RECLAMATION OF ABANDONED MANGANESE MINES IN SOUTHWEST VIRGINIA AND NORTHEAST TENNESSEE[1]

by
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ABSTRACT. In 1985 the Tennessee Valley Authority (TVA) initiated a plan to rehabilitate the South Fork of the Holston River Basin. The objective was to identify and seek resolution of all major water resource problems in the basin area through integrated management. A major component of the plan is alleviating nonpoint source water pollution impacts from abandoned manganese mine lands. Most of these abandoned mine lands (AML) were created in the years prior to State noncoal mineral mining and reclamation laws. TVA has taken a lead role in addressing this land and water quality problem. Cooperative project activities resulted in the reclamation of 72 separate minesites covering 521 acres in a four-county, two-state area.

Additional Key Words: erosion; sediment; land rehabilitation

Introduction

Manganese mining in southwest Virginia and northeast Tennessee began on a small scale during the World War I era (figure 1). The early mining was for the most part conducted underground by the pick and shovel method and disturbed limited acreage. In 1941, the U.S. Government started a program for stockpiling strategic metals such as manganese (Tipton 1988). The manganese was needed by the steel industry to make a high quality steel alloy for weaponry and planes. Also in 1941, methods were developed for making pure manganese from common manganese ore by using an electrolytic process. These new needs and processes stimulated manganese mining in southwest Virginia and northeast Tennessee. Surface mining with heavy equipment (i.e., small shovels and bulldozers) began in the early 1940s and fluctuated with market conditions until about 1958, when the U.S. Government's procurement program ended.

Surface mining was unregulated and created at least 130 separate minesites covering 747 acres in a four-county, two-state area (table 1). No reclamation or environmental protection standards were attempted on these mines because of the economic conditions during that period. The mining was also done several years before State laws came about to regulate the environmental impacts of noncoal mineral mining. Tennessee passed its law in 1968 and Virginia enacted its provisions in 1969. This paper summarizes reclamation efforts involved in this AML stabilization project.

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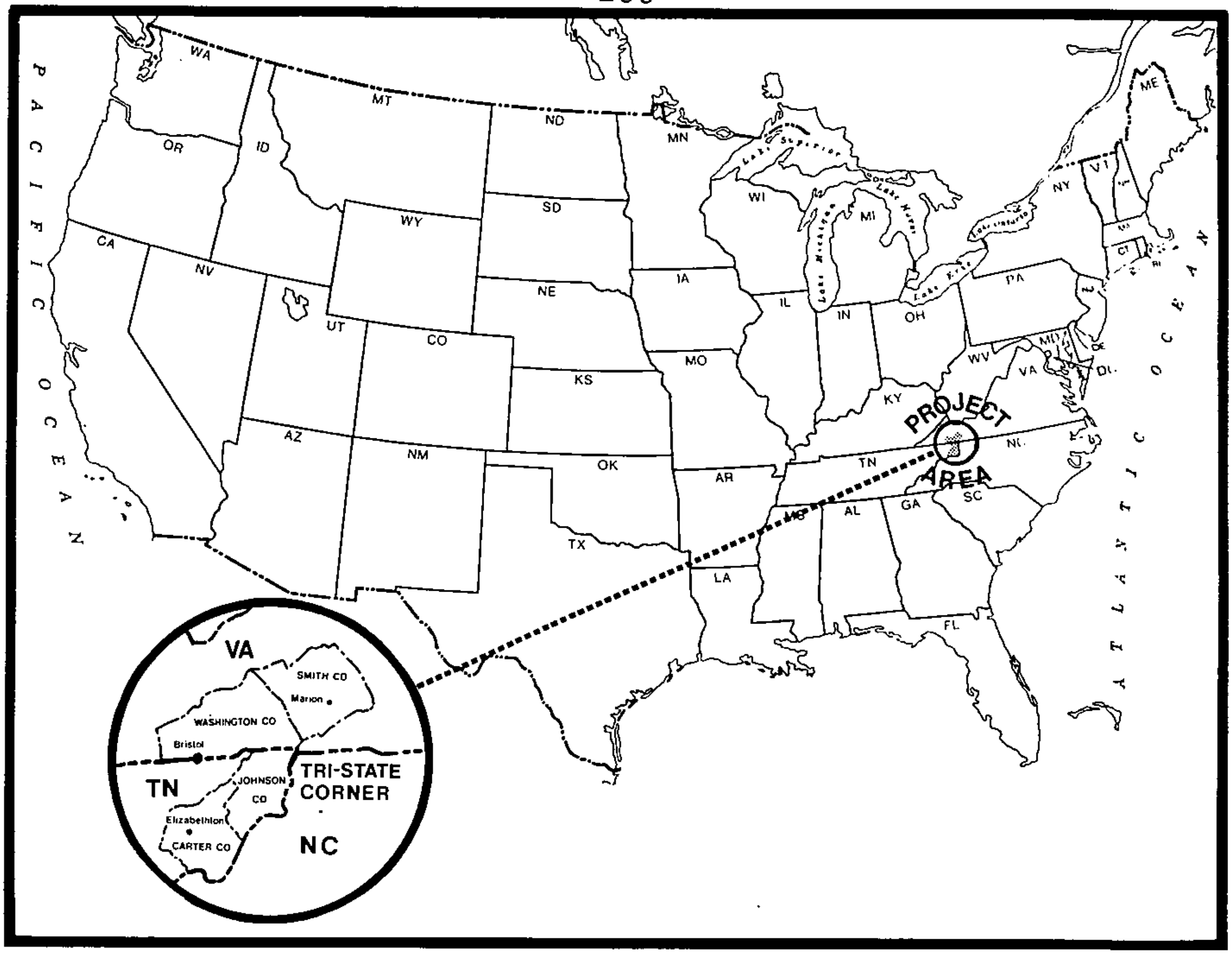

