Suggested Practices for Avian Protection On Power Lines:

The State of the Art in 2006

PIER FINAL PROJECT REPORT CEC-500-2006-022

EDISON ELECTRIC INSTITUTE

Avian Power Line Interaction Committee

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Prepared by:

Avian Power Line Interaction Committee

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ABSTRACT

PURPOSE AND USE OF THE PUBLICATION

In the early 1970s, an investigation of reported shootings and poisonings of eagles in Wyoming and other western states led to evidence that eagles were also being electrocuted on power lines. Since then, the utility industry, wildlife resource agencies, conservation groups, and manufacturers of avian protection products have worked together to understand the causes of raptor electrocution and to develop and implement solutions to the problem. Those efforts have improved our understanding of the biological factors that attract raptors and other birds to power lines, and the circumstances that lead to avian electrocutions.

This publication, *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*, summarizes the history and success of over three decades of work. It springs from three previous editions of *Suggested Practices for Raptor Protection on Power Lines*, and has been expanded and updated to assist those concerned with complying with federal laws, protecting and enhancing avian populations, and maintaining the reliability of electric power networks.

THE ISSUE

Discoveries of large numbers of electrocuted raptors in the early 1970s prompted utilities and government agencies to initiate efforts to identify the causes of and develop solutions to this problem. Literature from the 1980s and 1990s continued to document electrocutions of raptors throughout the world. Now, reports of electrocutions of birds other than raptors are appearing in the literature and the impacts of avian interactions on power reliability are becoming more evident.

REGULATIONS AND COMPLIANCE

Three federal laws in the United States protect almost all native avian species and prohibit “taking,” or killing, them. The Migratory Bird Treat Act protects over 800 species of native, North American migratory birds. The Bald and Golden Eagle Protection Act provides additional protection to both bald and golden eagles. The Endangered Species Act applies to species that are federally listed as threatened or endangered. Utilities should work with the U.S. Fish and Wildlife Service and their state resource agency(ies) to identify permits and procedures that may be required for nest management, carcass salvage, or other bird management purposes.

BIOLOGICAL ASPECTS OF AVIAN ELECTROCUTION

Bird electrocutions on power lines result from three interacting elements: biology, environment, and engineering. The biological and environmental components that influence electrocution risk include body size, habitat, prey, behavior, age, season, and weather.

Of the 31 species of diurnal raptors and 19 species of owls that regularly breed in North America, 29 have been reported as electrocution victims. Electrocutions have also been reported in over 30 non-raptor North American species, including crows, ravens, magpies, jays, storks, herons, pelicans, gulls, woodpeckers, sparrows, kingbirds, thrushes, starlings, pigeons, and others.

SUGGESTED PRACTICES: POWER LINE DESIGN AND AVIAN SAFETY

Avian electrocutions typically occur on power lines with voltages less than 60 kilovolts (kV). Electrocution can occur when a bird simultaneously contacts electrical equipment either phase-to-phase or phase-to-ground. The separation between energized and/or grounded parts influences the electrocution risk of a structure. Electrocution can occur where horizontal separation is less than the wrist-to-wrist (flesh-to-flesh) distance of a bird’s wingspan or where vertical separation is less than a bird’s length from head-to-foot (flesh-to-flesh). In this document, 150 cm

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(60 in) of horizontal separation and 100 cm (40 in) of vertical separation are recommended for eagles. Utilities may choose to adopt these recommendations or modify their design standards based on the species and conditions at issue.

Single-phase, two-phase, or three-phase configurations constructed of wood, concrete, metal, fiberglass, or other materials can pose avian electrocution risks if avian-safe separation is lacking. In particular, structures with transformers or other exposed, energized equipment account for a disproportionate number of avian electrocutions.

Both avian-safe new construction and retrofitted existing structures should be used to reduce avian electrocution risk. The principles of *isolation* and *insulation* should be considered when designing or retrofitting structures. *Isolation* refers to providing adequate separation to accommodate avian use of structures and should be employed where new construction warrants avian-safe design. *Insulation* refers to covering exposed energized or grounded parts to prevent avian contact. Although equipment that is covered with specifically-designed avian protection materials can prevent bird mortality, it should not be considered insulation for human protection.

PERCHING, ROOSTING, AND NESTING OF BIRDS ON POWER LINE STRUCTURES

In habitats where natural nest substrates are scarce, utility structures can provide nesting sites for raptors and other birds. Likewise, many birds use power poles and lines for perching, roosting, or hunting.

Bird nests on utility structures can reduce power reliability. Nest management, including the design and installation of platforms on or near power structures, can enhance nesting while minimizing the risk of electrocution, equipment damage, and loss of service. Utilities are encouraged to collect data on bird-related outages to quantify the impacts of birds on power systems, and to develop measures for preventing bird mortalities and their associated outages.

DEVELOPING AN AVIAN PROTECTION PLAN

In 2005, the Avian Power Line Interaction Committee and the U.S. Fish and Wildlife Service announced their jointly developed Avian Protection Plan Guidelines (Guidelines) that are intended to help utilities craft their own avian protection plans (APPs) for managing avian/power line issues. An APP should provide the framework necessary for implementing a program to reduce bird mortalities, document utility actions, and improve service reliability. It may include the following elements: corporate policy, training, permit compliance, construction design standards, nest management, avian reporting system, risk assessment methodology, mortality reduction measures, avian enhancement options, quality control, public awareness, and key resources. The Guidelines present a comprehensive overview of these elements. Although each utility's APP will be different, the overall goal of reducing avian mortality is the same. An APP should be a "living document" that is modified over time to improve its effectiveness.

FOREWORD

Avian interactions with power lines—including electrocutions, collisions, and nest construction—have been documented since the early 1900s when electric utilities began constructing power lines in rural areas. However, it was not until the early 1970s that biologists, engineers, resource agencies, and conservationists began to identify the extent of the problem and address it. Those early researchers and authors are to be commended for tackling a contentious issue and building a foundation of credibility and cooperation that continues today.

The U.S. Fish and Wildlife Service (USFWS) and the Avian Power Line Interaction Committee (APLIC) have a long history of working together on avian/power line issues. These efforts began in 1989 with an ad-hoc group that addressed whooping crane collisions with power lines in the Rocky Mountains. They continued with the release of Avian Protection Plan Guidelines (Guidelines) in April 2005, and have now produced this 2006 edition of *Suggested Practices*.

In 1975, the first edition of *Suggested Practices for Raptor Protection on Power Lines* had 21½ pages of text and 15 exhibit drawings. It summarized, "…studies conducted in the western United States document electrocution losses of egrets, herons, crows, ravens, wild turkeys and raptors, with 90% of the electrocution victims being golden eagles." The document concluded, "this loss of eagles is significant, but pesticide contamination, loss of habitat and illegal shooting remain the most threatening problems to raptors in general." The theme of reducing raptor electrocutions on power lines with an emphasis on "eagle-safe" designs was followed through the 1975, 1981 and 1996 editions.

Electric utilities have recognized that the interactions of migratory birds with electrical facilities may create operational risks, health and safety concerns, and avian injuries or mortalities. The USFWS understands these issues and is also responsible for conserving and protecting North American trust resources[1] under laws and regulations that include the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act. In the 2006 edition of *Suggested Practices*, APLIC and the USFWS have expanded the focus of avian/power line issues from raptors to include other protected

Signing of Avian Protection Plan Guidelines, April 2005. Pictured left to right: top – Jim Burruss (PacifiCorp), John Holt (National Rural Electric Cooperative Association), Quin Shea (Edison Electric Institute); bottom – Jim Lindsay (Florida Power and Light), Paul Schmidt (U.S. Fish and Wildlife Service).

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[1] Trust resources are wildlife, such as migratory birds, that are held in the public trust and managed and protected by federal and state agencies.

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migratory birds such as waterbirds, songbirds, and ravens and crows (corvids).

With this edition of *Suggested Practices* and the voluntary Guidelines, utilities have a "tool box" of the latest technology and science for tailoring an Avian Protection Plan (APP) that meets specific utility needs while conserving migratory birds. The 2006 edition of *Suggested Practices* represents a significant update from the 1996 edition.

APLIC and the USFWS hope you will use this edition of *Suggested Practices* along with the Guidelines to help utilities improve system reliability, implement APPs, and conserve migratory birds.

Paul Schmidt
USFWS, Assistant Director
Migratory Bird Programs

Jim Burruss
APLIC, Immediate Past Chairman

Jim Lindsay
APLIC, Chairman

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THIS PUBLICATION IS DEDICATED TO THE MEMORY OF

Morley Nelson

(1917 – 2005)

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"A man born with the heart and soul of an eagle"

Morley Nelson devoted his life to promoting raptor conservation and educating the public about their importance. He accomplished this through his personal zeal for working with raptors and his cinematography skills. Morley's achievements include: award-winning films on raptors, the establishment of the Snake River Birds of Prey National Conservation Area, raptor rehabilitation, public lectures that helped educate Americans about the importance of raptors, and research that formed the foundation of recommendations made to the electric utility industry for reducing raptor electrocutions.

A master falconer, Nelson raised public awareness about birds of prey through dozens of movies and TV specials starring his eagles, hawks and falcons—including seven films for Disney. His love of raptors began when he was a boy growing up on a farm in North Dakota. Moving to Boise after serving in World War II he began his raptor conservation efforts along with rehabilitating and training birds.

Morley's raptor/power line research became the focus for cooperation among conservation groups, resource agencies and electric utility companies. His legacy of pooling knowledge and resources for raptor conservation is reflected in this document.

To foster the memory of Morley, APLIC will periodically present its *Morley Nelson Award* to an individual who makes significant contributions to raptor conservation. The individual must demonstrate a long-term commitment to natural resources, a consistent history of investigating or managing the natural resource issues faced by the electric utility industry, and success in developing innovative solutions.

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CHAPTER 1

Introduction

IN THIS CHAPTER Purpose and Scope · Organization of this Document

This book presents engineers, biologists, utility planners, and the public with a comprehensive resource for addressing avian electrocutions at electric power facilities.[2] It outlines the importance of the issue, describes methods for avoiding or mitigating electrocution problems, and highlights management options and cooperative partnerships.

PURPOSE AND SCOPE

In the early 1970s, an investigation of reported shootings and poisonings of eagles in Wyoming and other western states led to evidence that eagles were also being electrocuted on power lines (Olendorff et al. 1981). Since then, the utility industry, wildlife resource agencies, conservation groups, and manufacturers of avian protection products have worked together to understand the causes of raptor electrocutions and to develop ways of preventing them. Those efforts have improved our understanding of the biological reasons why raptors and other birds can be attracted to power lines, and the power line configurations that lead to avian electrocutions.

This publication, *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*, summarizes the history and achievements of over three decades of work. It succeeds three previous editions and has been expanded and updated to assist those concerned with complying with federal laws, protecting and enhancing avian populations, and maintaining the reliability of electric power networks.

