pzcounter

From: Jacob Greenberg
Sent: Thursday, November 17, 2016 4:05 PM
To: pzcounter
Subject: FW: Idaho Power Transmission Line
Attachments: EPRI_Report.pdf

FYI

From: wendy.hosman@powereng.com [mailto:wendy.hosman@powereng.com]
Sent: Thursday, November 17, 2016 8:43 AM
To: Jacob Greenberg <jgreenberg@co.blaine.id.us>
Subject: Idaho Power Transmission Line

Jacob-

Perhaps you should educate yourself about all the pros and cons of an underground versus overhead transmission line before unilaterally deciding that undergrounding the line is the best option. Please see the attached report.

Wendy Hosman PWS
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D-43
EXHIBIT

Assessment of Environmental Effects of Current Underground and Overhead Transmission Line Construction and Maintenance in the United States

Assessment of Environmental Effects of Current Underground and Overhead Transmission Line Construction and Maintenance in the United States

1015597

Final Report, December 2008

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REPORT SUMMARY

This report assesses environmental effects of current underground and overhead transmission line construction and maintenance in the United States.

Background

The nation's transmission infrastructure consists primarily of overhead transmission, with a smaller component of underground transmission. As the transmission infrastructure is being improved and expanded to meet growing demand, consideration of alternative construction methods, including underground, are being suggested with more regularity. There are environmental impacts, positive and negative, associated with both overhead and underground transmission line construction, maintenance, and operations that require attention when considering transmission line construction.

Objectives

- To identify standard construction techniques for overhead and underground electric transmission facilities and to describe associated primary environmental issues.
- To identify routine maintenance activities for overhead and underground transmission facilities and corridors and describe applicable environmental impacts associated with these activities.
- To provide a consolidation of key environmental issues related to overhead and underground transmission line construction and maintenance.
- To serve as a basis for a decision-making process that guides EPRI members through key factors associated with above- and below-ground facility location issues primarily as it relates to environmental impacts.

Approach

The project team identified standard overhead and underground transmission line construction and maintenance methodologies used in the United States utility industry. Standard terminology is defined, and a discussion of general construction and maintenance methodologies is presented. The project team also conducted a search of available literature to determine documented effects of overhead and underground transmission line construction and maintenance. Natural resources typically affected by overhead and underground transmission line construction and maintenance include land use resources, biological resources, geological and soil resources, water resources, cultural resources, and visual resources. Specific impacts and mitigation techniques are assessed and defined. This report is specific to United States applications.

Results

Whether a new overhead or underground transmission line is built depends on many factors that are often influenced by site-specific conditions, including construction costs, operational reliability, anticipated maintenance outlays, and relative environmental impacts. This report identifies and assesses both beneficial and detrimental environmental impacts associated with underground and overhead transmission line construction and maintenance activities.

Environmental impacts associated with underground transmission cable installation and maintenance can be significantly greater than those of overhead transmission line construction and maintenance. A comparative summary indicates that out of 34 potential environmental impacts, 18 environmental impact areas associated with underground transmission line construction and maintenance activities have greater detrimental effects on the environment as compared to overhead transmission lines. Five environmental impact areas associated with underground lines have lesser detrimental impacts as compared to overhead lines. Overhead and underground transmission line construction and maintenance activities have similar detrimental environmental effects on 11 impact categories.

These potential environmental impacts are provided only as a general guide. Only through site-specific evaluation of environmental impacts associated with any specific proposed transmission construction project can the actual relative impacts of underground versus overhead lines be determined. Environmental assessments for a specific site also should consider practical mitigation techniques that could be used.

EPRI Perspective

This report succinctly summarizes environmental impacts associated with overhead and underground transmission lines to assist companies in addressing inquires from regulatory agencies and the public. Potentially beneficial and detrimental environmental impacts are categorized and subjectively assigned descriptions (Similar, Greater, or Lesser) comparing relative severity of the environmental effects between overhead and underground transmission line construction and maintenance activities.

Keywords

Avian interaction
Cable
Construction
Environmental impact
Maintenance
Overhead
Right-of-way
Transmission
Underground
Vegetation management

ABSTRACT

The Nation's transmission infrastructure consists primarily of overhead transmission, with a smaller component of underground transmission. As the transmission infrastructure is being improved and expanded to meet growing demand, consideration of alternative construction methods, including underground, are being suggested with more regularity. There are environmental impacts, positive and negative, associated with both overhead and underground transmission line construction and maintenance that require attention when considering transmission line construction options. This report identifies and assesses both beneficial and detrimental environmental impacts associated with underground and overhead transmission line construction and maintenance activities in the United States. Resources typically affected by overhead and underground transmission line construction, operation, and maintenance include land use, biological, geological and soils, water, cultural, and visual resources.

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1
INTRODUCTION

Electricity is critical to modern society. It is the most common form of energy utilized by homes, businesses, industry, and government. The construction, operation, and maintenance of electric utility transmission lines are integral to electric system safety and reliability. In general, transmission lines are highly reliable, not only because of their physical design, but because they are configured in a loop, allowing a back-up source of power if one of the transmission lines experiences a fault. Overhead construction is the predominant method of installing transmission lines. However, underground installation techniques are also utilized in some places and are considered more often as these lines have become technically feasible and, in some instances, their costs are falling within range of acceptability.[1] In addition, installing underground transmission cables are considered with more regularity due to advantages associated with aesthetics and property values.

Overhead electric lines have some distinct advantages over underground cables. The extra cost incurred to locate underground lines is still quite significant. When technically feasible, the costs of installing underground cables can be higher, with the cost driven by site-specific conditions (Kiessling et al., 2003). Relative costs are also identified in Table 3.3.4 of CIGRE Technical Brochure 110 "Comparison of High Voltage Overhead Lines and Underground Cables" (CIGRE, 2006). Overhead lines can also handle more short-term overloading, and line failures for such emergency loadings are quite rare. Underground utility construction is often perceived by the public as more reliable, primarily because lines are buried, and appear to not be as susceptible to inclement weather conditions or potential vegetation-related outages. This generally is accurate for vegetation-related line outages. Underground transmission facilities, however, are not impervious to weather-related outages. The majority of the transmission grid in the United States is constructed using overhead construction. Underground facilities are connected to the overhead system since they are integrated into the grid. Thus, weather related outages that affect regional and local portions of the overhead system will also affect the underground facilities attached to them. Underground transmission facilities always have some overhead components such as substation terminations and transition structures. These overhead components are subject to weather related failures just as overhead transmission lines are.

Electric reliability typically is measured by 1) the frequency with which customers experience a power outage, and 2) the duration of the power outage. Overhead and underground outage comparison data demonstrates that the frequency of outages associated with underground systems typically is less than for overhead systems. However, the duration of an underground outage can be substantially longer than an overhead-related outage. Underground transmission

[1] The cost effectiveness of under grounding high voltage transmission lines is still found primarily in urban and suburban settings and usually for the lower range of high voltages, i.e., usually only those voltages below 345kV.

facilities can be more difficult to troubleshoot than overhead facilities. It typically takes more time to locate and diagnose a problem, and perform repairs to an underground transmission line, lengthening the time the circuit is out of service. Repairs of failed underground lines can be quite costly as they are time-intensive and can be more environmentally disruptive, depending on the underground system. Long-term reliability is also an issue. As overhead and underground facilities get older, they become less reliable. However, the lifespan of underground facilities is typically less than overhead facilities.

Underground systems do have some distinct advantages to overhead systems, as well. First, the overt visual effects of overhead lines, particularly the support structures and conductors, on the esthetic environment are almost nonexistent when the transmission facilities are underground. Also, underground transmission cable systems do not typically require the frequency of maintenance and repair activities that overhead systems do. This is not always true for vegetation maintenance needs. A properly maintained underground right-of-way (ROW) typically is kept clear of trees and large shrubs that can interfere with underground lines via plant root systems. Depending on the site, a similar frequency and intensity of vegetation maintenance activity as compared to overhead transmission lines may be required.

When determining whether to install overhead or underground transmission facilities, a number of site-specific factors are considered including construction costs, operational reliability, anticipated maintenance outlays, and relative environmental impacts. High voltage transmission lines in general (overhead and underground), as rather long linear facilities, can transect many miles of countryside. They potentially intrude upon innumerable environmental and cultural features as they traverse various natural habitats and other manmade amenities and land uses.

The purpose of this report is not to provide detailed analyses of cost comparisons associated with the installation and maintenance of overhead versus underground transmission line facilities. Rather, this report identifies and discusses environmental issues associated with overhead and underground transmission line construction and maintenance activities in the United States. Health issues associated with overhead and underground transmission lines are not addressed in this report, as they are addressed elsewhere (see EPRI research Program 60 EMF Health Assessment and RF Safety, and health related reports in EPRI research Program 57 ROW: Siting, Vegetation Management, and Avian Issues).

2
TRANSMISSION LINE CONSTRUCTION METHODS

This chapter briefly presents the standard construction components and techniques utilized for both overhead and underground electric transmission facilities in the United States. For a more detailed discussion, the reader is referred to other EPRI publications (EPRI 2008, 2007) and the publications of the International Council on Large Electric Systems (CIGRE).

Overhead Transmission Line Components and Construction Technologies

Transmission lines are often referred to as the "Super Highways" for long-distance transport of electric energy within the bulk power supply system. The construction, operation, and maintenance of high voltage electric utility transmission lines (nominally those above 69kV, inclusive and exclusive of 69 kV depending on the utility and/or state) are integral to the Nation's bulk electric system safety and reliability. Construction of overhead transmission facilities is still the predominant method of installing new high voltage lines.

Components of the Overhead Transmission System

From an environmental impact assessment viewpoint there are just three basic major "hardware" components to the overhead electrical system; the underground foundations, the support structures[2] and the conductors.[3]

Foundations

At each support structure site some sort of underground disturbance will occur, as there is a need to place the foundation into the ground. The exact type of foundation installation required is dependent on the subsurface conditions and can range from drilling of cylindrical holes by augers for pouring of large concrete blocks to excavated grillage foundations hollowed out by backhoes. Various rock anchors can also be used when solid rock is encountered. Sometimes blasting is required to remove unsuitable rock materials. Pile foundations (driven or drilled) may be required when subsoil conditions are poor (i.e., high groundwater levels which can produce non-bearing or settlement sensitive soils). The larger the support structure (dead-end or heavy angle) the more extensive the foundation needed. Most wood poles (suitable for some of the lower voltage lines) only need to have a hole augured into the ground and then the wood pole is inserted and back-filled. Foundations necessitating large quantities of concrete will require numerous trips by concrete trucks. This, in turn, can influence the type of access road required.

[2] The insulators are part of the support structure.
[3] Shield wires should also be considered.

Pole type support structures usually require less total surface area (disturbance footprint) than the conventional four-legged lattice tower.

Support Structures

The two primary types of transmission support structures are poles (wood, steel, fiberglass or concrete) or steel lattice towers. Self-supporting four-legged lattice towers are common, particularly for higher voltages. However, minimalist V-shaped lattice structures require only a single point of primary contact with the ground but have numerous guy wires for support. The higher the voltage, the larger (heavier and taller) the support structure is required. Generally, the higher the voltage, the fewer support structures per mile of line required due to the taller structures allowing for longer spans. Normally the maximum height of transmission structures is 200 feet. Structures over 200 feet usually must conform to the Federal Aviation Administration requirements of being painted in bands of orange and white with flashing lights adorning the highest points. Support structures (towers or poles) erection by means of a mobile crane suitable for going cross-country is advantageous if the support sites can be accessed without difficulty. Figure 2-1 depicts the use of mobile cranes to erect a steel lattice tower structure. Where erection by mobile crane is not possible several methods are in use whereby the crane is replaced by a gin pole in combination with a hoisting winch. The use of helicopters may be advantageous when support structures have to be erected within short periods of time or ground access is difficult (Kiessling et al., 2003).

Figure 2-1
Crews Prepare to Attach the Bridge of a 500 kV Steel Lattice Tower

Conductors

Conductors can be placed in various horizontal or vertical configurations in single or multiple circuits. Generally, higher voltage lines also require increasing conductor diameters. For the most part, voltages 230kV or less have a single conductor per phase. Higher voltages, such as

345kV, usually have conductor bundles of two subconductors each, for a total of six overhead electric wires per facility. 500kV lines normally have three subconductors per conductor bundle, for a total of nine individual wires, whereas a 765kV line generally has at least 4 subconductors per conductor bundle resulting in a minimum of 12 overhead wires. Some new 765kV lines are now using a 6-conductor bundle per phase to reduce audible noise. New clean conductors reflect sunlight and can be quite visible, hence, non-specular conductors are often used to reduce glare and the gleaming visual contrast with a typically darker background environment. An additional wire (or two), called a shield wire may be connected directly to the transmission support structure at the highest point to protect the main conductors from a direct lightning strike. During line construction, the stringing of the conductors requires a separate cleared area (outside the support structure work zone) for the pulling site and another cleared area for the tensioning equipment. These conductor stringing sites usually are located a few miles apart. Further devices that are required to be installed temporarily during the stringing operations are guard structures or "rider poles" that are set up to ensure the conductors do not come in contact with any electrical lines or fall onto roads.

Support Structure Voltage and Type; Effects on Right-of-Way (ROW) Width

Generally, the higher the voltage of the transmission line the wider the ROW must be to accommodate the facility in a safe manner. For instance, for a single circuit horizontal configuration ROW widths will be about 100 feet for 115kV, 125 feet for 230kV, 150 feet for 345kV, 200 feet for 500kV, and 250 feet for 765kV. Some of the factors taken into consideration when establishing ROW width besides voltage are structure height and configuration, conductor size and weight, structure span length, amount of potential conductor sag and blow out, elevation and vegetation and building structures. However, vertical configurations allow for narrower ROW. Tightly configured double-circuit lines can be built on ROW the same width or even slightly narrower than their single circuit horizontal configuration counterparts. For example, a 345kV line is proposed to be built on a 50-foot wide ROW with vertical configuration that leaves only 25 feet to the outside edge of the ROW. In this situation, real-time vegetation management becomes critical, and the number of off-ROW danger trees would abound in such a narrow ROW.

Description of Overhead High Voltage Transmission Construction Methods

Overland/Road Transportation and Installation

All overland construction practices for the installation of high voltage transmission lines minimally require some type of access network to each support structure site for the transport of equipment, materials, and work crews. A major component of rights-of-way (ROW) preparation necessarily involves the clearing, grading, and building of these access routes or even the construction of higher standard access roads to facilitate this ground entry to the support structure site work zones. Complete clearing of the structure site, as well as a fabrication area and/or work zone in close proximity to the structure site, is also required, usually in close conjunction with the building of the vehicle access system. These access routes/roads are on average about 15 feet wide. However, if curves are required due to accommodations made for terrain conditions, and long poles or other lengthy materials are to be transported then the access must be wider than 15 feet to allow for longer vehicles to negotiate these turns. To confine the transmission line construction project impact and avoid off ROW disturbances there is effort made to keep the access within the ROW boundaries and to use, whenever possible, the most direct alignment to access the support structure site.

Continuous access down the center of the ROW facilitates the progression of all transmission line construction activities. Having uninterrupted access along the entire length of the ROW is also quite advantageous to the efficient performance of all future maintenance activities throughout the operation life of the line. Due to the time and cost of breaking down a crane and moving it via public roads, along with the ease of conductor stringing, such uninterrupted continuous access generally is considered a highly desirable ROW feature that will smooth the progress of all transmission line construction activities.

However, sometimes the construction of continuous access down the ROW is simply not possible. This is most often due to some type of natural terrain feature that poses a virtually insurmountable obstacle. It can be from an environmental perspective, such as, steep slopes and/or a cost to benefit ratio, such as, the road is simply too expensive to build. If ground access is to remain, there are two possible alternatives. One alternative is to evaluate the possibility of off ROW access. The other alternative is to simply pull all construction equipment back out and leave a span length of ROW without any access facilities and re-enter the ROW from public (existing roads) ahead. However, if all ground access is deemed too prohibitive, a third alternative is now available; access to the work site by helicopter, which will be discussed in the next section.

The exact access requirements as to the type (specifications) of road needed to be installed will depend in large part on the specific kind of construction activities planned for the site. Access requirements differ depending upon such variables as support structure types (e.g., lattice towers or poles), structure function (e.g., heavy angle, light angle, tangent or dead-end), and the resulting differences in foundation requirements (e.g., grillage, concrete, or rock anchor). These seemingly subtle construction differences often cause substantial changes in the class (size and weight) and number of vehicle trips, which must arrive at the work site. Crews preparing to drill a foundation hole for a 345 kV single pole line near a newly constructed road is shown in Figure 2-2.

Figure 2-2
Crews Preparing to Drill a Foundation Hole for a 345 kV Single Pole Line

The actual access route/road design and construction effort may be as negligible as simply physically locating (flagging) and clearing the proposed route of travel along the ROW when the optimum surface soil trafficability conditions are encountered. If the surface soils conditions are less favorable, but the underlying ground conditions (sub soils) offer more suitable trafficability potential, some minor stripping and grading may be all that is needed. In some cases the unsuitable overburden soils are peeled back to the more durable subsoil and then graded, compacted, crowned, and ditched. Depending upon the terrain features (soils, slope, drainage, etc.) encountered on the ROW, and the amount of materials (number of trips), and the various types of equipment (size and weight) to be transported (e.g., concrete trucks and cranes), additional road design parameters may be needed. The resulting access road is built to the various engineering standards required to support the anticipated transport loads.

The access system implemented during the ROW preparation phase of transmission line construction may also be used by line maintenance work forces for repairs, as well as for vegetation management activities over the life of the line, and thus can be considered as a permanent ROW feature. However, in some instances the roads used during construction may only be temporary in nature and are completely restored after the heavy construction phase has been completed (i.e., roads built in active farm fields or spur (stub) roads to conductor stringing/tensioning sites). These temporary access roads/routes are "abandoned" after line construction and are not used for future line maintenance. Instead, they are scarified and rough graded (ripped) to help restore native soil characteristics (reduce compaction) and then seeded and mulched to ensure short-term stability.

In developing the exact alignment of ROW access roads one should also evaluate the potential to use any presently available existing roads such as farm lanes, woods/logging roads, and even skid trails. Slight upgrading of an existing road (if it is properly situated) usually is preferable to building an entirely new road. One of the principle benefits of siting a new line next to another ROW is the ready potential to utilize significant portions of the existing assess system to aid in the construction of the new line. Also to be considered are the existing and future uses of the land, both within the ROW proper, as well as in the nearby vicinity, and the plans of the underlying fee and abutment owners in regard to their needs for access to and future uses of their property.

Steep slopes, highly erodible soils, and stream and wetland crossings are some of the most commonly encountered and critical ROW environmental features to be carefully considered to protect water quality during transmission line access road building activities. They often require a variety of specialized construction practices. All the appropriate drainage control features must be available to select from in the design phase and then carefully chosen and installed properly as needed and in a timely manner during construction as the site specific situation warrants. At all times the various appropriate erosion prevention and sediment control strategies must be considered and the proper devices installed as needed. These assorted best management practices (BMPs) designed to minimize non-point sources of pollution resulting from erosion and sedimentation can be both immediate (sometimes temporary) and long term (usually permanent) (EPRI, 2002). These devices (e.g., hay bales, silt fences, culverts) should be properly maintained, and upgraded as necessary, during both the access road installation phase and throughout the transmission line construction process. Then these drainage features, all permanent erosion and sediment control devices and other long-term BMPs must be continually maintained throughout the operating life of the electric transmission facility. Figure 2-3 depicts workers filling a caisson foundation with concrete for a steel pole 230 kV river crossing structure.

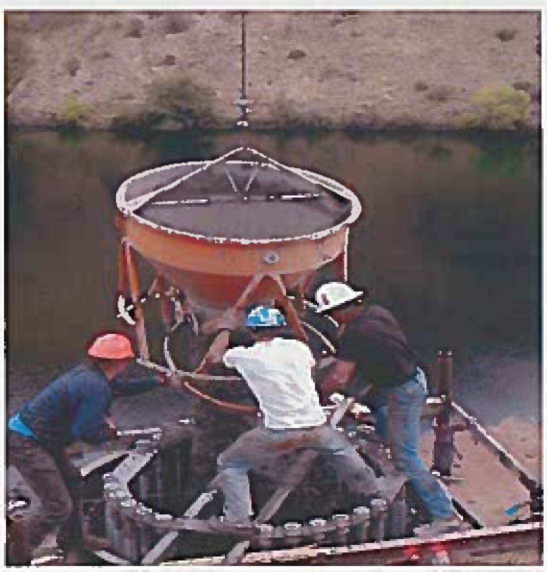

Figure 2-3
Crews Filling a Caisson Foundation for a 230 kV Steel Pole River Crossing

Helicopter Transportation and Installation

Occurring more frequently in recent decades, helicopter transport of materials and/or equipment to the transmission support structure work site is supplementing the conventional ground transport system. When helicopters are used they will, of course, decrease the number and types of vehicles requiring customary ground access to support structure work zones in direct proportion to the work that they are able to perform. In some instances, helicopters are used simply to expedite certain time-consuming elements of transmission line construction. By moving previously fabricated support structure sections from a centrally located fabrication facility (e.g., staging yards) work crews at the tower site can focus only on the assembly of the structure components and can work more efficiently than when they must fabricate each lattice tower piece by piece at the work site. In such situations, substantial amounts of equipment and materials must still access the work sites by ground transport over ROW access roads and/or routes. Excavators and concrete trucks for building foundations may still be necessary as well as cranes for hoisting the assembled tower pieces into position. A helicopter preparing to set the top half of a 345 kV single steel pole structure is shown in Figure 2-4.

Figure 2-4
A Helicopter Prepares to Set the Top Half of a 345 kV Single Pole Structure

However, in project areas where access road construction costs continue to escalate in order to overcome overt terrain difficulties, and concurrently, when attempts to minimize environmental disturbance to the landscape become prominent, more facets of transmission line construction work are being fully accomplished by helicopter transport. In these situations helicopters can be used to transport the full spectrum of materials, all necessary equipment, and personnel to the support structure work site. Helicopters can also be utilized to pull conductor and transport workers onto taller structures to avoid climbing. Other more specialized helicopters can also act as "flying cranes," with the pilots having full observation and control. In roadless areas (either by formal designation or due to severe topographic configurations) and other totally inaccessible areas, helicopters are now providing essentially all elements of support structure construction. Hence the use of helicopters in these limited situations has completely supplanted the need for any ground access to these critical support structure locations.

When employing such high performance helicopters for lifting the heavier weights necessary to erect taller and larger support structures, the wake of the rotor is so strong that linemen working on the towers could be in peril. For situations such as these, auxiliary erection remedies are required which provide guidance and temporary fastening of the tower components as they are flown into place. After the departure of the helicopter, linemen can bolt these parts into place permanently and the auxiliary erection remedies can be dismantled.

For those segments of high voltage transmission lines built without the need to construct any ground access and with full use of helicopter technology, almost all future maintenance activities occurring during the operation of line must likewise be performed by helicopter. Hence, many routine line repairs in areas that have limited ground access due to the lack of a road transport system will be expensive and other options to perform the work rather limited. One of the primary future difficulties with performing emergency line repairs with such restricted accessibility alternatives is the requirement of adequate flying weather to perform such complicated and dangerous work safely. Situations that hinder pilot visibility include ground fog and low clouds, rain, snow, and even nighttime darkness. These situations limit the opportunity to perform routine maintenance and even more so critical line repairs. Also high winds or even gusty conditions could curtail the ability to use helicopters to perform many routine line maintenance activities and severely handicap the timely completion of emergency repairs when catastrophic line failures occur.

Underground Transmission Line Components and Construction Technologies

Standard underground transmission technologies include open cut trenching, and trenchless technologies, such as horizontal directional drilling and horizontal boring. Cable types used in the utility industry include extruded dielectric cross linked cable, polyethylene (XLPE) cable, ethylene-propylene rubber (EPR) cable, high pressure pipe type (HPPT) cable, and self-contained fluid filled (SCFF) cable.

Open Cut Trenching

Open cut trenching, the most widely used method of installation for underground transmission lines, primarily utilizes mechanized digging equipment to create a trench with given dimensions per the design. With any trenching activity, OSHA Standards (sometimes state and local law), govern the working area. Sheeting and shoring are often required to mitigate any safety concerns for personnel as well as equipment. Dewatering is performed in any area where groundwater will be encountered, and storm water prevention plans are implemented to reduce any hazards caused by excess water within the work area. An example of an open cut trench is shown in Figure 2-5 and Figure 2-6.

Upon completion of excavation, the bottom of the trench is set to design grade where the cable system will be constructed. Depending on the type of cable system, pipes or conduit are positioned within the trench utilizing spacers or other means of mechanical stability to ensure the cable system maintains the correct dimensions while being backfilled. Often times manholes are placed within the system to allow for routine maintenance and cable installation. Because excess heat can be a detrimental factor to underground cable systems, select backfills are obtained with low thermal resistivities to allow for efficient dissipation of heat from the system. In most instances these backfills can be created and tested at a local batch plant.

In many applications, trenched installations use existing public access corridors such as road ROW and city streets. Trenching interference with the typical use of these public corridors can be minimized to alleviate traffic congestion as well as presenting as little hindrance to the community as possible. Steel plating over the trench is one method utilized to allow vehicular and pedestrian traffic across the trench. Traditionally, open cut trenching is labor intensive and time consuming. Aside from the associated high agency costs, open cut trenching operations often result in high user, or "social" costs due to the disruption of traffic and adverse impact on nearby businesses (Ariaratnam et al., 1999). Other potential problems caused by open-cut methods include damage to existing utilities and concerns for worker safety (Chung et al., 2004).

Figure 2-5
Open Cut Trenching

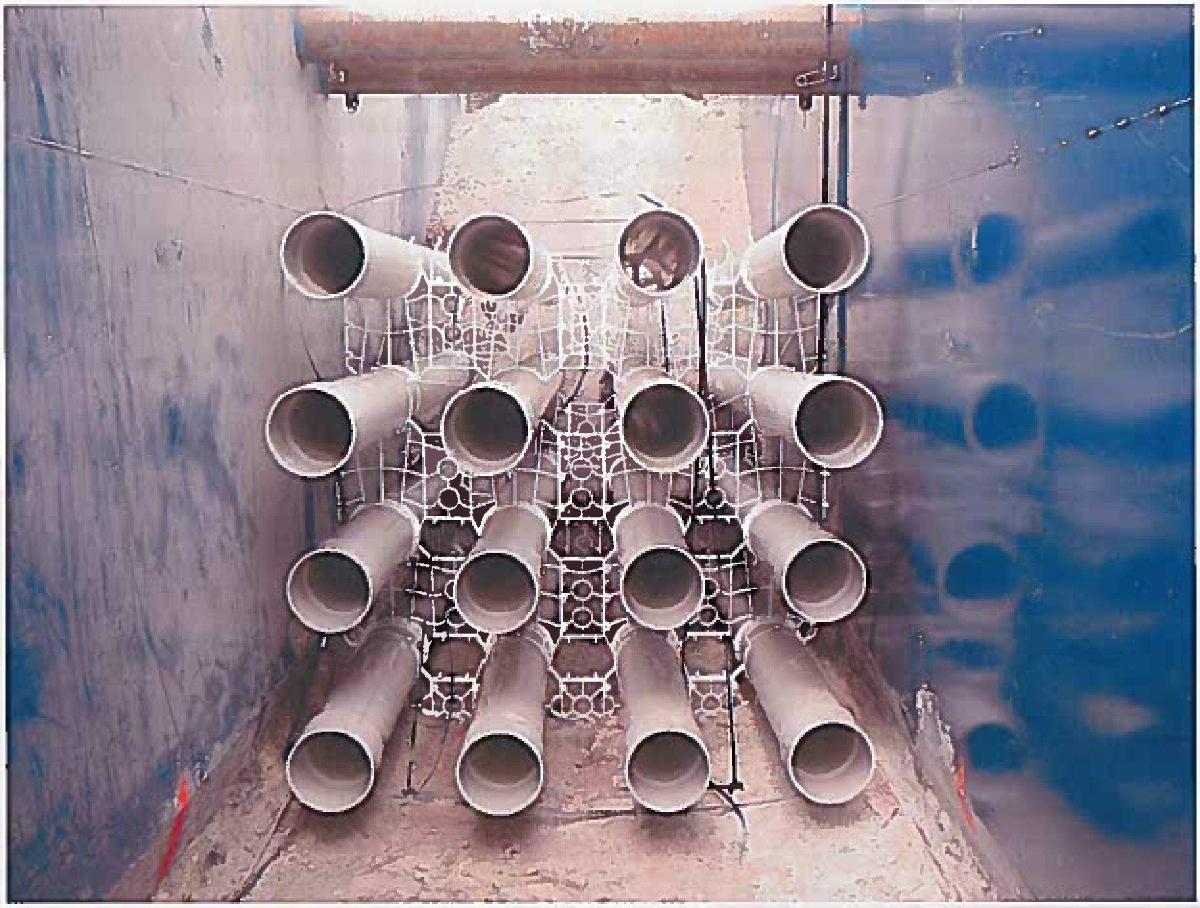

Figure 2-6
Conduits Set Into an Open Cut Trench

Trenchless Technologies

Several types of trenchless technologies exist and those construction techniques can be generally grouped into horizontal directional drilling (HDD) and horizontal boring (HB). Types of horizontal boring include microtunneling (MT), pipe jacking (PJ), and auger boring (AB). The use of trenchless technology is on the rise, increasingly viewed as an alternative to open cut methods (Ariaratnam et al., 1999), but still constitutes a small fraction of the methods used for undergrounding. Trenchless technology covers a range of methods that allows for the installation of small-bore tunnels or pipes without continuous surface excavation. The capabilities of these techniques vary considerably and many are be unsuitable for installing electrical cables over all but the shortest of distances.

Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) uses technologies associated with conventional road boring and directional drilling of oil wells; methods originally used in the 1970s. With its creation tailored to installing large diameter pipes for transporting oil, natural gas, and petrochemicals, the installation practices were quickly adapted to install electrical and fiber optic lines. The use of HDD technologies typically applies to areas where an open cut trench is either impractical or unfeasible. These locations include but are not limited to rivers and waterways, airport runways, congested cityscapes, and pipeline corridors.

The longest installation completed using horizontal directional drilling was 7,000 feet long with pipe diameters up to 60 inches. Although directional drilling was originally used primarily on the U.S. Gulf Coast through alluvial soils, the development of techniques and machinery have lead to directional drilling through gravel, cobble, glacial till, and hard rock.

There are numerous types of machines available for HDD, which are primarily categorized by thrust and pullback force capabilities. Small rigs have thrust and pullback forces of less than 50,000 pounds. Typically these rigs have ranges limited to 1,500 feet and can install up to 20-inch product casings depending on length and specific forces. Large-sized rigs have thrust and pullback forces greater than 50,000 and up to 1,000,000 pounds. Bore ranges can exceed 5,000 feet and can be used to install 6- to 60-inch product casings (Kramer et al., 1992). A typical layout for the HDD equipment is shown in Figure 2-7.

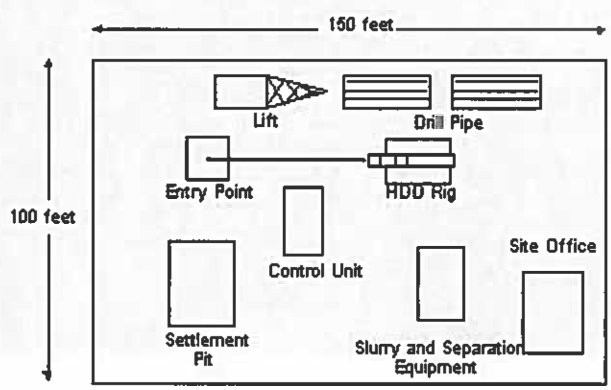

Figure 2-7
Typical Layout of Horizontal Directional Drill Equipment

The drill profile is designed after the geotechnical investigation is complete, and the locations of existing obstacles and crossings, such as other utilities, are determined. The drill profile is designed to allow a minimum depth of cover below surface grade and all obstacles. The recommended minimum depth of cover differs for each application but 10 feet below surface grade is typical to prevent loss of drilling fluids.

Designing entry and exit angles is one of the most important aspects to the drill profile. Utilizing entry angles between 8° and 20° for most installations allows for the driller to either gain maximum depth or minimize distance. However, obstacles within the route often dictate both parameters. Because the product pipeline constrains the bending radius, generally held to a curvature of 100 feet for every inch of diameter, very long bend radii must be taken into accounted. Exit angles generally are held between 5° and 12° to facilitate handling of the product pipeline during pullback, as well as allowing for ease of tie in to the continuing line. HDD Pipe is shown in Figure 2-8. HDD Casing Pipe is shown in Figure 2-9.

Figure 2-8
Horizontal Directional Drill Pipes

Figure 2-9
Horizontal Directional Casing Pipe

Upon completion of the drill profile, a pilot hole is drilled utilizing the design entry and exit angles, as well as the maximum radius bends. To control the direction of the drill, a small bend located just behind the cutting head is rotated only when directional control must change. For example, if the bend is orientated to the right the drill string will project to the right. Concurrent to drilling the pilot hole, the contractor may elect to run a larger diameter "wash pipe" that will encase the pilot drill string. Acting as a conductor casing, the wash pipe provides rigidity to the drill string and helps to minimize frac-out and cave in of the drilled section.

The drill path is monitored by an electronic package housed in the pilot drill string near the cutting head. Most downhole survey tools are electronic devices that provide a magnetic azimuth, for right and left control, and inclination, for up and down control. Surface locators can also be used in conjunction with the downhole electronic package to ensure accuracy. Alternate methods, such as gyroscoping or ground penetrating radar, may also be used to determine the as-built position. A reasonable drill target at the pilot hole exit location is 10 feet left or right, and –10 feet to +30 feet in length, due to variations in the earth's magnetic field and effects of large steel structures.

With completion of the pilot hole, enlargement occurs before installation of the product pipe. To enlarge the hole, a reamer is positioned where the cutting head used to be located on the drilling string and is pulled back through the pilot hole. To develop very large diameter holes, successive reaming may be required. Once the hole has reached a sufficient size, the product pipe is pulled through. To prevent translation of rotation into the product pipe, a swivel pulling head can be utilized. To minimize the strain placed on the product pipe, large amounts of drilling slurry, most commonly bentonite, can be used to lubricate the hole thus reducing friction. When the product pipe has reached the other side, the drill rig is demobilized and continuation of the line can be completed.

Horizontal Boring

Pipe jacking and microtunneling are similar pipeline installation techniques; these methods are used for installations greater than 6 inches in diameter. Pipe Jacking is a process that requires directly installing pipes from behind a shield machine by hydraulically jacking from a drive shaft so that the pipes form a continuous line in the ground (See Figure 2-10 and Figure 2-11). The specially designed pipes are able to withstand the jacking forces likely to be encountered during installation.

Within this description, microtunneling is specifically defined as a steerable remote-controlled shield for installing a pipejack with an internal diameter less than that permissible for man-entry. Microtunnelers often use a laser guidance system to maintain the line and level of the installation. Though, as with larger pipe jacking installations, both laser guidance and normal survey techniques can also be utilized.

To safely install lengths in excess of 300 feet, manufacturers and contractors had to look to other ways of reducing jacking stresses on the pipe. One obvious solution was to reduce the jacking load. The jacking load results from a relatively small constant load (from the cutting head) and from frictional resistance and adhesion between the soil and the pipe (the main component). Although the jacking load is linearly proportional to the length of the pipe driven, the soil and water table conditions can vary the frictional resistance by as much as a factor of twenty. By coating the pipe and introducing suitable lubricants, the frictional resistance can be greatly reduced. Lubricants are usually based on bentonite slurries, which need to be designed for the varying soil conditions and injected along the drive length to maintain a constant slurry around the pipe.

Figure 2-10
Workers Implement Jack & Bore Technique

Figure 2-11
Bore Equipment

Microtunneling is essentially a remotely controlled form of pipe jacking. Following are two basic categories of microtunneling machines:

- Pilot Bore
- Full Face Machines

Pilot-bore machines use a two-stage process that requires an initial pilot bore to be driven to the required centerline and level of the pipe. The second stage involves fitting a reamer head onto the end of the pilot line and drawing it through to enlarge the bore to the required size. At the same time, the permanent pipe being installed is pushed in behind the reaming head as it travels forward.

The type of head used on the pilot bore depends on the soil conditions. In softer conditions, when the soil is easily displaced and compacted, a non-excavating anvil-type head can be used. When the soil is harder or in granular materials, a rotary cutting head fed with water for removal of the spoil is employed. At the second stage of enlargement, the choice of reamer is also determined by soil conditions. In stable, cohesive materials, a straightforward cutting head equipped with teeth and bits will be used. In unstable soils, generally non-cohesive granular type, the reamer chamber will be pressurized and the soil forced through slots in the chamber.

In a full-face type of machine, a steerable cutting head is used to cut the full external diameter as the drive proceeds. There are a number of variations for full face cutting and disposal of spoil. Full-face machines can be broadly subdivided into the following:

- Auger Type – The cutting head rotation and spoil removal is done by shaft driven flight augers.
- Slurry Type – The cutting head is independently driven and incorporates a pressurized slurry chamber. Spoil is removed by the pressurized return slurry line, which carries the spoil in suspension.

Auger machines have been widely applied in soft through hard clays and also in finer granular material above the water table. These machines can be provided with pressurization devices that allow work to be carried out in granular materials three to nine feet below the water table. A variety of cutting-head arrangements can be used according to the soil conditions anticipated.

The slurry machines were particularly developed to work at depths of 30 feet or more below the water table in granular soils. Through adjustment of the slurry pressure in the face chamber, a counterbalance to the groundwater pressure is provided. Some slurry machines are also equipped to provide an adjustable positive thrust on the face to balance the earth pressure.

In slurry machines with a pressurized chamber, the head section is a drum construction. The cutting face is a flat plate or dome with replaceable bits and cutters configured according to the soil conditions. Soil is forced back through slots into the pressure chamber. These slots are adjusted to regulate the flow of material.

Cable Types

Extruded Dielectric

The components of a typical extruded dielectric cable are shown in Figure 2-12. The typical cable consists of a stranded copper or aluminum conductor, semi-conducting extruded conductor shield, extruded dielectric insulation, extruded semiconducting insulation shield, a lead, aluminum, copper or stainless steel sheath moisture barrier, and a protective jacket. A metallic shield, tape or drain wire, is required to carry fault current when a sheath is not used. Cable jackets typically are extruded polyethylene (PE) and on rare occasions polyvinyl chloride (PVC).

Figure 2-12
Typical Extruded Dielectric Cable

Insulation materials used for extruded dielectric cables include:

- Thermosetting Compounds:
  1. Ethylene propylene rubber (EPR)
  2. Cross-linked polyethylene (XLPE)

Extruded dielectric cables are manufactured using one of the following extrusion techniques:

- The conductor shield and insulation are extruded in tandem over the conductor. Extrusion of the insulation shield is a separate operation.
- The insulation shield, insulation and conductor shield is extruded in tandem over the conductor. This method is known as triple tandem extrusion. Triple extrusion is the preferred and recommended technique.

The metallic shield, tape, concentric neutrals, etc., and jacket, as applicable, are applied later in separate operations.

Vulcanization of thermosetting insulation compounds, EPR and XLPE, occurs via a dry cure or steam cure process (steam cure is not recommended for High Voltage cable) in a tube called a curing tube. After vulcanization, the insulation is cooled with water or gas in a cooling tube.

The manufacturing process for extruded cables is of critical importance to ensure a reliable end product, since extruded dielectric insulations are not self-healing. Fluid-impregnated paper insulation has higher tolerance for manufacture defects. As such, quality control during manufacture of extruded dielectric cables is critical to minimize moisture contamination, voids, contaminants and protrusions. Insulation contamination can be minimized by manufacture of and use of super clean insulation compounds; transportation and storage of the compounds in sealed facilities; and screening out of contaminants at the extruder head.

High Pressure Pipe Type Cable

The construction of a typical high-pressure pipe type (HPPT) cable is shown in Figure 2-13. The cables typically are composed of a conductor, conductor shield (carbon black or metalized paper tapes), insulation (Kraft paper or paper/polypropylene laminate impregnated with polybutene or alkylbenzene fluids), insulation shield (carbon black or metalized paper tapes), a moisture barrier (non-magnetic tapes and metalized Mylar tapes), and skid wires (zinc, stainless, brass). The moisture barrier prevents moisture and other contamination and loss of impregnating fluid prior to installation. The skid wires prevent damage to the cable during pulling.

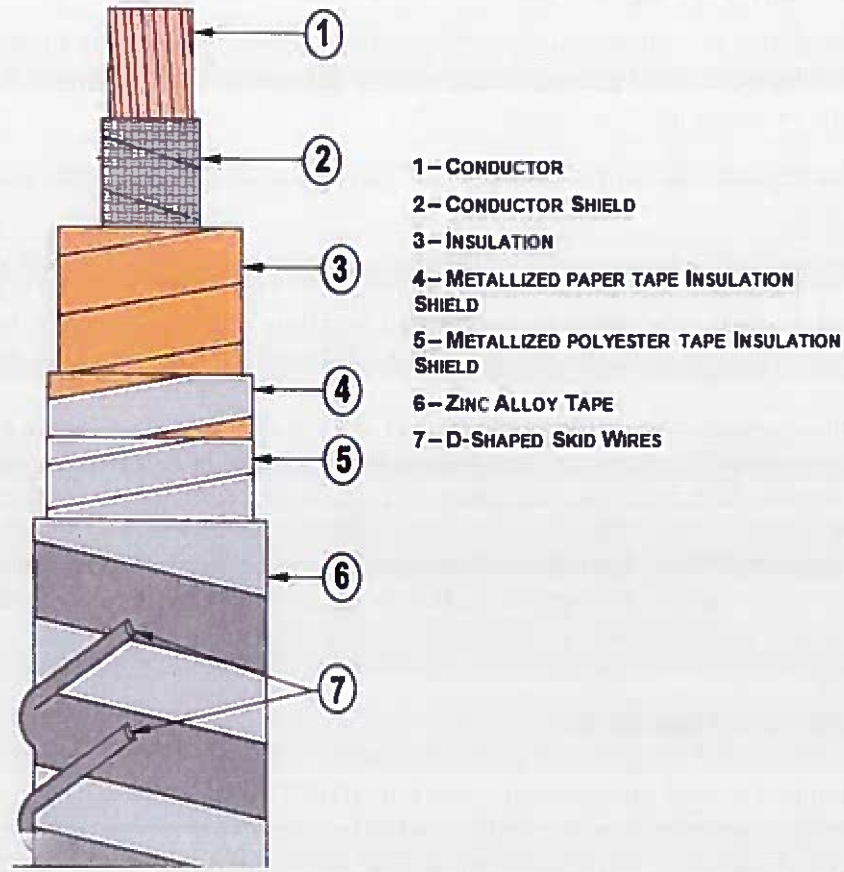

Figure 2-13
Typical HPPT Cable

Three HPPT cables are pulled into a low-carbon steel pipe to constitute a cable system. If the pipe is pressurized with a dielectric fluid, the system is called a High Pressure Fluid Filled (HPFF) system. If the system is pressurized with nitrogen, the system is called a High Pressure Gas Filled (HPGF) system. The pipe is coated on the inside with an epoxy coating to prevent oxidation prior to fluid/gas filling and to reduce pulling friction and tension. The pipe exterior is coated with fusion bonded epoxy or polyethylene to protect the pipe from environmental corrosion and to isolate the pipe from "ground" to allow use of a cathodic protection system.

HPPT cable systems are filled with pressurized low viscosity polybutene or alkylbenzene fluids. Cathodic protection is applied to pipes used in HPPT cable systems. This protection inhibits pipe corrosion, thereby minimizing or eliminating pipe leaks due to corrosion.

The manufacturing process for HPPT cables is similar to the process used for paper-insulated lead-covered cables. A conductor core is covered by helically wound layers of metalized or carbon black paper tape for conductor and insulation shield and high-quality Kraft paper or paper/polypropylene laminated for insulation. The insulated cable is dried and then impregnated with fluid in large pressurized tanks.

Self Contained Fluid Filled (SCFF) Cable

Self contained fluid filled (SCFF) cable systems are often referred to as low pressure fluid filled cables. A typical SCFF cable cross-section is shown in Figure 2-14. The cable is distinguished by a hollow central duct through the conductor, which carries low-viscosity dielectric fluid at pressures ranging between 25 psi and 40 psi. Higher pressures, up to 250 psi, have been used. The dielectric fluid in SCFF cables acts to eliminate voids and prevent ionization, corona discharge, and insulation breakdown. As dielectric fluid pressure is increased, void suppression is improved and the maximum allowable electrical stress may be increased. This results in higher allowable maximum operating voltages.

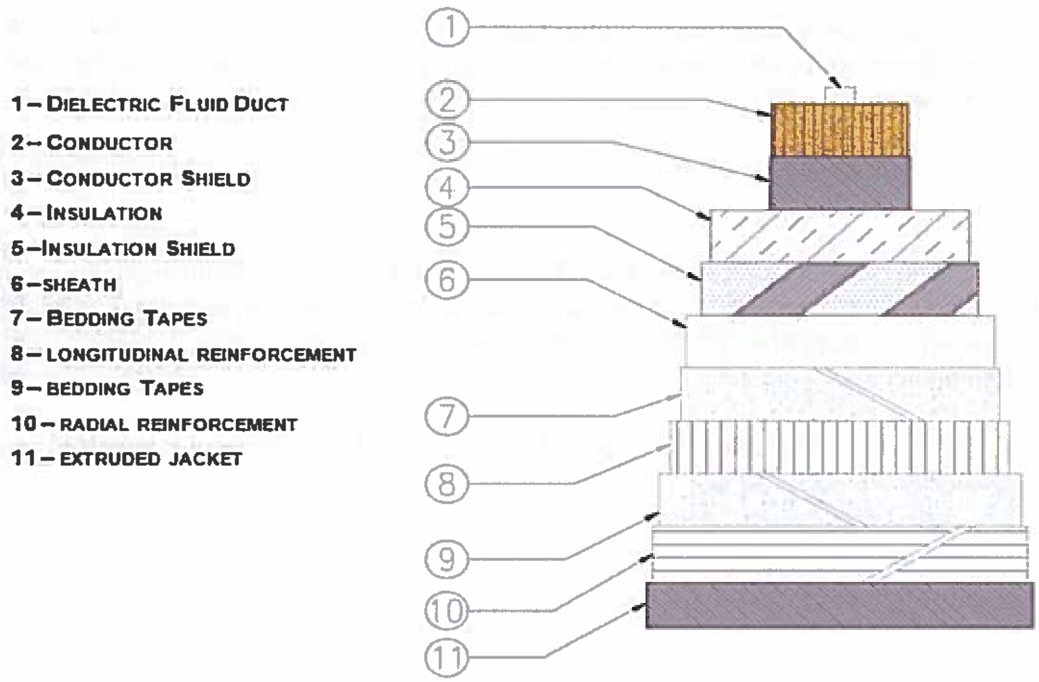

Figure 2-14
Typical SCFF Cable

Alkylbenzene is used in U.S., European, and other SCFF cables. Mineral oil was used historically in the U.S. Advantages of the synthetic fluid as compared to mineral oil include lower viscosity, better thermal and electrical stability, excellent gas and moisture absorption properties, and reduced thermal aging of paper dielectrics. Use of synthetic fluid allows normal cable operating temperatures of 85°C and short time intermittent operating temperature limits for emergency overload operation and faults of 100°C and 105°C, respectively. Synthetic fluid is, however, more susceptible to contamination than mineral oil.

SCFF cables require dielectric fluid feeding systems and reservoirs to maintain the dielectric fluid at minimum operating pressure. The reservoirs provide surge capacity to accommodate dielectric fluid flow into or out of the cable during load cycling. The cables are designed to withstand operating pressures plus static pressure variations along the cable route, due to changes in elevation. When large changes in elevation occur along a cable route, stop joints may be used to isolate sections of the cable and limit static pressure increases to acceptable levels. Isolation of cable sections with stop joints also limits the amount of dielectric fluid released due to a cable sheath break or dielectric fluid leak.

Dielectric fluid loss, due to a break in the sheath, can lead to a rapid degradation of the cable insulation. As such, dielectric fluid level is closely monitored.

At operating voltages exceeding 100kV, single-phase cables are used almost exclusively. When directly buried, these cables are separated; typical distances are six to ten inches, to improve thermal performance.

SCFF cable systems typically use a lead or extruded aluminum sheaths to prevent dielectric fluid loss.

The dielectric fluid must be completely degasified since SCFF cables systems typically operate at lower pressures compared to HPFF systems. At these lower pressures, not all latent gasses will be dissolved. Owners of SCFF cable system should possess degasifying equipment for repair and maintenance.

SCFF cables typically are installed direct buried with a protective covering, in tunnels or in a duct bank.

3
ENVIRONMENTAL EFFECTS ASSOCIATED WITH TRANSMISSION LINE CONSTRUCTION

This chapter describes the resources affected by overhead and underground transmission construction activities and assesses the documented effects of these construction activities on the associated primary environmental concerns.

Description of Resources Affected By Transmission Line Construction Activities

Within this broad overview of generic environmental impacts associated with current typical transmission line construction and operation practices it is simply not possible to identify detailed site-specific impacts and explicit consequences. This assessment of various environmental outcomes focuses on those resources most likely to be affected during the construction and operation of a new high-voltage transmission line project. Since project specifics and detailed mitigation measures are not fully known, and the range of possible environmental conditions includes practically all possible settings (e.g., land uses, biological resources, hydrologic conditions, etc.), this analysis, by necessity, takes a more programmatic approach.

Resources typically affected by overhead and underground transmission line construction and maintenance activities include the following resources:

- Land Use
- Biological Resources
- Geological Resources and Soils
- Water Resources
- Cultural Resources
- Visual Resources

Land Use

Most transmission line construction projects cross many miles of countryside, and thus traverse numerous land uses and property ownerships. Certain types of land uses are more compatible with transmission line construction and operation than others. Some land uses are more prone to short term disruption occurring during the construction phase, and these uses can be promptly resumed after the transmission facilities are installed (Programmatic EIS, 2007).

Classifications of Land Use

There are many land uses that can be affected by construction and operation of transmission lines. The major land use categories are, as follows:

- **Agriculture:** lands used for agriculture production including farm fields, row crops, irrigated lands, orchards, nurseries, pastures, and rangelands.
- **Forests:** lands that are primarily occupied by trees, including commercial, private, and public.
- **Parks, recreation, and preservation areas:** land areas where the established or proposed land use primarily is for recreational enjoyment or to protect and preserve a valuable environmental resource. Examples include significant ecological areas, wilderness areas, areas of critical environmental concern, environmentally sensitive habitats, wildlife refuges, preserves, rivers, floodplains, vacant urban lands, general rural lands, golf courses, national parks, local or regional parks, campgrounds, fairgrounds, and playgrounds.
- **Developed**
  a. Residential: single family residences, multi-family residences such as condominiums or apartments, townhouses, and mobile home parks.
  b. Commercial: retail stores, shopping centers, professional offices, business parks, retail plant nursery, and hotels/ motels.
  c. Public Facilities: educational institutions, religious facilities, health care buildings, government offices, police and sheriff stations, fire stations, public parking facilities, correctional facilities, day care centers, cemeteries, hospitals, and nursing homes.
  d. Industrial: lands used for manufacturing, and lands used for mineral extraction such as open pit mines (including mining claims), oil wells, oil refineries, tank farms, substations, gravel pits, concrete plants, solid and hazardous waste landfills, sewer plants, other transmission lines, or pipelines.
- **Transportation and access:** the existing network of access to lands in the area. This includes interstate highways, parkways and roads, airports, railroads, park and ride lots, bus, truck, and railroad terminals.

Biological Resources

Biological resources refer to all the species living together in an area. Biological resources can be divided into two broad categories, which can be affected by construction of an overhead or underground transmission line:

- Vegetation resources
- Wildlife resources

Vegetation resource is a general term for the plant life of a region. It refers to the ground cover life forms, structure, spatial extent or any other specific botanical or geographic characteristics, including cultivated, ornamental, domestic, and native plants.

Wildlife resource includes all living things that are a part of the natural ecosystem that are not tamed or domesticated. Wildlife includes, but is not limited to, insects, invertebrates, spiders, birds, reptiles, fish, amphibians, and mammals.

Geological Resources and Soils

Geological resources are based on geology, "geological formations or "geological forces." Soils are a type of geological resource. Soils are described as naturally occurring, unconsolidated, or loose covering of broken rock particles and decaying organic matter (humus) on the surface of the earth, capable of supporting life.

Water Resources

Water resource is a general term encompassing the concepts of availability (the location, spatial distribution, or natural fluctuations of water), accessibility (given availability, whether people can access it), and quality (whether accessed water is free of contaminants and safe for consumption). There are four categories of water resources that can be affected by construction of overhead and underground transmission lines:

- Surface water
- Wetlands
- Floodplains
- Groundwater

Cultural Resources

Cultural resources are defined as any prehistoric or historic district, site, building, structure, or object considered to be important to a culture, subculture, or community for scientific, traditional, religious, or other reason. There are three categories of cultural resources, which can be affected by construction, operation, and maintenance of overhead and underground transmission lines:

- Prehistoric and historic archaeological resources
- Architectural resources
- Tradition cultural properties

Prehistoric and historic archaeological resources are locations where human activity has measurably altered the earth or left deposits of physical remains (e.g., stone projectile points, bottles). Federal acts and regulations (e.g., NHPA, 36 CFR part 800) use the term "prehistoric" to refer to archaeological resources associated with Native Americans prior to contact with Euro-Americans. This term is also commonly understood to mean cultural resources that pre-date the use of written records for an area. Historic archaeological resources generally are those that post-date Euro-American contact with Native Americans.

Architectural resources are standing buildings or structures and may include houses or cabins, barns, dams, lined canals, and bridges.

Traditional cultural properties (TCPs) are resources associated with cultural practices and beliefs of a living community that are intimately tied to its past and are important in maintaining the continuing cultural identity of that community (Parker and King, 1998). Native Americans may consider these resources essential for the persistence of their traditional culture.

Visual Resources

Visual resources refer to the natural and man-made features in the project area landscape and include cultural and historic landmarks, landforms of particular beauty or significance, water surfaces, and vegetation. Together these features form the overall impression that a viewer receives of an area or its landscape character.

Environmental Impacts Associated with Overhead Transmission Line Construction

This section provides an assessment of potential environmental impacts of an overhead transmission line and associated structures, construction activities, and materials on land use, biological, geological, water, cultural, and visual resources. Environmental impacts are defined as modifications to the existing condition of the environment that can be brought about by the implementation of a project.

Various impacts can result from project activities directly or indirectly. These impacts can either be beneficial, adverse, or neutral and can last for the long term or short term. Long-term impacts are sometimes permanent, but are categorized as long lasting. Long-term impacts are those that remain substantial throughout the life of the project or beyond. Short-term impacts are temporary and are those that result in changes to the environment during construction, but revert to a pre-construction condition at or within a few years of the end of construction. However, impacts can vary in intensity from no change, to slightly discernible change, to a full modification of the environment.

Land Use

Most intensive land use, including residential and commercial developments, and public facilities in thickly settled areas, is virtually off-limits to overhead transmission line construction, as are some highly sensitive land uses (e.g., historic sites and structures). Other land uses, such as some agriculture activities, including rangeland and pastures, are highly amenable to the presence of a transmission line with virtually no noticeable long-term impact to livestock grazing within the ROW. However, more intensive agricultural operations, such as row crops, may have some permanent usurpation of the area under cultivation (i.e., around the support structure site) as well as have the potential to disrupt certain agronomic activities such as irrigation and aerial spraying as well as large-scale tillage, planting, and harvesting operations.

The overall scope (i.e., the significance and magnitude of the predictable land use impacts) will be contingent upon the existing land uses within the proposed ROW environs and their ultimate compatibility with the specific nature of the proposed delineation of the transmission structures and other associated appurtenant facilities (e.g., access roads). Each identified existing land use and type of ownership (public and private) needs to be assessed to determine impact and the significance (severity and longevity) of this impact. Land use assessments also include the identification of any applicable land use plans, policies, or regulations that may conflict with the construction and operation of a transmission facility. With a fuller understanding of the affected resources in the proposed ROW, various mitigation measures can be formulated that will allow for avoiding, minimizing, providing for restoration (and perhaps even enhancement), or otherwise controlling the degree of impact both during the construction phase of the facility and for the long-term operation and maintenance of the line.

Agriculture

To better understand the potential range of impacts and their severity to agricultural operations, it is essential to first classify the land's suitability for agricultural production, including the physical and chemical characteristics of soils. With this information, farmland that is prime, unique or may otherwise have regional or local importance can be determined. Also important is the configuration of any permanent irrigation features and the need to know the existence and general whereabouts of underground drainage tile systems. Here, the exact placement of support structures (i.e., aligning towers adjacent or parallel to agricultural field boundaries, as opposed to in the field) and the location of access roads are critical to determining the degree of impact imposed by the presence of the overhead transmission facility on a particular farm operation. If towers are placed in active farm fields then the area around the tower base will be taken out of production. Therefore, pole type support structures are often preferred in active farm fields to minimize the footprint of the structure. Various types of temporary access can also be used to minimize soil disturbance and compaction that may jeopardize future agricultural productivity. The overall goal of these mitigation measures is to reduce the amount of farmland permanently removed from production and minimizes impacts to farm operations. Two types of land classified under the agricultural land use heading, pasture and rangeland, are quite adaptable to overhead electric transmission facilities in that once construction is completed, virtually no long-term impacts (a few square feet per structure site) are noticeable. Also, orchards (depending on the height of the trees in respect to the overhead conductors) and vineyards are quite compatible within most of the ROW environs as are Christmas tree plantations and nurseries.

Mitigation techniques for prime agricultural lands can include special access road designs and installations that involve the placement of substantial wooden structures (square cut beams 12x12 inches, up to 20 feet long) on the proposed access route and at tower work sites in active agricultural situations that are normally subject to extensive soil compaction and disturbance. These wooden devices are removed after construction activities at the site are completed and then redeployed to other sensitive soil locations. In areas around the support structure work site the topsoil can be removed and stockpiled nearby. After construction is completed the topsoil is replaced.

In other situations it may be feasible to avoid construction operations completely on prime agricultural soils during the wet season. Minimal use of heavy equipment on agricultural land, coupled with other soil protective devices (mats and slab wood), help avoid undue soil compaction. In northern areas, or at higher elevations, working during the winter months when the ground is frozen is sometimes a viable method to limit soil disturbance. Deep tilling the severely compacted and or rutted areas after construction is completed will help restore the soils to their former productivity. Ideally, construction events on farmlands can take place in a timely manner to minimize disruption of normal seasonal activities for cropland (e.g., planting and harvesting). All existing farmland improvements, if damaged, destroyed, or otherwise impaired in any manner by construction activities, can be restored (repaired or replaced) to their original working condition prior to the event.

