Best Management Practices for Controlling Erosion and Sedimentation During Electrical Transmission Line Construction on Steep Terrain

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1. Abstract

Duke Energy Corporation, based in Charlotte, NC, USA, is building a 161,000-volt transmission line in the North Carolina, USA, mountains. Elevations range from 360 meters to 1695 meters. The terrain is rugged, with slopes of access roads to the tower sites frequently exceeding 25%. Furthermore, the physical setting is rich in aesthetic quality with forests, streams, and lakes. Duke Energy is utilizing a variety of Best Management Practices (BMPs) to comply with state laws and, more so, to demonstrate good environmental stewardship by minimizing the adverse impacts of soil erosion and sedimentation on the natural resources and scenic beauty of the area.

The primary BMP used on land-disturbed sites throughout the transmission line corridor is re-vegetation by seeding of grass/legume mixtures. Newly seeded areas are mulched with straw and excelsior blankets. Sediment control on the access roads is achieved through water control structures and sediment traps. These measures also prevent sediment contamination of pristine bodies of water. A combination of BMPs is often required to stabilize slopes and minimize off-site impacts. Security measures, e.g., gates, fences, are used to restrict public access to the transmission line right-of-way, thus avoiding damage to the access roads and installed BMPs.

Wetlands are critical environmentally sensitive areas in the transmission line corridor. Permission to build towers in wetlands is obtained through mitigation. High-density polyethylene (HDPE) mats are used to transport heavy equipment into wetlands for construction purposes. The mats are removed when construction is completed. The natural vegetation restores itself in the previously matted areas.

2. Introduction

Duke Energy Corporation is rebuilding an existing 161,000-volt transmission line in the Appalachian Mountain Region of the southeastern United States (Fig. 1).

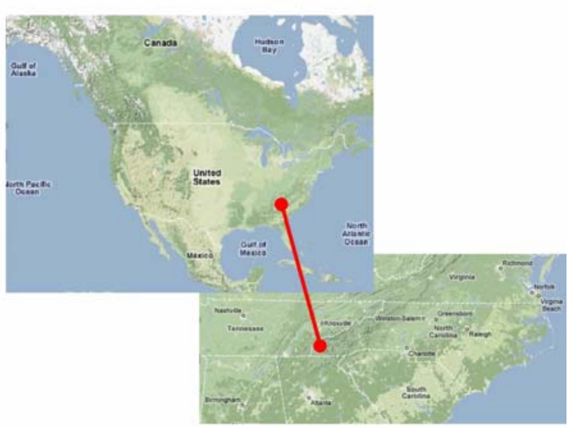

Figure 1 Location of the electrical transmission line project in western North Carolina, USA

The total line length is 30 kilometers (27 kilometers on private property and 3 kilometers on U. S. Forest Service lands). The upgrade of the line is necessary to maintain an adequate capacity of reliable electrical energy in the region.

The transmission line corridor is in mountainous terrain with elevations ranging from 360 to 1,695 meters. Two-thirds of the area is National Forest. There are numerous streams and lakes. The mountains, forests, streams, and lakes give the area a rich aesthetic quality. It follows that a major concern of Duke Energy is that the transmission line will have minimal adverse impacts on the natural resources and scenic beauty of the county.

The purpose of this paper is to report the Best Management Practices (BMPs) employed by Duke Energy Corporation on the transmission line upgrade project to minimize adverse environmental impacts.

3. Methods

A three-day field study was conducted to evaluate the utilization and efficacy of BMPs applied to tower sites and on access roads to the tower sites. Visual observation was the principal technique employed. Observation was supported by photographs and by occasional measurements of distances, seedbed thickness, and water depths.

4. Results

a. Obstacles to construction and BMP implementation

(1) Steep slopes

Many of the slopes for access roads to the tower sites exceed 25% . Furthermore, the width of the transmission line corridor is restricted in order to limit encroachment on national forest lands. This results in access roads with a steep ascent and numerous sharp "switchbacks" (Fig. 2). Consequently, providing logistical support, e.g., moving heavy equipment, hauling rocks, is slow and tedious on such roads.