Early attempts to understand the engineering aspects of raptor electrocution led to the first edition of *Suggested Practices* (Miller et al. 1975). The 1975 edition was followed by the 1981 edition (Olendorff et al. 1981), which explored the biological and electrical aspects of electrocution, provided guidance for reducing bird mortalities, and contained a comprehensive annotated bibliography. The 1996 edition (APLIC 1996) expanded and refined recommendations for power line structure designs and modifications for protecting raptors, included updated research

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[2] This book focuses on avian electrocutions, not collisions. Readers seeking information about the collision of birds with power lines may consult *Mitigating Bird Collisions with Power Lines: The State of the Art in 1994* (Avian Power Line Interaction Committee [APLIC] 1994) or the current edition of this manual.

results, and illustrated the effectiveness of cooperative efforts.

Although raptors remain a focal point of electrocution issues, utilities have found that many other birds also interact with electrical structures, and can reduce power reliability. Accordingly, this 2006 edition of *Suggested Practices* expands upon prior editions by addressing additional avian species. This edition also reflects utility efforts to improve configuration designs and to evaluate the effectiveness of various retrofitting options. The 2006 edition includes the following additions or updates:

- A new chapter on regulations and permits related to migratory birds,
- Biological perspectives and information on electrocution risks for nonraptor avian species, including wading birds, corvids,[3] and songbirds,
- Consideration of the National Electric Safety Code (NESC) relative to suggested practices,
- An overview of electrocution risks and mitigation measures associated with steel and concrete poles,
- Updated recommendations for post-mounted configurations,
- A discussion of perch discouragers and their proper use,
- An overview of new avian protection devices as well as their uses and installation[4],
- A review of bird-related outages,
- An updated bibliography and literature review (Appendix A),
- An appendix containing the voluntary Avian Protection Plan Guidelines (Guidelines) developed by APLIC and the United States Fish and Wildlife Service (USFWS) in 2005, as well as suggestions for developing and implementing an Avian Protection Plan (APP).

ORGANIZATION OF THIS DOCUMENT

This book is intended for use by electric utilities, resource agencies and scientists worldwide. International literature is included, but it is primarily focused on North America. A brief synopsis of each chapter is listed below.

Chapter 2: The Issue
Defines the avian electrocution problem, traces its history, and reviews the latest research on avian electrocutions and their prevention.

Chapter 3: Regulations and Compliance
Reviews the major federal laws related to migratory birds and identifies potential permit requirements.

Chapter 4: Biological Aspects of Avian Electrocution
Describes the range of avian/power line interactions and discusses the biological and environmental factors that influence avian electrocution risk.

Chapter 5: Suggested Practices: Power Line Design and Avian Safety
Presents the reader with the background necessary to understand avian electrocutions from an engineering perspective, i.e., the design and construction of power facilities. Suggests ways to retrofit existing facilities and design new facilities to prevent or minimize avian electrocution risk.

[3] The corvid family includes crows, ravens, magpies, and jays.

[4] See the APLIC website (www.aplic.org) for a current list of avian protection product manufacturers.

Chapter 6: Perching, Roosting, and Nesting of Birds on Power Line Structures
Explores the benefits of power lines to raptors and other birds and proposes strategies for relocating nests or providing alternative nesting sites that minimize electrocution risk while maintaining safe and reliable electrical service. Discusses the use of devices intended to discourage perching versus modifying structures to be avian-safe. Provides an overview of bird-related outages and their impacts on reliability and operating costs.

Chapter 7: Developing an Avian Protection Plan
Presents the elements of an APP and provides guidance for APP implementation.

For literature citations from the text and additional useful references, see the Appendix A Literature Cited and Bibliography section. Appendix B contains a history of early agency actions that addressed the electrocution issue; Appendix C Avian Protection Plan Guidelines; Appendix D a glossary; and Appendix E a list of acronyms.

Avian Power Line Interaction Committee

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CHAPTER 2

The Issue

IN THIS CHAPTER

- Early Reports
- Suggested Practices: 1975, 1981, and 1996
- Electrocution Issues to Date
- The Outlook

This chapter defines the avian electrocution issue, traces its history, reviews the literature, introduces the latest research, and discusses approaches to solving the problem. Particular emphasis is placed on studies completed since the previous edition of *Suggested Practices* (1996). This chapter also includes an overview of the avian electrocution issue in other countries.

Raptors (birds of prey) are ecologically important and sensitive to toxic substances, habitat alteration and destruction, and persecution by humans. Inadvertent harm to raptors can occur where humans and raptors interact. The biological importance and environmental sensitivity of raptors have led to substantial academic and public interest in these birds and to the problem of electrocution. This has resulted in better protection and management for raptors and their habitats.

The electrocution issue began with raptors because their size, hunting strategy, and nesting preferences make them particularly vulnerable. However, decades of research have found that other species also incorporate utility structures into their lifecycles. The interactions caused by perching, roosting, loafing, and nesting birds can result in electrocutions or power outages, each of which is receiving more attention from utilities, wildlife resource agencies, and the public.

In the United States, the federal government provides protection for migratory birds through several laws (see Chapter 3). Prominent among these are the Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. 668–668C), the Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703–712), and the Endangered Species Act (ESA) (16 U.S.C. 1531–1543). *Taking*[5] a bird protected by these laws can result in fines and/or imprisonment. Because electrocutions of protected birds on power lines are considered *takes* under the law, many utilities have acted

[5] In 50 CFR 10.12, *take* means "to pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to pursue, hunt, shoot, wound, kill, trap, capture or collect."

voluntarily and a few under duress to reduce electrocution mortality.

Another major impetus for action is the impact on the electric power network. Bird-caused outages reduce power reliability and increase power delivery costs (See Bird-Related Outages, Chapter 6). Some outages may impact only a few customers temporarily, yet they can still affect a utility's service reliability and customer guarantees. Larger outages can have dramatic consequences. For example, in 2004, several bird-related incidents resulted in power outages at the Los Angeles International Airport, which caused flight delays and threatened airport security. Wildlife-related outages in California alone are estimated to cost from millions to billions of dollars each year (Hunting 2002; Singer 2002; Energy and Environmental Economics, Inc. 2005). In a culture that depends upon electronic devices, power outages can cause inconveniences to residential customers, mortal risks to those who need electricity for heat or life-support systems, and major production losses for industrial and commercial customers.

The impact of electrocution on raptor populations, and avian populations in general, is poorly understood. Newton (1979:212) summarized the difficulties of addressing population impacts on raptors:

> *The importance of different mortality causes is also poorly understood, partly because it is hard to find a sample that is representative of the whole population, and partly because of the operation of pre-disposing causes. Starvation, predation and disease are all recorded as causing deaths of raptors, as are various accidents and collisions, electrocution, shooting, trapping and poisoning. The [banding] recoveries and post-mortem analyses which provide most information are inevitably biased towards deaths that occur from human action or around human habitation.*

Both direct and indirect mortality factors must be considered when studying raptor population dynamics. In addition to electrocution, Postivit and Postivit (1987) identified eight other human activities that affect birds of prey: (1) persecution,[6] (2) pesticide use and pollution, (3) agricultural development, (4) logging, (5) dam construction and water management, (6) energy and mineral development, (7) urbanization, and (8) recreation. Kochert and Steenhof (2002) identified the greatest threats to golden eagles *(Aquila chrysaetos)* in the United States and Canada as the adverse impacts of human activity, including collisions, electrocutions, shooting, and poisoning from lead or agricultural pesticides. Other human-related sources of mortality that impact birds in general include window and motor vehicle collisions, predation by domestic and feral cats, and collisions with power lines, communication towers, and wind generation facilities (National Wind Coordinating Committee [NWCC] 2001). Estimates of avian mortality due to these causes run in the millions annually, far greater than the estimated number of birds killed by electrocution (Figure 2.1).[7] Habitat destruction is thought to cause greater reductions in bird and other wildlife populations than any other factor, and is still the most serious long-term threat (Newton 1979; Wilcove et al. 1998; USFWS 2002).

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[6] The term *persecution* was used by Postivit and Postivit (1987) to mean shooting. Persecution could also include poisoning and direct trapping.

[7] Figure 2.1 was generated using estimates of avian mortality from NWCC 2001, Curry and Kerlinger LLC: What Kills Birds? (http://www.currykerlinger.com/birds.htm), and the U.S. Fish and Wildlife Service: Migratory Bird Mortality (http://www.fws.gov/birds/). Avian mortality rates associated with electrocution are presented for various species in Chapter 4. The numbers provided in Figure 2.1 are gross estimates collected using different techniques and levels of accuracy, therefore this graph is intended only to provide a relative perspective of various sources of avian mortality.

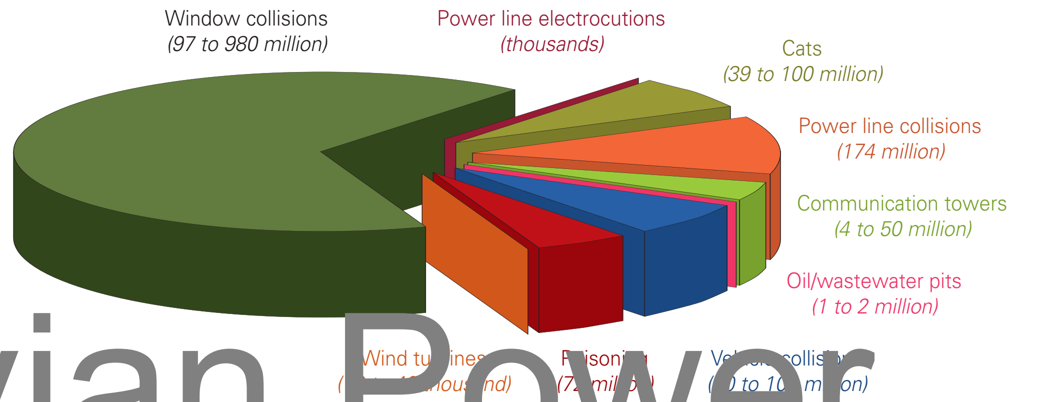

FIGURE 2.1: Comparison of human-caused avian mortality.

Nevertheless, electrocution on power facilities remains a legitimate concern and a source of mortality that can be reduced. Electrocutions can be minimized through a variety of mitigation measures that include applying "avian-safe"[8] designs to new construction, and retrofitting existing lines that pose an electrocution risk. It is in the interest of utility planners, biologists, and engineers to familiarize themselves with the issue and its dimensions, and to plan for and implement measures that identify and rectify existing and potential electrocution problems.