Forests

When clearing a new ROW in heavily forested areas without substantial topographic relief (no deep ravines, gorges, valleys) all tall-growing tree species are normally removed from the entire ROW and prevented from growing in the future for the secure and safe operation of the electric transmission line. Trees allowed to grow even close to the conductors can induce a flashover from the line through the air to the tree, resulting in a line to ground fault that can trip the line out of service or cause a sustained outage. Multiple line outages, sometimes referred to as cascading line outages, can result in a widespread system blackout. Even some very tall trees along the outside edges of the ROW may need to be removed individually. Such trees may pose a threat to the line if they fall and come in contact with the conductors. Trees that have a pronounced lean toward the facilities are considered high risk, and if they have other characteristics that define them as hazardous, are considered to be off ROW "danger trees" and thus in need of removal on a case-by-case basis.

However, complete and total clear cutting (i.e., removal of all woody biomass), need only occur on those portions of the ROW devoted to access roads and support structure sites. In other ROW locations old-field vegetation, many shrubs, and even some low stature trees may be kept intact to act as residual cover. In road-side screens and stream-side buffer zones even some of the taller-growing species can be kept in place if they are currently well below the conductors. These normally removed taller-growing tree species can then be removed over time as other more desirable vegetation begins to grow and develop thereby keeping the screens and buffers sufficiently vegetated at all times. All merchantable timber felled within the ROW and from along its outside edges can be piled in such a way that enables the underlying fee owner to retrieve this resource or otherwise make these logs available for salvage operations in an environmentally acceptable manner (Miller, 2007).

In some instances, particularly in mountainous terrain, support structures can be placed on high points and the height of the structures increased to span longer distances with greater ground clearance. In these situations trees of greater height potential can often be retained in ROW locations that have sufficient line to ground distances and many forestry related activities can proceed unaltered. In other situations, with only slightly increased conductor heights, some lower stature trees can still be maintained within the ROW, along with trees that have a slow growth rate (i.e., their annual height increment is marginal).

Clearing of a forested landscape often results in large amounts of slash (tops, limbs, and the trucks of small diameter trees) and other woody debris that requires appropriate handling procedures for proper management. In some locations, when such residues are not overly voluminous, these materials can be lopped and scattered on the ROW in a manner that puts them in close proximity to the ground (ideally within six inches) to provide cover, allowing for ROW mobility (foot access) and facilitating the eventual decay of this woody residue. An extension of this drop, lop, and scatter concept is often performed on steep slopes to avoid the need for vehicular movement on such erodible prone areas, as well as to provide a surface-stabilizing cover to minimize erosion and trap any sediment that is generated. When slash is produced in higher quantities it is sometimes piled or windrowed. In some situations the piles or windrows are further compacted by passing a dozer over the top of them to compress their loose "jack-strawed" arrangement. In areas of wildfire hazard this slash is either removed or burned on site under the proper weather conditions to reduce fuel loads. Chipping can be used in some limited areas if higher land uses are located nearby and the quantities of slash are not unreasonable.

Parks, Recreation, and Preservation

Short-term impacts on recreational land use within and adjacent to the transmission ROW can occur as a result of vegetation removal, road building, noise, and fugitive dust and air emissions generated during construction. Such outdoor recreation activities as hiking, camping, birding, and hunting are most affected by transmission construction activities, but impacts can also be longer term in some places depending on the increased level of vehicle use associated with the operations and maintenance of the transmission project. Short- and long-term impacts associated with the degradation in the quality of the visual landscape would also likely occur in some areas. Some areas may become more accessible, with increased opportunities for recreational activities in previously inaccessible (or less accessible) areas, while other areas may become less accessible (Programmatic EIS, 2007).

Many parks or large portions thereof, intensive recreation sites, special conservation areas, all federally designated wilderness areas[4] as well as properties on the National Register of Historic Places and many other areas also deemed to be ecologically sensitive or environmentally critical will, in most instances, be precluded from having a transmission line routed through them. Such distinctively classified areas contain natural resources or other cultural and historic features that are viewed as having special values and status to be preserved and protected from irreparable damage.

[4] However, the Wilderness Act of 1964 includes a special provision for the establishment of transmission lines within or across a Wilderness Area that is located within a national forest. Section 4(d) provides the following text regarding these transmission lines: Within wilderness areas in the national forests designated by this chapter, the President may, within a specific area and in accordance with such regulations as he may deem desirable, authorize prospecting for water resources, the establishment and maintenance of reservoirs, water-conservation works, power projects, transmission lines, and other facilities needed in the public interest, including the road construction and maintenance essential to development and use thereof, upon his determination that such use or uses in the specific area will better serve the interests of the United States and the people thereof than will its denial. (Public Law 88-577, Section 4[d])

If no other viable routing alternative is economically feasible then the removal and possible relocation of existing occupied residential buildings may be necessary since they are inherently incompatible with construction, operation, and maintenance of overhead transmission facilities. Also, the location of the transmission ROW within approved future subdivisions, or other similar planned uses can preclude or impair these anticipated residential developments or other planned activities.

Residential buildings located close to the ROW during the construction can be temporarily disrupted by construction activities such as noise, dust, and traffic. Depending upon the proximity to the facility and the intervening vegetation and other viewing limitations, the occupants of the residence may be able to see the conductors and/or the support structures. In the view area, poles are often preferred over lattice towers. If the residences are located within a few yards of the ROW, they may hear noise from corona discharge when the lines are wet. Unauthorized access to the ROW via all terrain vehicles (ATVs) and the use of other off-highway motorized vehicles (e.g., 4X4s and snowmobiles) and additional vehicles (mountain bikes) on the ROW access roads by recreation users could cause trespass-related impacts. These can cause an increase in litter, noise, as well as illegal hunting or dumping.

However, residential areas are normally avoided in most routing situations. Buffer areas between the ROW and the residential developments are often 300 feet or more.

Commercial

Larger commercial buildings are so directly incompatible within a high voltage electric transmission line ROW that these lines are purposefully routed around such obstacles. However, lone or small commercial facilities may need to be removed, much like single residential buildings, if no other routing alternatives are economically viable. However, many transmission lines are located over outdoor storage areas on lands classified as commercial. Parking lots surrounding many commercial establishments are likewise often compatible adjacent land uses, depending upon the presence and height of lights and other factors. All commercial areas are normally avoided and buffer zones are usually prescribed between such commercial uses and the transmission line ROW. (French et al., 2008)

Public Facilities

As previously stated, all major public building and institutional structures are not normally subject to having ROW located even in the lands adjacent to them. These are areas that are avoided during the routing of lines, and larger buffer zones of 500 feet or more are sometimes used around these facilities (e.g., schools) (French et al., 2008).

Industrial

Industrial manufacturing facilities are avoided during the routing of transmission lines. However, the lands adjacent to many of these industrial facilities are often of an 'open space' nature in that buffer zones surrounding these industrial plants have purposefully been established. These neighboring lands are usually vacant, but sometimes contain ancillary storage, materials handling, and waste treatment areas. Many older industrial locals are abandoned lands resulting from closure of older industrial plants. Some of these more passive land uses (open waste lands, lagoons, and storage yards) that otherwise have many characteristics to suggest a brownfield character, often lie contiguous to such industrial facilities that may be amenable to the presence of a transmission line. Also, since these areas are already industrial in nature, routing of transmission lines over such a land use may be a viable alternative.

However, due to the often long-term industrial nature of these properties, other potential problems may be encountered when attempting to build a transmission line over and in these developed landscapes. Previously unknown soil contamination associated with industrial contamination (e.g., solvents, hydrocarbons, heavy metals, etc.) could be encountered during access road grading or excavation of support structure sites potentially affecting the health of workers or the public. During grading or excavation work in such industrial environments, diligent efforts are taken to observe the exposed soil for visual evidence of contamination. If visual contamination indicators are observed during construction, all work stops until the material is properly characterized and appropriate measures are taken to protect human health and the environment. The utility complies with all local, state, and federal requirements for sampling and testing, and subsequent removal, transport, and disposal of these hazardous wastes (Final EIS, 2006).

Major mineral extraction activities and most active mining is cause to route around such extensive land uses. However, some more limited scale mining activities, such as gravel pits and some quarry operations, can be spanned. However, no surface blasting is allowed under or near the conductors and support structures. Building of a transmission line over areas of known mineral assets can render these resources inaccessible.

Transportation and Access

Transportation ROW, be they highways, pipelines, railroads or electric lines, can sometimes be viewed as "routing magnets," as they represent similar linear facilities that might meet the needs of the proposed overhead transmission line. Building a new line adjacent to an existing high voltage line is an expansion of a previously established land use. Here the width of the new ROW can often be less wide than when built alone, as one edge is already an established ROW. The access road system for the currently exiting line can be used with only the need to build new spur roads to the structure sites. The visual intrusion is less since a line already occupies the locale. Highways through less scenic regions are also, by their linear nature, often a desirable location to route a line along. However, the opposite is true when highways traverse highly scenic regions. In these cases the presence of the transmission line is often unwanted.

Railroads, particularly abandoned railroads, are often desirable locations for routing transmission lines. Their presence has modified the immediate environment for decades, and the inclusion of transmission lines in these preexisting corridors can often be accomplished.

Land Use Mitigation Techniques

In addition to the mitigation techniques previously described in this section, the following mitigation techniques could also be used to minimize effects on land use resources during construction of an overhead transmission line.

1. Repair or replace existing improvements to their original condition prior to disturbance if they are damaged or destroyed by construction activities.

2. Install, repair, or replace fences and gates to their original condition prior to disturbance if they are damaged or destroyed by construction activities. Close or lock gates as agreed to by landowners.

3. Leave existing roads in a condition equal to or better than their condition prior to the transmission line construction.

4. Project facilities, including structures and access roads, can be installed along property boundaries or in the location that creates the least potential for impact to the property and its uses.

5. Locate construction staging areas next to existing roads, when practical.

6. Make appropriate arrangements with landowners to remove livestock from necessary areas.

7. Coordinate with farmers to ensure access to livestock feeding and watering stations, as well as continued access across the ROW for farm equipment.

8. Limit new or improved accessibility into the area by off-highway and other motorized vehicles by coordinating with the appropriate agencies. Physically close appropriate roads using boulders, tank traps, and gates. Have the plan approved by the appropriate agencies.

9. Do not apply paint or permanent discoloring agents to rocks or vegetation to indicate survey limits or construction activity.

10. At residences, align the ROW to reduce impact on the residences whenever possible.

11. Provide advance notice to residents, property owners, and tenants within 300 feet of construction activities. Provide alternative access, if feasible.

12. Compensate landowners for short-term use and damages associated with construction activities within the construction easement.

13. Use warning signs at all designated trail and roadway crossings, and station flag-persons during construction for all state, federal, county, and local roads and highways. Identify appropriate detour routes for local road users.

14. Notify all utilities of construction to incorporate their facility location on the construction drawings. Prior to construction, flag and/or stake the locations of all utility lines.

15. Obtain necessary and appropriate land use permits.

16. Time construction activities, whenever practical, to minimize disruption of normal seasonal activities for cropland (planting and harvesting) and non-irrigated rangeland as well as avoid peak-use periods (e.g., weekends and holidays) at parks, recreation, and preservation areas. Coordinate construction activities with relevant agencies and landowners prior to construction.

17. Provide advance notice of construction activities to landowners and residents potentially affected by construction activities. Provide adequate access to existing land uses during periods of construction and, notify landowners of alternative access. Avoid nighttime construction near noise-sensitive land uses (e.g., residences and campers at recreation sites).

18. When possible, avoid construction operation disturbance of agricultural soil during the wet season. Minimize the use of heavy equipment on agricultural land to avoid soil compaction. Reduce the amount of soil compaction by working when the ground is frozen, using equipment with additional and wider tires to distribute the weight of the vehicle. Till the severely compacted areas after construction is completed.

19. Obtain encroachment permits or similar legal agreements from state authorities for each affected federal, state, and local roadway. Such permits are needed for roads crossed by the transmission line, as well as for parallel roads where transmission line construction activities require the use of the public ROW (e.g., temporary lane closures).

20. Coordinate in advance with emergency service providers to avoid restricting movements of emergency vehicles. Have local agencies notify respective police, fire, ambulance, and paramedic services. Notify local agencies of the proposed locations, nature, and duration of any construction activities, and advise of any access restrictions that impact their effectiveness.

21. Project design and construction should comply with applicable regulations associated with railroads/railways in the project area. Obtain required permits for entering railroad ROW from the appropriate railroads/railways.

Biological Resources

Vegetation Resources

Vegetation resource impacts from ROW construction preparation, (i.e., clearing of an overhead transmission line) can result in the following:

- Disruption of existing vegetation
- Change in habitat type or vegetation composition
- Habitat fragmentation
- Disruption of rare, threatened, and endangered plant species and habitat
- Introduction of invasive plant species

Disruption of Existing Vegetation

At a minimum, all woody vegetation is removed from the access road locations and support structure sites and their adjacent assembly work areas. These areas require complete clear cutting of all vegetation. However, all other ROW locations can be more selectively cleared to remove only the tall-growing species (virtually every tree and even some tall-growing shrubs) found within the ROW. In this general ROW situation most shrubs can be left along with all old-field type herbaceous vegetation. In some other special ROW locations, such as roadside screens and streamside buffer zones, clearing can be even more selective as to require only the removal of vegetation over a certain height.

The critical height over which the vegetation must be removed in these special consideration areas is dependent on the clearances of the overhead conductors at that specific location. Greater conductor clearances will allow the retention of more trees (e.g., many low-stature trees and tall shrubs) for a greater period of time. As the trees left continue to grow they will have to be trimmed, or most likely removed in the future. This leisurely removal will allow other vegetation to invade the buffer zone or screen, some of which will be low-growing species that will be perpetually retained. In other ROW situations where exceptional ground-to-conductor clearances exist, (such as in deep ravines and gullies, valley bottoms, or gorges and canyons), all vegetation can often be retained.

Other disruption factors affecting existing vegetation are the methods of log handling and slash disposal chosen. Often trees felled on the ROW are limbed and topped at the four-to-six inch diameter range. They are then moved to piles of tree length logs at a ROW location from which merchantable timber products can be easily extracted. Slash materials, consisting of tops and limbs, are bunched into piles and sometimes windrowed along the outside edges of the ROW. In clearing situations that are located on steep slopes or where tree density is light, the felled trees are bucked, topped, limbed, and further lopped into smaller pieces and scattered about the ROW. Other disposal methods include burning the slash, and chipping or carting it away for off-site disposal. Vehicular movement for the transport of logs and the handling of slash can often scarify the ROW soils to some extent. New vegetative growth will begin to develop naturally soon after clearing (during the growing season) with only the new tall-growing trees requiring removal in the future. Although grasses and other vegetation can be planted within the ROW after clearing to speed up revegetation, this proactive activity to achieve a return of the vegetative cover is usually only necessary on the highly disturbed bare soils around the support structure construction sites and their attendant access roads.

Change in Habitat Type or Vegetation Composition

Vegetation removal operations for overhead transmission lines largely depend on the height of the natural vegetation present and the ground to conductor clearances. Forests will by necessity usually be substantially and permanently altered (over the life of the line) to form a variety of low-growing, sun-loving, early successional plant communities. Some shrub communities, as well as old-field vegetation, can remain almost entirely intact (except at structure sites and access roads). Rangeland, grasslands, and many desert plant communities can be virtually unaffected from general ROW clearing, as none would be needed. Also, areas containing only short stature trees, such as a juniper and pinyon pine forest, might coexist within the ROW. Only a few taller specimens may need to be removed from under the maximum sag portion of the line due to the general low height and slow growth rate of these and similar species.

Creation of early successional plant communities composed of an assortment of locally extant and readily available low-growing native woody shrubs, herbs (forbs and grasses/sedges), ferns, vines, reeds, and other forms of plant life can be beneficial if the ROW is located in a predominately wooded setting. These ROW conditions replicate old-field plant communities that are becoming landscape rarities in many locations. The juxtaposition of these two different plant community types; one a forest and the other a mixture of plants having only their mature height as a criterion for their presence, creates a unique transition area from one habitat type to another. It produces a profusion of diversity (species richness) in a given area that is often referred to as the "edge effect." This term is used to describe the various consequences, on vegetation and wildlife, which occur as a result of one type of vegetation sharing a border with another. In general, when a ROW is created within a region that is primarily forested, the benefits of this new unique habitat along with the "edge effect" may be quite positive overall.

Habitat Fragmentation

Fragmentation can be defined as alterations in the amount or spatial configuration of a particular habitat on a landscape that negatively affects species (EPRI, 2003). The downside of too much "edge" in a given locale is often referred to as habitat fragmentation. When a limited habitat (e.g., a tract of forest) is partially cleared for a ROW and its forest area is reduced below a critical point, some species may become more isolated and others are negatively affected. The degree to which fragmentation is a negative environmental impact or that the creation of the edge effects renders positive outcomes for newly created ROW depends on just how much the surrounding landscape is already fragmented and, to some extent, on the specific composition of the new plant communities established within the ROW. Whether or not these ROW/forest ecotones provide a net ecological benefit, the "edge effect," or constitutes an ecological threat in the form of "forest fragmentation" is dependent on the overall landscape conditions surrounding the ROW and cannot be discerned solely by the sheer presence of the ROW or even by the condition of the vegetation on the ROW alone (Albrecht et al., 2000).

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to plants that are listed as threatened and endangered species are a major environmental concern when building a new transmission line. This is because of the official status given these plants due to their low population numbers and the general tendency for such listed species to be less resilient to habitat alterations than other more commonly found plants. Other plant species may be considered as rare in a given area for having low population numbers, a very narrow endemic range, and/or fragmented habitat. In some instances these rare plants are provided various types of protection (e.g., protected plants) by state or local laws, or are otherwise considered a species of concern5 for various reasons. Even temporary disturbances can have adverse impacts on plant populations with very limited ranges. Specific impacts are dependent on the exact species status within or near the proposed ROW and other habitat requirements in respect to the location of particular project activities.

[5] Informal term that refers to those species that might be in need of concentrated conservation actions.

The establishment of a ROW that ultimately becomes filled with early successional flora (i.e., often containing numerous low-growing, sun-loving species) normally results in an increase in local plant species diversity. In these situations many rare and unique plant species may take the opportunity to exploit the newly created ecological niches and, to the extent that some may be protected listed plants, the presence of the ROW may actually induce the occupancy of these species of concern.

Introduction of Invasive Plant Species

Exotic or alien plant species are non-native plants introduced into a new location by human activity, either intentionally or by accident. Invasive plants are a subset of such introduced exotic or alien species that can thrive in areas beyond their natural range of dispersal. These invasive non-native plants are characteristically adventitious species that are highly adaptable, capable of moving aggressively into a habitat, and have a high reproductive capacity. Their vigor, combined with lack of natural enemies, often leads to outbreak populations that are capable of monopolizing resources such as light, nutrients, water, and space to the detriment of other native species (EPRI, 2006). U.S. Executive Order 13112 (1999) defines "invasive species" as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health".

Noxious weeds are yet another subset of invasive species that have become so wide-spread that they now produce economic harm by threatening crops, livestock, or other native species. These pernicious plants have become more than just another alien species, and are now listed by law as officially noxious due to their economic damage. These formally listed noxious species can be attacked in a methodical manner with government support. A noxious weed, as defined by the 1974 Federal Noxious Weed Act, means any living stage, such as seeds and reproductive parts, of any parasitic or other plant of a kind, which is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including irrigation, or navigation, or the fish or wildlife resources of the United States or the public health. Hence any noxious weed is, by definition, alien or exotic (foreign origin).

The definition of undesirable plant species from the National Undesirable Plant Management Act of 1990 means plant species that are classified as undesirable, noxious, exotic, injurious, or poisonous, pursuant to state or federal law. Thus some native plant species such as poison ivy and locoweed may be considered as undesirable under this broader definition. Clearing of new ROW may open fresh environments for these deleterious plant species (alien, exotic, non native species that are invasive and may be listed as noxious weeds that also may be legally classified as undesirable) to occupy. Although electric transmission lines corridors are often viewed as a potential habitat and/or corridor for movement of invasive species, they do not, in most cases, undergo the degree of continuous disturbance that many exotic invasive species seem to prefer (EPRI, 2008). Usually rapid recolonization from the natural seed bank, in addition to expansion of previously established native species left purposefully uncleared, begin to dominate the resulting plant growth on the ROW after the initial clearing. Future ROW vegetation management strategies can also target the removal of invasive species as necessary.

Wildlife Resources

Impacts to wildlife resources from ROW construction of an overhead transmission line could result in the following:

- Habitat and population fragmentation
- Habitat loss and reduced species abundance
- Wildlife displacement and disturbance
- Disruption of rare, threatened, and endangered species

Habitat and Population Fragmentation

Habitat fragmentation can have positive or negative impacts on population persistence, both immediately and over time (Soulé, 1986; Noss and Copperrider, 1994; Tilman et al., 1994; EPRI, 2003). Increased fragmentation can increase habitat isolation (Andren, 1994) and may therefore alter population response to habitat change (Segelbacher et al., 2003). However, transmission corridors can function as biological corridors for species that are positively affected by the relatively small corridor width usually associated with transmission lines (EPRI, 2003).

Concern for habitat fragmentation is increasing in wildlife management (Baker & Knight, 2000) and is considered a global concern for biological diversity (Knight et. al., 2000). Species declines and shifts of animal distributions have led to a more modern focus on the causes of habitat fragmentation and the effect this may have on wildlife. Avian responses to habitat fragmentation included life cycle alterations, increased parasitism, and habitat affinity associations (Weller et al., 2002; Knight et al., 2000). Habitat removal and fragmentation as a result of transmission line construction can alter wildlife migration corridors and dispersal orientation and isolate wildlife populations and their gene pools. This significantly weakens the wildlife community.

Habitat fragmentation affects wildlife regardless of the location, but the degree to which wildlife is affected, and the species-specific effects as they relate to construction of an overhead transmission line, cannot be definitely concluded. Construction of access roads directly applies, but construction of the ROW, while similar to a road, is dissimilar enough that direct conclusions cannot be drawn.

Habitat Loss and Reduced Species Abundance

Direct habitat losses can result from the conversion of existing wildlife habitat to access road surfaces and other transmission facilities requiring nearly bare ground. Also, one existing habitat type (e.g., a forest) may be lost as a result of some ROW preparation activities (e.g., selective clearing), as the habitat may be converted or changed (e.g., to a shrubland). In general, wildlife species abundance will decline with any reduction in the size or quality of the habitat. To the extent that ROW habitat conversion (e.g., from forest to shrubland) may result in reduced wildlife species abundance will depend on the amount of fragmentation already existing in the landscape and exactly what types and amounts of habitat are being lost or gained. If the general landscape surrounding the ROW is already too fragmented then additional fragmenting will only serve to exacerbate the problem. If there is a nearly continuous or extensive habitat type covering the region (e.g., forests), creation of the ROW and its attendant edge may add a new desired disturbance regime to the locale. Thus the newly created ROW can have a net positive effect of providing to the relatively uniform current landscape, a new but distinctly unique habitat (i.e., a low-growing habitat that is early successional in nature and generally sun loving) that has a tendency to increase overall wildlife species diversity and abundance.

Wildlife Displacement and Disturbance

ROW preparation activities and facility construction of an overhead transmission line will undoubtedly cause temporary and even limited permanent wildlife disturbance by displacing various forms of fauna from sites that they normally occupy. Direct short-term disturbance comes from increased noise levels during construction, the frequency of vehicle traffic, and the presence of humans. Most larger and mobile wildlife occupying the ROW can simply be displaced during construction, but some species, such as the fledglings of nesting birds and amphibians and reptiles, can be vulnerable to direct mortality from the physical disruption of soils and vegetation.

Many wildlife species are quite sensitive to the range of raucous activities attending construction and, in some species, even the mere presence of humans. This human presence and vehicular traffic along the ROW over the long term is often facilitated by the ease of entry to the ROW from the access roads. Impact to fisheries resources can result from increased sediment in streams or rivers if erosion occurs. These potential wildlife impacts are greatest during and immediately after construction. In areas where the ROW crosses riparian zones, to the extent that clearing is required in these areas, ROW clearing has the potential to impact aquatic life. Reduction or removal of riparian vegetation due to selective clearing has many potential influences on the stream ecosystem. Riparian vegetation produces food for fishes and other animals, and habitat for insects that supplement the diet of fishes. Riparian vegetation also forms a protective canopy that helps maintain cool stream temperatures and insulate the stream from heat loss in winter. Since the influence of riparian vegetation generally decreases, as streams get larger, small streams are likely to experience more severe impact than large streams as a result of its removal (Murphy and Meehan, 1991).

Many types of vegetation can often be left in place when the ROW is very selectively cleared in these riparian zones. Although most tall-growing tree species can not be allowed to mature to their full heights within the ROW proper, they can be retained for some time when conductor to ground clearance allows, which is often common in these low lying stream bottoms. To minimize disruption in these riparian buffer zones individual trees can be felled as needed over time, which allows for the maximum retention of vegetation and provides an ample period to permit the establishment of new vegetation.

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to listed endangered and threatened wildlife species populations, or even their candidate species, are a major environmental concern when building a new transmission line. This is due to the official status given these species with low population numbers, and the general tendency for such listed species to be less resilient to habitat alterations than other more commonly found fauna. Even temporary disturbances can have adverse impacts. Breeding habitat is especially important because disruption during breeding season can reduce productivity for the entire year. Specific impacts are dependent on the species' habitat requirements and the exact location of transmission related facilities.

Other wildlife species that may be deemed of concern in that they are rarely found or unique to the project vicinity, or have some type of special status placed upon them are also to be closely considered as to potential impacts. Such other impacts to be considered are the potential for substantial interference with the movement of native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or activities that impede the use of wildlife nursery sites.

Biological Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on biological resources during construction of an overhead transmission line.

1. Control vehicular travel by restricting all construction vehicle movement outside the ROW to pre-designated and approved access routes and roads or public roads. All vehicular travel on the ROW can be on established access routes and roads at all times.

2. Implement a Supervisor and Worker Environmental Awareness Program. Prior to construction, provide detailed instruction to all supervisory construction personnel on the protection of biological resources. In addition, implement a worker Environmental Awareness Program for construction crews by a qualified biologist prior to the commencement of construction activities. Training materials and briefings may include but not be limited to: discussion of the Federal and State Endangered Species Acts, the consequences of noncompliance with these acts, identification and values of sensitive plant and wildlife species, significant natural plant community habitats along with the purpose and necessity of protecting them, and specific methods for protecting sensitive resources. Include instruction on wildlife policy to prohibit unauthorized off-road vehicle use in the project area, and to discourage wildlife harassment and littering.

3. Conduct pre-construction surveys and delineate boundaries. Prior to construction, conduct surveys in areas of suitable habitat for certain sensitive wildlife species within 48 hours prior to the start of construction activities. Some species found may need to be relocated to nearby suitable habitats outside the construction area. Following the clearance surveys, erect exclusion fencing or post a biological monitor onsite during construction activities. Delineate the boundaries of sensitive plant populations with clearly visible flagging or fencing based on the surveys completed prior to construction. Obtain permission from the appropriate agencies can any special-status plants require relocation.

4. Develop a noxious weed and invasive plant control plan in consultation with the appropriate agencies to minimize the effects of noxious weeds due to proposed construction activities. In the weed control plan specify the location of existing weed populations; measures to control introduction and spread of noxious weeds in the transmission line ROW; worker training, specifications, and inspection procedures for construction materials and equipment used in

the ROW; post-construction monitoring for noxious weeds; and eradication and control methods. Evaluate known populations of invasive and noxious weeds in the ROW to identify candidates for eradication. Eradicate selected weed populations prior to construction. Use certified weed free gravel, fill material, seeds, and straw material during project construction and maintenance.

5. Implement control measures for invasive and noxious weeds. Best management practices can be used for reducing the potential of the introduction of noxious weeds and invasive, non-native plant species including implementation of the following:

   a. Wash all vehicles before and after entering all construction sites. This includes wheels, undercarriages, bumpers and all parts of the vehicle.

   b. Wash all equipment before and after entering all ROW work areas. This includes all construction and maintenance tools such as chain saws, hand clippers, and pruners.

   c. Conduct post-construction follow-up weed abatement on the work areas. Conduct weed abatement activities during the spring following construction and prior to when the weeds establish flowers or produce seeds.

Geological and Soil Resources

Most construction or industrial activity normally requires the copious use of sand and gravel and/or crushed rock. This includes building the infrastructure required for overhead transmission lines. These basic construction materials are used in ROW access roads, staging areas, stream crossing installations, and other construction sites and are for concrete, gravel pads, roadbeds, stream bank protection, and other building materials.

Applying sand, gravel, or crushed rock on land alters the drainage in the immediate area where these materials are applied. The size of the area affected can range from a relatively isolated few hundred square feet (for a single support structure foundation) to a few hundred acres (for the linked sections of the access road system). The impact on the natural surface drainage, therefore, depends on the size of the areas affected, local terrain conditions, precipitation patterns and amounts, and the mitigation measures employed.

These transmission construction activities can impact the water quality downstream from the affected disturbance area. Ground disturbance is unavoidable during some ROW preparation activities and most facility construction events. The disturbance comes from clearing, grading, excavations, drilling, or blasting to construct support structures, and associated facilities. Other causes are heavy equipment traffic near staging areas, access roads, and at other critical work locations along the ROW. The disturbance can be intense during the construction phase and is expected to be temporary and local, assuming that best management practices and mitigation measures are applied.