Figure 2 Typical access road on transmission line corridor

(2) Narrow tower-siting points

The shaping of the mountains over centuries has produced very narrow ridges, insufficient for normal construction activities. Construction adjustments must be made, e.g., shortening or lengthening the lengths of the individual tower legs. Extra safety precautions must be taken with personnel and equipment. Abrupt and long drop-offs are associated with the small and narrow tower sites.

(3) Rocks

There is very little topsoil on many of the steep slopes. Rocks are prevalent on and near the surface. Furthermore, much of the rock is hard rock, i.e., igneous and metamorphic rocks such as granite and quartzite. Many of the tower sites and access roads to them are rocky. This makes construction more difficult. It also makes it harder to establish vegetation on them.

(4) Wetlands

Wetlands are critical environmentally sensitive areas. Because wetlands are highly protected areas, access to them and within them for an activity such as transmission line, can only be achieved through mitigation.

b. Best Management Practices

(1) Seeding and mulching

Although land clearing for the upgrade line project is minimal, there is still significant land disturbance as a natural consequence of transporting heavy equipment to and from the tower sites. New grading at tower sites and along access roads also produces much land disturbance, thus creating the potential for massive soil erosion and sedimentation.

Seeding and mulching are being implemented effectively. Seeding is done after each land-disturbing activity. The aim is to allow 10 months for vegetation to be established after access road development is completed and before line construction begins. The standard seed mixture is sericea lespedeza and fescue. Both are good for erosion control because of their dense root systems. Sericea also provides nitrogen to the soil through the nitrogen-fixation process. Annual plants are added to obtain quick ground cover. Rye is used in the fall and spring, millet in the summer.

Lime is applied at the rate of two tons per acre to adjust the soil pH and to provide calcium and magnesium. A 19-19-19 grade of fertilizer is applied at the rate of 500 pounds per acre to provide nitrogen, phosphorus and potassium.

There is considerable variation in the growth of the newly seeded vegetation due to differences in site condition, i. e., slope, soil, time of seeding, and microclimate. Seeding is occasionally required several times to obtain a stand. Growth is much better in cool, moist regimes along the line (Fig. 3).

Figure 3 Excellent vegetative growth on road banks and access roads

Newly seeded areas are mulched with straw and/or excelsior matting. Excelsior is a fibrous woody product that has a high water-absorbing capacity. Excelsior matting is a “blanket” that protects the soil from erosion while young vegetation is getting established.

(2) Slope stabilization

Given the steep slopes, narrow tower sites, rocky surfaces, and the close proximity of important water bodies, a combination of BMPs is often required to minimize off-site impacts of soil erosion and sedimentation. A typical BMP combination is vegetation, riprap, and silt fence.

(3). Water control

Unchecked movement of water down slope is a major cause of erosion and sedimentation. This is especially significant on steep terrain like that encountered in this project. A combination of BMPs is generally required to achieve successful water control. On access roads to towers, the slope has been "shortened" by grading to reduce the amount of sediment-laden water that will accrue. A water control structure called a water bar "catches" the water from the upper part of the slope and diverts it across the road, either into a sediment trap or into a protected area. Vegetation on the access roads and road banks complement water bars and sediment traps in slowing water flow and, hence, in reducing erosion.

(4) Water quality

As indicated earlier, lakes and streams are abundant in the project area and they are vital for domestic use, recreation, and other purposes. Sediment can be a major contaminant when land-disturbing activities are conducted on steep terrain susceptible to erosion. The BMPs employed on the project, when properly installed and managed, enable the clean waters to remain that way.

(5) Wetlands

Because of their soft, spongy nature, wetlands cannot directly support heavy vehicles and equipment. Several strategies need to be employed to access tower sites and undertake tower construction in wetland areas. A specially designed mat, commonly called a "swamp mat", has proved to be very effective for enabling transport of vehicles and equipment in wetlands. The mat is composed of high-density polyethylene (HDPE). The principle of the mat function is that the mats are interlocked, and this distributes the weight of vehicles and equipment across a large surface area. The mats have a tread pattern that improves traction for load-bearing vehicles and heavy equipment (Fig. 4).

Figure 4 Wetland tower site with truck and crane on "swamp" mats

Duke Energy Corporation is aggressive in implementing appropriate BMPs to insure that its transmission line construction will have minimal adverse impacts on the natural resources and scenic beauty of the mountainous area. BMPs are being employed that are environmentally effective and economically sound.