EARLY REPORTS

Before the 1970s, raptor electrocutions had been noted by several researchers (Hallinan 1922; Marshall 1940; Dickinson 1957; Benton and Dickinson 1966; Edwards 1969; Coon et al. 1970), although the extent of the problem was not known. Surveys in Wyoming and Colorado during the 1970s found nearly 1,200 eagle mortalities that were due to poisoning, shooting from aircraft, and electrocution. Although most of these eagles had been shot, others had been electrocuted by contact with lines not designed with eagle protection in mind. In northeastern Colorado, 17 golden eagles, 1 red-tailed hawk *(Buteo jamaicensis)*, and 1 great horned owl *(Bubo virginianus)* were found dead—all probably electrocuted, along 5.6 kilometers (km) (3.5 miles [mi]) of line (Olendorff 1972a). Five golden eagles and 4 bald eagles *(Haliaeetus leucocephalus)* were found dead under a power line in Tooele County, Utah, and more than 40 electrocuted eagles were found along a line in Beaver County, Utah (Richardson 1972; Smith and Murphy 1972). Of 60 autopsied golden eagles in Idaho, 55% had been electrocuted (M. Kochert, pers. comm. in Snow 1973). In June of 1974, 37 golden eagles and 1 short-eared owl *(Asio flammeus)* were found dead under a line southwest of Delta, Utah (Benson 1977, 1981). In a review of bald eagle mortality data from 1960 to 1974, 4% of the eagle deaths were attributed to electrocution (total sample size not given) (Meyer 1980). Similar electrocution problems were also noted in

[8] The term *raptor-safe* has been used in previous editions of *Suggested Practices* to identify power poles that are designed or retrofitted to prevent raptor electrocutions. Because this edition of *Suggested Practices* encompasses many avian species, the term *avian-safe* is used.

New Mexico (Denver Post 1974), Oregon (White 1974), Nevada (U.S. Fish and Wildlife Service 1975a), Louisiana (Pendleton 1978), and Idaho (Peacock 1980).

Much of the information from the early 1970s was summarized by Boeker and Nickerson (1975). This 1971 summary documented 37 golden eagle deaths along a power line of just 88 poles in Moffat County, Colorado. Carcasses and skeletons of 416 raptors were found along 24 different 8 km (5 mi) sections of power lines in six western states (Benson 1981). In Utah, U.S. Fish and Wildlife Service (USFWS) employees found the remains of 594 raptors (some dead up to five years) under 36 different distribution lines (spanning approximately 400 km [250 mi]). Of these carcasses, 64 were fresh enough to determine the cause of death: 87.5% had been electrocuted (R. Joseph, pers. comm. in Avian Power Line Interaction Committee [APLIC] 1996).

SUGGESTED PRACTICES: 1975, 1981, AND 1996

The eagle deaths documented in the western United States during the 1970s raised serious concern about raptors and electric power facilities. Industry, government, and conservation organizations began to work together to identify and solve the problem of raptor electrocution.[9] Agencies involved included the Rural Electrification Administration (REA; now the Rural Utilities Service [RUS]), U.S. Forest Service (USFS), Bureau of Land Management (BLM), USFWS, National Park Service (NPS), and Bureau of Indian Affairs (BIA). The USFWS began searching for lethal lines, while the REA began developing line modification methods to minimize eagle electrocutions. The National Audubon Society and the Edison Electric Institute (EEI) initiated workshops, sought utility participation, raised funds, and began to develop ways to address the problem. In 1972, the REA published a bulletin describing causes of raptor electrocution resulting from certain grounding practices and conductor spacing. This bulletin (61-10) was revised in 1975 and again in 1979 to incorporate research conducted since each earlier edition, including revised inter-phase clearances (Figure 2.2) (U.S. REA 1979).[10] In the 1970s, the USFWS also initiated a raptor mortality data bank to track electrocutions.

As data were gathered on the magnitude of raptor electrocution numbers during the early 1970s, regional meetings were held to familiarize industry and agency personnel with the problem. Several electric companies, most notably Idaho Power Company, had retained Morley Nelson[11] of Boise, Idaho, to begin testing the safety of new power line designs and to propose modifications of existing lines. These tests were instrumental in forming the basis for the first definitive work on the subject: *Suggested Practices for Raptor Protection on Power Lines* (Miller et al. 1975). This publication was widely circulated and used by both industry and government (Damon 1975; EEI 1975). For example, the BLM and other agencies began requiring "raptor-safe" construction as a condition of rights-of-way permits on federal land and explicitly stipulated that such actions be consistent with *Suggested Practices* (Olendorff and Kochert 1977).

Field tests of the recommendations contained in the 1975 edition of *Suggested Practices* led to a need for further documentation and evaluation, as some of the recommended dimensions were found inadequate. For

[9] Appendix B presents a history of individual and agency contributions.

[10] REA Bulletin 61-10 was the precursor to the *Suggested Practices* series.

[11] Morley was a cinematographer and pioneer in North American falconry. He filmed trained eagles, hawks, and falcons to study and demonstrate their behavior on a variety of utility pole configurations.

instance, the suggested 61 centimeters (cm) (24 inches [in]) height of the overhead perch was too high, and needed to be reduced to 41 cm (16 in) to keep birds from landing beneath the perch. New cover-up materials and conductor support schemes were also developed. In the 1981 edition of *Suggested Practices* (Olendorff et al. 1981), earlier recommendations were corrected and updated, and a complete literature review and annotated bibliography was provided. This edition of *Suggested Practices* was adopted (incorporated by reference at 7 CFR 1724.52(a)) by the REA as their standard for raptor protection. *Suggested Practices* continues to be used by the RUS as a resource for mitigating problems in areas where birds are a concern.

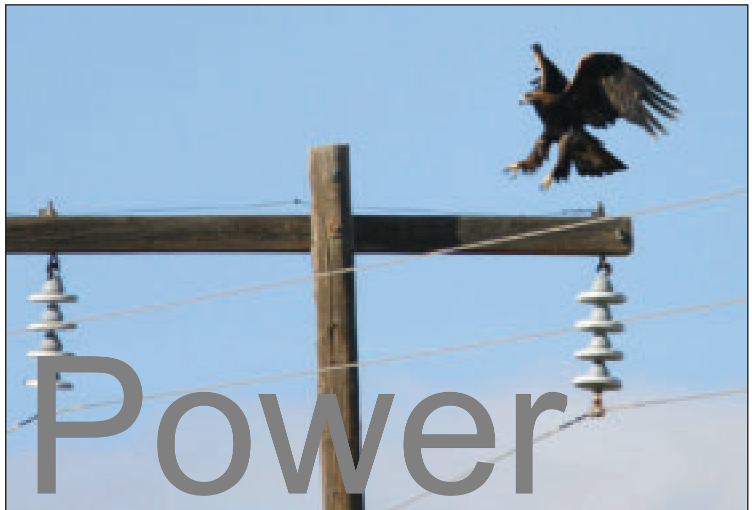

FIGURE 2.2: Golden eagle landing on avian-safe pole. Early research on avian electrocutions and pole modifications focused largely on golden eagles.

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By the mid-1990s, continued progress was being made in reducing raptor electrocution risks. Many utilities had adopted or participated in raptor enhancement or protection programs (Blue 1996). However, despite these efforts, electrocutions continued in North America and concerns remained over electrocution problems internationally (Lehman 2001). The 1996 edition of *Suggested Practices* refined recommendations from the previous editions, updated the literature review, offered suggestions for cooperative actions among agencies and utilities, and began to identify avian electrocution issues outside of North America.

In the past decade, great strides have been made in preventing avian electrocutions. Many utilities consider avian safety in new construction and continue to retrofit existing poles that pose electrocution risks. There is a growing variety of products and materials manufactured for avian protection (see www.aplic.org). Increased awareness within utilities has improved electrocution reporting and corrective actions. In 2005, APLIC-member utilities were surveyed to obtain information on utility programs, electrocution rates, bird-related outages, and progresses made in avian protection efforts. Of survey respondents (*n* = 12), most utilities had either an avian protection plan (69%) or policy (77%) (APLIC 2005). Survey respondents were asked to compare their utility's current avian protection efforts to those of 10 and 20 years ago. All utilities surveyed currently retrofit poles for avian protection, however, two decades ago only 31% retrofitted poles for birds. Likewise, the amount of money spent on avian protection efforts has increased substantially. Twenty years ago, half of the utilities surveyed did not have a budget for avian protection; whereas currently all utilities surveyed spend money on avian protection. In addition to expanding their avian protection efforts, many utilities noted that they have experienced improved relationships with resource agencies. Communication with agencies was considered to be fair by the majority of utilities (45%) 20 years ago, while 58% considered communication good 10 years ago, and 58% reported that they currently have excellent communication with wildlife resource agencies.

ELECTROCUTION ISSUES TO DATE

ELECTROCUTION ISSUES AND PROGRESS IN NORTH AMERICA

Recent literature indicates that electrocution continues to be a cause of mortality for various raptors in North America—particularly eagles and some hawks and owls. Because of increased awareness, non-raptor electrocutions are also being documented. The small number of comprehensive field surveys, however, limits the extent of our knowledge of electrocution mortality. Differences in the scope of electrocution studies and the type of data collected make it difficult to compare historic and current information. Additionally, little data exist that quantify the risk of electrocutions relative to other sources of avian mortality. Assessments that use data subsets or incidental reports for extrapolating results based on an estimated number of poles are inaccurate because electrocution risk is not uniformly distributed. Though quite difficult, systematic surveys over large areas can provide more accurate electrocution rate estimates.

Several recent studies have quantified avian electrocution rates. In a survey of over 70,000 poles in Utah and Wyoming in 2001 and 2002, 547 avian mortalities were found —32% of which were common ravens *(Corvus corax)*, 21% buteos, 19% eagles, 6% passerines/small birds, 4% owls, 2% falcons, 2% waterbirds, and 14% unidentified (Liguori and Burruss 2003). In a survey of 3,120 poles in Colorado, 68 carcasses were discovered, including eagles (53%), hawks (23%), and corvids (7%) (Harness 2001). In a study of 4,090 poles in Montana, golden eagle electrocutions were documented at 4.4% of poles, 20 of which had electrocuted more than one eagle (Schomburg 2003). In Chihuahua, Mexico, studies in 2000 and 2001 documented an average annual electrocution rate of 1 bird per 6.5 concrete poles in non-urban areas (Cartron et al. 2005). In northern California and southern Oregon, confirmed and suspected avian electrocutions were documented at 0.9% of poles surveyed (*n*=11,8[illegible]9) in 2004 and 2005 (PacifiCorp, unpubl. data). Of these mortalities, 48% were buteos, 27% owls, 11% eagles, 5% corvids, 5% unidentified raptors, 2% vultures, 1% harriers, and 1% herons.