Much less impact is expected during the operation and maintenance phase. The ground disturbance can increase soil erosion and affect the water quality of the surface water downstream from the disturbed areas, affecting both sediment load and dissolved salt content in the waters. The first item of concern is most important in areas of steep slopes and erodible soils. The second item becomes an important issue in arid or semi-arid environments and in areas where bedrock has a high content of soluble salts. The surface soils in arid environments generally are rich in soluble salts where intermittent and ephemeral streams dominate in these areas.

Soil erosion can occur along the ROW primarily at individual construction sites. The potential for erosion is most likely to occur during the construction phases of a project when clearing, excavation, and fill operations are most intense. The potential for erosion usually occurs in portions of the disturbed areas (e.g., borrow pits, ROW access roads, stream crossings, staging areas, and support structure construction sites) of the project until vegetation is re-established. The impacts can be localized and limited in extent and magnitude, if appropriate best management practices and mitigation measures are implemented. In the operation and maintenance phase of an overhead transmission line, the soil erosion near the access roads (especially in areas of steep slopes and erodible soils) can continue, as drainage water may be channeled to nearby surface water bodies.

Heavy equipment traffic can also damage the protective vegetation covers. However, the extent and degree of the soil erosion impacts can be substantially lower during operations and maintenance than during the construction phases. Herbicide use may be expected for ROW vegetation management in areas harboring tall-growing trees of substantial size as well as for the control of noxious weeds and invasive species, creating the potential for soil contamination. The use of herbicides and other unintentional spills of liquid materials (e.g., lubricating oils and hydraulic fluids) likewise have the potential to cause soil contamination. The impacts on soil erosion and potential soil contamination can be localized and limited in their extent and magnitude, if appropriate best management practices and other mitigation measures are implemented in a timely fashion. These impacts can be confined primarily to ROW areas near the transmission line work sites.

Geological and Soil Resources Mitigation Techniques

The potential for impacts to geological resources can occur primarily during the transmission line construction phase. Impacts during the transmission operations phase occur mainly due to vehicle traffic and will normally be lower while performing various routine maintenance activities. To avoid and minimize the range of potential impacts, the selection process for the appropriate use of the applicable best management practices and other mitigation measures can be established at the project planning stage and then promptly implemented as needed during the actual field operations. These various measures may be incorporated into the ROW management and construction plans of responsible agencies.

Best management practices and other mitigation measures can be applied in the field during ROW preparation, facility construction, and during ROW restoration to moderate and reduce to the lowest level practical impacts on soil. Specific measures can be selected after considering all pertinent site factors that play a role in the initiation of soil erosion, such as rainfall characteristics (amounts and expected intensity), runoff potential, soil erodibility, slope length and steepness, aspect, and vegetation cover present.

Erosion and sediment control plans, best management practices, and other mitigation measures can be included in the construction bidding specifications as per-unit pay items and then incorporated into the legally binding contract documents to ensure full and timely compliance.

Potential mitigation measures and other best management practices to reduce impacts due to the ROW preparation and subsequent installation of overhead transmission lines are:

1. Implement suitable precautionary measures following identification of soils with high erosion potential and/or soluble salt content so that suitable precautionary measures can be properly planned and implemented.

2. Avoid excavating materials from, or storing excavated materials in, any stream, drainage, lake, or wetland.

3. Conduct a field verification of all landslide-prone areas, and make appropriate adjustments as needed.

4. Prepare a geotechnical report prior to construction to address risks to structures and roads due to potential seismicity and liquefaction.

5. Maintain long-term adequate ground cover and soil structural characteristics by:

    a. Stockpiling topsoil removed during construction activities can be stockpiled, salvaged and reapplied during restoration.

    b. Retain plant debris to be left on-site as much as practical to serve as mulch.

    c. Reclaim disturbed erodible soils as quickly as possible, or apply protective covers where necessary.

6. Avoid constructing access roads and routes near wetlands, when feasible. Avoid actions that may dewater or reduce water budgets in wetlands.

7. Design all ditches, berms, and culvert pipes with at least an 80% chance of passing high flows and remaining stable during their life.

8. Limit ROW access roads/routes and other disturbed sites to the minimum feasible number. Restrict all construction vehicle movement outside the ROW to pre-designated access roads/routes, or public roads. Keep the width and total length of access roads/routes consistent with the purpose of specific operations and local topography conditions. Restore disturbed areas at all work sites and areas adjacent to access roads, immediately following construction.

9. Use existing roads and borrow pits as much as possible. Leave all existing roads in a condition equal to or better than their condition prior to construction of the transmission line.

10. Construct access roads on ridge tops, stable upper slopes, or wide valley terraces, if feasible. Stabilize soils on-site. Avoid slopes steeper than 70%.

11. Avoid soil-disturbing actions during periods of heavy rain or wet soils. Apply appropriate travel restrictions (mud locks) to protect soil and water.

12. Install cross drains to disperse runoff into filter strips and minimize connected disturbed areas. Make cuts, fills, and road surfaces strongly resistant to erosion between each stream crossing and at least the nearest cross drain. Revegetate using certified local native plants, as feasible; avoid persistent or invasive exotic plants.

13. Construct roads with rolling grades instead of ditches and culverts, whenever possible.

14. Retain stabilizing vegetation on unstable soils. Avoid placing new access roads or allow heavy equipment use on unstable or highly erodible soils.

15. Use existing roads unless other options will produce less long-term sediment. Reconstruct for long-term soil and drainage stability.

16. Use special construction techniques, where applicable, in areas of steep slopes, erodible soils, and stream channel/wash crossings.

17. Avoid ground skidding with blades lowered or on highly erodible slopes steeper than 40%. Conduct clearing operations to disperse runoff, as feasible.

18. Construct roads and other disturbed sites to minimize sediment discharge into streams, lakes, and wetlands.

19. Design all access roads/routes and other soil disturbances to the minimum standard for their use and to work with the terrain, as feasible. Minimize slope hill cuts.

20. Apply erosion controls to comply with county, state, and federal standards, (e.g., Clean Water Act) and practices can be implemented such as erecting jute netting, silt fences, and check dams near disturbed areas.

21. Use filter strips and sediment traps, if needed, to keep all sand-sized sediment on the land and disconnect disturbed soil from entering streams, lakes, and wetlands. Disperse runoff into filter strips.

22. Install sediment traps well into the ground. Clean them out when 80% full. Remove sediment to a stable gentle upland site and revegetate.

23. Keep heavy equipment out of filter strips except for restoration work or to build hardened stream or lake approaches. Move logs out of each filter strip after any necessary clearing with minimum disturbance of ground cover.

24. Design road ditches and cross drains to limit flow-to-ditch capacity and to prevent ditch erosion and failure.

25. Stabilize and maintain roads and other disturbed sites during and after construction to control erosion.

26. Avoid introducing soil into streams, swales, lakes, or wetlands.

27. Properly compact fills and keep woody debris out of them. Revegetate cuts and fills upon final shaping to restore ground cover using certified local native plants, as feasible. Avoid invasive exotic plants. Provide sediment control measures until erosion control is permanent.

28. Avoid disturbing ditches during maintenance unless needed to restore drainage capacity or repair damage. Avoid undercutting the cut slope.

29. Space cross drains no more than 120 feet apart in highly erodible soils on steep grades to no more than 1,000 feet in resistant soils on flat grades. Do not divert water from one stream to another.

30. Empty cross drains onto stable slopes that disperse runoff into filter strips. On soils that may gully, armor outlets to disperse runoff. Tighten cross-drain spacing so gullies are not created.

31. Harden rolling dips as needed to prevent rutting damage. Ensure that road maintenance provides stable surfaces and drainage.

32. Construct and maintain berms, when necessary, to protect the road surface, drainage features, and slope integrity while also providing vehicle user safety.

33. Restore roads and other disturbed sites when use ends, as needed to prevent resource damage.

34. Site-prepare, drain, revegetate, and close temporary use roads and other transitory disturbed sites after use ends. Provide natural drainage that disperses runoff into filter strips and maintains stable fills. Perform this work concurrently. Use native vegetation as feasible.

35. Remove all temporary stream crossings (including all fill material in the active channel), restore the natural channel form, and revegetate the channel banks using native revegetation, as feasible.

36. Monitor stabilization methods and revegetation success for a minimum of two growing seasons or until 75-80% revegetation has been achieved as approved by the appropriate agency or landowner.

37. Maintain or improve long-term levels of organic matter and nutrients on all lands:

38. On soils with topsoil thinner than 1 inch, topsoil organic matter less than 2%, or effective rooting depth less than 15 inches, retain 90% or more of the fine (less than three inches in diameter) logging slash in the ROW after clear cutting, and retain 50% or more of such slash in the ROW after each selective clearing operation, considering existing and projected levels of fine slash.

39. Conduct piling to leave topsoil in place to avoid displacing soil into piles or windrows.

40. Place new sources of chemical and pathogenic pollutants where such pollutants will not reach surface or groundwater.

41. Put sanitary sites outside the water influence zone (WIZ).

42. Put vehicle service and fuel areas, chemical storage and use areas, and waste dumps on gentle upland sites. Mix, load, and clean on gentle upland sites. Dispose of chemicals and containers in certified disposal areas.

43. Apply runoff controls to disconnect new pollutant sources from surface and groundwater. Install contour berms and trenches around vehicle service and refueling areas, chemical storage and use areas, and waste dumps to fully contain spills. Use liners as needed to prevent seepage into groundwater.

44. Apply chemicals using methods that minimize risk of entry to surface and groundwater.

45. Followed standard best operating procedures when using herbicides to minimize unintended impacts to soil.

46. Employ herbicides with half-lives of three months or less. Apply them at the lowest effective rates as large droplets to reduce or avoid drift. Always follow label directions, and treat target vegetation as selectively as possible. Use only aquatic-labeled herbicides in the WIZ.

47. Backfill tower foundations with original excavated materials as much as possible and dispose of only in approved areas to control soil erosion and to minimize leaching of any potential hazardous constituents. If suitable, excess excavation materials may be stockpiled for use in restoration activities.

Water Resources

Impacts to water resources from ROW preparation and facility construction of an overhead transmission line can result in the following:

- Disturbance to surface water flows and floodplains
- Disturbance to wetlands
- Disturbance to groundwater
- Water quality degradation

Disturbance to Surface Water Flows and Floodplains

Physical changes to surface water resources from the installation of an overhead transmission line are directly linked with the runoff from the land surface. An increase in surface runoff entering a stream can produce the following impacts: an increase in downstream flow, an increase in channel width or depth, erosion of the stream's bed and/or banks and build up of sediment in a stream. During construction, some streams or waterways may need to be crossed by access roads. Such direct impacts on the stream environs can cause erosion of the streambed and banks causing increased sediment loads and downstream aggradations. The need to selectively clear some riparian vegetation may affect surface water flows and floodplains. ROW preparation and facility construction near surface water has the potential to alter localized drainage patterns to the area. A permanently altered drainage pattern can increase erosion and sedimentation. If drainage patterns are altered, this can change floodwater flows and associated floodplains. Selective clearing of the ROW can eliminate some portions of the existing riparian vegetation from around streams. Encroachment into a floodplain or watercourse by a permanent aboveground project feature, such as the tower leg of a support structure, can result in flood diversions, or erosion (localized scouring).

Disturbance to Wetlands

Wetlands provide a variety of direct and indirect public benefits including flood protection, sediment control, water quality maintenance, and wildlife habitat. ROW preparation (clearing of trees within the ROW and access roads) and facility construction (support structure foundations and/or erection work zones) of an overhead transmission line can temporarily or permanently alter wetland systems. Certain functions and values of wetlands can be permanently adversely affected during the construction of overhead transmission lines, such as the conversion of a forested wetland to an herbaceous wetland in the permanently maintained utility line ROW. However, Thibodeau and Nickerson (1986) reported on the effects of utility ROW construction and maintenance on the vegetation of a wooded wetland and found that except for differences in size and maturity, the vegetation recovered in two years from nearly total destruction caused by construction. Maintenance that included the periodic removal of tall-growing species led to the formation of a plant association different from the one occurring naturally, but as diverse and species rich (Thibodeau and Nickerson, 1986).

Disturbance to Groundwater

In general, groundwater is often found near the surface in the vicinity of substantial surface water bodies. In other areas (e.g., mountainous regions), groundwater can occur at great depths. When located at a shallow depth (i.e., on the order of tens of feet), groundwater is more susceptible to adverse impacts associated with construction, maintenance, and surface spills; and changes in recharge (Programmatic EIS, 2007).

Excavations for overhead transmission line foundations which encounter such groundwater close to the surface can temporarily or permanently alter groundwater flows by changing the underground channels and/or pools that exist. This has the potential of affecting existing groundwater pumping in the near vicinity for domestic uses. Dewatering the transmission support structure foundation site is often necessary in areas with high water tables (tens of feet from the surface) in order to remove excess water from the construction worksite so as to prevent an excavation from filling with groundwater. The main dewatering techniques include sumps and shallow wellpoint systems. These dewatering techniques can impact the level of the existing water table in the surrounding area as well as cause potential for soil erosion, increase in surface water downslope, depending on where, in what quantity, and the duration of the water diversion activity. Soil compaction from access roads and compacted backfills at structure sites can alter ground surface percolation rates, which can subsequently affect groundwater recharge to underlying aquifers.

Water Quality Degradation

The quality of surface water is as important as its quantity. The quality of surface water in regards to transmission line construction activities is primarily influenced by the presence of sediment, microbes, pesticides, and nutrients. Surface water quality is also affected by the amount of solar radiation received and the shade-producing vegetation in the riparian area that, in turn, affects water temperature, as well as other water quality factors such as flow rates, total suspended solids (TSS), total dissolved solids (TDS), turbidity, and changes in dissolved oxygen, salinity, and acidity. Construction near surface water has the potential to directly impact the quality of these water resources through erosion or discharge of materials.

The period of highest potential impact from overhead transmission projects is during and immediately following construction from the ROW work sites, staging areas, or access roads. Construction in ephemeral drainages, when waterless, could deposit sediment on the dry streambed, which could then be available for transport to the stream system when flows resume. ROW clearing requirements can affect the riparian vegetation ability to positively influence water quality characteristics. Water quality of surface waters can also be directly affected through the accidental release of pollutants such as fuel, lubricants, or antifreeze during construction. Also the use of herbicides to eradicate invasive plant species from the ROW environs can result in potential degradation of surface and groundwater quality.

Water Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on water resources during construction of an underground transmission line:

1. Restrict all construction vehicle movement outside the ROW to pre-designated off ROW access roads/routes, or public roads.

2. Prior to construction, establish an environmental training program to communicate environmental concerns and appropriate work practices to all supervisory construction personnel on the methods available to protect water resources. The construction contract can specify all mitigation measures and other best management practices available regarding water resources, the importance of these resources, and the purpose and necessity of protecting them.

3. Use existing public roads to the extent possible. Install culverts where needed to ensure proper cross drainage. Conduct construction activities in a manner that minimizes disturbance to vegetation, drainage channels, and stream banks. Any exposed slopes and stream banks can be stabilized immediately upon completion of the work in that area. Build roads at right angles to the streams when practical. Install culverts or temporary work bridges across all streams that are flowing at the time of construction to provide access to the work areas on both sides of the streams. This will minimize stream bank degradation, erosion, and sediment into the waterway. When establishing a stream crossing for vehicles and construction equipment, attempt to preserve an appropriate vegetation buffer, particularly on adjacent slopes. If the soil within the vegetation buffer is disturbed prior to construction, install sediment barriers across the transmission line ROW. Vegetated buffers on slopes can

be used to trap sediment and promote groundwater recharge. The buffer width needed to maintain water quality ranges from as little as 10 to 15 feet on flat land to over 100 feet on steep slopes. On gentle slopes, most of the filtering occurs within the first 30 feet. Steeper slopes require a greater width of vegetative buffer to provide the same water quality benefits.

4. Have all construction vehicles and equipment traffic travel around wetland areas where possible.

5. Locate staging areas for stream and wetland crossings a minimum of 50 feet away from the stream bank or edge of designated wetland area. Install the appropriate sediment traps and/or filter barriers as needed. Limit the size of the staging area to the minimum amount needed to construct the crossings. All construction equipment is kept out of flowing stream channels except when absolutely necessary to construct crossings. Clean, washed gravel can be used in stream crossing construction activities to reduce solid suspension in adjacent surface waters.

6. Store hazardous materials, chemicals, fuels, and lubricating oils a minimum of 500 feet away from stream banks, lakes, reservoirs and wetlands, or municipal watershed areas. Refuel equipment or vehicles typically are no closer than 300 feet from a stream bank or wetland. Monitor onsite vehicles and equipment for leaks and conduct regular preventative maintenance to reduce the chance of petroleum leaks. Develop a spill prevention plan to address containment and cleanup of spills affecting soils, surface and groundwaters.

7. Apply herbicides for weed control and other vegetation management activities following the established tenets of Integrated Vegetation Management according to the label instructions and by qualified personnel under the supervision of a certified pesticide applicator. Direct applicators to spray away from streams and use appropriate drift control agents, equipment, and techniques to minimize chemical entry into streams. Use no-spray buffer zones along streams to reduce or eliminate the effects of herbicide spraying on aquatic environments (Miller, 2007).

8. During the first year following construction, all permanent erosion and sediment control devices and potential soil erosion sites can be inspected after each major rainstorm. Remedial actions are immediately taken to repair or upgrade any problems encountered.

9. Support structures can be located, if feasible, to avoid active drainage channels, and to minimize the potential for damage by flash flooding. Diversion dikes or other structural enhancements are required to divert runoff around the base or leg(s) of structures if the location in an active channel cannot be avoided. In floodplains, appropriate design of support structure footing foundations, such as raised foundations and/or enclosing flood control dikes, will be used to prevent scour and/or inundation by a 100-year flood.

Cultural Resources

Cultural resources located within a ROW can be directly affected as a result of site disturbance. For instance, some cultural resources can be jeopardized simply as a result of access road development. Alteration of the physical setting by the mere presence of an overhead transmission line can reduce the character of an historic dwelling or cause an intrusion of modern development into a sacred landscape. The development of a ROW can result in increased accessibility to previously inaccessible locations that contain cultural resources. This can, in turn, lead to illegal looting, erosion, disturbance, and other alteration of those resources.

Impacts to cultural resources from ROW preparation and facility construction of an overhead transmission line can result in the following:

- Ground disturbance
- Visual intrusions
- Vandalism

Ground Disturbance

Archaeological sites are non-renewable resources. Any disturbance to the vertical and horizontal distribution of artifacts and other pertinent cultural material is permanent and irreparable. Even temporary or short-term activities associated with transmission line construction that can crush or destroy surface or subsurface artifacts, or evidence of past activities, can cause permanent damage to these vulnerable resources. Therefore, archaeological sites are very sensitive to any construction activities that result in ground disturbance such as earthmoving for support structure foundations or cut and fill for building the access road system.

Visual Intrusions

While the scientific value of archaeological data is not affected by the visibility of a transmission structure, some architectural resources and some Native American sacred sites may be very sensitive to such visual intrusions in the otherwise natural landscape. Overhead transmission lines result in the creation of a ROW, with support structures and overhead conductors that are plainly visible, often for some distances. During the construction phase this visual imposition can be even greater as the presence and movement of large-scale machinery, equipment, and the number of vehicles can also contribute to adverse impacts on those cultural resources with a landscape component.

Vandalism

Improved access to a previously remote area may result in increased levels of vandalism. Any increase in the presence of humans in an uncontrolled and unmonitored environment containing significant cultural resources increases the potential for adverse impacts caused by looting (unauthorized collection of artifacts), vandalism, and inadvertent destruction to unrecognized resources (Programmatic EIS, 2007). Cultural resources that are visually obvious (e.g., rock art, standing buildings) or attractive to vandals (e.g., large prehistoric archaeological sites, 19th century trash dumps) are more sensitive than smaller, less visible resources.

Cultural Resources Mitigation Techniques

The primary focus of paleontological mitigation efforts is on the areas of greatest disturbance and areas likely to have significant fossils. The following mitigation techniques can be used to minimize effects on cultural resources during construction of an overhead transmission line.

1. Prior to transmission line construction and any other surface disturbing activities conduct an inventory of cultural resources within the project area. The nature and extent of this inventory is based upon project engineering details and construction specifications. All cultural resource work undertaken is carried out by qualified professionals. As part of the inventory, field surveys are conducted within the ROW to identify cultural resources that can be affected by support structure construction, access road installation, and all other sites affected by transmission line construction and operation. Field surveys can also be conducted along newly proposed access roads, new staging yards, and any other projected impact areas outside of the ROW.

2. Upon completion of the inventory, a treatment plan to mitigate identified impacts on cultural resources can be prepared. Avoidance, recordation, and data recovery can be used as mitigation alternatives. Mitigation may require the relocation of the line, support structure site placement, access road routes, movement of other ancillary or temporary facilities or work areas, where relocation can avoid or reduce damage to cultural resource values. When necessary to relocate the line and any other components of the transmission facility as a method of mitigation, it is recommended that the proposed new locations be inventoried for cultural resources and provide inventory results prior to construction. Any mitigation deemed necessary can be completed prior to undertaking any surface disturbing activities. If avoidance of specific cultural resources is not feasible, additional treatments can be carried out in consultation with experts in cultural resources.

3. Restrict all construction vehicle movement outside the ROW to pre-designated (and inventoried) access roads/routes or public roads.

4. Prior to construction, instruct all supervisory construction personnel on the protection of cultural resources. The construction contract can address:

   a. Federal, state and tribal laws regarding antiquities and fossils, including collection and removal.

   b. The importance of these resources and the purpose and necessity of protecting them.

   c. Methods for protecting sensitive resources.

5. In the event that potentially historic or cultural resources are discovered during construction, halt any potentially destructive work within 300 feet of the find. Immediately implement the following measures:

   a. Erect flagging to prohibit potentially destructive activities from occurring in a given area.

   b. Have an archeologist make a preliminary assessment of the newly discovered resource.

   c. Notify the appropriate landowner, agencies, and State Historic Preservation Office (SHPO) if the archeologist determines that the discovery represents a potential new site or an undocumented feature of a documented site.

   d. Do not resume construction in the identified area until cleared by the archeologist (private land) and the agencies' authorized officer.

6. Pursuant to 43 CFR 10.4(g), the permit holder must notify the authorized officer, by telephone with written confirmation, immediately upon the discovery of human remains, funerary items, sacred objects of cultural patrimony. Further, pursuant to 43 CFR 10.4(c) and (d), activities must stop in the vicinity of the discovery and protect it for 30 days or until notified to proceed by the authorized officer.

7. Specific agencies may require a cultural resource monitor be present during construction in areas the agency determines to be culturally sensitive.

Visual Resources

Direct, long-term impacts are expected in areas where overhead transmission lines cross areas of outstanding scenic quality or visual appeal; where lines are in the vicinity of cities, towns, communities, and other population concentrations; and where ROW are near or cross sensitive recreation and transportation viewpoints. Hence a visual environmental impact assessment is a combination of the areas scenic quality coupled to viewer sensitivity (value of the visual landscape to the viewing public). Visual effects associated with the construction of an overhead transmission line include potential impacts to:

- Views from residents and communities – rural residences and communities dispersed throughout the study area.
- Views from parks, recreation and preservation areas – potential views from existing and proposed facilities and other developed sites including national monuments, state parks, national natural landmarks, proposed wilderness areas, and other public and private recreation areas.
- Views from sensitive transportation corridors – backcountry byways, scenic byways, and other sensitive travel routes.
- Views from sensitive cultural sites – National Historic Landmarks and other National Register sites or districts
- Visual resource management – compatibility with BLM and USFS visual management designations.
- Scenic quality – impacts affecting the inherent aesthetic value of the landscape.

The visual impacts of overhead line ROW are substantially greater than underground lines due to presence of large above ground structures (towers and poles) and substantially wider ROW. There are also visual impacts from construction and maintenance activities.

High voltage electric transmission structures (lattice towers or poles), where visible, can create potentially substantial visual impacts in almost all landscapes. The support structures and conductors, as well as the insulators, can collectively create substantial visual impacts. A transmission line's visual presence can last from the time it is fabricated throughout the duration of the line usefulness.

Support structures for the high voltage lines can typically be some kind of steel lattice tower, or, in some cases, a pole tower. These structures can be as tall as 200 feet[6] with crossarms as much as 100 feet wide, although typically crossarms are much shorter. Taller structures are generally needed for special situations (e.g., spanning valley crossings). Lattice towers have an open framework composed of numerous thin individual members (compared to poles), but are overall much wider than poles visually. Poles present a single (or sometimes double, i.e., two poles are required), but more bulky upright member, but overall their width is much smaller than that of a lattice tower. Special steel lattice angle or turning towers may be employed to bear the extra weight and tension of conductors where a turn occurs in the line. Such angle towers utilize stronger, thicker, steel members than are used for typical tangent steel lattice towers, and are more substantial than typical towers. Dead-end structures are likewise heavier and similar in appearance due to their need to withstand a collapse of all structures on one side

Under certain conditions, lattice towers tend to blend better into the background when viewed from a distance against mountains or vegetation. With their slender members and open structure, they allow the forms, lines, colors, and textures of the background landscape to show through. The simpler, narrower monopoles may create less contrast with the natural environment in foreground views when seen against the sky (i.e., skylined) compared to the "industrial" structural look of lattice towers, which can be visually overbearing at short distances (Programmatic EIS, 2007).

Visual impacts resulting from construction of an overhead transmission line can be both short and long term. Short-term visual impacts result from views of construction activities including the presence and storage of materials, construction workers, equipment, and landform contrasts as a result of any ROW vegetation clearing, as well as from access road grading and foundation excavation. Long-term impacts result from permanent visual contrasts of the structures and conductors in the ROW. The presence of the overhead transmission line requires a permanent ROW, which includes clearing of all trees and tall shrubs, if present. This condition is maintained in perpetuity to allow access and maintenance of the line.

Given the relative openness of some nearly treeless landscapes, the view shed may be quite extensive with the height and number of the structures, and the availability of viewing opportunities from travel routes, recreational use areas, and nearby residential and commercial areas can be very high. In such open landscapes, present in much of the American West, and under favorable viewing conditions, the support structures and conductors might be visible for many miles, especially if sky lined. In areas that are heavily forested, such long views might be restricted and the views of the line may be much more limited in distance. The viewing analysis conducted to determine the visual impact of the transmission facility can be conducted at a time

[6] Support structures over 200 feet would need to comply with FAA requirements of having blinking red aircraft warning lights installed and the structures may be required to be painted in bands of orange and white. These requirements usually suffice to keep structures to less than 200 feet.

of year when no leaves are present on the trees to get a more accurate portrayal of the line's visibility.

Tower structures, insulators, and particularly conductors are sometimes subject to specular reflection. That is, at times they may be capable of reflecting light like a mirror. These "mirror images" of light can cause bright reflections of sunlight to appear under certain optical conditions when the sun directly illuminates the reflective surface. These bright reflections can extend the visibility of transmission facilities for several miles. Non-reflective coatings or processes to eliminate or diminish specular reflection are commercially available and are often used to mitigate these impacts.

Visual Resources Mitigation Techniques

Some possible opportunities to mitigate visual resources impacts associated with overhead transmission line construction activities are provided below.

1. When building a new line next to an existing one, the existing support structure types, spacings, heights, and conductor heights can be matched to the extent practical.

2. Non-specular conductors can be used to reduce glare and visual contrast.

3. When crossing highways, rivers and trails, support structures can be placed at the maximum feasible distance. The ROW can also cross these linear features at right angles whenever possible to minimize the viewing area and duration.

4. Place support structures to avoid features and/or to allow conductors to clearly span the feature (within limits of standard tower design) to minimize the amount of sensitive feature disturbed and/or reduce visual contrast (e.g., avoiding skyline situations through placement of tower to one side of a ridge or adjusting tower location to avoid highly visible locations and utilize screening of nearby landforms) (Final EIS, 2006).

5. In deserts and semiarid land areas where views of land scars from sensitive public viewing locations are unavoidable, disturbed soils can be treated with Eonite or something similar to reduce the visual contrast created by the lighter-colored disturbed soils and the darker vegetated surroundings.

6. In forested locales extra vegetation can be left in roadside screens by the judicious selective clearing techniques to reduce the view down the ROW, although great care can be given to minimize or eliminate outage risks.

7. In forested environments the support structures can be lowered to the surrounding vegetation canopy heights. However, this technique often requires more structures.

8. Siting of the ROW within a specific corridor can take advantage of both topography and vegetation as screening devices to restrict views of transmission facilities from visually sensitive areas.

9. Where screening topography and vegetation are absent, natural-looking earthwork berms and vegetative or architectural screening can be used to minimize visual impacts. Vegetative screening can be particularly effective along roadways (Programmatic EIS, 2007).

10. Appropriate colored structures, with coatings or paints having little or no reflectivity, can be used.

11. Poles may reduce visual impact more effectively than lattice towers in the near view areas, whereas lattice towers may be more visually suitable for more distant views where the smaller individual lattice pieces seemingly vanish in the distance allowing the background environment to come into view.

12. Reduce visual contrast in construction areas (e.g., marshalling yards, structure sites, or spur roads from existing access roads) where ground disturbance is substantial, by re-contouring and restoring the site. Re-contour the land to the original contours as much as practicable. The method of restoration normally consists of loosening the soil surface, reseeding, installing cross drains for erosion control, placing water bars in the road, and filling ditches.