Figure 1. Location of Project Area.

Table 1. Status of abandoned manganese mines in the Tennessee Valley.

Mine Location	No. of Mines[1]	Disturbed	Naturally Revegetated	Reclaimed by TVA and Cooperators	Unreclaimed
		acres			
TN Counties					
Carter	15	79	11	68	–
Johnson	46	183	54	115	14
VA Counties					
Smyth	56	414	92	322	–
Washington	13	71	55	16	–
Total	130	747	212	521	14

[1]Also includes a limited number of abandoned sand mines and rock quarries.

In 1985 TVA took a lead role in addressing the land and water quality problems associated with these unreclaimed manganese mines. TVA's reclamation work on these AML sites is part of the agency's overall effort to seek resolution of all major water resource problems in the South Fork of the Holston River Basin (TVA 1985). For example, TVA is also working with farmers to control agricultural nonpoint pollution sources through use of best management practices and with homeowners to control or restore failing septic tank drain fields. The project also addressed the reclamation of unreclaimed sand mines that were causing offsite environmental problems.

Environmental Problems

The major environmental problem associated with abandoned manganese mines is excessive soil erosion and subsequent sedimentation of receiving waters. The effect of sedimentation from AML on streams, rivers, lakes, reservoirs and hydro-power operations in the Tennessee Valley has been previously reported (Muncy and Bollinger 1984, Muncy 1985, and Muncy 1986A).

The major watersheds adversely impacted by large amounts of sediment from these lands are the South Fork of the Holston and Watauga Rivers. These rivers, along with the North and Middle Forks of the Holston, form the Holston River. The tributary watersheds of the South Fork of the Holston and Watauga Rivers where most of the mining occurred includes: Georges Branch, Bishop Branch, Buzzard Den Branch, Cressy Creek, Jerrys Creek, and Staley Creek (sand) in Virginia; and Beaverdam Creek, Laurel Creek, Roan Creek, Doe Creek, Stony Creek, and Blue Spring Branch in Tennessee. Several of these streams are high quality headwater trout streams that support good fisheries. Also, the State of Virginia's Buller Fish Hatchery near Thomas Bridge encountered adverse water quality problems that were attributed to upstream mines located on Georges Branch and Bishop Branch watersheds.

Project Area

The mining for manganese in the Tennessee River watershed occurred in Smyth and Washington Counties, Virginia, and Johnson and Carter Counties, Tennessee. The AML sites are located from Sugar Grove, Virginia southwest to Mountain City and Elizabethton, Tennessee. Additional lands were mined near Cedar Springs, Virginia in Smyth and Wythe Counties. These other lands are not part of the project area because they are located outside the watershed of the Tennessee River.