Studies that have documented electrocutions through incident reports without systematic pole surveys provide conservative estimates of electrocution rates. Harness and Wilson (2001) documented 1,428 raptor electrocutions in a review of mortality records from utilities in the rural western United States from 1986 to 1996. From 1988 to 2003, 210 raptor electrocutions were documented in Nebraska (USFWS/Nebraska, unpubl. data). In Montana, 32 golden eagle mortalities were confirmed from 1980 to 1985 (O'Neil 1988). From 1978 to 2004, nearly 800 electrocutions were reported by Alaska utilities to the USFWS (USFWS/Alaska, unpubl. data). Prior to 2000, most electrocutions reported in this database were of bald eagles, which accounted for 83% of reports from 1978 to early 2005. Other birds reported in Alaska include ravens, magpies, crows, owls, gulls, ospreys *(Pandion haliaetus)*, and great blue herons *(Ardea herodias)*.

Bald and golden eagles continue to be a focus of electrocution research in North America, with electrocution accounting for <1% to 25% of eagle deaths in various studies. The U.S. Geological Survey's (USGS)

National Wildlife Health Laboratory (1985) reported that 9.1% of 1,429 dead bald eagles examined from 1963 to 1984 were electrocuted. In a summary of eagle mortalities from the early 1960s to the mid-1990s, electrocution accounted for 25% of golden eagle and 12% of bald eagle deaths (Franson et al. 1995). Electrocution accounted for 0.5% of deaths in a study of raptor mortality (*n*=409) in California from 1983 to 1994 (Morishita et al. 1998). Of bald eagles banded in the Yellowstone area (*n*=49), 20% died from electrocution or collision with power lines (Harmata et al. 1999). In Florida, 17% of bald eagle mortalities (*n*=309) from 1963 to 1994 were due to electrocution (Forrester and Spalding 2003). Electrocution also accounted for 6% of eagle mortalities (*n*=274) from a rehabilitation database in Florida from 1988 to 1994 (Forrester and Spalding 2003). Electrocution was the cause of death for 11.5% of bald and golden eagles evaluated (*n*=546) from 1986 to 1998 in western Canada (Wayland et al. 2003). Of 61 eagles killed in the Diablo Range of the Altamont Pass Wind Resource Area, California, from 1994 to 1997, 16% were electrocuted (Hunt et al. 1999). Of birds admitted to the Michigan Department of Natural Resources' (MDNR) Wildlife Disease Laboratory, the number electrocuted was low compared to other causes of death, and most often involved bald eagles, ospreys, and great horned owls (MDNR 2004; T. Cooley, pers. comm.).

The frequency of electrocutions and associated outages has been dramatically reduced in areas where concerted efforts have been made to retrofit or replace hazardous poles. The Klamath Basin of southern Oregon and northern California attracts one of the largest concentrations of wintering raptors in the lower 48 states. In the Butte Valley, an area of the Klamath Basin used extensively by raptors, 90 electrocuted eagles were found between 1986 and 1992 (PacifiCorp, unpubl. data). During the 1990s, extensive pole retrofitting, using recommendations from previous editions of *Suggested Practices*, was completed in this area. Subsequently, in a comprehensive survey of poles in Butte Valley in 2004, only 4 eagle carcasses were found (PacifiCorp, unpubl. data). Likewise, following extensive retrofitting efforts in Worland, Wyoming, the number of eagle electrocutions fell from 49 birds in three years to 1 bird in three years (PacifiCorp, unpubl. data). In the Queen Charlotte Islands of Canada where bird protection was installed on a large proportion of poles, the number of bird-related outages fell from 41 to 16 in two years (BC Hydro 1999). Similarly, in one year following the installation of protective devices on problem circuits in Vermont, animal- and bird-caused outages declined by 56% (Central Vermont Public Service 2002). Electrocution rates of Harris' hawks *(Parabuteo unicinctus)* near nests in Tucson, Arizona, fell from 1.4 electrocutions per nest in 2003 to 0.2 in 2004 (Dwyer 2004).

Mortalities of other raptors, particularly buteos, continue to occur in North America. The majority of APLIC-member utilities surveyed in 2005 cited red-tailed hawks as

FIGURE 2.3: Rough-legged hawk perched on insulator.

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one of their most commonly electrocuted species (APLIC 2005). Southern California Edison records indicate that red-tailed hawks constitute about 75% of electrocuted raptors found along their distribution lines (D. Pearson, pers. comm.). Buteos accounted for 21.4% of electrocuted raptors found in Utah and Wyoming (*n*=547), and included red-tailed hawks (7.5%), Swainson's hawks (5.9%) *(Buteo swainsoni)*, ferruginous hawks (1.6%) *(B. regalis)*, rough-legged hawks (0.2%) *(B. lagopus)*, and unidentified buteos (6.2%) (Liguori and Burruss 2003) (Figure 2.3). In a 2004 survey of poles in the Butte Valley of California, buteos accounted for 50% of suspected electrocutions (*n*=18), 5 of which were red-tailed hawks (PacifiCorp, unpubl. data).

Osprey, a species that the 1996 edition of *Suggested Practices* considered "surprisingly rare" in electrocution records, has greatly increased in population over the past few decades (Sauer et al. 2004). Although records of osprey electrocutions remain infrequent, ospreys are nesting on power poles in growing numbers (USGS 2005; Wisconsin Department of Natural Resources 2003). Consequently, many utilities throughout North America are spending considerable effort on osprey nest management (see Chapter 6).

Pelicans and wading birds, such as herons, egrets, ibises, and storks, have received increased attention from utilities, particularly in the southeastern United States. The lengthy wingspans and heights of these birds put them at risk of electrocution. Like other large birds, they may be electrocuted if they fly into lines mid-span and bridge two conductors. Although waterbirds occur in large concentrations in the southeastern United States and along the Gulf Coast, common and widely distributed species, such as the great blue heron, may be encountered throughout North America.

Although raptor electrocutions typically occur in remote or rural areas, there is a growing awareness of avian electrocutions and outages in urban and suburban locations. In many cases, these interactions involve species that are not protected by the MBTA, i.e., European starlings *(Sturnus vulgaris)*, house (English) sparrows *(Passer domesticus)*, or rock doves (feral pigeons, *Columba livia*) (Figure 2.4). Regardless of their status, outages caused by these species can result in substantial costs to utilities and their customers. Other protected species—such as jays, crows, ravens, magpies, kingbirds, and woodpeckers—may be common in developed areas and can interact with power lines. In suburban Tucson, Arizona, populations of Harris' hawks have increased and family groups of birds perch or nest on or near power poles. The monk parakeet *(Myiopsitta monachus)*, introduced from South America, has presented an increasing problem for utilities in the United

FIGURE 2.4. Flock of European starlings on power lines.

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States within the last decade. Their large communal nests can cause electrocutions, outages, and fires (see Chapter 6).

Increased awareness of avian electrocutions has led to improved reporting of all birds protected by the MBTA. Of APLIC-member utilities surveyed in 2005 (*n*=13), 77% currently track electrocutions of all protected species (APLIC 2005). In contrast, ten years ago, most of these utilities only documented electrocutions of eagles, raptors, or other large birds, with only 25% reporting electrocutions of all protected species. Regardless of the species, conducting proactive remedial measures can provide the benefits of reduced mortality and improved reliability.

Since the 1996 edition of *Suggested Practices*, researchers have begun to identify electrocution risk and to quantify electrocution rates in parts of Mexico (Cartron et al. 2000, 2005, in press; Manzano-Fischer 2004). After numerous electrocuted ravens and raptors were detected under newly constructed distribution lines in northern Mexico in 1999, efforts to address this issue began. Surveys were conducted to assess the scope of the problem and to evaluate possible solutions along lines in northwestern Chihuahua, where the largest black-tailed prairie dog *(Cynomys ludovicianus)* town complex in North America remains (Cartron et al. 2000, 2005). The use of steel-reinforced concrete poles with steel crossarms in this area, coupled with raptor and raven populations attracted to the prairie dog town, increased the electrocution risk. Because the poles and steel crossarms are grounded, birds that perch on them can be electrocuted by touching one conductor (see Chapter 5). In addition, the voltage of distribution lines in Mexico is greater than in the United States, which may create an electrocution risk through arcing. Double dead-end poles pose a particular risk when energized jumper wires are mounted over the crossarms. The problem for raptors such as red-tailed hawks, ferruginous hawks, and golden eagles is greatest during fall and winter and in areas with large prairie dog colonies (Cartron et al. 2005). For the Chihuahuan raven *(Corvus cryptoleucus)*, the species most frequently electrocuted in this area, electrocutions occur throughout the year and peak during nesting and after fledging (J-L. Cartron, pers. comm.).

With the added incentive of reducing power outages, Mexico's Federal Utility Company (Comisión Federal de Electricidad; [CFE]) began to replace conductive steel crossarms with wooden crossarms on concrete poles located within the prairie dog town. No dead birds were found at retrofitted concrete poles in a subsequent survey of this area (Cartron et al., in press). In 2002, non-governmental organizations (NGOs), academic institutions, government agencies, and the CFE took part in a workshop, *Avian Electrocutions on Power Lines in Mexico, 1st Workshop*, to address the electrocution problem in Mexico and develop solutions (INE-SEMARNAT 2002). The workshop was the first meeting of its kind in Mexico, and identified bird electrocutions on distribution lines, collisions with transmission lines, nest construction, and fecal contamination of power lines and optic fiber cable as the main avian-related problems.

Although retrofitting of hazardous lines in Chihuahua and Sonora has been implemented, electrocutions still continue along other lines and the extent of the electrocution problem has yet to be determined in other parts of the country (Cartron et al., in press; Manzano-Fischer et al., in press). Agrupación Dodo is currently developing a training manual for CFE maintenance crews. From this they expect to improve data collection on electrocuted birds. All future information will be collected in a national database to help identify problem areas and poles, to support more efficient remedial action.

The CFE has also begun installing bird flight diverters on some transmission lines in coastal areas to minimize bird collisions, and has installed devices on transmission towers to prevent fecal contamination of insulators by roosting vultures.

In Canada, utilities have documented avian electrocutions and typically retrofit high-risk poles as needed. Manitoba Hydro has surveyed power lines and poles to document bird use and to estimate electrocution and collision mortality rates (G.M. Platt, pers. comm.). ATCO Electric helped fund an electrocution study with the University of Alberta (Platt 2005). The goals of this study were to quantify raptor electrocution rates, determine the species affected, and identify pole configurations that present the greatest risk.