Decommissioning of Overhead Transmission Facilities

Actions required for decommissioning (i.e., the dismantling of the overhead transmission facilities) are similar to some of those used for construction but on a much more constrained level and over a shorter time interval. Decommissioning is often viewed as construction in reverse, but potential environmental impacts and their severity from typical decommissioning activities may be lower, and in many cases for transmission lines much lower, than those from the original construction activities. The existing access road system is in place for the dismantling of the support structures (towers and/or poles) and recovery of the conductors and shield wires. Hence, all the associated impacts from construction are correspondingly less in the decommissioning phase. This is particularly true if the foundations for the transmission support structures are left in place. Leaving the underground foundations buried in place almost eliminates the need for excavation and other soil disturbance activities and can be far less disruptive of ecosystems that became established after the initial disruptions occurring from construction. Materials from the salvage operations and the attendant equipment necessary are far less impacting and are on site for only a short duration as compared to the original construction effort.

Potential impacts include the presence of workers, vehicles, and equipment with intermittent or phased activity persisting over extended periods of time, as well as the presence of idle or dismantled equipment for as long as it remains on-site. Decommissioning activities can generate dust, emissions, litter, and other effects associated with the presence of workers, vehicles, and equipment (Programmatic EIS, 2007). Salvaged steel from poles and towers are checked for the presence of lead paint residues (current paint ingredients eliminate this concern). Treated wood poles removed are managed in accordance with state and Federal regulations concerning the type and amounts of wood preservatives present. However, removal of all access roads and tower work pads (laydown areas) and other staging sites after being used for the decommissioning effort can be quite problematic. Consequently, the restoration of these slightly re-disturbed ancillary facilities is often done by scarifying of the surface soils and seeding as needed.

Environmental Impacts Associated with Underground Transmission Line Construction

Environmental impacts are defined as modifications to the existing condition of the environment that can be brought about by the implementation of a project.

The potential environmental impacts of an underground transmission line and associated structures, construction activities, and materials on land use, biological resources, geological resources and soils, water resources, cultural resources and visual resources associated are assessed below.

Land Use – Impacts of Trenching and Underground ROW Construction

Agriculture

Agriculture land uses in the area at or near the underground transmission line can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites, and returning to construction staging areas can also cause a temporary disturbance to adjacent land uses. Agriculture users may temporarily lose access due to construction activities.

Existing utility lines (e.g., telephone, cable, gas, etc.) may require relocation or can be damaged as a result of construction of the underground transmission line possibly leading to disruption of electrical service.

Negative impacts to agricultural lands result from the construction of underground transmission lines. In order to operate and perform maintenance on the line, the ROW for the underground lines is kept clear at all times. Cropping activities cannot be performed over the top of underground transmission lines. Tillage equipment can contact and damage the underground installation and disrupt the thermal backfill that is used to dissipate heat from the installation. This differs from overhead installations where agriculture is typically allowed to occur as long as farming practices do not have the potential to interfere with the required electrical clearances of the overhead line and can be conducted safely.

Grasses are used to stabilize the surface of the underground installation. In some cases grazing is a compatible use of the ROW if the project is located in pastures or range land.

Soils designated as farmland are displaced and disrupted by underground transmission installation. The presence of new project components and ROW can permanently disrupt active farming operations by dividing or fragmenting agricultural fields, obstructing access, impeding the delivery and use of water for livestock and irrigation, reducing the efficiency of windbreaks, and/or disrupting the operation of farm equipment.

A frac-out event can potentially cause damage to agriculture properties and associated structures. A frac-out event occurs when excessive drilling pressure is applied and drilling mud propagates vertically toward the surface through fractured bedrock or overlying soils.

Conservation Reserve Program (CRP) lands that are crossed by an underground transmission line require a Farm Service Agency (FSA) assessment of the adverse effects on the participant's CRP acreage. If the FSA determines that the use will have adverse effect on CRP acreage, the affected acreage will be terminated and refunds assessed.

Forests

Forestlands, which are at or near the underground transmission line, can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites, and returning to construction staging areas can also cause a temporary disturbance to adjacent land uses. Forestland users may temporarily lose access due to construction activities.

Negative impacts occur to timber producing forestlands from the construction of underground transmission lines. In order to operate and perform maintenance on the line, the ROW for the underground lines is kept clear of trees and therefore unavailable for timber production.

Installation of an underground transmission line may not be compatible with applicable forest management plans or designated forest conservation uses.

A frac-out event can potentially cause damage to forested properties and associated structures.

Developed

Location of underground transmission lines in developed areas is normally in a street or alley, which reduces the impact to residential, commercial, public facilities, and industrial land uses.

Residential

Residential uses in the area at or near the underground transmission line can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites, and returning to construction staging areas can also cause a temporary disturbance to residential uses. Residential users may temporarily lose access due to construction activities.

Existing utility lines (e.g., telephone, cable, gas, etc.) may require relocation or can be damaged as a result of construction of the underground transmission line possibly leading to disruption of electrical service.

The removal of existing buildings, including residential dwellings and related structures, may be required for a project ROW since they are incompatible with construction, operation, and maintenance of an underground transmission line. The location of the project ROW within platted subdivisions can preclude or impair future development or planned activities.

A frac-out event could potentially cause damage to residential properties and associated structures.

Positive impacts to residential land uses include the potential increased property value effect due to no overhead transmission lines and the elimination of the electrical field (but not the magnetic field).

Commercial

Commercial land uses in the area at or near the underground transmission line can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites and returning to construction staging areas could also cause a temporary disturbance to adjacent land uses. Commercial land users may temporarily lose business due to construction activities and lack of access.

Existing utility lines (e.g., telephone, cable, gas, etc.) may require relocation or can be damaged as a result of construction of the underground transmission line possibly leading to disruption of electrical service.

The removal of existing buildings including commercial buildings and related structures may be required for a project ROW since they are incompatible with construction, operation, and maintenance of an underground transmission line. The location of the project ROW can preclude or impair future commercial development or planned activities.

A frac-out event can potentially cause damage to commercial properties and associated structures.

Positive impacts to commercial land uses include the potential increased property value effect due to no overhead transmission lines and the elimination of the electrical field (but not the magnetic field).

Public Facilities

Public facilities in the area at or near the underground transmission line can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites, and returning to construction staging areas could also cause a temporary disturbance to adjacent land uses. Public facilities may temporarily lose access due to construction activities.

Existing utility lines (e.g., telephone, cable, gas, etc.) may require relocation or can be damaged as a result of construction of the underground transmission line possibly leading to disruption of electrical service.

The removal of existing buildings including public facilities and related structures may be required for a project ROW since they are incompatible with construction, operation, and maintenance of an underground transmission line. The location of the project ROW can preclude or impair future public facility development or planned activities.

Generally, city parks and city/county-owned properties like public education land areas are deemed unacceptable for underground transmission lines.

A frac-out event can potentially cause damage to public facility properties and associated structures.

A positive impact to public facilities would be no overhead transmission lines and the elimination of the electrical field (but not the magnetic field).

Industrial

Industrial land uses in the area at or near the underground transmission line can be temporarily disrupted by construction activities such as noise, dust, and traffic. Heavy construction equipment on temporary and permanent access roads, moving construction materials to sites, and returning to construction staging areas can also cause a temporary disturbance to adjacent land uses. Industrial land users may temporarily lose access due to construction activities.

Existing utility lines (e.g., telephone, cable, gas, etc.) may require relocation or can be damaged as a result of construction of the underground transmission line possibly leading to disruption of electrical service.

The removal of existing buildings including occupied dwellings and related structures may be required for a project ROW since they are incompatible with construction, operation, and maintenance of an underground transmission line. The location of the project ROW can preclude or impair future industrial development or planned activities.

A frac-out event can potentially cause damage to industrial properties and associated structures.

Underground transmission lines may be incompatible with some industrial land uses such as mines, gravel pits, and landfills.

A positive impact to industrial land uses would be no overhead transmission lines and the elimination of the electrical field (but not the magnetic field).

Parks, Recreation and Preservation Areas

Project construction activities create a number of temporary impacts that can diminish the value of parks, recreation, and preservation areas. Noise, dust, and heavy equipment traffic generated during construction activities can negatively affect a visitor's enjoyment of these areas or sway visitors from visiting the recreation areas during project construction. Construction equipment may temporarily block access to these areas. If visitors choose to access the recreation facilities, temporary closure of some recreation facilities may occur in order to ensure the safety of visitors during construction, which may result in a temporary reduction in visitation.

The construction and maintenance of underground transmission lines can negatively impact parks, recreation, and preservation areas due to temporary loss of the ROW area for dispersed recreation activities during the construction period. Inappropriate access to the ROW and adjacent properties via off highway and other motorized vehicles by recreation users may cause indirect impacts on the maintenance of the permanent ROW and access roads. Increased vehicle access may increase with new access roads and indirectly result in increased littering, illegal hunting, and other unauthorized activities on the special management areas as well as adjacent properties. However, national land preserves and scenic river ways such as forests, lakes, and rivers typically resist the installation of overhead transmission lines except where they may provide much needed firebreak. In these cases, underground transmission is not readily accepted, but it is preferred when compared to an overhead transmission installation.

Underground transmission lines lack overhead structures with the exception of the two transition points, which lessen the visual impact on special management areas. However, maintenance of the ROW in certain areas could be negative due to the creation of differences in vegetation. For example, an underground transmission line installed through a forested area requires the elimination of trees during construction and ROW maintenance, thus disrupting the visual continuity of the forest.

Lands with conservation easements that are crossed by an underground transmission line (if allowed under the easement) require an assessment by the administrator of the conservation easement regarding the adverse effects from the construction, operation, and maintenance of the line. The organization that holds the conservation easement may require specific rehabilitation or restoration of the property. In the worst case, the property may no longer meet the requirements of the conservation easement, in which case it would be rescinded.

Projects crossing parks, recreation, and preservation areas, which received Land and Water Conservation Fund grant funding, can require the granting of a ROW across the property. If the project requires a conversion of land, this would constitute a conflict with the Land and Water Conservation Fund.

Transportation and Access

Transportation and access impacts will be temporary during construction of an underground transmission line. Construction of the project can result in roadway closures at locations where the construction activities are within ROW of public streets and highways. Construction vehicles might have to utilize private roads to access the transmission line ROW during construction, which increases dust, noise, and overall traffic in the short term. If private roads are used, long-term impacts are minimal from vehicles accessing the ROW for periodic maintenance of the ROW and/or underground transmission line.

Construction activities can interfere with emergency response by ambulance, fire, paramedic, and police vehicles. Potential roadway segments most affected are two-lane roadways, which provide one travel lane per direction. On roadways with multiple lanes, the loss of a lane, and the resulting increase in congestion, can lengthen the response time for emergency vehicles to pass through the construction zone. Additionally, it is possible that emergency services may be needed at a location where access is temporarily blocked by the construction zone.

There is potential for unexpected damage to roads by vehicles and equipment that entering and leaving the project area. Project construction of a project temporarily increases traffic (project trip generation) on adjacent roads and highways. Depending on location, construction personnel will likely access worksites using primary and secondary roadways in the project area. The impacts on roads are short term and related to the movement of personnel and equipment during construction. These concerns are not specifically related to underground transmission construction, but can occur in both the construction of overhead and underground transmission.

Land Use – Impacts of Trenchless Methods and ROW Construction

The environmental impacts to land use resources as a result of trenchless methods such as directional drilling are essentially the same as for open-cut trenching and ROW construction, with the exception of a frac-out event. This event has the potential to cause damage to land use resources at the site of the frac-out. The damage can be small or large depending on its severity and location.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project. There will also be temporary disturbance around the entry and exit pits from equipment and workers.

Land Use Mitigation Techniques

Refer to the land use mitigation techniques described for overhead construction in Chapter 3. These same mitigation techniques can be used to minimize effects on land use resources during construction of underground transmission lines.

Biological Resources – Impacts of Trenching and ROW Construction

Vegetation Resources

Impacts to vegetation resources from trenching and ROW construction of an underground transmission line could result in the following:

- Disruption of existing vegetation
- Change in habitat type or vegetation composition
- Habitat fragmentation
- Disruption of rare, threatened, and endangered plant species and habitats
- Introduction of invasive plant species

Disruption of Existing Vegetation

Trenching activities associated with underground transmission line construction disrupts the existing vegetation no matter what type of vegetation exists. Trenching can damage the root systems of existing trees to the extent that the trees are weakened or killed. A properly maintained underground ROW typically is kept clear of trees and large shrubs that can interfere with underground lines via plant root systems (Wisconsin Public Service Commission, 2004). Trees, shrubs, and most vegetation cannot be re-planted in the ROW of underground transmission lines; however, grass or similar vegetation may be used.

Changes in Habitat Type or Vegetation Composition

Changes in habitat type or vegetation composition can occur within the transmission line ROW, but results may vary significantly depending on the type of habitat being affected. Also, vegetation recovery rates will depend on soil type, landform, precipitation regime, and other physical features of the disturbed sites. Direct studies with regard to habitat and vegetation composition impacts due to construction of an underground transmission line are lacking. However, inferences can be made from studies referencing overhead transmission line projects and their associated impacts. More studies need to be conducted in this area, but a lack of native species recovery exists in certain ecosystems following severe disturbance such as trenching for an underground transmission line, as indicated in the following studies.

In the Mojave Desert, Lathrop and Archbold discovered that disturbed areas from transmission line construction and control areas may appear to have similar vegetation covers, biomasses, and densities, but the similarities often vanished when qualitative aspects were examined, such as proportion of long-lived species and presence of characteristic dominants (Lathrop & Archbold, 1980).

A study by Thibodeau and Nickerson revealed that overhead transmission line construction did not have a substantial, long-term negative impact on a wooded wetland. Except for differences in size and maturity, the wooded wetland vegetation recovered in two years from nearly total destruction caused by construction (Thibodeau & Nickerson, 1986). A similar study examined the response of vegetation communities to overhead transmission line construction in three different wetland types: a cattail marsh, a wooded swamp, and a shrub/bog wetland. While both the cattail marsh and wooded swamp recovered within a few years, measures of plant community composition in the shrub/bog wetland were still lower, compared to controls after ten years (Nickerson, Dobberteen, & Jarman, 1989).

Stylinski and Allen investigated the effects of severe disturbance (construction, heavy-vehicle activity, soil excavation, landfill operations, and tillage) on shrub communities in southern California. Their study revealed that these disturbances led to the conversion of indigenous shrublands to exotic annual communities with low native species richness. The cover of native species remained low on disturbed sites even 71 years after initial disturbance ceased. The study supported their hypothesis that altered stable states can occur if a community is pushed beyond its threshold of resilience (Stylinski & Allen, 1999).

It may be concluded from these studies that certain ecosystems are more resilient than others to disturbance caused by underground transmission line construction and that permanently altered vegetation communities can occur if pushed beyond their thresholds of resilience. Shrub/bog wetlands, as well as arid and semi-arid ecosystems, appear to be particularly susceptible to permanent damage from underground transmission line construction.

Additionally, because the vegetation composition within the ROW is kept free of large trees and shrubs, a permanent early successional habitat is created. The creation of these open and early successional habitats in a ROW is beneficial to some species and detrimental to others. In Wisconsin, transmission ROW have a positive effect on the federally endangered Karner Blue Butterfly, where blue lupine, a plant vital to the butterfly's survival, is increasing in abundance because of the open areas in the overhead transmission line ROW (Willyard et al., 2004). The Karner Blue Butterfly serves as an example of a positive outcome of ROW corridors.

Habitat Fragmentation

Habitat fragmentation can occur with construction of an underground transmission line, but results will vary depending on the plant species composition both within the ROW and adjacent to it. Effects seem to be species-specific and localized.

The literature on the ecological effects of fragmentation focuses on reduced habitat area, species isolation, and increased habitat edge. Plants that are area, isolation, or edge sensitive will be negatively affected by fragmentation; however, plants that are not sensitive to fragmentation may be unaffected or even positively affected by the separation if it results in an increase in habitat or favorable conditions for these species.

With regard to reduced habitat area, a survey of twenty transmission line corridors in the forests of northern Kentucky reveals that construction of a single power line corridor within forests, already fragmented by development activities, may render forest patches unsuitable for plant species requiring large forest interior habitats (Lukenet et al., 1990).

The habitat fragmentation effects of roads on the landscape include dissecting vegetation patches, increasing the edge-affected area, decreasing interior area, and increasing the uniformity of patch characteristics, such as shape and size (Reed et al., 1996).

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to rare, threatened, and endangered species populations are a key concern because of the tendency for these species to be less stable than other plant species. Even temporary disturbances can have adverse impacts. Impacts are dependent on species and project location.

Increased edge created by a transmission line corridor enhances local plant species diversity and has a positive effect on some individual species, typically those that are habitat generalists and are already common in the landscape. As a result, increased local diversity often comes at the expense of global species diversity, as rare plants are replaced by common ones. This phenomenon causes ecosystems to lose complexity (Willyard, 2004).

Rare plant species may also be affected by the introduction of invasive plant species, not only in the ROW, but also near the edges of the ROW, if the invasive species encroach into these areas.

Introduction of Invasive Plant Species

Noxious weeds and invasive plants can pose serious threats to the composition, structure, and function of native plant communities (Olson, 1999). Noxious weeds produce abundant seed, have fast growth rates, and can displace native species (Olson, 1999). Project activities that disturb the ground and the subsequent loss of native vegetation can make an area vulnerable to noxious weed invasions (Olson, 1999). In addition, open roads can serve as corridors for weed spread. Noxious weed seeds can be carried in the undercarriage of vehicles and distributed along the roadway, and the movement of animals or humans for management or recreational purposes can facilitate the spread of invasive species into previously inaccessible areas. Invasive species monopolize ecosystems and often out-compete native vegetation, which in turn negatively affects the animals dependent on these habitats.

A study in the southern California shrublands found that sites with severe disturbance from activities such as soil excavation and heavy-vehicle equipment consisted of 60% non-native annual species compared with undisturbed sites that were primarily covered with native shrub species (68%) (Stylinski & Allen, 1999).

Wildlife Resources

Impacts to wildlife resources from trenching and ROW construction of an underground transmission line could result in the following:

- Habitat and population fragmentation
- Habitat loss and reduced species abundance
- Wildlife displacement and disturbance
- Disruption of rare, threatened, and endangered species

Habitat and Population Fragmentation

Habitat and populations can become fragmented through the construction of linear projects such as transmission lines (e.g., access roads, ROW, facilities). Habitat fragmentation is comprised of four components (Franklin et al., 2002), which include the following:

- What is being fragmented? (wildlife habitat, including terrestrial and aerial)
- What scale is being used?
- What is the mechanism causing fragmentation? (ROW, access roads, facilities)
- What is the extent and pattern of fragmentation? (depends on the organism being evaluated)

Direct studies are lacking with regard to habitat fragmentation due to construction of an underground transmission line. However, inferences can be made from studies referencing linear projects (buried pipeline, roads, transmission line corridors) and their associated impacts. Studies referenced in this report focus on fragmentation from linear features and the impacts to wildlife.

Roads fragment by changing landscape structure and by directly and indirectly affecting species. Road-avoidance behavior is characteristic of large mammals such as elk, deer, bighorn sheep, grizzly, and wolf. Avoidance distances of 100 to 200 meters are common for these species (Lyon, 1983). Road density is a useful index for the effect of roads on wildlife populations (Forman et al., 1997). Some studies show that a few large areas of low-road density, even in a landscape of high average road density, may be the best indicator of suitable habitat for large vertebrates (Rudis, 1995).

There is strong evidence that forest roads displace some large mammals and certain birds (such as spotted owls and marbled murrelets), and that displaced animals may suffer habitat loss as a result. Effects of roads on small mammals and songbirds are generally described as less severe, with changes expressed as modifications of habitat that cannot readily be classified as detrimental or beneficial.

Roads also create habitat edge (Mader, 1984; Reed et al., 1996); increased edge changes habitat in favor of species that use edges, and to the detriment of species that avoid edges or experience increased mortality near or along edges (Marcot et al., 1994). The continuity of the road system also creates a corridor by which edge-dwelling species of birds and animals can penetrate the previously closed environment of continuous forest cover. Species diversity can increase, and increased habitat for edge-dwelling species can be created.

Roads and their adjacent environment qualify as a distinct habitat and have various species, population, and landscape-scale effects (Baker and Knight, 2000, Dawson, 1991, van der Zande et al., 1980). Some research attempts to describe habitat modifications caused specifically by roads, but most of this work is species and site-specific (Lyon, 1983).

In general, road building fragments habitat, and creates habitat edge, modifying the habitat in favor of species that use edges. Edge-dwelling species are generally not threatened, however, because the human-dominated environment has provided ample habitat for them. Any habitat modifications attributed to the road may be insignificant compared to the effects of the activity, such as gas development activity, for which the road was built.

Concern for habitat fragmentation is increasing in wildlife management (Baker & Knight, 2000) and is considered a global concern for biological diversity (Knight et al., 2000). Species declines and shifts of animal distributions have led to a more modern focus on the causes of habitat fragmentation and the effect this may have on wildlife. Avian responses to habitat fragmentation include life cycle alterations, increased parasitism, and habitat affinity associations (Weller et al., 2002; Knight et al., 2000).

Habitat removal and fragmentation as a result of transmission line construction can alter wildlife migration corridors and dispersal orientation, as well as isolate wildlife populations and their gene pools. This significantly weakens the wildlife community.

Habitat fragmentation affects wildlife regardless of the location, but the degree to which wildlife is affected, and the species-specific effects, as they relate to construction of an underground transmission line cannot be definitely concluded. Construction of access roads directly applies, but construction of the ROW, while similar to a road, is dissimilar enough that direct conclusions cannot be drawn.

Some positive benefits do result from underground transmission construction. Bird strikes into overhead lines are reduced to zero where underground construction is used. Additionally, underground construction does not provide hunting perches for predator birds, which can prey on small mammals, amphibians and reptiles. This can be especially helpful in areas where rare, threatened, and endangered species are affected by predators that can use overhead line structures for perching and observation during hunting.

Habitat Loss and Reduced Species Abundance

Habitat loss can result from the conversion of land to road surfaces and facilities. Habitat loss can also result from construction of the ROW, as the habitat may be converted or changed from that prior to construction.

Fragmentation can also result in habitat loss and reduced species abundance. As the number of fragments increase in a given area, the core area size decreases, reducing the patches uninterrupted by human disturbance. The amount of edge area grows with the increase of fragments, and habitat connectivity decreases with increased fragmentation (Knight et al., 2000). Decreased connectivity may favor the habitat generalist wildlife species over the forest-adapted species, threatening species richness or diversity at regional scales (Knight et al., 2002). Habitat generalists, such as coyotes and brown-headed cowbirds, use road corridors to easily access the interior forest. These predators and nest parasites can have direct impacts on forest-adapted species populations. Opening up forest and to a lesser degree shrubland habitat also increases solar exposure during winter months creating earlier forage exposure for several species.

Wildlife Displacement and Disturbance

Construction of an underground transmission line may provide temporary or permanent wildlife disturbance by displacing animals from their typical habitat. Disruption comes from increased noise levels (e.g., construction); increased vehicle traffic (e.g., construction, maintenance, recreation use); and facility presence (e.g., manholes, access roads, and pad-mounted equipment). Most wildlife occupying a project area are displaced during construction, but some species such as nesting birds and amphibians are vulnerable to mortality from the physical disruption of soils and vegetation.

Many wildlife species are sensitive to harassment or human presence, often facilitated by construction activities and road access. Potential reductions in productivity, increases in energy expenditures, or displacements in population distribution or habitat use can occur (Bennett, 1991; Mader, 1984). However, the magnitude of impact to the species often depends on the experience associated with the disturbance (Geist et al., 1978). For example, road disturbance leads to elk avoidance of large areas near roads open to traffic (Lyon, 1983; Rowland et al., 2000), with elk avoidance increasing with the increasing rate of traffic (Wisdom et al., 2000; Johnson et al., 2000). Hayden-Wing (1991) reported significant declines in mule deer populations in Wyoming due to increased hunting access associated with access roads from development.

Impact to fisheries resources can result from increased sediment in streams or rivers. Potential impacts are greatest during and immediately after construction. Fish tend to avoid streams or stream reaches with high-suspended sediment levels. Deposited sediment affects the reproductive success of salmonids. Sediment can coat eggs and embryos and fill the interstitial spaces of the redd (nest for depositing eggs) so completely that the flow of water containing oxygen is impeded or stopped, resulting in mortality. Another problem occurs when sedimentation on the streambed produces a consolidated armor layer through which emerging sac fry cannot penetrate, resulting in entombment of the fry (Waters, 1995). Salmonids are particularly sensitive to sediment in spawning gravels. Therefore, increases in instream sediment deposition are undesirable and are avoided whenever possible.

In areas where the ROW crosses riparian zones, the cleared ROW has the potential to impact aquatic life. Riparian vegetation has many influences on the stream ecosystem. Riparian vegetation produces food for fishes and other animals, and habitat for insects that supplement the diet of fishes. Riparian vegetation also forms a protective canopy that helps maintain cool stream temperatures and insulate the stream from heat loss in winter. Since the influence of riparian vegetation generally decreases as streams get larger, small streams are likely to experience more severe impacts than large streams as a result of riparian vegetation removal (Murphy and Meehan, 1991).

The loss of riparian vegetation is a long-term, direct impact of underground transmission line construction. Some types of vegetation, as indicated in the previous studies, take years to recover; trees and large shrubs are not allowed to mature within the permanent ROW.

When transmission lines are placed underneath a stream or river, frac-outs of drilling muds used in trenchless technologies can occur resulting in unfavorable conditions for riparian vegetation and aquatic life.

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to rare, threatened, and endangered species populations are a key concern because of the tendency for these species to be less stable than other wildlife species. Even temporary disturbances can have adverse impacts. Breeding habitat is especially important because disruption during breeding season can reduce productivity for the entire year. Impacts are dependent on species and project location.

Biological Resources – Impacts of Trenchless Methods and ROW Construction

Vegetation Resources

Directional drilling will not disrupt the existing vegetation to the extent of trenching because the soil and vegetation will remain intact. Since the soil won't be disturbed to the extent of trenching, any impacts from invasive species, as well as impacts to rare plants, are reduced.

Changes in habitat types, habitat fragmentation, and disruption of rare plants from directional drilling would be relatively consistent with the trenching technique due to disturbance from construction and maintenance of the ROW.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project.

Wildlife Resources

Impacts to wildlife resources from directional drilling are relatively consistent with the trenching technique due to disturbance from construction and maintenance of the ROW and access roads. There is less impact regarding wildlife disturbance and mortality because directional drilling does not disturb the existing vegetation and soil.

Biological Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on biological resources during construction of an underground transmission line.

1. Restrict all construction vehicle movement outside the ROW to pre-designated access, contractor-acquired access, or public roads.

2. In construction areas where recontouring is not required, leave the vegetation in place wherever possible and maintain the original contour to avoid excessive root damage and allow for resprouting. Limit disturbance to overland driving where feasible to minimize changes in the original contours.

3. Prior to construction, instruct all supervisory construction personnel on the protection of biological resources. The construction contract can address:

   a. Federal, state and tribal laws regarding plants and wildlife, including collection and removal.

   b. The importance of biological resources and the purpose and necessity of protecting them.

   c. Methods for protecting sensitive resources, including instruction on wildlife policy to prohibit unauthorized off-road vehicle use in the project area, and to discourage wildlife harassment and littering.

4. Adhere to Section 7 of the Endangered Species Act (1973) as specified by the U.S. Fish and Wildlife Service (USFS), Biological Opinion of the USFS, and other appropriate agencies.

5. Delineate the boundaries of sensitive plant populations with clearly visible flagging or fencing based on surveys completed prior to construction. In the event any special-status plants require relocation, obtain permission from the appropriate agencies. If avoidance or

relocation is not practical, the topsoil surrounding the plants can be salvaged, stored separately from the subsoil, and spread during the restoration process.

6. Develop a noxious weed and invasive plant control plan in consultation with the appropriate agencies and local weed control districts to minimize the effects of noxious weeds due to proposed project activities. The plan can address measures to minimize the spread of noxious weeds and invasive plants and control methods after construction.

7. Train the contractor on the methods for cleaning equipment, identification of problem plant species in the project area, and procedures when an invasive or noxious weed is located. Supply the contractor with a list and pictures of noxious and invasive species that may exist in the project area.

8. Promptly seed disturbed areas following completion of construction activities to reduce the potential for the spread and establishment of noxious weeds and invasive plants. Seeding can occur as soon as possible following construction and during the optimal time period.

9. Apply herbicides for weed control by qualified personnel according to the label instructions. Orient spray units to avoid streams and drift to minimize chemical entry into streams. Use spray buffer strips along streams to reduce or eliminate the effects of herbicide spraying on aquatic environments..

10. Limit ground disturbance to what is necessary to safely and efficiently install the proposed facilities.

11. Prepare a revegetation plan in consultation with the appropriate agencies. The plan can specify the disturbance types and their appropriate revegetation techniques to be applied for all proposed project work areas and access roads. Techniques could include reseeding native or other acceptable vegetation species with certified weed-free seed. The plan can include approved management and maintenance procedures for ongoing use of access roads and temporary work areas.

12. Erosion and sediment control measures can be specified and meet the requirements of the Clean Water Act.

13. Bear-proof all project-related containers holding attractants and remove garbage in a timely manner.

14. Do not permit harassment of wildlife at any time during project construction activities.

15. Install barriers along travel ways bisecting the underground transmission line easement to minimize erosion potential and encourage vegetation regeneration. Barriers may include gates and post/pole fencing, in addition to the use of natural obstacles such as rocks, logs, planted native shrubs, and vegetation slash.

16. Avoid sedimentation loading downstream and impacts on fisheries at specific stream crossings by scheduling trenching operations to occur through streams during dry or low flow periods.

