre. Due to the qualities of the available borrow material and the additional costs of clearing and revegetating the borrow area, it was concluded that using the borrow area topsoil to reclaim the site would not be feasible.

The environmental assessment process also included a determination of archeological, historic, and recreational sites which might be affected by the project. This task was accomplished by a field examination of the project area and by contacting the appropriate local and state agencies such as the Virginia Historic Landmarks Commission and others. The investigation revealed that the project would not affect any such sites as none existed in the immediate vicinity of the project area.

DEVELOPMENT OF RECLAMATION ALTERNATIVES

After the problem assessment phase was completed, alternative reclamation plans were formulated and their impacts on the environment were determined. Four reclamation alternatives were developed. The environmental impact categories included surface water hydrology, fish and wildlife habitat, vegetative resources, aesthetics, public health and safety, land usage, and recreational resources.

Alternative No. 1 was to take no remedial action whatsoever. Problems such as flooding, stagnant water, erosion, and unappealing aesthetics would persist. The refuse area was marginally stable and slides of large quantities could develop which would accelerate erosion and sedimentation problems in Laurel Fork. Sliding would also expose pyrite in the refuse to further production of acid and would further degrade surface water quality and existing vegetative resources. Under this no-action alternative the aquatic and terrestrial habitat would not be enhanced and might be further depleted by refuse sliding. As previously mentioned, public health and safety concerns, primarily flooding and slides, would not be served under Alternative No. 1.

Reclamation Alternative No. 2 involved creating a valley refuse fill area on site with surface drainage and discharge facilities. Areas with sparse vegetation would receive localized revegetation treatments including lime, fertilizer and seed and mulch. The plan also proposed streambed improvements to eliminate ponding. The estimated cost of Alternative No. 2 was $641,250.

Reclamation Alternative No. 3 was similar to Alternative No. 2 except that disposal of the refuse would occur offsite. It was determined that about 30 percent of the refuse was coal and could be recovered. An offsite disposal area of approximately 10 acres was proposed. This alternative proposed the reclamation of the refuse site and disposal area, reseeding, liming and fertilizing sparse vegetation areas, and streambed improvements. The estimated cost of Alternative No. 3 was $1,781,875. Revenue from sale of reprocessed coal was not included in the cost estimate for Alternative No. 3 since Consolidated Coal had ownership rights.

Alternative No. 4 was directed at the alleviation of adverse existing conditions with minimal work on the refuse area. The hydrologic work consisted of streambank restoration to drain ponded water of Laurel Fork and to improve discharge capabilities. This plan included the stabilization and in-place reclamation of refuse piles and minimal revegetation work on sparsely covered areas. The estimated cost for Alternative No. 4 was $304,607. Table 1 contains the estimated costs by item for each of the three action alternatives. Reclamation Alternatives

TABLE 1.--ESTIMATED COSTS FOR RECLAMATION ALTERNATIVES

	ALTERNATIVE NO. 2		ALTERNATIVE NO. 3		ALTERNATIVE NO. 4	
ITEM	QUANTITY	COST*	QUANTITY	COST	QUANTITY	COST
Refuse Excavation and Placement Area 2	60,000 CY	300	300,000 CY	1,525**	--	--
Drainage Facilities Excavation and Riprap Areas 2 & 3	4,000 CY	72	--	--	1,000 CY	18
Grading Areas	34.5 Ac	34.5	--	--	42 Ac	48
Revegetation	46 Ac	47	46 Ac	73.5	26 Ac	37.8
Stream Work Grade Improvement	1,400 CY	35	1,400 CY	35	1,400 CY	35
Stream Excavation	--	--	--	--	4,300 CY	43
CONSTRUCTION COSTS		488.5		1,633.5		181.8
OTHER COSTS***		152.7		148.4		122.8
TOTAL COST		641.2		1,781.9		304.6

* Costs are in thousands of dollars.
** Cost includes purchase of disposal site.
*** Other costs include the following:
1) Operation and maintenance for 5 years.
2) Cost of permanent facilities.
3) Planning and engineering costs.
4) Environmental monitoring.
5) Upstream road improvements.