Since the 1996 edition of *Suggested Practices*, several landmarks regarding avian electrocution have occurred: (1) an electric utility has been prosecuted for avian electrocutions, (2) settlement agreements over avian electrocutions have been reached between utilities and USFWS, (3) Avian Protection Plan Guidelines were collaboratively developed by utilities and USFWS, and (4) the focus of electrocution issues broadened to include non-raptor species. In 1999, the USFWS prosecuted Moon Lake Electric Association (MLEA) for violations of the MBTA and BGEPA. For the electrocutions of 12 eagles, 4 hawks and 1 owl in Colorado, MLEA was sentenced to three years probation for six violations of the MBTA and seven violations of the BGEPA. In addition, MLEA paid a $50,000 fine, donated $50,000 to raptor conservation efforts, entered into a Memorandum of Understanding (MOU) with the USFWS, and developed a plan to reduce raptor electrocution risk on its facilities. The MLEA case brought heightened attention to raptor electrocution issues from both utilities and agencies. Prior to the MLEA case, fines had been levied against two electric utilities, one in 1993 and the other in 1998, for violations of the MBTA and BGEPA.

In 2005, APLIC and the USFWS published the voluntary Avian Protection Plan Guidelines (Guidelines) to aid utilities in developing programs, policies, and procedures to reduce bird mortality on power lines while enhancing service reliability (see Chapter 7 and Appendix C). Just as the Guidelines were developed in a cooperative manner, the creation of Avian Protection Plans (APPs) by individual utilities is intended to be voluntary but open to collaboration with the USFWS and other agencies.

INTERNATIONAL EFFORTS

Workshops

Avian interactions with power lines are global issues. In recent years, awareness of these issues has increased and several international avian conferences have dedicated special sessions to avian/power line interactions. In 1996, the Raptor Research Foundation organized the *2nd International Conference on Raptors* in Urbino, Italy. This conference was unique because it included a symposium on energy development with presentations on avian electrocutions from South Africa, Spain, Australia, Russia, and Italy. Papers were also presented on wind energy, bird collisions, and electric and magnetic fields.

In 1998, the *5th World Conference on Birds of Prey and Owls* was held in South Africa and included a session on the impacts of electrical utility structures on raptors. In 2001, the *4th Eurasian Congress on Raptors* was held in Seville, Spain, also with a special session on avian electrocutions. Presentations identified electrocution issues in Mexico, Russia, and Spain. Positive influences from nesting on utility structures were reported in Mongolia and Spain. A field trip was conducted to Doñana National Park where power lines have been retrofitted to prevent electrocutions of Spanish imperial eagles *(Aquila adalberti)*. In

2003, the *6th World Conference on Birds of Prey and Owls* was held in Hungary where papers on avian electrocutions were presented from the Slovak Republic, Bulgaria, and Hungary.

Addressing the Issue

The challenges faced outside the United States are often disparate. International distribution line construction often includes the use of grounded metal/concrete poles with metal crossarms that present a high electrocution risk to birds and can be difficult to retrofit. Additionally, some countries lack the resources to build power lines that minimize electrocution risks to birds, resulting in increased animal contacts and power outages. Like the United States, many countries have programs that range from being reactive to proactive, designed to address electrocutions.

A model program addressing avian electrocutions on power lines exists in South Africa, with a partnership between Eskom, the national electricity supplier, and the Endangered Wildlife Trust (EWT) (C.S. van Rooyen, pers. comm.). The partnership deals specifically with bird collisions, electrocutions, bird pollution and streamers, and nesting-caused electrical outages. The EWT acts as a consultant to the utility, focusing on reducing negative interactions between wildlife and electrical structures by systematically managing avian interaction problems. Eskom staff acts on the EWT's advice to address problems encountered in the course of everyday utility duties. A comprehensive research program is also supported that includes raptor electrocution risk assessments of existing power lines, investigations of faulting mechanisms, and the impacts of power lines on sensitive bird species. Several million dollars are invested annually into Eskom's combined research and mitigation programs. The partnership has also initiated programs in other parts of Africa that assist with impact assessments of new lines in Namibia and Botswana. Environmental personnel from other electrical utilities in the Southern African Development Community are being trained to establish other cooperative management initiatives in Africa.

Retrofitting power lines in Doñana National Park to prevent electrocutions of Spanish imperial eagles is one of Spain's conservation success stories. Between 1991 and 1999, high-risk power line towers were modified, considerably reducing the number of raptor electrocutions. The Spanish Government (Ministry for the Environment) is currently preparing a Royal Decree to establish protective measures to prevent bird collisions (A.C. Cardenal, pers. comm.). There are 17 local governments in Spain and most have cooperative agreements with their electric companies for reducing the impact of power lines on birds. Recovery plans for endangered species, such as Bonelli's eagle *(Hieraaetus fasciatus)* and bearded vulture *(Gypaetus barbatus)* include measures to mitigate interactions with power lines. Nearby, in the early 1990s, Portugal embarked on a program to deal with large numbers of white storks *(Ciconia ciconia)* on transmission towers by preventing nesting in dangerous areas and encouraging nesting on platforms carefully located on the towers ([illegible] A[illegible], pers. comm.).

In 2002, Germany responded to bird electrocutions by passing a Federal Nature Conservation Act to provide avian protection (D.G. Haas, pers. comm.). This regulation states, *"all newly erected power poles and technical structures in the medium voltage range have to be designed to protect birds. Power poles and technical hardware in the medium voltage range that are already in use and pose a high risk to birds are to be retrofitted to exclude electrocution as a threat within the next 10 years."* Raptor-friendly construction standards also have been published by NABU-German Society for Nature Conservation in *Suggested Practices for Bird Protection on Power Lines* (NABU 2002).

The brochure contains the technical standards necessary for avian-safe construction as well as mitigation measures for medium voltages. Although electrocutions do occur in the United Kingdom (J. Parry-Jones, pers. comm.) and northern Europe (K. Bevanger, pers. com.), less is known about their mitigation efforts.

Eastern European countries are also addressing avian electrocution risks. The State Nature Conservancy of the Slovak Republic is partnering with the three Slovakian energy companies to improve mitigation strategies and develop avian-safe configuration standards for new construction (M. Adamec, pers. comm.). The State Nature Conservancy also monitors power lines to help identify areas in need of proactive retrofitting, and is preparing a long-term strategy for Eastern Slovakia to retrofit all medium-voltage structures over the next 10 years. In Hungary, MME BirdLife-Hungary is working with utilities to identify and mitigate problems and to design safe utility configurations (I. Demeter, pers. comm.). Avian electrocution also is acknowledged as a serious problem in Bulgaria, with 50% of the country's poles posing a risk to raptors (S. Stoychev, pers. comm.). The Bulgarian Society for the Protection of Birds/BirdLife Bulgaria (BSPB) is addressing the issue. The BSPB is working with some of the Bulgarian electric companies, providing information on rare species' breeding and foraging grounds, migration routes, and possible solutions to reducing electrocution problems. Protective devices are being deployed as part of a pilot project to determine their effectiveness in reducing mortality and associated power outages. In 2004, the BSPB also implemented an electrocution study in several "Important Bird Areas" (IBAs).

Less is known about avian electrocution issues in Russia and Asia. In Russia, it has been reported that high-risk power lines exist and eagles have been electrocuted, especially in the Kazakhstan steppes and deserts. One report estimates that 10% of the USSR population of steppe eagles *(Aquila nipalensis)*, primarily juvenile or subadult birds, is electrocuted each year in the northern Caspian areas (V. Moseikin, pers. comm.). Given these reports, it is vital to determine the scope of the problem and develop cooperative strategies with the local power companies. Avian interactions with power lines have also been reported in Australia (B. Brown, pers. comm.) and New Zealand. Although Tasmania Hydro participated in the production of the *Raptors at Risk* electrocution video, little is known about the scope of the problem in Australia.

Except for Israel, the extent of avian electrocutions is relatively unknown in the Middle East. The Israel Birds of Prey Research and Conservation Project, the Israel Electric Corporation, the Israel Nature Reserves and Parks Authority, and the Society for the Protection of Nature in Israel work closely together to address electrocution issues (O. Bahat, pers. comm.). Through their efforts, electrocution "hot spots" have been identified and retrofitted, significantly reducing bird electrocutions while improving service reliability. Presently they are developing a Geographic Information System (GIS)-based program to avoid siting future lines in IBAs.

Little information is available about retrofitting efforts in Central and South America, although avian interactions with power lines have been documented in Brazil (P. Américo, pers. comm.).

THE OUTLOOK

Since the first edition of *Suggested Practices* in 1975, there has been considerable progress in identifying electrocution hazards and developing solutions. In the decade since the 1996 edition, utilities and resource agencies have made significant strides in communicating and collaborating on avian/power line issues. A product of this collaboration was the development of Avian Protection Plan Guidelines by APLIC and the USFWS in 2005 (Appendix C). The Guidelines, which are intended to help utilities develop their own APPs, focus on reducing bird mortality and improving power system reliability by identifying the key policies and practices to achieve these goals. Voluntary cooperation among electric utilities and agencies has improved communication and will benefit participants through reduced avian risk and enhanced power reliability.

As in 1996, avian mortality, particularly raptor mortality, continues to play an important role in federal land management decisions. Avian protection measures are often mandated as part of permitting and licensing requirements by most federal agencies in the United States, including the BLM, USFS and USFWS. In addition, the Federal Energy Regulatory Commission (FERC) routinely includes special articles mandating raptor protection on power lines in licenses for hydroelectric projects (FERC 1990).

Although utilities have worked for several decades to make lines on federal lands safe for raptor use, they now face an interesting challenge in areas with sage-grouse *(Centrocercus spp.)*, prairie chickens *(Tympanuchus spp.)*, mountain plovers *(Charadrius montanus)*, Utah prairie dogs *(Cynomys parvidens)*, and desert tortoises *(Gopherus agassizii)*. In some cases, land management agencies have requested that raptors and corvids be prevented from perching on power lines where these rare or endangered species are found (Figure 2.5). The goal of such efforts is to reduce predation, although the actual impact of raptors hunting from poles on populations of these species has not been adequately studied, quantified or verified. Utilities that attempt to discourage raptors from using portions of a power line, as well as agencies requiring such actions, should be aware of several important points: (1) perch discouragers are intended to move birds from an unsafe location to a safe location and do not *prevent* perching, (2) predation can occur regardless of the presence of a power line, (3) raptors and corvids prey upon mammalian predators of sage-grouse and prairie chickens, and (4) electrocution risk may be increased if perch discouragers are installed on long consecutive spans without providing alternative perch

FIGURE 2.5: Perch discouragers have been installed on utility poles to prevent raptors or corvids from preying upon sensitive species. However, this is not recommended, as perch discouragers are intended to manage where birds perch, not to entirely prevent perching.

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sites (because this may cause birds to perch on exposed pole-mounted equipment). Utilities and agencies should work together to identify predation risk to sensitive species that results from raptor and corvid use of poles; determine retrofitting methods that are appropriate, effective, and commensurate with the level of risk; and develop best management practices or guidelines.