17. Modify or curtail construction activities during sensitive periods (e.g., nesting and breeding) for candidate, proposed threatened and endangered, or other sensitive animal species.

18. Time construction activities when feasible in areas known to be sensitive to wildlife species.

Geological and Soil Resources

Trenching and ROW Construction

Impacts on geological and soil resources from trenching and ROW construction of an underground transmission line can result in the following:

- Soil erosion and/or compaction
- Disruption of soil profile
- Reclamation constraints due to soil type
- Disturbance to unique geological features

Soil Erosion and/or Compaction

All soils crossed by an underground transmission line are subject to vegetation removal or disturbance, displacement, compaction, and erosion. These disturbances, although temporary (e.g., construction and any reclamation), result in a minor increase in soil erosion and compaction levels. Some soils may need to be relocated during trenching and backfill operations.

Temporary impacts result from the grading of existing and new access roads, and construction of any staging areas. These soil surface-disturbing activities may include, but are not limited to, ROW clearing when necessary and construction equipment travel.

Soil surface disturbance results in short-term impacts associated with increased erosion rates. Actual erosion depends on factors at a particular site such as weather events, soil permeability, slope, and adjacent vegetation or lack thereof.

Heavy vehicles and equipment travel along the project ROW resulting in increased soil compaction. Moderate or severe soil compaction affects soil productive potential. The extent of compaction depends on soil moisture content and the physical characteristics of a particular soil type. Compaction tends to be less severe when soils are dry and more severe when soils are moist to wet.

Disruption of Soil Profile

Impacts to soil resources can occur from inversion of the soil profile, loss of structure, and mixing of layers as the trench is backfilled. This may result in increased erosion and compaction and less productive soil for vegetation. Underground transmission lines require the importation of select thermal backfill in many instances. The sources of these materials can be located many miles from the project area. Borrow sites for these materials result in significant disturbances to the soil profiles of the borrow area and can contribute to land use and erosion impacts at the borrow sites without proper reclamation and stabilization techniques.

Reclamation Constraints Due to Soil Type

Soils developed on Cretaceous shales, intrusive shales, and lacustrine sediments are more difficult to reclaim and revegetate due to their chemical composition and mechanical weathering products. Cretaceous shales and lacustrine sediments often produce highly saline soils, and intrusive rocks generally weather to granular sands with little nutrient availability.

Disturbance to Unique Geological Features

ROW construction and trenching activities associated with the construction of an underground transmission line have the potential to disturb unique geological features of a particular area.

Trenchless Methods and ROW Construction

Directional drilling reduces the impacts from erosion and compaction because there is no trenching. There are still impacts from erosion and compaction due to construction of the ROW.

Directional drilling eliminates disruption of the soil profile except in cases of a frac-out.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet, with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project.

Directional drilling also reduces both reclamation constraints and disturbance to unique geological features because of the reduced soil and vegetation disturbance.

Geological and Soil Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on biological resources during construction of an underground transmission line.

1. Restrict all construction vehicle movement outside the ROW to pre-designated access, contractor-acquired access, or public roads.

2. In construction areas where recontouring is not required, leave the vegetation in place wherever possible and maintain the original contour to avoid excessive root damage and allow for resprouting. Limit disturbance to overland driving where feasible to minimize changes in the original contours.

3. Erosion and sediment control measures must be specified and meet the requirements of the Clean Water Act.

4. Limit ground disturbance to that necessary to safely and efficiently install the proposed facilities.

5. Install barriers along travel ways, bisecting the underground transmission line easement to minimize erosion potential and encourage vegetation regeneration. The barriers can lower soil impacts by discouraging motorized vehicle access and travel. Barriers may include gates and post/pole fencing in addition to the use of natural obstacles such as rocks, logs, planted native shrubs, and vegetation slash.

6. Use existing public roads and conduct all construction activities in a manner that minimizes soil disturbance to the extent possible. Use dust-control measures during road construction in sensitive areas, as required. Leave all existing roads in a condition equal to or better than their condition prior to construction of the transmission line.

7. Conduct a field verification of all landslide-prone areas and make appropriate adjustments as needed.

8. Rehabilitate disturbed areas at all work sites, areas adjacent to access roads, and in the ROW following construction.

9. Prepare a geotechnical report prior to construction to address risks to structures and roads due to potential seismicity and liquefaction.

10. To facilitate revegetation and minimize soil compaction, target only severely compacted areas for disking (ripping), with the depth extending to subsoils if necessary.

11. To minimize erosion and sedimentation transport, temporary control measures (e.g., silt fences, straw bale fences, terracing, water bars, matting, settling ponds, or other erosion control techniques) can be installed prior to and during construction in graded or disturbed areas, steep slopes that exceed 30%, and in other sensitive areas.

12. Preserve the topsoil for more successful soil reclamation.

13. Monitor stabilization methods and revegetation success for a minimum of two growing seasons or until 75-80% revegetation is achieved as approved by the appropriate agency or landowner.

14. Promote soil restoration in sloped disturbance areas with placement of the appropriate amount and type of erosion control material.

15. Complete a thorough survey of the proposed project ROW to avoid any unique geological features.

Water Resources

Trenching and ROW Construction

Impacts on water resources from trenching and ROW construction of an underground transmission line can result in the following:

- Disturbance to surface water flows and floodplains
- Disturbance to wetlands
- Disturbance to groundwater
- Water quality degradation

Disturbance to Surface Water Flows and Floodplains

During construction, streams or waterways may need to be diverted. In addition to impacts on aquatic wildlife, riparian vegetation, and recreation activities, the diversion of streams or waterways during the construction of underground transmission lines can affect surface water flows and floodplains.

Construction near surface water has the potential to alter localized drainage patterns of the area. A permanently altered drainage pattern can temporarily increase erosion and sedimentation, eliminate the previous riparian corridor while eliminating non-riparian vegetation in the new corridor, harm wildlife, or damage existing land uses.

If drainage patterns are altered, this can change floodwater flows and associated floodplains.

Disturbance to Wetlands

Wetlands provide a variety of direct and indirect public benefits including flood protection, erosion control, water quality maintenance, and wildlife habitat. Construction of an underground transmission line can temporarily or permanently alter wetland systems. Because wetland systems are a unique combination of hydrology, soils, and vegetation, disrupting one of these conditions may irreversibly damage the wetland ecosystem processes. Little data exists concerning long-term effects of many types of construction activities in wetland ecosystems.

Nickerson et al. (1989) reported on the long-term effects of construction of an overhead utility ROW through a cattail marsh, wooded swamp, and shrub/bog wetland, and discovered that both the cattail marsh and wooded swamp recovered within a few years, while the plant composition of the shrub/bog wetland plant was still lower after ten years.

Thibodeau and Nickerson (1986) reported on the effects of overhead utility ROW construction and maintenance on the vegetation of a wooded wetland and found that except for differences in size and maturity, the vegetation recovered in two years from nearly total destruction caused by construction. Maintenance that included the periodic removal of tall-growing species led to the formation of a plant association different from the one occurring naturally, but as diverse and species rich.

While little data exists on construction of an underground transmission line through a wetland, the potential for irreversible damage to wetland systems is significant.

Disturbance to Groundwater

Trenches for underground transmission lines which encounter groundwater can temporarily or permanently alter groundwater flows by changing the underground channels or pools that exist. This has the potential of affecting existing and proposed groundwater pumping for domestic use, irrigation, and other uses.

Dewatering is often necessary in areas with high water tables in order to remove excess water from the construction worksite. The main dewatering techniques include: barriers, sump and ditches, wellpoint systems, deep-well systems, and cutoffs. These techniques can impact the existing water table as well as adjacent land use, vegetation, soil, and wildlife depending on where and how the water is diverted.

Water Quality Degradation

Construction near surface water has the potential to directly impact the quality of these water resources through erosion or discharge of materials. The period of highest potential impact is during and immediately following construction from the ROW construction, staging areas, or access roads. Construction in ephemeral drainages can deposit sediment on the dry streambed, which could then be delivered to the stream system when flows resume.

Water quality of surface waters can also be directly affected through the accidental release of pollutants such as fuel, lubricants, or antifreeze during construction.

Trenchless Methods and ROW Construction

There is less impact to water resources from directional drilling with the exception of potential disturbance to groundwater. The ROW construction still has the potential of disturbing surface water flows and floodplains, wetlands, and water quality.

An impact from directional drilling under a river could be a frac-out.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet, with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project.

Water Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on water resources during construction of an underground transmission line.

1. Restrict all construction vehicle movement outside the ROW to pre-designated access, contractor-acquired access, or public roads.

2. Prior to construction, instruct all supervisory construction personnel on the protection of water resources. The construction contract can address:

   a. Federal, state and tribal laws regarding water resources.

   b. The importance of water resources and the purpose and necessity of protecting them.

3. Build roads at right angles to the streams and use existing public roads to the extent possible. Install culverts where needed. Conduct construction activities in a manner that minimizes disturbance to vegetation, drainage channels, and stream banks.

4. Establish a crossing for vehicles and construction equipment and create an appropriate undisturbed vegetation buffer. If the soil within the vegetation buffer is disturbed prior to construction, install sediment barriers across the transmission line ROW.

5. Install culverts or temporary work bridges across all streams that are flowing at the time of construction to provide access to the work areas on both sides of the streams. This will minimize stream bank degradation, erosion, and sediment into the waterway.

6. Have all construction vehicles and equipment traffic travel around wetland areas when possible, with permission from the landowner.

7. Locate staging areas for stream and wetland crossings a minimum of 50 feet away from the stream bank or edge of designated wetland areas. Install the appropriate sediment traps and/or filter barriers as needed.

8. Limit the size of the staging area to the minimum amount needed to construct the crossings.

9. Store hazardous materials, chemicals, fuels, and lubricating oils a minimum of 300 feet from stream banks, wetlands, or municipal watershed areas. Refuel equipment or vehicles no closer than 100 feet from a stream bank or wetland. Monitor onsite vehicles and equipment for leaks, and conduct regular preventative maintenance to reduce the chance of petroleum leaks.

10. Remove trench topsoil from the streambed for segregated stockpiling in adjacent upland areas. When possible, place trench spoil at least 10 feet away from stream banks at all stream crossings. When this cannot be accomplished, locate the spoil pile in the stream in such a manner as to prevent undue flow restrictions. Prevent the flow of spoil off the construction ROW. Set aside streamside woody shrubs with attached root wads during construction for reestablishment along stream banks following construction.

11. Backfill the transmission line in such a manner as to prevent the additional disturbance of previously undisturbed soil in the streambeds or wetland areas.

12. Salvage wetland topsoil containing wetland plant parts and seeds to an approximate depth of 12 inches and stockpile adjacent to the trench. Stockpile excavated subsoil separately from the salvaged topsoil.

13. Restore streambeds, banks, and wetlands as near to pre-construction contours as possible and reseed. Place boulders in original locations and set to the original soil line. Facilitate channel recovery by retaining and re-establishing woody shrubs after construction is complete. If existing shrubs cannot be salvaged, obtain native shrubs from nearby nurseries and plant. Ground matting (excelsior blankets) can be installed on slopes of stream banks to accelerate vegetation stabilization.

14. Backfill the trench with previously excavated subsoils and place the salvaged topsoil on top of the trench and disturbed areas within the construction zone.

15. Allow no vehicle traffic on the ROW except as needed to maintain the ROW and for transmission line maintenance and repair.

16. Do not apply paint or permanent discoloring agents to rocks or vegetation to indicate limits of survey or construction activity.

17. Develop a spill prevention plan to address containment and cleanup of spills affecting surface waters.

18. Pre-approve the use of water for construction activities such as dust suppression.

19. Apply herbicides for weed control according to the label instructions and by qualified personnel. Orientate spray units to avoid streams and drift to minimize chemical entry into streams. Use spray buffer strips along streams to reduce or eliminate the effects of herbicide spraying on aquatic environments.

20. Avoid sedimentation loading downstream and impacts to fisheries at specific stream crossings by scheduling trenching operations to occur through streams during dry or low flow periods.

Cultural Resources

Trenching and ROW Construction

Impacts to cultural resources from trenching and ROW construction of an underground transmission line can result in the following:

- Ground disturbance
- Visual intrusions
- Vandalism

Ground Disturbance

Archaeological sites are non-renewable resources. Any disturbance to the vertical and horizontal distribution of artifacts and other material is permanent and irreparable. Even temporary or short-term activities can cause permanent damage to resources. Therefore, archaeological sites are very sensitive to any construction activities that result in ground disturbance.

The same project action (i.e., building an underground transmission line) can affect two resources very differently based on the overall size and shape of each cultural resource. For example, crossing a narrow, linear feature like a historic trail, even in a remote area, has a much lower potential impact than crossing a National Register district large enough to require extensive ground disturbance within the district.

Visual Intrusions

While the scientific value of archaeological data is not affected by the visibility of a transmission structure, some architectural resources and some Native American sacred sites may be very sensitive to visual intrusions, such as ROW construction, in the natural landscape. Any visual impacts to cultural resources during construction may exist only for the duration of the particular activities and the time required for restoration and revegetation.

Compared to the long-term visual intrusions of overhead transmission lines and associated towers, underground transmission lines have less visual intrusion because they lack overhead structures. An exception is towers placed at the end points of the underground line.

Vandalism

Improved access to a previously remote area may result in increased levels of vandalism. Cultural resources that are visually obvious (e.g., rock art, standing buildings) or attractive to vandals (e.g., large prehistoric archaeological sites, 19th century trash dumps) are more sensitive than smaller, less visible resources.

Trenchless Methods and ROW Construction

The environmental impacts on cultural resources as a result of directional drilling are essentially the same as for trenching and ROW construction.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet, with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project.

Cultural Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on biological resources during construction of an underground transmission line.

1. Restrict all construction vehicle movement outside the ROW to pre-designated access, contractor-acquired access, or public roads.

2. In construction areas where recontouring is not required, leave the vegetation in place wherever possible and maintain the original contour to avoid excessive root damage and allow for resprouting. Limit disturbance to overland driving where feasible to minimize changes in the original contours.

3. Prior to construction, instruct all supervisory construction personnel on the protection of cultural resources. The construction contract can address:

    a. Federal, state and tribal laws regarding antiquities and fossils, including collection and removal

    b. The importance of cultural resources and the purpose and necessity of protecting them

    c. Methods for protecting sensitive cultural resources

4. In the event that potentially historic or cultural resources are discovered during construction, halt any potentially destructive work within 300 feet of the find. Immediately implement the following measures:

    a. Erect flagging to prohibit potentially destructive activities from occurring in a given area.

    b. Utilize an archeologist to make a preliminary assessment of the newly discovered resource.

    c. Notify the appropriate landowner, agencies, and State Historic Preservation Office (SHPO) if the archeologist determines that the discovery represents a potential new site or an undocumented feature of a documented site.

    d. Do not resume construction in the identified area until cleared by the archeologist (private land) and the agencies' authorized officer.

5. Pursuant to 43 CFR 10.4(g), the permit holder must notify the authorized officer by telephone (along with written confirmation) immediately upon the discovery of human remains, funerary items, or sacred objects of cultural patrimony. Further, pursuant to 43 CFR 10.4(c) and (d), activities must stop in the vicinity of the discovery and it must be protected for 30 days or until the authorized officer notifies with approval to proceed.

6. Identify and survey the specific areas of ground disturbance activities (e.g., access road construction, structure sites, staging areas, etc.) prior to construction.

7. Specific agencies may require a cultural resource monitor to be present during construction in areas the agency determines to be culturally sensitive.

8. The primary focus of paleontological mitigation efforts is on areas of greatest disturbance and areas likely to have significant fossils.

Visual Resources

Trenching and ROW Construction

Direct, long-term impacts are expected in areas where corridors cross areas of outstanding scenic quality or visual integrity; where corridors are in the vicinity of cities, towns, communities, and other population concentrations; and where corridors are near or cross sensitive recreation and transportation viewpoints. Visual effects associated with the construction of an underground project include potential impacts to:

- Views from residents and communities – rural residences and communities dispersed throughout the study area.
- Views from parks, recreation and preservation areas – potential views from existing and proposed facilities and other developed sites including national monuments, state parks, national natural landmarks, proposed wilderness areas, and other public and private recreation areas.
- Views from sensitive transportation corridors – backcountry byways, scenic byways, and other sensitive travel routes.
- Views from sensitive cultural sites – National Historic Landmarks and other National Register sites or districts. Refer to the Cultural Resources Technical Report for mapping of these sites and discussion of their visual sensitivity.
- Visual resource management – compatibility with BLM and USFS visual management designations.
- Scenic quality – impacts affecting the inherent aesthetic value of the landscape.

The visual impacts of underground lines are substantially less than overhead lines due to absence of above ground structures and substantially narrower ROW, but there are visual impacts from construction and maintenance activities.

Visual impacts resulting from construction of an underground transmission line can be both short and long term. Short-term visual impacts can result from views of construction activities including the presence and storage of materials, construction workers, equipment, and landform contrasts from grading and trench excavation. These short-term visual impacts include the ROW, access roads, and staging areas.

Long-term impacts result from permanent visual contrasts (changes in vegetation, landform, or structure) that are seen by sensitive viewers. For example, construction of the permanent ROW includes clearing of all trees and tall shrubs, if present, and this condition is maintained to allow access and maintenance of the line.

Impacts occur when a sensitive viewer notices the contrasts resulting from the project. Sensitive viewers can be highway drivers, recreation users, residents on private lands, etc. High impacts are expected where high sensitivity viewers have foreground views of the project with high contrasts.

Underground transmission lines placed in existing developed corridors (e.g., road, utility) are not likely to detract from the existing view area. For example, a ROW through a forest has noticeable differences in vegetation for the first few years. With each successive year, however, the contrast is weaker, and within a few years is not noticeable to the casual viewer. There can be impacts due to loss of roadside vegetation, potentially including notable old trees. Vegetation loss impacts are greatest along more rural or residential streets than roadways in commercial areas.

The most recurring benefit regarding underground transmission lines is the aesthetic appeal to a vista without the interruption of utility lines. One aspect of aesthetics that is often overlooked is the overall impact it has on the quality of life. It is often the quality of places where people seek to relax, recharge and revitalize their lives. The state of Hawaii recognizes this by requiring an evaluation on the proximity and visibility of above ground high-voltage transmission systems to high density population areas, conservation and other valuable natural resource areas, public recreation areas, areas of special importance to the tourist industry, and other industries particularly dependent on Hawaii's natural beauty (Martin, 1999).

Trenchless Methods and ROW Construction

The environmental impacts to visual resources as a result of directional drilling is essentially the same as for trenching except for the visual impact of digging the trench, stockpiling the soil, and backfilling the trench.

Trenchless methods other than directional drilling require the installation of an entry and exit pit approximately 20 feet by 40 feet, with a depth sufficient for the casing product. The number of pits required on a given project depends on the length of the project.

Visual Resources Mitigation Techniques

The following mitigation techniques can be used to minimize effects on visual resources from construction of an underground transmission line.

1. Restrict all construction vehicle movement outside the ROW to pre-designated access, contractor-acquired access, or public roads.

2. Reduce visual contrast of the landscape by aligning any new access roads or cross-country routes to follow the landform contours where practicable, providing that such alignment does not additionally impact resource values.

3. Reduce visual contrast in construction areas (e.g., marshaling yards, structure sites, spur roads from existing access roads) where ground disturbance is substantial, by re-contouring and restoring the site. Re-contour the land to the original as much as practicable. This method of restoration normally consists of loosening the soil surface, reseeding, installing cross drains for erosion control, placing water bars in the road, and filling ditches.

4. Do not apply paint or permanent discoloring agents to rocks or vegetation to indicate limits of survey or construction activity.

5. Align the ROW at residences, as practical, to reduce impact on the residences and inhabitants.

6. Deposit all waste products and food garbage from construction sites in covered waste receptacles, or remove daily. Haul garbage to a suitable disposal facility.

7. Reduce visual contrast in areas where overstory vegetation is removed for access or other construction activities by feathering the clearing edges to give a natural appearance.

Decommissioning of Underground Transmission Facilities

The details involved with the decommissioning or abandonment of an underground transmission line primarily depend on the permitting requirements enacted prior to construction. In the U. S., the total removal of an underground transmission line is rare. In the rare instance where complete removal of the underground transmission line is required, the environmental impacts are essentially the same as for construction of an open cut trench line, with the exception of thermal backfill installation.

When a trenchless underground transmission line is decommissioned or abandoned, the conduit is usually left in place in order to protect the resources or structures the trenchless method initially meant to protect. If the conduit must be removed, environmental impacts could result in temporary or permanent disturbance. Disturbance may occur from collapse of the conduit tunnel or unforeseen environmental events resulting in damage to wetlands, streams or rivers, vegetation, wildlife, cultural resources, or even visual character. While conduits from trenchless underground transmission lines are usually left in place, the cable is usually removed. There can be temporary disturbances at both ends of the bore site similar to trenchless construction techniques. There is an entry and exit pit of approximately 20 feet by 40 feet and to the depth of the casing product. One pit would be used to cut the cable and the other pit would be used to pull the cable out of the conduit.

Decommissioning or abandonment of extruded dielectric underground cables usually involves disconnecting the system by cutting the ends, sealing the system, and leaving the entire system in place. Manholes are typically removed and if the cable is of economic value, it may be removed as well. There can be a temporary disturbance from removal of the manholes and at the entry and exit pits, which are approximately 20 feet by 40 feet, and to the depth of the casing product. Use of these pits is required to cut and pull the cable out of the conduit.

Decommissioning of underground cable systems with oil or other fluids, including HPFF and SCFF usually involves removal of the fluid and cable while leaving the ducts in place. When the oil or fluid is drained and pumped out of the system there is the potential for a fluid spill. The spilled fluid can result in temporary or permanent environmental impacts to resources adjacent to the spill as well as to resources surrounding the site if the fluid were to get into the groundwater, surface water, or move through the soil. Removal of the cable can result in temporary disturbance at the entry and exit pit, in the same manner as with the decommissioning of extruded dielectric underground cable system.

4
ROUTINE MAINTENANCE OF TRANSMISSION LINES

This chapter identifies and describes the standard maintenance practices utilized for both overhead and underground electric transmission facilities.

Utilities are responsible for operating and maintaining their transmission line corridors and facilities in order to provide safe, reliable, and cost effective electric service. Extreme caution is used when working around energized lines. Work is performed per standard utility practices.

General maintenance activities can be classified into the following categories:

- Equipment and Lines
- Roads and Access
- Vegetation Management

Equipment and Line Maintenance

Overhead Transmission

In general, ongoing routine preventative maintenance inspections and work are performed regularly. Visual inspections of lines and equipment are usually performed from the ground or from a helicopter. An aerial patrol can swiftly identify more obvious maintenance and repair needs after which a ground crew can be dispatched to perform the actual maintenance activity. Some line maintenance activities are performed aerially by helicopter (e.g., insulator washing, marker ball placement, and danger tree identification). Aerial inspections are typically more cost effective; however, closer ground inspections can sometimes identify maintenance opportunities not easily identifiable from the air. Clear ROW access is critical to safely maintaining overhead transmission equipment.

Typical overhead equipment and line maintenance activities include, but are not limited to:

- Repairing wood and/or steel support structures
- Installing and/or repairing footings
- Repairing or replacing line conductors
- Installing line dampeners
- Replacing or repairing crossarms
- Replacing defective insulators or washing insulators

- Installing lightning arrestors and driving ground rods

Underground Transmission

Routine maintenance on underground cable systems is performed regularly to ensure the cables will operate with uninterrupted services. Inspections usually are conducted on a regular basis or are scheduled around an outage. The method of checking the condition and maintenance of the equipment involves various methods of inspection, primarily visual. Visual inspection is made for any sign of oil leaks, cracked lead wipes, damaged grounds, sagging support brackets, overheating of connections, and damaged standoff insulators. Some inspections are performed only during an outage. Clear ROW access is critical to safely maintaining underground transmission equipment.

Typical underground equipment and line maintenance activities include, but are not limited to:

- Terminators – Terminators are inspected to determine if the porcelain skirts are chipped, cracked, or contaminated. Terminators can be cleaned, repaired, or replaced.
- Manholes – Manholes are inspected to ensure cables are securely fastened to the brackets and clamps, ground connections are intact, and brackets are securely attached to the walls.
- Lightning Arrestors – Lightning arrestors are checked for signs of tracking, and for cracked or chipped skirts.
- Grounds – Grounds are checked to ensure all connections are tight, non-corroded, and show no signs of overheating.
- Cables and Pipes – Cables and pipes are checked for signs of mechanical damage, such as accidental dig in cable movement. Cable jackets or pipe coating are checked to ensure that none have cracked, or been scrapped or eroded due to movement.

Roads and Access Maintenance

Both overhead and underground transmission facilities are generally accessible via service roads and trails or from public roads and highways. Service roads and trails are intended to provide safe access for utility personnel to conduct maintenance activities on the transmission ROW and facilities. Access routes are typically closed to the general public; however adjacent property owners may utilize the service roads to access their property. Service roads may also provide access for existing non-developed land uses, including forestry and/or agricultural activities.

Service roads, including road structures and culverts, typically receive the minimum maintenance required to provide reasonable and safe access to the transmission ROW and abutting properties for the land uses served. Service roads should be sufficiently clear of vegetation so that work crews, machinery, and vehicles can travel safely and efficiently to perform emergency or routine maintenance activities on the electric facilities. Typical access road maintenance activities include grading, spot graveling, spot grading, drainage improvements, and fence construction or repair.

Vegetation Management

Vegetation frequently interferes with transmission lines and facilities posing threats to both public safety and system reliability. Managing vegetation on electric utility ROW is essential to ensure safe and reliable transmission of power. In an effort to manage vegetation, utilities strive to minimize environmental impacts, work cost effectively, and comply with all applicable laws and regulations.

Integrated Vegetation Management (IVM) is a strategy designed to minimize tall-growing vegetation by establishing stable, low-growing plant communities on overhead transmission ROW through utilization of complementary control methods that maximize public health and safety, cost effectiveness, and protection of the environment (EPRI, 2002, 2004). A relatively stable, low-growing plant community on the utility ROW is the desired goal. Such a community can be attractive and useful for humans, provide a diverse array of habitat for wildlife, and be relatively inexpensive to maintain using vegetation management methods that have relatively minor environmental impacts. IVM is also an applicable management strategy for maintenance of vegetation above underground utilities (Integrated…GRI, 2002).

A variety of manual, mechanical, biological, and chemical methods are used alone or in combination for this purpose. Each of these methods has its own unique characteristics in terms of benefit, cost effectiveness, and environmental impact. Equally important, the method used at one point in time establishes the future trajectory of the development of vegetation on the site, influencing the frequency, extent, and type of future treatment needs. Effectiveness is a dominant factor in selecting vegetation control methods, but choice of method is equally influenced by site characteristics, applicable regulations, environmental effects, cost, and, to varying degrees, public sentiment.

Many transmission ROW are managed using the Wire Zone – Border Zone method (See Figure 4-1). This approach typically involves a combination of vegetation control methods (e.g., manual, mechanical, biological, and/or chemical). Low-growing vegetation is encouraged in the Wire Zone (i.e., under the overhead wires or above the underground cables, and in the immediate adjacent area). The Border Zone is a transition zone extending toward the edge of the ROW and is managed for taller vegetation.

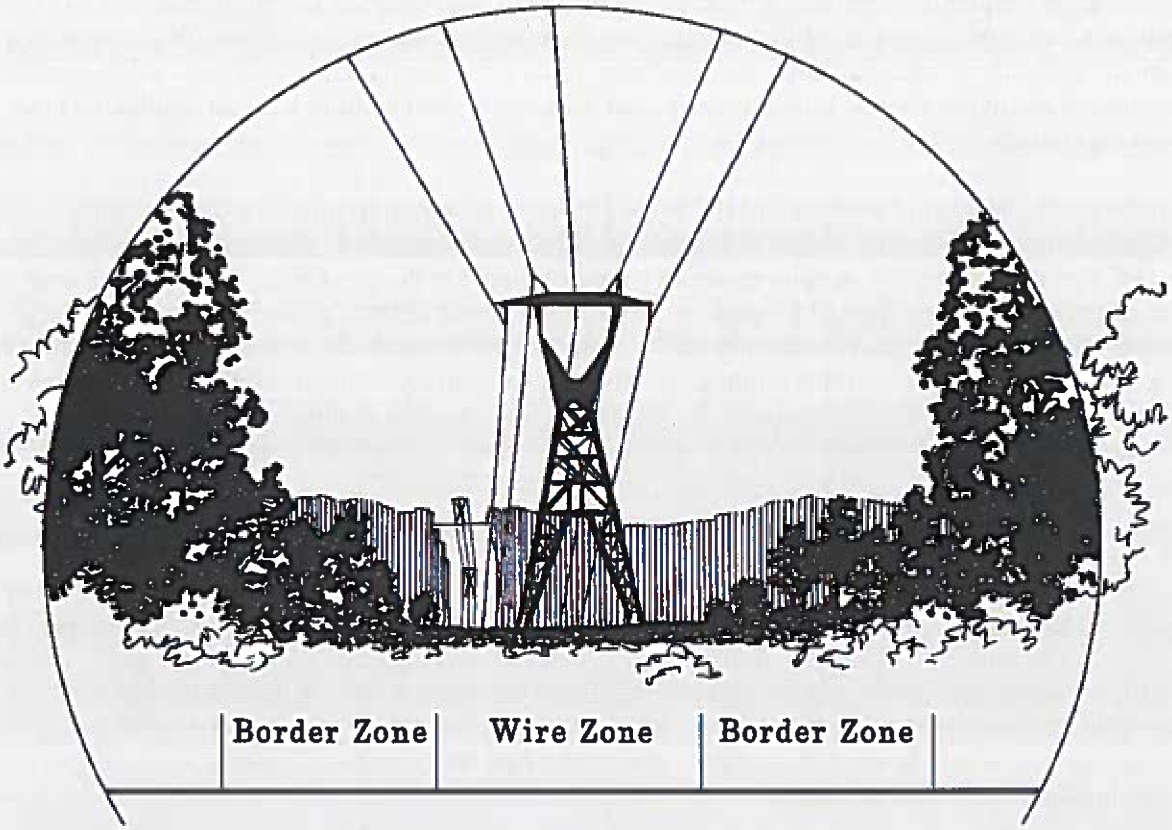

Figure 4-1
Vegetation Management Wire Zone – Border Zone Method

Vegetation control activities are performed on underground transmission ROW, above trenches or tunnels, around the vault manholes, and on access roads. Vegetation is controlled on regular cycles in order to maintain clear access to underground facilities for emergency or routine maintenance needs. A properly maintained underground ROW is typically kept clear of trees and large shrubs that can interfere with underground lines via plant root systems. Depending on the site, a similar frequency and intensity of vegetation maintenance activity as compared to overhead transmission lines may be required.