Most of the project minesites in Virginia are clustered on the south slopes of Brushy Mountain in the Jefferson National Forest northwest of Sugar Grove. The old minesites are also located on the north slopes of the Iron Mountains in Virginia and Tennessee. Other locations in Tennessee include Forge Mountain, Doe Mountain, Dry Run Mountain, and the lower south slopes of Holston Mountain. Some of the Tennessee AML sites are located in or near the Cherokee National Forest.

The four-county, two-state project area is located in the Unaka Mountains. The Unaka Mountains are a major unit of Cambrian rocks in the northwest segment of the southern section of the Blue Ridge Physiographic Province (Fenneman 1938). The project area is adjacent to and drains into the Ridge and Valley province. Both provinces are divisions of the Appalachian Highland Region. The project area covers about 650 square miles; 12 miles wide and 54 miles in length. The topography is rolling to mountainous and minesite elevation ranges from 2,000 to 3,300 feet. The climate is characterized by cold winters and mild summers. Monthly mean temperatures range from 33 degrees (Fahrenheit) in January to 74 degrees in July (USDC, NOAA 1982A and 1982B). Precipitation averages 49 inches per year with monthly extremes of 3 inches in October and 5 inches in July (USDC, NOAA 1982A and 1982B). However, much of the rain is in the form of intense storms. Droughts of sufficient intensity to limit tree growth are most likely to occur in June, September, and October. However, the project area, along with the entire southeastern U.S. has experienced major, extended droughts over the last four years. These droughts were especially severe during the 1986 and 1988 growing seasons.

Most of the old minesites were in forest cover prior to mining. The three major forest cover types found in this area include white pine, oak-hickory, and oak-pine (SAF 1980).

Project Cooperators

TVA cooperated with private landowners, U.S. Forest Service (USFS), U.S. Soil Conservation Service (SCS), Virginia Division of Mineral Mining (VDMM), Virginia Game Commission (VGC), and Tennessee Department of Health and Environment (TDHE) in achieving on-the-ground reclamation. Throughout project implementation, TVA sought and obtained financial and in-kind contributions from landowners and State and Federal agencies.

In Virginia, the USFS, TVA, and VGC joined together to reclaim the old minesites in the Jefferson National Forest near Sugar Grove in Smyth County (figure 2). In this cooperative effort, 107 acres were intensively reclaimed and remedial treatments were also conducted (USDA, FS 1983). TVA secured an agreement with a private landowner to reclaim 36 acres in the same ore deposit near Sugar Grove.

TVA also worked with the USFS to treat 5 acres on the Mount Rogers National Recreation Area (MRNRA) near Teas in Smyth County. In the 1960s, the USFS also reclaimed 169 acres (in the Tennessee Valley) on the MRNRA around Sugar Grove in Smyth County. The State of Virginia with its limited reclamation bond interest monies reclaimed 16 acres near Damascus in Washington County and 5 acres near Thomas Bridge in Smyth County. Virginia also worked on a 2 acre minesite (included in the 107 acres above) near Sugar Grove in Smyth County.

In Tennessee, TVA secured agreements with 23 private landowners to reclaim 107 acres scattered throughout Johnson County and 21 acres east of Elizabethton in Carter County. The landowner agreements authorized the reclamation work and provided for the protection of the reclaimed site for five years. Certain landowners assisted with the reclamation efforts by providing in-kind services such as heavy equipment operation and storage facilities. In the early 1960s, a farmer reclaimed a 5 acre minesite on his property near Blue Spring in Carter County. This site now supports a healthy loblolly pine (Pinus taeda) stand.

The State of Tennessee provided special funding to establish a reclamation demonstration on a minesite (19 acres included in the 107 acres above) near Laurel Bloomery in Johnson County. The two landowners of this demonstration site assisted financially. The SCS prepared the technical plan and administered the sediment control and site preparation work. TVA conducted the revegetation work. Tennessee and SCS also reclaimed a 3 acre minesite near Crandull in Johnson County.