As the human population grows and energy demands increase, new power lines will inevitably be built. Since overhead power lines will continue to be built in avian habitat, and because perching on power line structures involves some degree of risk, electrocutions will occur in the future. In addition, increasing populations of some avian species in North America, such as bald eagles, ospreys, monk parakeets, and some corvids, present utilities with a growing need to manage avian electrocutions or nests on power poles. Electrocution problems may be most severe on those continents that contain large, expanding human populations (Africa, South America, and Asia) (Bevanger 1994a). Raising global awareness of avian electrocution problems and solutions remains a priority and a challenge for conservation organizations. For utilities, the use of avian-safe designs and construction techniques (see Chapter 5) for distribution systems will help reduce future electrocution problems. Much retrofitting work also remains for existing high-risk lines worldwide.

This 2006 edition of *Suggested Practices* contains a new section on steel and concrete poles. These poles can pose serious electrocution hazards and are increasingly being used worldwide. In addition, a Spanish translation of *Suggested Practices* is intended to provide this resource to those in Spanish-speaking countries. The authors hope that *Suggested Practices* will continue to promote an awareness of avian interactions with power facilities and provide a range of electrocution prevention solutions that can be used throughout the world.

CHAPTER 3

Regulations and Compliance

IN THIS CHAPTER

Overview of Existing Laws
Permits

Three federal laws in the United States protect almost all native avian species and prohibit "taking," or killing, them. The Migratory Bird Treaty Act (MBTA) protects over 800 species of native, North American migratory birds. The Bald and Golden Eagle Protection Act (BGEPA) provides additional protection to both bald and golden eagles. The Endangered Species Act (ESA) applies to species that are federally listed as threatened or endangered. This chapter provides an overview of each of these laws and the permits that may be required for nest management, carcass salvage, or other bird management purposes.

OVERVIEW OF EXISTING LAWS

The **Migratory Bird Treaty Act** of 1918 (MBTA) (16 U.S.C. 703–712), which is administered by United States Fish and Wildlife Service (USFWS), is the legal cornerstone of migratory bird conservation and protection in the United States. The MBTA implements four treaties that provide international protection for migratory birds. It is a strict liability statute meaning that proof of intent is not required in the prosecution of a "taking"[12] violation. Most actions that result in *taking* or possessing (permanently or temporarily) a protected species can be violations.

The MBTA states: "Unless and except as permitted by regulations … it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill … possess, offer for sale, sell … purchase … ship, export, import … transport or cause to be transported … any migratory bird, any part, nest, or eggs of any such bird, or any product … composed in whole or in part, of any such bird or any part, nest, or egg thereof…"

A 1972 amendment to the MBTA provided legal protection to birds of prey (e.g., eagles, hawks, falcons, owls) and corvids (e.g., crows, ravens). The MBTA currently protects 836 migratory bird species, including waterfowl, shorebirds, seabirds, wading birds, raptors, and songbirds. Generally speaking, the MBTA protects all birds native to North America, and excludes house (English) sparrows (*Passer domesticus*), European starlings

[12] "Take" in this context means to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect.

(Sturnus vulgaris), rock doves (or common/feral pigeons, *Columba livia*), monk parakeets *(Myiopsitta monachus)*, any other species published in the Federal Register, and non-migratory upland game birds. The list of migratory bird species protected under the MBTA appears in Title 50 of the Code of Federal Regulations part 10.13 (50 CFR 10.13) and is available online at www.access.gpo.gov/nara/cfr/waisidx_03/50cfr10_03.html.

An individual who violates the MBTA by taking a migratory bird may be fined up to $15,000 and/or imprisoned for up to six months for a misdemeanor[13] violation. An individual who knowingly takes any migratory bird with the intent to sell, offer to sell, barter, or offer to barter such bird or who knowingly sells, offers for sale, barters, or offers to barter any migratory bird is subject to a felony violation with fines of up to $250,000 and/or imprisonment for up to two years.

Under the authority of the **Bald and Golden Eagle Protection Act** of 1940 (BGEPA) (16 U.S.C. 668–668d), bald *(Haliaeetus leucocephalus)* and golden *(Aquila chrysaetos)* eagles are given additional legal protection. *Take* under the BGEPA is defined as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." Violators of the Act's *take* provision may be fined up to $100,000 and/or imprisoned for up to one year. The BGEPA has additional provisions where, in the case of a second or subsequent conviction, penalties of up to $250,000 and/or two years imprisonment may be imposed.

The **Endangered Species Act** (ESA) (16 U.S.C. 1531–1544) was passed by Congress in 1973 to protect our nation's native plants and animals that were in danger of becoming extinct and to conserve their habitats. Federal agencies are directed to use their authority to conserve listed species, as well as "candidate"[14] species, and to ensure that their actions do not jeopardize the existence of these species. The law is administered by two agencies, (1) the USFWS and (2) the Commerce Department's National Marine Fisheries Service (NMFS). The USFWS has primary responsibility for terrestrial and freshwater organisms, while the NMFS has primary responsibility for marine life. These two agencies work with other agencies to plan or modify federal projects to minimize impacts on listed species and their habitats. Protection is also achieved through partnerships with the states, with federal financial assistance, and a system of incentives that encourage state participation. The USFWS also works with private landowners by providing financial and technical land management assistance for the benefit of listed and other protected species. To obtain a list of all federally listed (threatened and endangered) birds, or all federally listed animals and plants, consult 50 CFR parts 17.11 and 17.12. This list is available online at www.fws.gov/endangered/wildlife.html.

- Section 9 of the ESA makes it unlawful for a person to *take* a listed species. *Take* under the ESA is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The regulations define the term "harm" as "an act that actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." Unlike the MBTA and the BGEPA, the ESA authorizes the USFWS to issue permits for "incidental take" (*take* that results from an otherwise legal activity).

Section 10 of the ESA allows for "Habitat

[13] A *misdemeanor* is a crime that is punishable by less than one year imprisonment. A *felony* is a serious crime punishable by incarceration for more than a year.

[14] *Candidate* species are those which may be added to the list of threatened and endangered species in the near future.

Conservation Plans" for endangered species on private lands or for the maintenance of facilities on private lands. This provision helps private landowners incorporate conservation measures for listed species into their land and/or water development plans. Private landowners who develop and implement approved habitat conservation plans can receive incidental take permits that allow their development to proceed.

In addition to federal regulations, individual states may also have bird-protection regulations. A utility should consult with its respective state resource agency(ies) to determine what regulations apply and if permits are required.

Although the MBTA and BGEPA have no provision for allowing *take*, the USFWS realizes that some birds will be killed even if all reasonable measures to avoid it are used. The USFWS Office of Law Enforcement carries out its mission to protect migratory birds through investigations and enforcement, as well as by fostering relationships with individuals, companies, and industries that have programs to minimize their impacts on migratory birds. Since a *take* cannot be authorized, it is not possible to absolve individuals, companies, or agencies from liability even if they implement avian mortality avoidance or similar conservation measures. However, the Office of Law Enforcement does have enforcement discretion and focuses on those individuals, companies, or agencies that *take* migratory birds without regard for their actions and the law, especially when conservation measures had been developed but had not been implemented.

PERMITS

Federal and/or state permits may be required for activities related to species protected by the MBTA, BGEPA, ESA, or state laws. A utility should consult with resource agencies to determine if permits are required for operational activities that may impact protected avian species. Special Purpose or related permits are required for activities such as nest relocation, temporary possession, depredation, salvage/disposal, and scientific collection. Utilities are encouraged to contact their regional USFWS Migratory Bird Permit Office to identify permit requirements and obtain permit applications (See Avian Protection Plan Guidelines, Appendix C, for contact information). In addition, utilities should obtain information regarding state-required permits from their state's resource agency.

MIGRATORY BIRD PERMITS

USFWS regional offices administer permits for the following types of activities: falconry, raptor propagation, scientific collecting, rehabilitation, conservation education, migratory game bird propagation, salvage, take of depredating birds, taxidermy, and waterfowl sale and disposal. These offices also administer the permits authorized by the BGEPA.

The Division of Migratory Bird Management develops migratory bird permit policy and the permits themselves are issued by the regional Migratory Bird Permit Offices. The regulations governing migratory bird permits can be found in 50 CFR part 13, General Permit Procedures (www.access.gpo.gov/nara/cfr/waisidx_03/50cfr13_03.html), and 50 CFR part 21, Migratory Bird Permits (www.access.gpo.gov/nara/cfr/waisidx_03/50cfr21_03.html).

In 2003, the USFWS released a memorandum regarding the destruction of nests of species protected under the MBTA (see Appendix C or www.fws.gov/permits/mbpermits/PoliciesHandbooks/MBPM-2.nest.pdf). The memo clarified that the definition of *take* under the MBTA applies to active nests (containing eggs or young). The collection, possession, and transfer of possession of inactive bird nests are also illegal under the MBTA; however, the destruction of nests that do not contain eggs or birds is not illegal. This, however, **does not** apply to eagles or species listed under ESA, whose active and inactive nests may not be destroyed. The memo also stated that the USFWS may issue permits for the removal of occupied nests when public safety is at risk.

EAGLE PERMITS

Under the BGEPA, the USFWS issues permits to *take*, possess, and transport bald and golden eagles for scientific, educational, Native American religious purposes, depredation, and falconry (golden eagles). No permit authorizes the sale, purchase, barter, trade, importation, or exportation of eagles, eagle feathers, or any of their parts, nests, or eggs. The regulations governing eagle permits can be found in 50 CFR part 13, General Permit Procedures (www.access.gpo.gov/nara/cfr/waisidx_03/50cfr13_03.html) and 50 CFR part 22, Eagle Permits (www.access.gpo.gov/nara/cfr/waisidx_03/50cfr22_03.html).

ESA CONSULTATIONS/ HABITAT CONSERVATION PLANS

When power companies propose to construct power generation or transmission facilities or related equipment on federal lands, they must first consult with the USFWS through Section 7 of the ESA. Before initiating an action, the federal agency owning the land or its non-federal permit applicant (e.g., a power company), must ask the USFWS to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitats that may be present in the project area. The USFWS has developed a handbook describing the consultation process in detail, which is available at www.fws.gov/endangered/consultations.

When non-federal activities (activities not on federal lands and/or lacking a federal nexus such as federal funding or a federal permit) will *take* threatened or endangered species, an Incidental Take Permit (ITP) is required under Section 10 of the ESA. Some states may also have regulations that require permits or conservation plans. Approval of an ITP issued in conjunction with a Habitat Conservation Plan (HCP) requires the Secretary of Interior to find, after an opportunity for public comment, that among other things, the *taking* of ESA protected species will be incidental and that the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such *taking*. An HCP must accompany the application for an ITP. The HCP associated with the permit is to ensure that conservation measures are adequate for avoiding jeopardy to the species. Information about consultations and HCPs can be obtained from the nearest USFWS Ecological Services Field Office, generally located in each state. A list of those offices and their phone numbers can be accessed at www.fws.gov/info/pocketguide.