The following control methods are used on both overhead and underground transmission corridors to manage vegetation.

Manual Control Methods

Manual techniques for vegetation management such as pulling, cutting, and otherwise damaging plants could be used to control vegetation particularly if the population is relatively small. These techniques can be extremely specific, minimizing damage to desirable plants and animals, but they are generally labor and time intensive.

Pulling or Uprooting Plants

This technique can be effective against some shrubs, tree saplings, herbaceous plants, and weeds. Annuals and tap-rooted plants are particularly susceptible to control by hand pulling. Weed wrenches and other tools are surprisingly powerful and can enable the control of large saplings and shrubs that are too big to be pulled by hand. It is not as effective against vegetation with deep underground stems and roots that are often left behind to re-sprout.

Cutting

One of the most commonly used methods of controlling vegetation in the ROW is cutting with chainsaws or other handheld power tools to sever above-ground vegetation. Shears, clippers, brush saws, axes, and machetes can also be used to cut vegetation.

Girdling

This technique is often used to control trees or shrubs that have a single trunk. It involves cutting away a strip of bark several centimeters wide all the way around the trunk. The removed strip is cut deep enough into the trunk to remove the vascular cambium (inner bark), the thin layer of living tissue that moves sugars and other carbohydrates between areas of production (leaves), storage (roots), and growing points. This inner cambium layer also produces all new wood and bark.

Mechanical Control Methods

Mechanical techniques for vegetation management such as mowing, cutting, and otherwise damaging plants can be used to control vegetation particularly if the vegetation is dense and relatively large. Mechanical methods are very effective for removing dense vegetation. Some mechanical equipment can cut and dispose of vegetation in one step as it moves through the area cutting, mulching, or lopping and scattering. Mechanical methods are non-selective for the most part and tend to clear or cut all vegetation within the path, thereby damaging undesirable plants and animals.

Mowing or Brush-Cutting

Mowing or brush cutting can be used to manage the height of native vegetation as well as for the control of invasive species. Mowing or cutting of invasive species is often used as a primary treatment to remove aboveground biomass in combination with herbicide treatments. Mowing equipment typically used on transmission ROW includes:

- Mowers with a rotary-cutting head mounted on an articulated arm driven by a heavy equipment vehicle base (e.g., track or rubber-tired tractor).
- Blading equipment attached to a heavy equipment vehicle base that uses a blade to remove vegetation by a combination of pushing and uplifting motions.

- Roller-choppers with blades or chains attached to rotating drums that roll, chop, and destroy vegetation.
- Feller-bunchers that hold trees, cut the trunk at the base, pick them up, and place the trees in a pile or move them to the back of a truck.

Tilling

This technique means the turning-over of soil and is often used for weed control in agricultural crops. Its use in wildland management is largely limited to restoration sites where soils are already badly disturbed. Tilling is effective against annuals and shallow-rooted perennials, but small fragments of some species, particularly those perennials with rhizomes, can often re-sprout following tillage. Tilling can be completed before seeds develop and are shed onto the soil. The best control is achieved when the soil is dry, so that remaining plant fragments dry out. Moist soils help the fragments survive and re-grow.

Biological Control Method

Biological control is the use of animals (e.g., goats or cattle), plants, insects, fungi, or other microbes to feed upon, parasitize, suppress, or otherwise interfere with a targeted plant or pest species. It is hypothesized that some non-native plants become invasive, superabundant, and damaging, at least in part because they have escaped the control of their "natural enemies," the herbivores and pathogens that checked the abundance in their native ranges. Biological control methods address this by locating one or more herbivore and/or pathogen species from the weed's native range and introducing them to control the pests in their new range. These biological control agents are carefully selected and screened to determine if they will attack crops or other non-target plant species. For example, some plants species can suppress other plant species growing around them by releasing certain chemicals. This characteristic, known as allelopathy, can serve as a type of biological control against undesirable plant species (Miller, 2007).

Successful biological control programs result in permanent establishment of the control agent(s) and consequent permanent reduction in the abundance or at least the damaging impacts of the weed overall, or in part of its introduced range. Biological control is not expected to eliminate the plant or pest species completely and it often takes years or even decades after the initial release of control agents before effects are obvious. Biological control programs may fail for a variety of reasons. Some biological control agents never establish, or it may take repeated releases to establish viable populations. Some biological control agents may become established, then have little or no detectable impact on the targeted pest (Greathead, 1995).

Chemical Control Methods

Herbicides belong to a group of chemicals known as pesticides, which prevent, destroy, repel, or mitigate any pest. Herbicides are any chemical substance used specifically to kill plants. An herbicide's mode of action is the biochemical or physical mechanism by which it kills plants. Most herbicides kill plants by disrupting or altering one or more of their metabolic processes.

Some disrupt the cellular membranes of plants, allowing cellular contents to leak out, but do not directly disrupt other metabolic processes.

Pre-emergent herbicides are those applied to the soil before the target plant germinates, and either disrupt germination or kill the germinating seedling. Post-emergent herbicides are those that are applied directly to already established plants and/or soil. Some herbicides are effective both before (pre-emergent) and after (post-emergent) germination.

An herbicide formulation is the total marketed product, and is typically available in forms that can be sprayed on as liquids or applied as dry solids. It includes the active ingredient(s); any additives that enhance herbicide effectiveness, stability, or ease of application such as surfactants and other adjuvants; and any other ingredients including solvents, carriers, or dyes. Herbicides may be selective or non-selective in terms of their effect on different groups of plants or plant species. The application method and species to be treated will determine which formulation is best to use. In most cases, manufacturers produce formulations that make applications and handling simpler and safer. Some herbicides are available in forms that can reduce risk of exposure during mixing, such as pre-measured packets that dissolve in water, or as liquid form already mixed with surfactant and dye.

Application Methods

Herbicides can be applied in a variety of ways. The most appropriate application method is determined by the plant being treated, the herbicide being applied, the skills of the applicator, and the application site. Standard application techniques can sometimes be modified to better suit the needs of the land management.

Foliar application

This method applies herbicide directly to the leaves and stems of a plant. An adjuvant or surfactant is often needed to enable the herbicide to penetrate the plant cuticle, a thick, waxy layer present on leaves and stems of most plants. There are several types of foliar application tools available.

<u>Spot applicators</u>: Spray herbicide directly onto target plants only, and avoid spraying other desirable plants. These applicators range from motorized rigs with spray hoses to backpack sprayers, to hand-pumped spray or squirt bottles, which can target very small plants or parts of plants.

<u>Wick (wipe-on) applicators</u>: Use a sponge or wick on a long handle to wipe herbicide onto foliage and stems.

"Paint sticks" and "stain sticks" sold at local hardware stores have been used successfully for wick application. These sticks have a reservoir in the handle that can hold herbicide, which soaks a roller brush at the end of the handle. The brush is wiped or rolled across leaves and stems.

The "glove of death" is a technique developed by some innovative land managers for applying herbicide in an otherwise high-quality site. Herbicide is sprayed directly onto a heavy cotton glove worn over a thick rubber/latex (or nitrile) glove. The wearer of the glove can then apply the herbicide with total precision and little or no runoff.

Boom applicator: A boom, a long horizontal tube with multiple spray heads, is mounted or attached to a tractor, ATV (or other four-wheel drive vehicle), helicopter, or small plane. The boom is then carried above the target plants while spraying herbicide, allowing large areas to be treated rapidly with each sweep of the boom.

Basal Bark

This method applies a six to twelve inch band of herbicide around the circumference of the trunk of the target plant, approximately one foot above ground. The width of the sprayed band depends on the size of the plant and the species' susceptibility to the herbicide. The herbicide can be applied with a backpack sprayer, handheld bottle, or a wick. Ester formulations are usually best for basal bark treatments, as esters can pass most readily through the bark (as compared to salts). Esters can be highly volatile, however, so basal bark treatments are performed only on calm, cool days. During summer, treatment is best carried out in the mornings, which tend to be cooler. The basal bark treatment works best on young trees with smooth bark. It is usually not effective against older plants with thick corky bark.

Frill or Hack & Squirt

The frill method, also called the "hack & squirt" treatment, is often used to treat woody species with large, thick trunks. The tree is cut using a sharp knife, saw, or ax, or drilled with a power drill or other device. Herbicide is then immediately applied to the cut with a backpack sprayer, squirt bottle, syringe, or similar equipment. Because the herbicide is placed directly onto the thin layer of growing tissue in the trunk (the cambium), an ester formulation is not required.

Injection

Herbicide pellets can be injected into the trunk of a tree using a specialized tool such as the EZ-Ject Lance. The EZ-Ject Lance's five-foot long, metal tube has "teeth" on one end that grip the trunk of the tree. A sharp push on the other end of the tube sends a brass capsule of herbicide into the tree trunk. It is a convenient way to apply herbicide and requires minimal preparation or clean up. In addition, it is an easy and safe way to apply herbicides with minimal exposure.

There are, however, some serious drawbacks to this method. The lance and capsules are expensive and full-sized lances can be unwieldy, particularly in thickets. Furthermore, the lance is difficult to thrust with enough power to drive the capsules far enough into thick barked trees to be effective. A large number of capsules placed close together are often necessary to kill large trees.

Herbicides can also be injected into herbaceous stems by using a needle and syringe.

Cut-Stump Treatment

This method is often used on woody species that normally re-sprout after being cut. Cut down the tree or shrub, and immediately spray or squirt herbicide on the exposed cambium (living inner bark) of the stump. The herbicide must be applied to the entire inner bark within minutes after the trunk is cut. The outer bark and heartwood do not need to be treated since these tissues are not alive, although they support and protect the tree's living tissues.

Herbicides can be applied to cut stumps in many ways, including spray and squirt bottles, or even paint brushes. Care is taken to avoid applying too much herbicide, and allowing it to run off the stump and onto the ground.

Sometimes even treated stumps can re-sprout, so it is important to check them at regular intervals (two to six months) for at least a year. Depending on the vigor of the re-sprouts, these can be treated by cutting, basal bark applications, or foliar applications. Even when foliar applications are called for, treating re-sprouts is usually far easier, and requires much less herbicide, than treating the tree (before it was cut down) with a foliar application.

5
ENVIRONMENTAL EFFECTS ASSOCIATED WITH ROUTINE MAINTENANCE OF TRANSMISSION LINES

This chapter provides an assessment of potential environmental impacts associated with overhead and underground transmission line operations and maintenance activities and materials on land use, soil, water, biological, cultural and visual resources.

Equipment and Line Maintenance

Overhead and underground transmission line ROW require regular inspections and maintenance to identify problems caused by weather, vandalism, and vegetation. Inspection and maintenance activities can potentially interfere with regular land use activities. Impacts on land use, soils, water, vegetation, wildlife, and cultural resources associated with both overhead and underground transmission line maintenance activities are described below.

Land Use

Lands surrounding the transmission line ROW can be temporarily disrupted by noise, dust, and traffic resulting from routine or emergency maintenance activities. Heavy maintenance equipment on the ROW and access roads can cause a temporary disturbance to adjacent land uses and property owners. Land users may temporarily lose access and usage due to significant maintenance and repair activities.

Soil and Water Resources

Maintenance trucks and vehicles can disturb soil and water resources, including streams, rivers, lakes, and wetlands, resulting in compaction and/or erosion impacts that can directly or indirectly affect water quality. Associated water quality impacts include increased surface water run-off, turbidity, and sedimentation. Fish and other aquatic species are affected when waterways are affected by local increases in surface water run off, turbidity, and sedimentation.

Vegetation Resources

Vegetation resources are affected when heavy-duty maintenance vehicles and equipment leave established access roads crushing plants. Vegetation is also affected when accidental oil or fuel spills occur.

Wildlife Resources

Operation and maintenance of transmission lines can temporarily disturb wildlife. Disruption results from noise produced by routine operation and maintenance activities, vehicle traffic on access roads and ROW, helicopter patrols, and facility presence (e.g., tower structures, manholes, pad-mounted equipment, and access roads). Helicopter patrols can adversely affect wildlife, particularly big game species during parturition periods (Bridges et al., 1997).

Cultural Resources

Equipment and line maintenance activities can damage or expose cultural or historical sites, harm plants with traditional cultural value, and cause visible or audible impacts on sites of traditional cultural value. Heavy equipment or vehicles utilized for maintenance activities can also disturb surface or subsurface artifacts as a result of soil and erosion impacts.

Roads and Access Maintenance

Road maintenance is necessary to maintain access to transmission facilities; prevent damage to the road; maintain safety by reducing dust, washboards, and graveling; and preclude adverse impacts to resources resulting from lack of road maintenance. The potential adverse effects of road maintenance are considered in the context of performing maintenance versus possible consequences of not maintaining roads.

Impacts on land use, soils, water, vegetation, wildlife, and cultural resources associated with road maintenance activities are described below.

Land Use

Lands surrounding the transmission line ROW can be temporarily disrupted by noise, dust, and traffic resulting from routine or emergency roads and access maintenance activities. Heavy maintenance equipment on the ROW and access roads can cause a temporary disturbance to adjacent land uses and property owners. Land users may temporarily lose access and usage due to significant road maintenance and repair activities.

Soil and Water Resources

Proper and timely road maintenance can minimize sediment delivery to streams from open roads; however, road maintenance activities can also result in direct sediment delivery to streams. Performing road maintenance can result in severe rutting and gullying during wet periods, resulting in large amounts of sediment into the watershed. Ground disturbance from road blading, particularly where the road is immediately adjacent to streams, constitutes the greatest risk from increased sediment production. Other activities such as culvert and ditch maintenance can also increase sediment delivery to streams.

However, a lack of road maintenance can result in serious impacts to streams as well. This includes washouts, as well as increased risk of vehicle accidents, which may introduce potential toxic fuels to streams. This is especially critical when roads are adjacent to streams with sensitive species.

Vegetation Resources

Road maintenance activities can result in reduction or removal of streamside vegetation through brushing activities, possibly resulting in water temperature increases. The risk of temperature increases is highest in very small streams. Road maintenance involving brush removal can reduce stabilizing vegetation on both cut and fill slopes contributing to erosion impacts.

Wildlife Resources

Maintenance vehicles and equipment can disturb soils and ground-dwelling species such as snakes, salamanders, squirrels, gophers, moles, and ground-nesting birds. Loud noise associated with road maintenance activities and equipment can also temporarily disrupt wildlife.

Cultural Resources

Road maintenance equipment and activities can impact cultural or historical sites, harm plants having traditional cultural value, or disturb surface or sub-surface artifacts as a result of erosion and soil impacts.

Equipment, Line, and Road Maintenance Mitigation Techniques

The following mitigation techniques can be used to minimize environmental effects associated with both overhead and underground transmission line and ROW access road maintenance activities:

1. Limit maintenance area accessibility of off-highway and other motorized vehicles by coordinating with the appropriate agencies or landowners.

2. Time operation and maintenance activities, whenever practical, to minimize disruption of normal seasonal activities for cropland (planting and harvesting) and non-irrigated rangeland. Avoid peak-use periods (e.g., weekends and holidays) at parks, recreation, and preservation areas. Coordinate operation and maintenance activities with relevant agencies and landowners as needed.

3. Provide advance notice of major operation or maintenance activities to landowners and residents potentially affected by the activities. Avoid nighttime maintenance near noise-sensitive land uses (e.g., residences and campers at recreation sites).

4. Restrict all operation and maintenance vehicle movement outside the ROW to pre-designated access or public roads.

5. Do not permit wildlife harassment at any time during project operation and maintenance activities.

6. Modify or curtail operation and maintenance activities during sensitive periods (e.g., nesting and breeding periods) for proposed threatened and endangered, or other sensitive wildlife species.

7. Time operation and maintenance activities, where feasible, in areas known to be sensitive to wildlife species.

8. Use existing public roads to the extent possible when performing operation and maintenance activities. Use dust-control measures in sensitive areas, as needed, when performing access road maintenance.

9. Use rubber-tired work vehicles instead of tracked vehicles to reduce environmental impacts on soil, vegetation, and water resources.

10. Use culverts that are properly sized, designed, and reinforced at intermittent stream crossings to minimize impacts affecting stream flow, stream gradient, and long-term sediment delivery.

11. Monitor operation and maintenance vehicles and equipment for leaks, and conduct regular preventative maintenance to reduce the chance of petroleum leaks.

12. Avoid vehicle traffic on the ROW except as needed to maintain the ROW and for transmission line maintenance and repair.

13. Develop and follow an appropriate maintenance program for transmission line systems and ROW.

14. Develop a spill-control plan for all appropriate fluids, such as lubricating oil, coolant, and high-pressure fluid filled and self-contained fluid filled underground cable systems.

Vegetation Management

Vegetation management typically is a major maintenance activity on overhead and underground transmission line corridors. Vegetation on ROW and access roads is controlled and managed by a variety of methods, including trimming, mowing, and use of herbicides. In general, utilities strive to remove intrusive vegetation or direct tall-growing vegetation away from transmission facilities and the ROW.

Numerous studies conclude that the use of stable, low-growing, less intrusive plant communities can be one of the most effective vegetation management tools on overhead transmission ROW (Bramble and Byrnes, 1983; Nesmith et al., 2008). Documented benefits of this vegetation management approach include improved cost effectiveness, service reliability, safety, aesthetic appeal, as well as decreased fire risk, and wildlife habitat enhancement. However, there can also be detrimental environmental impacts associated with vegetation management activities.

This section describes general vegetation management-related environmental impacts on land use, biological resources, geological resources and soils, water resources, cultural resources, and visual resources.

Land Use

Manual vegetation control techniques have relatively little environmental impact. As such, these techniques are often preferred when agriculture, recreation, developed (residential, commercial, and industrial), and sensitive land use areas are near the ROW. The use of chainsaws or other handheld power tools can create short-term noise impacts affecting recreationists or persons residing in homes, businesses, or schools.

Heavy equipment utilized for mechanical methods of vegetation control (mowing, etc.) can also disturb residents and/or recreationists. Lands surrounding the transmission line ROW can be temporarily disrupted by noise, dust, and traffic, resulting from routine or emergency vegetation management activities. Heavy maintenance equipment on the ROW and access roads can cause a temporary disturbance to adjacent land uses and property owners. Mechanical methods can sometimes leave piles of vegetation debris on or nearby the ROW. The remaining debris can create obstacles or hazards for pedestrians, bicyclists, motorcyclists, or ATV riders.

Agricultural land, when located on or near a transmission ROW, can be significantly affected if adequate care is not taken when managing vegetation. Agriculturally significant plants or crops should not be harmed when controlling undesirable vegetation on the ROW.

If appropriately utilized, biological and herbicide control methods can have little to no impact on land use resources. It is recommended that herbicide application techniques be appropriate for the land use classification. For example, aerial or broadcast foliar application of herbicides is avoided in residential, commercial, and agriculture land use areas. In areas where people are concentrated, it is recommended that more selective herbicide application techniques be utilized.

Biological Resources

Vegetation Resources

Vegetation resource impacts from ROW vegetation management can result in the following:

- Disruption of existing vegetation
- Change in habitat type or vegetation composition
- Habitat fragmentation
- Disruption of rare, threatened, and endangered plant species and habitat

Disruption of Existing Vegetation

The purpose of vegetation management activities associated with transmission line ROW is to remove or cut intrusive vegetation (target vegetation) growing on or near the ROW. Target vegetation includes trees and shrubs growing in the ROW or off the ROW that can grow into, fall into, or otherwise interfere with transmission lines. The same is true for underground transmission ROW. A properly maintained underground ROW typically is kept clear of trees and large shrubs that can interfere with underground lines via plant root systems (Wisconsin Public Service Commission, 2004). Non-target vegetation can also be affected by general vegetation management activities including accidental trampling or killing of plant species, increased exposure to sunlight and weather, increased noxious weed growth, and/or changes in soil nutrient levels and soil moisture.

Changes in Habitat Type or Vegetation Composition

Vegetation management activities can affect habitat type, plant community composition, and diversity on the ROW. Changes associated with habitat, composition, and diversity can vary depending on the type of habitat being affected. For example, existing low-growing vegetation communities (grasslands or shrublands) typically require very little vegetation control on overhead transmission ROW, thus the vegetation control activities have little potential impact on vegetation composition or habitat type. Conversely, vegetation management activities on forested areas have a much greater propensity for impacts associated with plant habitat, composition, and diversity.

Vegetation composition within the overhead and underground ROW is kept clear of tall-growing trees and shrubs. When large trees are removed, plant communities living below are exposed to sunlight and weather. Exposure can kill some plant species while other species might flourish. Regardless, a permanent early successional habitat is created. The creation of these open and early successional habitats in a ROW is beneficial to some species and detrimental to others.

A negative effect of fostering early successional habitat in the ROW is the propensity for noxious weeds to colonize and become the predominant ground cover. Noxious weeds are non-native plants that can dominate and out-compete desirable native plants, greatly reducing plant diversity. It is important to use proper vegetation control methods to avoid this potential negative impact.

A positive effect of an early successional habitat in the ROW is the potential for an overall increase in plant species diversity. The ROW creates an open space that when surrounded by trees, provides a habitat for meadow-type plants to thrive (Bramble and Byrnes, 1983).

Habitat Fragmentation

Habitat fragmentation can be perpetuated as a result of ongoing vegetation management activities, but results vary depending on the plant species composition both on the ROW and adjacent to it. Habitat fragmentation effects can be positive or negative. The predominant effects of fragmentation relevant to transmission ROW through forested areas include increased forest-edge habitat, early-successional habitat, and risk of noxious weeds or other invasive plant species. However, research suggests that transmission line ROW do not have widespread ecological impacts on plant communities (Willyard and Tikalsky, 2008). Plants that are area, isolation, or edge sensitive can be negatively affected by fragmentation; however, some plants are not sensitive to fragmentation, and may be positively affected by the separation if it results in an increase in habitat or favorable conditions for these species.

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to rare, threatened, and endangered species populations are a key concern because of the tendency for these species to be less stable than other wildlife species. Even temporary disturbances can have adverse impacts. Vegetation management activities can have positive and negative effects on rare, threatened, and endangered plant species. For example, rare, threatened, or endangered plants that are shade tolerant can be adversely affected when trees providing shade are removed or cut back. However, some rare, threatened, and endangered plant species can thrive when vegetation control efforts remove plant species that normally compete with these plants.

Wildlife Resources

Impacts to wildlife resources from vegetation management activities can result in the following:

- Wildlife displacement and disturbance
- Habitat and population impacts
- Disruption of rare, threatened, and endangered species
- Herbicide impacts

Wildlife Displacement and Disturbance

Vegetation management activities on overhead and underground transmission corridors can temporarily or permanently disrupt wildlife by displacing animals from their habitat. Trees are utilized for nesting, perching, hunting, shelter, and food, providing habitat for birds, mammals, and insects. Tree-dwelling wildlife can be disturbed and/or displaced when trees are removed or pruned. Increased noise levels and vehicle traffic from vegetation control equipment and vehicles can temporarily disturb animals causing them to flee the area. Ground-nesting birds, amphibians, and reptiles are vulnerable to mortality from the physical disruption of soils and vegetation caused by vegetation control equipment.

Habitat and Population Impacts

In a forested area, maintaining stable low-growing plant communities on the ROW creates an edge effect where two habitats meet or transition between each other. This edge effect can be beneficial for wildlife species that live or nest in the forest area, but prefer to use the open ROW for foraging or hunting.

However, some wildlife species are negatively affected by habitat fragmentation caused by the transmission ROW. For example, a relatively open ROW through the middle of a forest area divides or fragments wildlife habitat. A forest inhabiting species may not cross through the ROW to get to the other side, especially in areas where snowfall is prevalent during winter. Without tree cover, wind exposure increases, fewer shelter areas exist, and snow depth is increased, resulting in an inhospitable environment for some wildlife species.

Vegetation control activities also have a potential impact on aquatic life in areas where the ROW crosses over or is adjacent to riparian zones. Riparian plants and trees provide food for fishes and other animals, and habitats for insects that supplement fish diets. Riparian vegetation also provides shade to maintain cool stream temperatures and insulate the stream from heat loss in winter.

The loss of riparian vegetation is a long-term, direct impact of ROW vegetation management activities. When riparian vegetation is removed or pruned, stream shading is immediately reduced, resulting in stream temperature increases. Erosion impacts occur when soil-stabilizing riparian vegetation is removed. Erosion increases turbidity and sedimentation, potentially impacting fish feeding success. In some cases, increased sedimentation can keep fry from emerging or it can fill in deeper pools preferred by some fish species.

However, one study conducted on a forested transmission ROW in New York found a greater abundance of fish associated with ROW streams than in nearby forested streams (Peterson, 1993). The study suggests that tree canopy removal in the ROW increased sunlight in the riparian zone. This facilitated dense low-growing vegetation to grow on stream banks, which stabilized stream bank soils, minimizing erosion. In contrast, the forested stream banks were largely vegetation free, which contributed to erosion related impacts.

Insects used for biological control of undesirable vegetation may act as a food source, enhancing habit for birds and other wildlife.

Disruption of Rare, Threatened, and Endangered Plant Species and Habitat

Direct and indirect impacts to rare, threatened, and endangered species populations are a key concern because of the tendency for these species to be less stable than other wildlife species. Even temporary disturbances can have adverse impacts. Breeding habitat is especially important because disruption during breeding season can reduce productivity for the entire year. Impacts are dependent on species and ROW location. Vegetation management changes to the ROW can potentially have significant impacts on wildlife species with home ranges that are limited to the ROW. Wildlife species with broader home ranges can either be temporarily displaced or experience minor impacts from the ROW vegetation management activities.

Herbicide Impacts

Modern herbicides used for ROW vegetation management have been studied in considerable detail, enabling researchers to assess the effects of herbicides, including the results of interactions of chemical with biological systems. The key to safe and effective use of herbicides is the principle of dose response. As dose increases, so also does the effect. For every compound there is a dose below which no effect can be detected. Risk analysis allows different products to be compared to determine if expected exposure will result in toxic effects (EPRI, 2003, 2004 and Norris et al., 1997).

Common herbicides examined in detail as part of the Environmental Impact Statement for Vegetation Management on Electric Utility ROW on the Allegheny National Forest (and used commonly throughout the U.S.) were found to have very low toxicity "with virtually no potential for reproductive or genetic effects" and were not found to cause cancer. This EIS pointed out that "every chemical, whatever its source, can cause toxic effects at some dose; not truly non-toxic chemical exists". Safe use of these products is based on knowing the pattern of toxicity for each herbicide as well as the doses at which toxicity occurs and the doses below which no effect takes place. While use of registered herbicides according to label requirements does not pose detrimental environmental consequences, misuse of these products may result in significant harm. Methodologies have been developed to monitor the off-target application of herbicides that could pose avoidable risks to water resources (Norris et al., 1997).

The most dramatic effects of herbicides on non-target plants and animals often result from the habitat alterations they cause by killing the targeted plants. For example, loss of invasive riparian plants can cause changes in water temperature and clarity that can potentially impact the entire aquatic community, and the physical structure of the system through bank erosion. Removing a shrubby understory can make a habitat unsuitable for certain bird species and expose small mammals to predation.

Geological Resources and Soils

Impacts on geological and soil resources from vegetation management activities can result in the following:

- Soil erosion and/or compaction
- Disruption of soil profile

Soil Erosion and/or Compaction

All soils crossed by underground or overhead transmission lines can be affected by vegetation removal or disturbance, displacement, compaction, and erosion. Soil erosion impacts are dependent upon slope, land use, soil characteristics, weather events, and vegetation cover or a lack thereof. Vegetation creates a canopy covering the soil, and root systems bind soils reducing runoff and erosion. Erosion rates can increase significantly when vegetation is removed.

Vegetation control equipment and vehicles can increase soil compaction. Moderate or severe soil compaction affects soil productivity potential. The extent of compaction depends on soil moisture content and the physical characteristics of a particular soil type. Compaction tends to be less severe when soils are dry and more severe when soils are moist to wet.

Disruption of Soil Profile

Vegetation management activities can affect soils and geological resources by altering soil nutrient levels. Impacts to soil resources can occur from inversion of the soil profile, loss of structure, and alteration of soil chemistry. For example, removing brush cover can, over time, reduce the amount of carbon in the soil, especially if revegetation does not occur. Removing nitrogen-fixing plants can also reduce soil nitrogen levels and impact plant productivity. Removing vegetation can also create erosion impacts. Erosion allows increased water to leach soluble nutrients and transport organic matter and nutrients offsite, thereby reducing soil productivity potential.