In the mid 1960s, the USFS reclaimed 6 minesites totaling 42 acres located on the Cherokee National Forest near Unaka and Blue Spring in Carter County. The USFS also reclaimed 2 minesites covering 5 acres on the Cherokee National Forest near Sutherland and Laurel Bloomery in Johnson County.

Characteristics of Minesites

The AML sites are generally on dry upland sites on the mid-to-lower slopes of various mountains. Moist conditions exist within subsites of the AMLs and along drainages. The premining natural slopes ranged from moderate to steep. The postmining physical configuration varies from site to site, but generally consists of outslopes that were created by pushing or casting spoil downslope, randomly located spoil piles, and open cuts with small highwalls or steep banks.

A. Before reclamation of the Georges Branch mine in Smyth County, Virginia, June 1985.

B. After cooperative USFS and TVA reclamation of the Georges Branch mine in Smyth County, Virginia, July 1987.

Figure 2. Before and after reclamation of a minesite on the Jefferson National Forest.

Most surface water drains offsite since few depressions exist for water to impound. Severe sheet, rill, and gully erosion occurred over the years. Sheet erosion was so intensive that it exposed the roots of numerous volunteer woody-stem species. Gullies are common. During major rainfall events, soil splashes upwards of two feet on volunteer plants because of the lack of adequate vegetative cover. Most of the original access roads were not properly constructed and have been impassable to rubber-tired equipment for years. The access roads washed out because of the lack of proper water control devices such as culverts, water turnouts, and drainage ditches.

No soil structure remained after mining, and what little topsoil existed either eroded away or was hauled away with the manganese to be processed. The remaining spoil material at most minesites consists of few rock fragments and is composed of sand, clay, and silt particles in descending order. A textural analysis classifies the spoil material primarily as a clay loam. The spoil contains limited organic matter and is nutrient deficient. Spoil samples were randomly collected from several minesites. Analysis indicated pH in the top six inches ranged from 4.7 to 6.3. Average pH is identified at 5.3. The spoil is a reddish coloration with various intermingled darker shades of red, brown, and gray. In the winter, subsurface ice crystal formation or frost-heaving is common.

The minesites that did not naturally revegetate have a combination of limiting factors that created a harsh growing environment for plants. Such limiting factors include steep slopes, severe sheet and gully erosion, high surface temperatures during the growing season caused by the semi-dark spoil color, and southernly aspects, infertile and moderately acidic plant-growth media, and frost-heaving.

The minesites that naturally revegetated are supporting both early successional volunteer herbaceous and woody-stem cover, with trees and shrubs dominating. Major woody-stem volunteers include yellow-poplar (_Liriodendron tulipifera_), Virginia pine (_Pinus virginiana_), black locust (_Robinia pseudoacacia_), and red maple (_Acer rubrum_).

Reclamation Activities

The objective of this on-the-ground land reclamation work was to cost-effectively stabilize the AML sites that were causing offsite environmental impacts. This was accomplished through a reclamation approach TVA has used in reclaiming other AML in the Tennessee Valley region (Muncy 1986C). The reclamation approach stresses correcting problems of surface waterflow and active erosion, returning the land to productive watershed, forest, and wildlife uses, and enhancing overall aesthetic values. The levels of reclamation range from minimum revegetation efforts to intensive water and sediment control, site preparation, and revegetation work.

Water and Sediment Control

Proper surface water drainage patterns were established at minesites and along access roads where grading occurred. For example, in several cases, surface waterflow was diverted back into natural stream courses and away from problem spoil areas. On one extensive minesite slope 3,750 feet of terraces were constructed to intercept runoff and to divert it to wooded buffer areas. Six-hundred feet of solid agricultural polyethylene tubing (soil pipe) was incorporated into the terraces at strategic locations with eight surface inlets to assist in safely moving concentrated terrace flow to the toe of the slope. Other runoff control techniques included small channel stabilization with riprap, diversion and drainage ditches, and grassed waterways. Access roads were properly drained through the use of broad-base dips, water bars or turnouts, culverts, ditches, and outsloping.

Sediment control was achieved by constructing perforated drop inlet sediment basins, small depressions, small check dams, and filter strips. Excelsior backed erosion control netting was used to stabilize several erosive slopes.