CHAPTER 4

Biological Aspects of Avian Electrocution

IN THIS CHAPTER

- Susceptibility of Different Birds to Electrocution
- Factors Influencing Electrocution Risk
- Identifying Evidence of Electrocution
- Scavenging Rates of Carcasses

Minimizing avian electrocutions requires an understanding of the biological, engineering, and environmental factors that influence risk. This chapter identifies the causes of bird electrocutions and focuses on the factors that predispose raptors to electrocution.

Bird electrocutions on power lines result from three interacting elements: biology, environment, and engineering. The biological and environmental components that influence electrocution risk include body size, habitat, prey, behavior, age, season, and weather.

- Body size is one of the most important characteristics that make certain species susceptible to electrocution. Outstretched wings or other body parts that span the distance between energized conductors make electrocution risk much greater for large birds; however, small birds can be electrocuted on closely spaced energized equipment such as transformers.
- Habitat is a key factor influencing avian use of poles. In open areas lacking natural perches, power poles provide sites for hunting, feeding, resting, roosting, or nesting.
- Habitats with abundant prey may also attract predatory birds.
- Territorial, nesting, and other behavioral characteristics may bring multiple birds to a pole, increasing electrocution risk.
- Young birds may be more susceptible to electrocution because they are inexperienced and less agile at taking off and landing on poles.
- Local changes in species distribution and abundance during breeding, migration, or wintering can result in a seasonal variation in electrocution rates.
- Wet weather can increase electrocution risk, as wet feathers are electrically more conductive than dry feathers.
- Finally, configurations with closely spaced energized phase conductors and grounded wires are more readily bridged by birds, causing electrocutions (see Chapter 5).

Of the 31 species of diurnal raptors and 19 species of owls that regularly breed in North America, 29 have been reported as electrocution victims. Electrocutions have also been reported in over 30 non-raptor North American species, including crows, ravens, magpies, jays, storks, herons, pelicans, gulls, woodpeckers, sparrows, kingbirds, thrushes, starlings, pigeons, and others.

SUSCEPTIBILITY OF DIFFERENT BIRDS TO ELECTROCUTION

RAPTORS

Accipiters

The three North American accipiters—sharp-shinned hawk *(Accipiter striatus)*, Cooper's hawk *(A. cooperii)*, and northern goshawk *(A. gentilis)*—typically inhabit forested areas. Because natural perches are abundant in these habitats, accipiters are more likely to perch in trees than on the exposed perches provided by electric transmission and distribution facilities. Consequently, forested habitats generally have fewer reported raptor electrocutions than do open habitats (Switzer 1977; Benson 1981). In a survey of over 70,000 power poles in various habitats throughout Utah and Wyoming, no electrocutions were found on the 2,500 poles surveyed in forested areas (PacifiCorp, unpubl. data).

Of 2,711 combined electrocution records from six studies (O'Neil 1988; Harness 1996; Idaho Power Co., unpubl. data; Harness and Wilson 2001; Dwyer 200[illegible]; USFWS/Nebraska, unpubl. data), 4 electrocutions were northern goshawks and 4 were Cooper's hawks. Of 40 radio-tagged Cooper's hawks in Arizona, 1 (a male) was electrocuted (Mannan et al. 2004). Northern goshawks accounted for <5% of raptor mortality in both Germany (*n*=567) and France (*n*=686) (Bayle 1999). In Spain, goshawks accounted for <10% of electrocutions in several studies: 0.4% of electrocutions documented by Ferrer et al. (1991) (*n*=233), 1.1% of electrocutions documented by Janss (2000) (*n*=467), and between 5% and 10% of electrocutions documented by Bayle (1999) (*n*=[illegible]282).

Buteos

Buteos comprise the largest non-eagle group of raptors that is electrocuted on power lines. In particular, red-tailed *(Buteo jamaicensis)*, ferruginous *(B. regalis)*, Swainson's *(B. swainsoni)*, and rough-legged *(B. lagopus)* hawks occur in open habitats and commonly perch on power poles and towers (Figure 4.1). Combined electrocution mortality of these four hawks has ranged between [illegible]% and 48% of reported electrocutions in a number of studies (e.g., Ansell and Smith 1980; Peacock 1980; Benson 1981; O'Neil 1988; PacifiCorp, unpubl. data; USFWS/Nebraska, unpubl. data). In

FIGURE 4.1: Ferruginous hawk taking off from a distribution pole.

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Utah and Wyoming, buteo electrocutions exceeded eagle electrocutions (21% vs. 19%; n=547) (Liguori and Burruss 2003). Red-tailed hawks were the most commonly electrocuted buteo in this study (7.5%), followed by Swainson's hawks (5.9%), ferruginous hawks (1.6%), and rough-legged hawks (0.2%). In Nebraska, red-tailed hawks accounted for 11% of electrocutions (n=199) from 1988 to 2003 (USFWS/Nebraska, unpubl. data). In addition, rough-legged hawks comprised 0.5% of electrocutions in this data set. Red-tailed hawks comprised 37% of avian mortalities (n=105) in northern California and southern Oregon from 2004 and 2005 (PacifiCorp, unpubl. data). In Chihuahua, Mexico, the red-tailed hawk was the second most frequently electrocuted species (after Chihuahuan raven *[Corvus cryptoleucus]*), accounting for 15% of mortalities (n=178) (Cartron et al. 2005).

Although these four buteos comprise a large proportion of electrocuted birds, their mortality rate due to electrocution is low compared to other causes of death and has ranged from 3% to 13% in a number of studies. For example, in an analysis of 163 red-tailed hawk carcasses, 4% died from electrocution (Franson et al. 1996). Electrocution was the cause of death for 13% of rough-legged hawks (n=8), 11% of ferruginous hawks (n=9), 3% of Swainson's hawks (n=37), and no red-tailed hawks (n=31) that were admitted to the Colorado State University Veterinary Teaching Hospital (Wendell et al. 2002). The low overall electrocution rate (3%) of birds in this study (n=409) was attributed to two factors: electrocuted birds are unlikely to survive, be detected, and brought to a rehabilitation facility; and, the frequency of electrocutions may be declining due to modification of power poles.

Electrocution records for other buteos are uncommon. Red-shouldered hawk *(Buteo lineatus)* electrocutions have been documented in Florida (J. Lindsay, pers. comm.) and California (M. Best, pers. comm.). Although documented, electrocution of the common black-hawk *(Buteogallus anthracinus)* is rare (Schnell 1980, 1994). The Harris' hawk *(Parabuteo unicinctus)* is a uniquely social raptor that resides in family groups of multiple individuals and commonly uses power poles (Bednarz 1995). Eight cases of electrocution were reported by Whaley (1986) in the Sonoran Desert of southern Arizona, but the author thought that additional electrocutions probably went unreported. In and near Tucson, Arizona, between 1991 and 1994, 63% of Harris' hawk mortalities with known causes (n=177) were due to electrocution (Dawson and Mannan 1994). Electrocution was suspected as the cause of death for an additional 44 carcasses. In 2003 and 2004, 75 electrocuted Harris' hawks were found in the metropolitan Tucson area, 29 of which were within 300 meters (m) (1,000 feet [ft]) of a nest (Dwyer 2004). Following the retrofitting of hazardous poles in this area, the electrocution rate per nest fell from 1.4 in 2003 to 0.2 in 2004.

Other Diurnal Raptors

Small diurnal raptors (e.g., American kestrel *(Falco sparverius)*, merlin *(F. columbarius)*, and most kites) with wingspans less than 102 centimeters (cm) (40 inches [in]) generally cannot span the distance between two electric conductors (see Figures 4.11, 4.12 and Table 4.1 for an illustration of avian wingspans). However, electrocution of smaller raptors may be underestimated since they are less noticeable than large birds and because scavengers may consume or remove them before they are found. Small raptors are probably more at risk on poles with transformers or other equipment where only inches of spacing exist between energized and grounded parts. Although uncommon, records of electrocutions do exist for smaller raptors, including American kestrels (Figure 4.2) (Ellis et al. 1978; Harness and Wilson 2001; Smallwood and Bird 2002; Wendell et al. 2002; Cartron et al. 2005; Idaho Power Co., unpubl. data; USFWS/Nebraska, unpubl. data; PacifiCorp, unpubl. data) and merlins (Bayle 1999). Of avian electrocutions identified by species in the western United States from 1986 to 1996 (*n*=555), 6 were American kestrels (Harness and Wilson 2001). Likewise, kestrels comprised 1.1% of mortalities in Utah and Wyoming from 2001 to 2002 (*n*=547) (Liguori and Burruss 2003). Merlins accounted for <5% of raptor mortalities in France (*n*=686) (Bayle 1999).

FIGURE 4.2: American kestrel with prey on wire.

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Few electrocution records are available for the large falcons. Despite their size and frequent use of power poles, electrocutions of peregrine *(F. peregrinus)* and prairie falcons *(F. mexicanus)* are rare. Two prairie falcons were documented out of 547 electrocutions in Utah and Wyoming from 2001 to 2002 (Liguori and Burruss 2003). Prior to this, very few prairie falcon electrocutions had been documented (Benson 1981; Harmata 1991; Harness and Wilson 2001; Idaho Power Company, unpubl. data). Electrocutions of peregrine falcons have been reported by Cade and Dague (1977), Burnham (1982), Cade (1985), McDonnell and Levesque (1987), Powell et al. (2002), White et al. (2002), and the State of Michigan (2005). Of avian electrocutions in the western United States from 1986 to 1996 (*n*=555), only 6 were peregrine falcons (Harness and Wilson 2001). Peregrine electrocutions have also occurred in low numbers in other countries, such as France, where <5% of raptor electrocutions (*n*=686) were peregrines (Bayle 1999) and South Africa, where peregrines accounted for 1.4% of electrocutions (*n*=147) from 1996 to 1998 (Kruger 2001a). Likewise, in Spain, peregrines have accounted for 0.4%, 0.9%, and <5% of electrocutions (*n*=233), (*n*=467) and (*n*=1,282) in studies conducted by Ferrer et al. (1991), Janss (2000), and Bayle (1999). An electrocution of a fledgling crested caracara *(Caracara cheriway)* from a nest in a substation was documented in Florida (J. Lindsay, pers. comm.). Although aplomado falcons *(F. femoralis)* may nest on power poles, electrocutions in the United States have not been documented. There is one record of a suspected aplomado falcon electrocution in Mexico (A. Montoya, pers. comm.). Records of electrocuted gyrfalcons *(F. rusticolus)* are rare and typically [illegible] of falconry birds rather than wild birds (Schindgren 1980; Harness and Wilson 2001; USFWS/Nebraska, unpubl. data).

Northern harriers *(Circus cyaneus)* are electrocuted infrequently as they rarely perch on poles, but some records exist (Williams and Colson 1989; APLIC 1996). In Germany, the hen harrier *(C. cyaneus)* accounted for <5% of raptor electrocutions (*n*=567) (Bayle 1999).