Accidental liquid spills (e.g., herbicides, oil, and hydraulic fluids) can cause soil contamination. The potential impacts on soil contamination can be localized and limited in their extent and magnitude, if appropriate best management practices and other mitigation measures are implemented in a timely fashion.

An herbicide's persistence in soils is often described by its half-life (also known as the DT50). The half-life is the time it takes for half of the herbicide applied to the soil to dissipate. The half-life gives only a rough estimate of the persistence of an herbicide, since the half-life of a particular herbicide can vary significantly depending on soil characteristics, weather (especially temperature and soil moisture), and the vegetation at the site. Dissipation rates often change with time (Parker and Doxtader, 1983). For example, McCall et al. (1981) found that the rate of dissipation increased until approximately 20% of the applied herbicide remained, and then declined. Nonetheless, half-life values do provide a means of comparing the relative persistence of herbicides.

The distribution of an herbicide in the soil is determined primarily by the amount, type, and surface area of clays and organic matter in the soil, the amount and quality of soil moisture, and soil temperature and soil pH (Helling et al., 1971). Most natural soils have pH values between five and eight. Rainfall and the amount of leaching that has occurred strongly influence these values. In wet areas and/or coarse soils, cations (positively charged ions) can be leached out, leaving the soil acidic. In arid and semi-arid regions, soils retain cations and are more alkaline. Acidic soils can also be found in wetlands where organic acids lower the soil's pH.

Water Resources

Vegetation management can affect surface water (ponds, lakes, wetlands, streams, and rivers) and groundwater (wells and aquifers) resources when vegetation is cut or removed. Vegetation control activities can impact water resources by increasing surface runoff, causing erosion, facilitating sedimentation, reducing shading, increasing water temperatures, and inhibiting nutrients from entering the water by limiting plant debris buildup.

Using herbicides for vegetation control that are not labeled for aquatic use can also potentially affect water resources. Water resources can be contaminated by overspray, or when herbicides drift, volatilize, leach through soils to groundwater, or are carried in surface or subsurface runoff (EPRI, 1999). Amounts of leaching and runoff are largely dependent on total rainfall the first few days after an application. Total losses to runoff generally do not exceed five to ten percent of the total applied, even following heavy rains (Taylor and Glotfelty, 1988). High soil adsorption capacity, low rates of application, and low rainfall reduce total runoff and contamination of local waterways (Bovey et al., 1978).

Cultural Resources

Vegetation management activities can damage or expose cultural or historical sites, harm plants with traditional cultural value, or cause temporary visible or audible impacts on sites of cultural value. Removing vegetation or utilizing heavy equipment or vehicles for vegetation control activities can disturb surface or sub-surface artifacts as a result of soil and erosion impacts.

Visual Resources

Vegetation management activities can change the visual quality of the landscape and local view area on transmission ROW. The following factors influence the impact of vegetation control activities on visual resources:

- Land use (agriculture, forest, rural, urban, transportation)
- Landscape setting and color (desert, mountainous, wetland, grassland, forest)
- Season
- Vegetation cover

Removing tall-growing vegetation can create a sudden, but temporary impact on local visual resources. Long-term visual effects can result when the removed vegetation acts as a screen for unsightly views. For example, removing a row of trees along the ROW may reveal an open-pit mine and tailings pond otherwise hidden when recreationists use the area.

Herbicide treatment can temporarily affect visual quality by turning the treated vegetation brown. The brown vegetation can be left standing, making the effect more noticeable, but the effect usually lasts less than one year. Mechanical or manual cutting can create brown, dead vegetation as well, but it is typically not left standing after treatment and may be less visible.

Method–Specific Environmental Impacts

As previously described, there are four general vegetation management methods used to control vegetation on overhead and underground transmission ROW. When considered as part of a system of managing plant communities, these methods become part of IVM practices where choice of control methods is based on environmental impact and anticipated effectiveness, along with site characteristics, security, economics, current land use and other factors (Miller, 2007).

- Manual
- Mechanical
- Biological

- Chemical

Environmental impacts associated with each of the above vegetation management methods are described below.

Manual Methods

The advantages of manual vegetation management techniques include the relatively small environmental impact, through control of the targeted species only, and minimal damage to neighboring non-target plants. Manual vegetation control methods are very selective and generally only impact vegetation that is targeted for pruning or removal. Surrounding non-target vegetation can be trampled or damaged by workers or debris. Manual methods, however, can be ineffective for controlling vegetation long term because these methods can encourage regrowth of multiple-stemmed sprouts for certain plant species. As such, it can be difficult to eliminate undesirable brush or tree species that are prone to resprouting using manual techniques alone (i.e., no post herbicide treatments).

Pulling or Uprooting

Pulling or uprooting plants may disturb the soil sufficiently to provide the right conditions for undesirable or invasive species to establish or re-establish.

Cutting

Using a chain saw can cause noise impacts for recreationists, adjacent landowners, motorists, etc. At times, cutting vegetation leaves a stump, which can create a visual impact for land users. If the debris is left on or near the site it can increase the risk of fire, depending on the amount of debris and the area's fire regime characteristics. Vegetation debris can also provide wildlife habitat. As the vegetation decomposes, nutrients return to the ecosystem.

Girdling

Girdling kills plants but leaves no residue except the standing trunks. In addition, a dead standing tree (snag) can provide valuable wildlife habitat, and if left to decay, allows the nutrients of the tree to be returned to the system, rather than being removed and deposited elsewhere. Dead trees should not be left standing if they are tall enough to strike nearby transmission facilities or conductors. Girdling is seldom a recommended method

Mechanical Methods

Mechanical methods are generally non-selective and tend to clear or cut all vegetation within the path, thereby damaging undesirable plants and animals. Laborers and machines may severely trample vegetation and disturb soil, leading to diminished native vegetation and providing an opportunity for invasive species to establish or re-establish. In general, mechanical methods using heavy equipment or soil disturbing equipment (e.g., scraping) can cause compaction and erosion impacts and are avoided near water resources, cultural resources, steep slopes, and areas of soft or wet soils. The noise, exhaust, and dust associated with the use of heavy-duty vehicles and machinery can disturb wildlife and humans.

Environmental impacts associated with the predominant mechanical vegetation control techniques are described below.

Mowing and Brush-Cutting

In general, mowing and brush-cutting methods are effective for removing dense vegetation. These techniques are non-selective and can remove desirable native and/or rare, threatened, or endangered plant species. Mowing can disturb and potentially kill ground-dwelling wildlife, including birds, squirrels, gophers, mice, and salamanders. Rare, threatened, or endangered wildlife species can be affected as well. In addition, mechanical cutting and mowing can impact wildlife habitat, including food sources, shelter, and nests.

Mowing and brush cutting have the greatest soil impacts compared to other vegetation management techniques. Mowing equipment can expose, compact, and disturb soils, making them vulnerable to erosion and drying. Compaction reduces the soil's ability to retain water, causing increased surface runoff and erosion. Compaction can also inhibit presence of beneficial soil microbes and mycorrhizal fungi. Mycorrhizal fungi works symbiotically with the plant root system, improving the host plant's ability to assimilate soil moisture and nutrients. Erosion impacts can also potentially affect water quality due to increased surface runoff, turbidity, and sedimentation in surface water resources. Water quality impacts, including increased turbidity and sedimentation, can detrimentally affect fish and other aquatic species.

Mowing and brush-cutting equipment creates noise, dust, and traffic impacts. These methods can sometimes leave piles of vegetation debris on or nearby the ROW. The remaining debris can create obstacles or hazards if the ROW is utilized for recreational purposes.

Tilling

Low-growing plants, including forbs and grasses, are encouraged to grow when compatible with the use and access of the ROW. Tilling is a non-selective vegetation control method that eliminates or damages all vegetation in an area, whether the vegetation is desirable or not. In general, tilling is not utilized near water resources or on ROW sections that are known to contain rare, threatened, and endangered plant and wildlife species.

Biological Method

Biological control is often viewed as a progressive and environmentally friendly way to control pest organisms because it leaves behind no chemical residues that might have harmful impacts on humans or other organisms. When successful, it can provide essentially permanent, widespread control. However, some biological control programs have resulted in significant, irreversible harm to untargeted (non-pest) organisms and to ecological processes (Pemberton, 1985; Lockwood, 1993, 2000; McEvoy and Coombs, 2000). Of course, all pest control methods have the potential to harm non-target native species, and the pests themselves can cause harm to non-target species if they are left uncontrolled. Therefore, before releasing a biological agent (or using other methods), it is important to balance its potential to benefit management goals against its potential to cause harm.

Chemical Methods

There is a chance of herbicide spills with any of the following methods, and the concentrated herbicide from a spill can harm plants, wildlife, soils, and water resources. Environmental impacts associated with the predominant chemical control methods are described below.

Foliar Applications

Use of spot and wick applicators allows for a great deal of control over the site of herbicide application, and therefore, has a low probability of affecting non-target species or contaminating the environment. Use of a wick eliminates the possibility of spray drift or droplets falling on non-target plants. Boom application can create offsite movement due to vaporization or drift, and possible treatment of non-target plants and damage to wildlife are of concern when using this method.

Basal Bark

This technique controls the specific plant with little to no negative effect on the desirable vegetation or environment. However, if used, esters are highly volatile, so impacts to desirable vegetation, wildlife, and water resources can occur if not done in the right weather conditions.

Frill or Hack & Squirt

This technique allows for a great deal of control over the site of herbicide application, and therefore, has a low probability of affecting non-target species or contaminating the environment.

Injection

This technique allows for a great deal of control over the site of herbicide application, and therefore, has a low probability of affecting non-target species or contaminating the environment. However, this method may actually use more herbicide than foliar spraying since higher concentrations of the herbicide are used, which can result in concentrated spills into the environment.

Cut-Stump Treatment

Herbicide may run off the stump and onto the ground. The cut-stump treatment allows for a great deal of control over the site of herbicide application, and therefore, has a low probability of affecting non-target species or contaminating the environment. It also requires a small amount of herbicide to be effective, so any spills are of low concentration.

Vegetation Management Mitigation Techniques

Some possible opportunities to mitigate impacts associated vegetation management activities on overhead and underground transmission ROW are provided below.

Manual and Mechanical

1. If soil disturbance from vegetation control activity is significant on slopes with potential erosion impacts, re-seed the area with desirable native vegetation or take other erosion control measures as necessary.
2. Leave debris from vegetation cutting, mowing, brush cutting, or weed eating on site, as appropriate, to provide wildlife habitat and nutrients to the ecosystem.
3. Avoid or minimize the amount of vegetation debris falling into or being left in any surface water sources.
4. Avoid using heavy ground-disturbing equipment to clear vegetation on surfaces with slopes greater than 20%.
5. Utilize heavy equipment or trucks only when the ground is sufficiently dry to avoid excessive rutting and potential erosion impacts.
6. Use the tilling technique only in highly disturbed soils.
7. Maintain all equipment, machinery, and vehicles in good working condition to avoid oil or fuel spills. Avoid repairing or washing equipment near surface water sources.

Chemical

1. Strive to select herbicides that are effective against the plant, not likely to drift, leach to groundwater or wash into streams, are non-toxic to people and other organisms, not persistent in the environment, and are easy to apply.
2. Consider the following site conditions before application: accessibility, proximity to open water, depth to groundwater, the presence of rare species and other sensitive plants or animals, and the site's sensitivity to trampling that can occur when the herbicide is being applied.
3. Orient spray units to avoid direct spray and indirect drift into surface water resources, unless using aquatic herbicides. Use spray buffer strips along surface water resources to reduce or eliminate the effects of herbicide spraying on aquatic environments.
4. Develop safety protocols for storing, mixing, transporting, handling spills, and disposing of unused herbicides and containers before obtaining herbicides.
5. Follow all federal, state, and local regulations regarding herbicide use. Read and follow product labels. It is a violation of federal law to use an herbicide in a manner inconsistent with its label.

6. Require herbicide applicators to have all certificates and licenses required by the state and/or county.
7. Follow all county and state rules and regulations regarding pesticide spills. Develop a spill response protocol. Contact the local fire department or county hazardous materials office for large spills (generally over 100 gallons).
8. When using herbicides, it is critical (and, in some cases, required by law) to keep records of all plants/areas treated, amounts and types of herbicide used, and dates of application. This information can be used to evaluate the project's success, improve methodology, identify mistakes, and protect the environment.
9. Mix a dye with the herbicide so applicators can see which plants are treated and whether the applicators inadvertently sprayed any herbicide on themselves or their equipment.
10. Apply the herbicide at the appropriate time of year for the herbicide's mode of action, the physiology of the target species, and the site conditions. Check the label or consult with the distributor for the best application time under the conditions at the site.

Special Environmental Impacts Associated with Overhead Transmission Line Operations and Maintenance

Avian Interactions

Overhead transmission structures and ROW are utilized by many bird species for habitat. Typically, avian species utilize overhead transmission facilities for perching, hunting, roosting, and nesting purposes in areas where natural supports (e.g., trees) are uncommon. Birds landing on or colliding with transmission lines and associated support structures can result in outages and bird fatalities. Power line electrocutions and collisions are not the primary causes of bird mortality and population reductions. Habitat loss is the most significant cause of avian population declines worldwide. However, overhead transmission installations have direct impacts on bird populations and, in turn, avian populations have direct impacts on transmission facilities. Many avian-transmission interactions result in power outages negatively impacting electric service reliability, as well as increasing costs associated with power delivery.

Avian interactions and transmission ROW impacts can be divided into the following general categories:

- Collisions
- Electrocutions
- Outages
- Habitat Enhancement

Collisions

Avian collisions occur when flying birds are unable to avoid overhead transmission wires or structures and strike the facilities, typically resulting in injury or death. Collisions are more likely to occur in conditions of poor visibility (EPRI 2000, 2001, 2004 and 2006). Some bird species are more prone to power line collisions depending upon their morphology, flocking habits, and flight behavior (Roig-Soles and Navaso-Lopez, 1997). It is estimated that 174 million birds are killed every year by colliding with both distribution and transmission power lines (APLIC, 2006).

Electrocutions

Thousands of birds are electrocuted every year by distribution and transmission facilities, including, raptors (birds of prey), crows, ravens, vultures, herons, owls, pelicans, and pigeons (APLIC, 2006). Avian electrocutions are far more common on distribution lines than on transmission lines because the distance between wire conductors or distances between wires and their support structures are greater on transmission facilities than on distribution facilities. Transmission-related bird electrocutions are more likely to occur on lower voltage transmission lines (i.e., 60 kV to 70 kV) due to their structure types and wire configurations. Avian electrocutions occur when a bird either touches two conductors at the same time (phase-to-phase) or when it simultaneously comes in contact with an energized conductor and the transmission support structure causing electric current to go to ground (phase-to-ground). A bird's propensity to be electrocuted is also driven by its size (i.e., wingspan), hunting habits, and nesting habits.

Outages

Bird collisions and electrocutions do not necessarily result in bird-caused outages. Additional bird-related outage causes include:

- Nesting materials causing phase-to-phase or phase-to-ground conditions
- Prey remains coming in contact with energized conductors or equipment
- Damage caused by pecking or acid degradation from accumulation of fecal contamination reducing component life expectancy
- Long streams of excrement (streamers) discharged from large birds causing flashovers

Avian-related outages detrimentally impact system reliability, increase revenue loss due to outages, and increase costs associated with power restoration and equipment repair. Many utilities have increased their efforts (and costs) to implement bird management programs as bird populations continue to use transmission line corridors for habitat.

Habitat Enhancement

Numerous scientific studies conclude that overhead transmission line corridors provide valuable habitat for avian populations. The wire and border zones provide for the foraging and nesting of numerous bird species. Initial ROW clearance in a forest habitat will cause an initial decrease in the local bird population, but as early successional plant and shrub habitats develop, a net increase in bird populations typically occurs (Bramble et al., 1987). Forest-inhabiting bird species will use the transmission ROW as foraging and nesting sites (Yahner et al., 2002). In addition, ongoing maintenance activities do not detrimentally impact bird populations or bird species diversity (Bramble et al., 1986).

Bird species that nest in brushy or grassy vegetation created by the Wire Zone-Border Zone method are particularly prevalent on transmission ROW. On the State Game Lands 33 Research and Demonstration Project in central Pennsylvania, the abundance of birds along the ROW was about seven times higher than in the adjacent forest and nearly four times as many birds were observed in the shrubby border zones than in the wire zones (Yahner et al., 2002). With its combination of trees and shrubs, the border zone is important habitat for avian species.

Transmission structures also provide suitable habitat for raptors and owls that employ perch-and-dive hunting techniques. Transmission towers and poles provide a perching support with widespread views of the surrounding hunting area. One study demonstrated that raptor density significantly increased following construction of a 245 kV overhead transmission line in Colorado (Stahlecker, 1978).

Many bird species also use transmission structures as nesting sites. For example, 133 pair of raptors and ravens were successfully nesting on transmission towers within 10 years of construction of a 500 kV transmission line in the Snake River Valley of Idaho and Oregon (Steenhof et al., 1993). In general, there is greater clearance between conductors on transmission spans, and support structures allow sufficient space and support for birds to nest without causing significant problems for electrical operations (APLIC, 2006). However, as previously discussed, nests that are located above insulators or conductors may cause equipment failures and outages due to nest materials, prey remains, or fecal contamination. Also, birds utilizing transmission towers or poles are more likely to be electrocuted or collide with conductors.

Avian Interaction Mitigation Techniques

The following mitigation techniques can be implemented to minimize effects on bird populations resulting from the operations and maintenance activities of overhead transmission lines:

1. Develop and implement a comprehensive Avian Protection Plan (APP) or at least portions of an APP. An APP's purpose is to minimize utility impacts to bird populations while, at the same time, facilitate safe and reliable electric service. The following 12 components of an APP can be considered (APLIC, 2006; Liguori and Burress, 2008):
   a. **Corporate Policy:** Develop a statement and policy committing a utility to balance the protection of avian species with providing safe, reliable, and cost effective service. The statement typically includes provisions for avian interaction and mortality reporting, efforts toward avian-friendly design and construction, and regulatory compliance.
   b. **Training:** Training can be provided to all leadership, management, supervision, engineers, design, and field personnel on avian interaction issues and applicable utility policies including, but not limited to regulatory compliance, construction and design standards, nest management, and incident reporting. Ongoing supplemental training can be provided as needed.
   c. **Permit Compliance:** Develop and communicate utility processes under which employees secure necessary permits related to avian interaction issues.

d. **Construction and Design Standards:** Utilities can consider avian interactions during the design and construction of new transmission facilities as well as during ongoing operations and maintenance efforts. Bird-safe construction and retrofitting options include, but are not limited to installing nesting platforms, anti-perch or perch-friendly devices, and/or requiring sufficient clearance between phases or phases and grounds.

e. **Nest Management:** Develop, implement, and train employees on nest management procedures including, but not limited to nest siting, nest removal, and how to obtain applicable nest relocation or removal permits.

f. **Avian Reporting System:** Develop an avian interaction reporting system. Utilize a database to track trends associated with avian interactions in order to identify concern areas with high incident frequencies.

g. **Risk Assessment Methodology:** Focus efforts cost effectively by identifying and prioritizing areas and structures that pose the greatest risk for avian mortalities. Conduct a risk assessment by evaluating available data related to avian electrocutions, nesting areas, established migratory bird flyways, prey populations, perch availability, and other factors contributing to avian-utility interactions.

h. **Mortality Reduction Measures:** Develop a mortality risk reduction plan that identifies and prioritizes options for reducing avian electrocutions and outages (high priority monitoring areas, lines to be retrofitted, etc.) and set a task completion schedule.

i. **Avian Enhancement Options:** Develop an avian enhancement plan that incorporates initiatives to enhance avian populations and habitat through use of nesting platforms, managing habitat to attract migratory birds or prey for raptors, or working collaboratively with organizations and/or agencies that are involved in such efforts.

j. **Quality Control:** Develop provisions or policies designed to ensure quality control and continuous improvement related to the utility's avian interaction management efforts.

k. **Public Awareness:** Document and communicate avian conservation efforts to agencies and the public. Communication efforts can facilitate program buy-in and a positive public image.

l. **Key Resources for Troubleshooting:** Identify resources and personnel who are capable of being avian interaction experts. For example, environmental specialists can assist operations and maintenance personnel to identify retrofit opportunities designed to maximize bird protection and system reliability.

Special Environmental Impacts Associated with Underground Transmission Line Operations and Maintenance

Increased Soil Temperature

Operation of an underground line produces heat, thereby raising the temperature a few degrees at the surface of the earth above the transmission line. This heat is not enough to disrupt growing plants, but it can cause premature seed germination in the spring. Heat can also build up in enclosed buildings near underground transmission lines. According to an EPRI report titled Study of Environmental Impact of Underground Electric Transmission Systems, this local increase in soil temperature becomes negligible (even at maximum load conditions) at distances of 15 to 20 feet from the trench center line (EPRI, 1975).

Potential Fluid Leaks

Both HPFF and SCFF cables most commonly utilize an insulating fluid that can be released to the environment from underground cables through leaks in pipe joints, from corrosion, or by accidental damage to the cable system. The two most common types of dielectric fluid are alkylbenzene (which is used in making detergents) and polybutene (which is chemically related to styrofoam). Although they are non-toxic, they are slow to degrade in the environment.

A fluid leak can migrate downward through the soil or may preferentially follow a migration path along the pipe backfill material and along intersecting utilities. Depending on the volume of fluid released, the soil properties, and the depth to groundwater, the fluid may reach the groundwater and accumulate as a lens or plume floating on the water table, potentially impacting nearby wells. Fluid-reaching storm sewers or other conduits may discharge to waterways and degrade surface water quality. In addition, the release and degradation of alkylbenzene could cause benzene compounds to show up in plants or wildlife (benzene is a known carcinogen).

Any soil contaminated with leaking dielectric oil is classified as a hazardous waste. This means that any contaminated soil or water must be remediated. Contamination areas (soil and water) are delineated, characterized, and cleaned up. Costs associated with these activities can rapidly escalate because of the diffusive nature of the dielectric fluids, especially in water. Older cable systems can be more prone to leaks and seeps and thus may present higher risks.

6
SUMMARY

Whether or not a new transmission line is built, overhead or underground, depends on many factors that are often influenced by site specific conditions including construction costs, operational reliability, anticipated maintenance costs, and relative environmental impacts. Electric transmission lines (overhead and underground) can potentially impact an extensive array of environmental gradients and cultural features as they traverse various natural habitats and other manmade amenities and land uses. As such, constructing and maintaining overhead or underground transmission lines can result in both negative and positive environmental effects. The particular site and situation will dictate the degree and number of both negative and positive environmental effects. Resources typically affected by overhead and underground transmission line construction and maintenance include land use resources, biological (vegetation and wildlife) resources, geological and soil resources, water resources, cultural resources, and visual resources.

The primary negative effects associated with land use can include temporary and permanent impacts associated with transmission line construction and maintenance activities such as dust, noise, traffic, and access issues; potential temporary disruption of existing utility lines; a permanent change in existing land use such as cropping, timber production, recreation use, and buildings; and temporary disruption of services such as emergency response, travel, and access.

The primary negative effects on biological, geological, water, and cultural resources can be a result of temporary and potentially permanent disruption of the existing resource as well as changes that may take place to the resources over time due to the initial disruption and subsequent maintenance activities including habitat loss, habitat and population fragmentation, disruption of vegetation and wildlife species, introduction of invasive species, soil compaction and erosion, disturbance to surface water and groundwater resources, water quality degradation, and damage to archaeological sites and/or cultural artifacts.

The primary negative effects on visual resources resulting from transmission line construction and maintenance include construction activities such as equipment stockpiling; presence of construction equipment and vehicles and installation activities; and the presence and maintenance of the ROW.

Overhead-Specific Environmental Effects

The visual impacts of overhead transmission line ROW are greater than underground ROW due to the presence of large above ground support structures. In addition, overhead ROW are typically wider than underground ROW.

Overhead transmission facilities can have positive and negative environmental effects on avian species. Many bird species utilize overhead transmission structures for perching, hunting, roosting, and nesting purposes. Birds landing on or colliding with transmission lines and associated support structures can result in bird injury or fatality due to electrocution or collision with the facilities. However, overhead transmission structures and corridors provide valuable habitat for numerous bird species that utilize the ROW for foraging and nesting opportunities.

A positive environmental effect associated with overhead transmission line corridors includes habitat enhancement for certain wildlife and plant species as a result construction and maintenance of the ROW. In addition, overhead lines can span and not disrupt sensitive environmental features such as wetlands, sensitive plant and wildlife species, and archaeological/cultural sites.

Underground-Specific Environmental Effects

Installation of an underground transmission line may result in a frac-out event and there is the potential for fluid leaks once the line is installed, both of which could negatively affect all environmental resources. Increased soil temperatures may also negatively impact some environmental resources.

Trenchless installation can be less disruptive resulting in fewer negative impacts to all environmental resources, but is not without some negative effects. The negative effects of trenchless installation include disturbance from construction activities; disturbance from the entry and exit pits; and negative effects associated with construction and maintenance of the ROW.

The positive environmental effects of an underground transmission line include the potential increased property value for developed land; construction and maintenance of the right-of-way may benefit certain plant and animal species; and the aesthetic appeal to a vista without the interruption of overhead utility lines.

In general, the negative environmental effects of constructing and maintaining an underground transmission line are greater as compared to construction and maintenance of an overhead transmission line, but there may be projects, particularly in urban settings, where underground transmission facilities may be more appropriate or have fewer impacts. Each project must be evaluated based on the particular site, associated environmental resource impacts, project goals, and desired outcome. In some cases, installing a portion of the transmission line underground may be the most advantageous solution in order to avoid specific impacts. For example, Figure 6-1 depicts a concrete vault (in the foreground) being prepared to transition a 345 kV overhead line to underground. The steel pole structures (in the background) are about to be strung.

Figure 6-1
Concrete Vault Being Prepared to Transition a 345 kV Overhead Line to Underground

It is, however, important to assess every project individually to determine the best type of transmission line for each location. Only through site-specific evaluation of environmental impacts associated with any specific proposed transmission construction project, can the actual relative impacts of underground versus overhead lines be determined. Environmental assessments for a specific site should also consider practical mitigation techniques that could be utilized.

A
RELATIVE ENVIRONMENTAL IMPACT SEVERITY OF OVERHEAD VERSUS UNDERGROUND TRANSMISSION LINES

There is an extensive amount of information related to the environmental effects of overhead and underground transmission line construction and maintenance. Appendix A has two purposes: 1) to summarize a large volume of material and 2) to provide a concise comparison of potential environmental impacts associated with underground and overhead transmission lines.

Many variables are not taken into consideration. For example, underground construction methodologies (underground boring versus trenching), overhead structure selection (lattice tower versus single pole), and construction mitigation methods are not taken into consideration.

The following tables succinctly summarize the environmental impacts associated with overhead and underground transmission lines as described in Chapter 3 and Chapter 5 of this report. Potentially beneficial and detrimental environmental impacts are categorized and subjectively assigned descriptions (Similar, Greater, or Lesser) comparing relative severity of the environmental effects between overhead and underground transmission line construction (Table A-1) and maintenance activities (Table A-2).

Table A-1
CONSTRUCTION and DECOMMISSIONING OF TRANSMISSION LINES
Categorization of Potentially Beneficial and Detrimental Environmental Issues that are Either Similar (S), Greater (G) or Lesser (L) in Impact between Overhead and Underground Transmission Construction

Environmental Issue	Underground Detrimental	Overhead Detrimental
Land Use		
• Agriculture	G	L
• Forest	G	L
• Residential	L	G
• Commercial	S	S
• Parks, Recreation, Preserves	G	L
• Public Facilities	G	L
• Industrial	G	L
Environmental Issue	**Underground Detrimental**	**Overhead Detrimental**
Land Use Resources Continued		
• Transportation and Access	S	S
Biological Resources		
• Disrupting Existing Vegetation	S	S
• Changing Habitat / Vegetation Composition	S[7]	S[7]
• Habitat / Species Fragmentation	S	S
• Habitat Loss / Reduced Species Abundance	S[7]	S[7]
• Disruption to Rare, Threatened, Endangered Species	S	S
• Introduction of Invasive Species	S	S
• Wildlife Displacement	G	L
Geological and Soil Resources	G	L

[7] Habitat and species diversity can be enhanced through proper mitigation during construction and implementing industry best management practices for follow-up maintenance.

Water Resources		
• Surface Flow and Flood Plains	G	L
• Wetlands	G	L
• Groundwater	G	L
• Water Quality Degradation	G	L
Cultural Resources		
• Ground	G	L
• Visual	L	G
• Vandalism	S	S
Visual Resources	L	G
Decommissioning of Lines	G	L

Table A-2
MAINTENANCE and OPERATIONS OF TRANSMISSION LINES
Categorization of Potentially Beneficial and Detrimental Environmental Issues that are Either Similar (S), Greater (G), or Lesser (L) in Impact between Overhead and Underground Transmission Facilities

Environmental Issue	Underground Detrimental	Overhead Detrimental
Avian Interactions		
• Collisions	L	G
• Electrocutions	L	G
• Habitat Enhancement	G	L
Soil Temperatures	G	L
Soil Contamination	G	L
Soil Compaction	G	L
Soil Erosion	G	L
Vegetation Maintenance Frequency / Intensity	S[8]	S
Plant Community Diversity and Composition	S	S

[8] A properly maintained underground ROW typically is kept clear of trees and large shrubs that can interfere with underground lines via plant root systems. Depending on the site, a similar frequency and intensity of vegetation maintenance activity as compared to overhead transmission lines may be required.

B
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