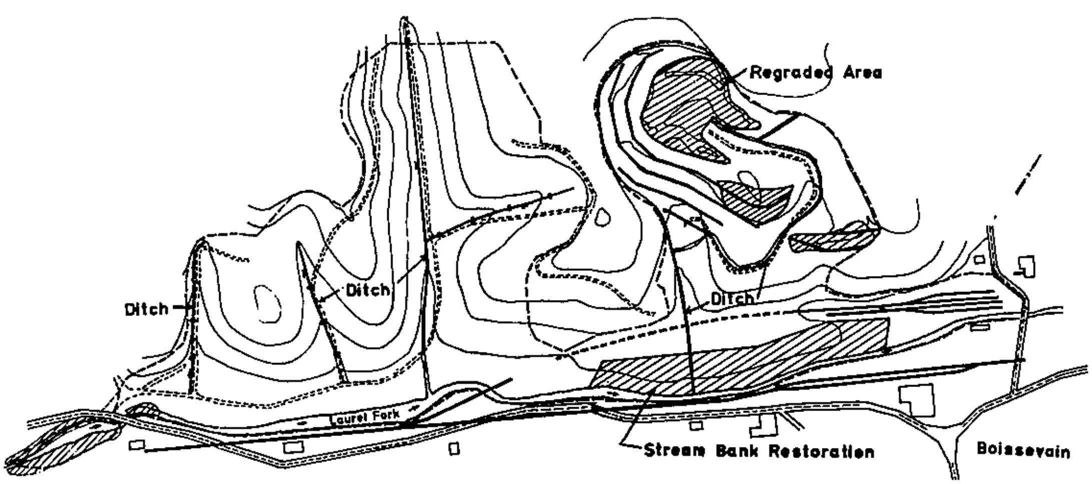

Figure 3. -- Project area after reclamation showing fill areas and drainage ditches.

Nos. 2, 3, and 4 included 5-year operation and maintenance cost estimates of approximately $56,000 for Alternatives No. 2 and 4 and $72,000 for Alternative No. 3.

The environmental impacts on the project area were similar for all three action alternatives. Surface water quality should improve by eliminating stagnant ponded water and by reducing sedimentation. As a direct result the aquatic biology should improve with improved water quality. Additional terrestrial wildlife habitat would also be created by the reclamation of previously denuded areas. Aesthetically, all three action alternatives would improve the site greatly by removing or covering unsightly refuse and trash scattered along Laurel Fork and in the refuse piles themselves. Perhaps the most important concern of the proposed reclamation alternatives is their effect on public health and safety. Two major areas of concern are the increased potential for flooding caused by placement of refuse in and along Laurel Fork and the potential for slides in the refuse piles. The action alternatives would reduce the potential for flooding through drainage controls and grading improvements in and along Laurel Fork. The potential for refuse slides would also be eliminated by the action alternatives. Other minor positive environmental impacts from the action alternatives include an increase in recreational resources, vegetative resources, and usable land base.

After careful review of the four reclamation plan alternatives by the Virginia Division of Mined Land Reclamation, Alternative No. 4 was selected for implementation with minor modifications. With the exception of planning and engineering costs listed in the category of Other Costs in Table 1; the other items were rejected. These included costs associated with operation and maintenance, environmental monitoring, and upstream road improvements. Commonwealth Technology, Inc. was contracted to develop construction plans and specifications.

CONSTRUCTION

Construction began on the project in January 1983 with clearing and grubbing activities. Channel improvement work on Laurel Fork was started and included the removal of coal refuse and trash along the banks of Laurel Fork. Grading work on the refuse piles began in February 1983 using conventional earth-moving equipment. Excess material was placed in a small hollow fill and compacted to the desired density using a sheepsfoot roller. As the refuse piles and fill areas were graded to new contours, benches and ditches were installed at effective locations. Figure 3 shows the regraded surface contours and construction features. Revegetation activities began in mid-March 1983 with the application of agricultural lime on graded areas. Lime was applied in two steps. First, 10 tons of lime/acre was applied and incorporated into the refuse to 12 inches using a disk harrow. The remaining 5 tons of lime/acre were applied and disked lightly. All lime was applied with conventional dry spreaders with side casting capabilities to reach outslopes. Seedbed preparation was performed by disking areas to receive revegetation treatments, especially the areas with sparse vegetation. Lime and fertilizer rates were determined from composite refuse/soil samples collected throughout the project area the previous year. The required fertilizer analysis and rate included 350 lb/acre of diammonium phosphate (18-46-0) and 100 lb/acre of muriate of potash. The fertilizers were applied in a slurry mixture with the seed and mulch using a hydraulic spreader. The following seed mixture and rates were used on the project area (Table 2).

TABLE 2.--SEED MIXTURE AND APPLICATION RATES ON REFUSE SPOIL IN PROJECT AREA

SPECIES	RATE (lbs/Acre)
KY Tall Fescue (Festuca arundinacea)	35
Sericea Lespedeza (Lespedeza cuneata)	20
Perennial Ryegrass (Lolium perenne)	20
Birdsfoot Trefoil (Lotus corniculatus)	10

Species selection was designed to provide both erosion control and long-term site protection. The contractor had the option of using one of the following mulch treatments:

Woodfiber mulch - 1,500 lbs/Acre plus binding agent
Hay or straw mulch - 1-1/2 tons/Acre plus asphalt tackifier
Hardwood bark mulch - 45 yds /Acre

Woodfiber mulch was the mulch option selected by the contractor. The seed, fertilizer, mulch, and binding agent were applied simultaneously using a hydraulic seeder.

On the area with existing herbaceous cover with scattered pine saplings, 5 tons of lime, 350 lbs/Acre of diammonium phosphate, 100 lbs/Acre muriate of potash, and the following seed mixture and rates of application were applied (Table 3).

TABLE 3.--SEED MIXTURE AND APPLICATION RATES ON AREAS OF EXISTING COVER IN PROJECT AREA

SPECIES	RATE (lbs/Acre)
KY 31 Tall Fescue	30
Sericea Lespedeza	20
Perennial Ryegrass	20
Birdsfoot Trefoil	10

Application of seed, fertilizer, and mulch was made using a hydraulic seeder, and lime was applied using conventional agricultural lime spreading equipment.