Grading and Site Preparation

Certain minesites needed to be graded with a bulldozer to provide a suitable environment for vegetation establishment. Objectives of the grading were to open up access roads, eliminate rills and gullies, bury debris, cover nonfertile material, create gentle slopes, establish proper surface water drainage patterns, and prepare seedbeds. Graded surfaces were not backbladed to a smooth finish since this practice impedes successful revegetation.

Seedbeds were prepared on accessible sections of selected minesites by conventional methods such as disking and dragging. Where grading was conducted, final surfaces were left semi-rough to provide microsites to trap amendments and provide favorable conditions for seed catchment, germination and plant growth. The rough spoil is also more conducive to tree planting and allows for better infiltration of rainfall. Several acres at one minesite were subsoiled with a bulldozer to a depth of about 24 inches. This technique breaks up crusted, compacted and impervious subsoil layers which creates improved conditions for tree and shrub planting and increases water infiltration. "Tracking in" with a bulldozer was conducted on steep slopes to establish a seedbed and prevent sheet erosion. On inaccessible minesites, aerial seeding was done during late winter to take advantage of loosened soil from freezing and thawing periods.

Revegetation

The primary goal of this project was to reestablish herbaceous and woody-stem species over the AML for erosion control purposes. This was accomplished through identifying individual minesite treatment needs and employing a proper revegetation scheme within the scope of available resources. Major revegetation activities consisted of applying soil amendments, seeding, mulching, tree and shrub planting, and follow-up maintenance.

Soil amendments. Liming was conducted on selected minesites where spoil acidity was of concern in vegetation establishment. However, minesite pH was generally within acceptable limits for successful revegetation. Proven acid-tolerant plant species were generally used to assure success. Typical pulverized agricultural lime was spread by conventional spreader trucks and pelletized agricultural lime was aerially distributed by helicopter. The aerial lime application was conducted only on extremely critical and inaccessible sites because of the high cost of the material ($50 per ton).

A blend of three high analysis fertilizers was used for ground cover establishment whether hydroseeded or aerially applied. It included 150 pounds per acre of 0-0-60 or potash, 300 pounds per acre of 18-46-0 or diamonia phosphate, and 50 pounds per acre of 45-0-0 or urea.

Seeding. Seeding of grasses and legumes and certain tree species was done by two broadcast methods, hydroseeding and helicopter seeding. Hydroseeding occurred on most minesites that were graded, along with certain other selected and accessible sites. Aerial seeding was the only practical and environmentally acceptable way to treat the inaccessible minesites spread out over the four mountainous counties. This saved the costs of opening up access roads, but more importantly, it circumvented the offsite environmental damages associated with reconstructing several miles of roads. Aerial seeding is also cost-effective (Muncy 1986B).

Two seed mixtures were primarily used. Mixture number 1 included Kentucky-31 tall fescue (*Festuca arundinacea*), birdsfoot trefoil (*Lotus corniculatus*), kobe lespedeza (*Lespedeza striata*), perennial ryegrass (*Lolium perenne*), redtop (*Agrostis gigantea*), and scarified black locust. Mixture number 2 consisted of interstate sericea lespedeza (*Lespedeza cuneata*), Kentucky-31 tall fescue, kobe lespedeza, weeping lovegrass (*Eragrostis curvula*), and scarified black locust. Mixture number 1 was applied by hydroseeders at the rate of 67 pounds per acre. Minesites that were aerially seeded received 75 pounds per acre of mixture number 2. Both mixtures provided excellent cover.

Mulching. Fifteen-hundred pounds per acre of quality wood fiber mulch with tackifier was used on all minesites that were hydroseeded. The tackifier is premixed with the hydromulch fibers to better enable the mulch to remain in place on treatment areas, including steep slopes. Hay was used to mulch some touch-up areas. On several steep slopes excelsior backed erosion control netting was used. The netting was secured with 6-inch metal pins. No mulching was conducted on minesites that were aerially seeded. Aerial treatments were completed in late winter and early spring, in time to take advantage of normal spring rainfall.