The final phase of revegetation was tree seedlings planting. Nursery-grown one-year-old eastern white pine (Pinus strobus) and autumn olive (Elaeagnus umbellata) seedlings were hand planted on the outslopes of the graded refuse. Approximately 375 seedlings of each species were planted at an approximate spacing of 10 feet between seedlings in a row and 10 feet between rows. Revegetation was completed in late April, 1983. By the summer of 1983, it became apparent that the drainage ditches installed using a filter fabric liner had not functioned properly. The corrective action taken was to replace the filter fabric in the ditches with rip-rap. All areas disturbed were revegetated as per contract specifications.

The remedial work was performed by the original contractor in August 1983. Vegetative cover was established successfully on virtually the entire project area by early summer. Lack of rainfall during the summer months stunted the herbaceous cover established on the project area. Some areas of sparse vegetation remained through the following spring (1984). A contract for revegetation maintenance was awarded for 10 acres on the project area. Areas with unsatisfactory vegetative cover received maintenance treatments in May 1984 (Table 4). The total construction costs were $180,000 which was about $100,000 less than projected costs.

TABLE 4.—MAINTENANCE TREATMENTS IN AREAS OF UNSATISFACTORY VEGETATIVE COVER

SPECIES	RATE (lbs/ACRE)
KY 31 Tall Fescue	10
Sericea Lespedeza	5
Weeping Lovegrass (Eragrostis curvula)	2
Pearl Millet (Pennisetum americanum)	20
Ryegrass	15
Fertilizer	
Ammonium Nitrate	100
Mulch	
Wood Fiber Mulch	1000

RESULTS AND DISCUSSION

One year after seeding, the work was evaluated. By this time the dominant components of the herbaceous stand were fescue and birdsfoot trefoil. Percent cover was estimated to be approximately 50 percent. The best vegetative cover was achieved on flatter surfaces, shaded areas, and in the small depressions created by the disk and dozer tracks. Obviously, the ability to hold moisture for plant growth became very important during the first summer of growth when rainfall was lacking.

Moderately high survival rates were observed in both the autumn olive and white pine seedlings after one year. Estimates of survival ranged from 50 to 70 percent for both species planted. The white pine seedlings were taller after one year, averaging approximately 30 cm while the autumn olive seedlings were about 15 cm tall. The difference in height is not all due to first season growth since the pine seedlings averaged 10 cm taller than the autumn olive seedlings when planted. Composite soil samples collected from the refuse area indicated that the soil remained nonacid with pH values of 7.3 and 8.0. Nutrient levels were moderately high also. Average levels of available nitrogen, phosphorus, and potassium were 28 lbs/acre, 45 lbs/acre, and 232 lbs/acre, respectively.

Four years after reclamation, the site was revisited. By this time the site was well covered with herbaceous plants. The dominant components were serecia lespedeza and birdsfoot trefoil. Fescue was also observed below the canopy of the dominant species. Percent cover was estimated to be at least 80 percent. In a typical area, the serecia and birdsfoot trefoil were almost a meter in height. Of the tree seedlings planted, the autumn olive appeared to survive and grow better. Several of the olive trees were 2 meters in height. The white pine did not fair nearly as well. Survival was estimated at 10 percent with those surviving being stunted, probably from the herbaceous competition.

Vegetative cover on the areas with sparse vegetation responded well to the applications of lime, fertilizer, and seed. Serecia lespedeza dominated the area with lush growth. Several white pine saplings existing prior to the reclamation also responded favorably to the treatments. Several of these trees were over 6 meters in height having grown approximately 3 or 4 meters in 4 years. Revegetation of the site and the installation of permanent drainage ditches significantly reduced erosion from the site and sedimentation in Laurel Fork. The excavation of sediment and debris in and along the banks of Laurel Fork through the project area noticeably improved water flow through the project area and partially eliminated ponded water conditions of the upstream end of the project area. Although no water quality monitoring has been performed after construction due to lack of funding, it is evident that water quality has improved with the improved hydraulics and the significant reduction in sedimentation. No evidence of landslides or land mass movement has been observed in the regraded refuse since reclamation.

CONCLUSIONS

Most often a reclamation project is judged on the basis of revegetation alone; consequently it is typically a major goal of such reclamation projects. Revegetation plans should be made by an experienced soil scientist, agronomist, or other professional and should be custom-made for a specific site. Assessment of the problem and collection of preliminary data are essential steps in formulating reclamation plans. Recognition of financial constraints and cooperation with the administering agency are also essential elements in reclaiming abandoned mine lands.

The success of the Boissevain Reclamation Project was a result of several factors including: an effective approach to problem assessment including determination of goals, utilizing the expertise of several science disciplines; the formulation of a cost-effective workable plan designed to achieve the stated goals; and the effective implementation of the plan. While the materials and methods used to successfully reclaim the Boissevain site would not be effective in every situation, the approach to problem evaluation and design plan formulation employed on this project can contribute to the successful conclusion of most reclamation projects.

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