Tree and shrub planting. The AML sites were overplanted in bare root stock trees and shrubs beneficial to wildlife. The seedlings were planted by hand with hoedads because of the steep topography and the generally scattered, small minesites. A slow release fertilizer tablet was inserted adjacent to each planted seedling. Both 9-gram (22-8-2) and 21-gram (20-10-5) tablets were used. The 21-gram tablet reportedly improves seedling survival and growth significantly (Berry 1979). A fertilizer tablet supplies major nutrients needed by a transplanted seedling for two or three growing seasons. The tree seedlings were planted on a 6- by 6-foot offset spacing. This spacing is easily achieved and understood by tree planters and adequately allows for mortality losses. The shrub seedlings were planted on closer spacings in clumps, contour borders, and along edges for soil stabilization and enhanced wildlife habitat benefits. All seedlings were dipped in a synthetic soil moisturizer prior to planting and planted deeper than normal to compensate for potential sheet erosion and frost-heaving. The seedlings were 1-0, except for eastern white pine (*Pinus strobus*) which were 2-0.

Efforts were made to match species to subsite conditions and needs. The general planting pattern included black locust on the steep slopes and severe gullies, eastern white pine on the flats and better spoils, and autumn olive (*Elaeagnus umbellata*) and shrub lespedeza (*Lespedeza bicolor*) in pockets and selected rows to benefit wildlife. The herbaceous cover was not established dense enough to be considered a competitive threat to the trees and shrubs. This tree-herbaceous combination is possible because the amount of rainfall normally received is almost 50 inches annually.

Species planted included 63,000 black locust, 37,000 eastern white pine, 27,000 autumn olive, 8,000 shrub lespedeza, 7,000 Virginia pine, 6,000 green ash (*Fraxinus pennsylvanica*), and 5,000 eastern cottonwood (*Populus deltoides*). Higher than expected mortality rates occurred because of the extended drought.

Maintenance. The treated minesites received at least one maintenance aerial application of 12-24-24 fertilizer. Some of the harsher minesites received two and three supplemental aerial fertilizations. Other remedial work included spot tree and shrub planting, terrace clean out, and touch-up hand cyclone seeding and fertilizing. Several access roads were blocked off to vehicular traffic to prevent unnecessary damage from off road "joy riders." The most effective closure method found to stop four-wheel drivers is by constructing a double dipped earth berm or double tank trap.

Project Costs

Costs varied by reclamation activity. An itemized cost listing by activity follows: (1) grading with an International TD25C bulldozer, $90 per hour, (2) hydroseeding 67 pounds of an acid-tolerant seed mixture, 500 pounds of high analysis fertilizer, and 1,500 pounds of quality wood fiber mulch, $700 per acre, (3) aerially spreading 2 tons of pelletized lime, $377 per acre, (4) aerially spreading 75 pounds of an acid tolerant seed mixture and 500 pounds of high analysis fertilizer, $200 per acre, (5) aerially spreading 500 pounds of high analysis fertilizer, $100 per acre, (6) planting woody-stem bare root seedlings and inserting 21-gram fertilizer tablets, $275 per thousand, and (7) securing excelsior backed erosion control netting on steep slopes $6,000 per acre.

An approximate breakdown of dollars provide by project cooperators include TVA $247,000, USFS (Wythe Ranger District) in Virginia $149,653, USFS (MRNRA) in Virginia $106,756, VGC $750, VDMM $63,850, USFS (Watauga Ranger District) in Tennessee $25,608, TDHE $4,835, and voluntary landowner assistance $6,583. The total project cost was $605,035. Average cost was $1,161 per acre. TVA's financial support was provided by its Water Quality Department and project implementation by its Reclamation Program.

Conclusion

Abandoned manganese mine lands in southwest Virginia and northeast Tennessee were considered a major nonpoint source of pollution to receiving waters. Through cooperative efforts with State and Federal agencies and private landowners, most of the environmental problem lands have been stabilized and returned to productive watershed, forest, and wildlife uses, along with greatly improving their aesthetic values. The on-the-ground reclamation work was accomplished through a practical cost-effective approach. A total of 72 separate minesites covering 521 acres were successfully reclaimed by TVA and cooperators. Only 14 acres remain in need of treatment.

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