Although ospreys *(Pandion haliaetus)* commonly nest on power poles (see Chapter 6), electrocutions of this species are uncommon (Figure 4.3). Of Avian Power Line Interaction Committee (APLIC)-member utilities surveyed in 2005, several in the northwest and southeast noted osprey issues, particularly in regard to nest management (APLIC 2005). Poole and Agler (1987) reported that <4% of banded ospreys (n=451) recovered between 1972 and 1984 died from electrocution, collisions with power lines and TV/radio towers, and entanglements with fishing equipment. Of ospreys admitted to wildlife rehabilitation centers in Florida from 1988 to 1995, 9% (n=284) were electrocuted (Forrester and Spaulding 2003). Additional osprey electrocution mortalities have been documented by Dunstan (1967, 1968), Yager (1978), Fulton (1984), Williams and Colson (1989), Munoz-Pulido (1990), Harness (1996), Poole et al. (2002), State of Michigan (2005), and the Idaho Power Company (unpubl. data). In the western United States, 11 electrocutions identified to species (n=555) from 1986 to 1996 were ospreys (Harness and Wilson 2001). In France, ospreys accounted for <5% of raptor mortalities (n=[illegible]86) (Bayle 1999).

Osprey populations have increased in parts of their North American range over the past few decades (Sauer et al. 2004). Growing osprey populations in Canada have been attributed to the provision of artificial nest platforms, increased survey efforts, and the ban of DDT (Kirk and Hyslop 1997). In the Willamette Valley of Oregon, where the number of nesting ospreys has more than doubled in six years from the late 1990s to the early 2000s, most nests are located on distribution poles or adjacent nest platforms (Henny et al. 2003; USGS 2003). Osprey populations in the Chesapeake Bay area more than doubled from the 1970s to the mid-1990s as the use of man-made nesting substrates, particularly navigational markers, had also increased (Watts et al. 2004). In this region, 68% of osprey nests were located on man-made structures during the 1970s, as compared to 93% in the 1990s. Types of man-made structures used during the 1990s included navigational aids (53.5%), nesting platforms (12.1%), duck blinds (9.7%), and other man-made structures (17.6%; including boat houses, chimneys, docks, ships, electrical power poles, bridges, cell phone towers, and pilings). In New Jersey, the number of osprey pairs increased from 68 in 1975 to over 200 in the mid-1980s to 340 in 2001 (Liguori 2005). Many of these nests are located on platforms in coastal marshes.

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FIGURE 4.3: Osprey.

Eagles

The proportion of golden eagles (*Aquila chrysaetos*) electrocuted has ranged dramatically among various studies conducted over the past three decades (Figure 4.4). Electrocution research from the 1970s focused on causes of eagle mortality, which may account for high proportions of golden eagles documented in these studies. For example, golden eagles comprised between 89% and 93% of electrocutions documented by Olendorff (1972a), Smith and Murphy (1972), and Boeker and Nickerson (1975). Recent electrocution studies have documented much smaller proportions of golden eagles. Golden eagles comprised 17% of electrocutions in Utah and Wyoming (n=547) and 5% of electrocutions in Oregon

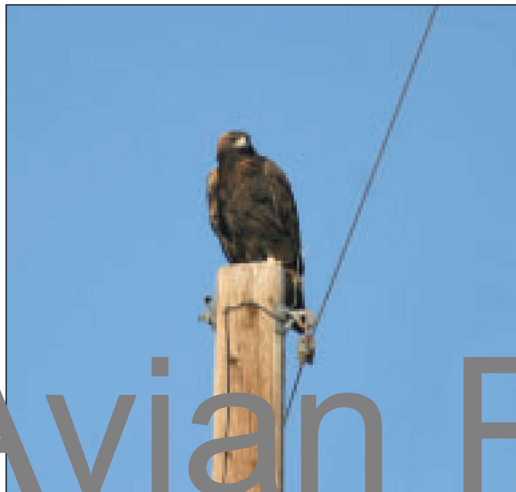

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FIGURE 4.4: Golden eagle perched on pole top.

and California (*n*=103) discovered during systematic line surveys that investigated electrocutions of all avian species (Liguori and Burruss 2003; PacifiCorp, unpubl. data). Data gathered from utilities in the western United States from 1986 to 1996 documented 748 eagles out of 1,428 electrocution records (Harness and Wilson 2001). Of these eagles, 36% were golden eagles, 16% were bald eagles (*Haliaeetus leucocephalus*), and 48% were unidentified eagles.

Bald eagle electrocutions are less common than golden eagle electrocutions. In Idaho, bald eagles comprised 2% (*n*=91) and 5% (*n*=133) of electrocutions (Ansell and Smith 1980; Peacock 1980). In Colorado, 5% of electrocutions (*n*=300) were bald eagles (Boeker 1972). Likewise, bald eagles comprised 5% of all avian electrocutions (*n*=103) documented in Oregon and California in 2004 and 2005 (PacifiCorp, unpubl. data). In Utah and Wyoming, <1% of electrocutions (*n*=547) were bald eagles (Liguori and Burruss 2003). Of bald eagles admitted to wildlife rehabilitation centers in Florida from 1988 to 1994, 6% (*n*=274) were electrocuted (Forrester and Spaulding 2003).

Although electrocution has been documented as a cause of mortality for golden eagles for several decades, the frequency of eagle electrocutions may be declining, likely due to utilities' efforts to prevent electrocutions. From 1980 to 1984, 80% of golden eagles found along power lines in the western United States with known causes of death (*n*=375) died from electrocution (Phillips 1986). From the early 1960s to the mid-1990s, electrocution accounted for 25% of golden eagle deaths in North America (Kochert and Steenhof 2002). More recently, electrocution was documented as the cause of death in 16% of golden eagles radio-tagged and recovered (*n*=61) from 1994 to 1997 in California (Predatory Bird Research Group 1999). Despite increased detection efforts, the number of eagle electrocutions documented by PacifiCorp (unpubl. data) in western states has declined by 22% from the early 1990s to the early 2000s. Of APLIC-member utilities surveyed in 2005 (*n*=13), only 3[illegible]% cited eagles as species at issue in their area (APLIC 2005).

Owls

The great horned owl *(Bubo virginianus)* is the most commonly electrocuted owl in North America (Figure 4.5). In the western United States, 95% of electrocuted owl species identified (*n*=91) from 1986 to 1996 were great horned owls (Harness and Wilson 2001). Likewise, great horned owls accounted for 90% of owl electrocutions (*n*=20) in Utah and Wyoming in 2001 and 2002 (Liguori and Burruss 2003). Although great horned owls comprise the majority of owl electrocutions, mortalities of this species are often low in comparison to many diurnal species. Low numbers of great horned owls in electrocution records were reported by Stewart (1969), Houston (1978), Benson (1981), and Harmata (1991). Great horned owls accounted for 4% of mortalities (*n*=113) in

Idaho between 1972 and 1979 (Ansell and Smith 1980). Some studies have documented higher percentages of great horned owls in electrocution records. For example, of the species identified, great horned owls accounted for 15% of avian electrocutions (*n*=555) in the western United States from 1986 to 1996 (Harness and Wilson 2001), 20% of electrocutions (*n*=61) in Montana from 1980 to 198[illegible] (O'Neil 1988), and 33% of electrocutions (*n*=210) in Nebraska from 1988 to 2003 (USFWS/Nebraska unpubl. data). Of APLIC-member utilities surveyed (*n*=13), 69% noted electrocutions of owls, with [illegible]4% specifically listing great horned owls as one of the species most frequently electrocuted in their areas (APLIC 2005). Electrocution was the cause of death in <[illegible]% of great horned owl mortalities (*n*=207) in Saskatchewan (Gillard 1977). Likewise, 2% of great horned owls admitted to wildlife rehabilitation centers in Florida from 1988 to 1995 (*n*=174) were electrocuted (Forrester and Spaulding 2003). Electrocution accounted for [illegible]% to 7% of great horned owl mortalities evaluated in Colorado from 199[illegible] to 199[illegible] (*n*=[illegible]5) (Wendell et al. 2002) and by the National Wildlife Health Center from 1975 to 1993 (*n*=132) (Franson and Little 1996).

In North America, the barn owl *(Tyto alba)* is the second most frequently electrocuted owl. Barn owls accounted for 10% of owl electrocutions (*n*=20) in Utah and Wyoming from 2001 to 2002 (Liguori and Burruss 2003). Barn owl electrocutions have also been documented by Williams and Colson (1989), Harness and Wilson (2001), and USFWS/Nebraska (unpubl. data). In an assessment of barn owls in the northeastern United States, electrocution was noted as a cause of mortality, yet was not considered a population limiting factor (Blodget 1989). In Hawaii, 1% of barn owls evaluated for cause of death from 1992 to 1994 (*n*=81) was killed by electrocution (Work and Hale 1996). Of barn owls admitted to wildlife rehabilitation centers in Florida from 1988 to 1995, 5% (*n*=63) were electrocuted (Forrester and Spaulding 2003).

FIGURE 4.5: Great horned owl nest on transformer bank.

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Barn owl electrocutions are not limited to North America. Of marked and recovered barn owls (*n*=[illegible]71) in England, 5.8% died of electrocution (Meek et al. 2003). In a study of barn owl carcasses (*n*=627) in Britain from 1963 to 1989, electrocution was documented as the cause of death in <1% of birds (Newton et al. 1991). Barn owls comprised <5% of raptor electrocutions in Germany (*n*=567) and between 5% and 10% of mortalities in France (*n*=686) (Bayle 1999). In Spain, barn owls comprised 3% of electrocutions (*n*=233) documented by Ferrer et al. (1991) and <5% of raptor electrocutions (*n*=1,282) documented by Bayle (1999). In South Africa, barn owls accounted for 6% of electrocutions (*n*=147) documented from 1996 to 1998 (Kruger 2001a).

Electrocution records of other North American owls are rare. Much like accipiters, many owl species inhabit forested areas and infrequently perch on power poles. No records were found for spotted owl *(Strix occidentalis)*. Barred owl *(S. varia)* electrocutions have been documented on transformer poles in Washington (M. Walters, pers. comm.). In Florida, 1.2% of barred owls admitted to wildlife rehabilitation centers from 1988 to 1995 (*n*=330) were electrocuted (Forrester and Spalding 2003). Bull and Duncan (1993) cite electrocution as a cause of mortality for a great gray owl *(S. nebulosa)*. Electrocutions of this species are probably uncommon, as <1% of electrocution records (*n*=301) reported for four western states were great gray owls (Harness 1996). Records of other forest owls are also rare, although electrocution has been documented in the eastern screech-owl *(Otus asio)* (APLIC 1996, 2005), western screech-owl *(O. kennicottii)* (Harness 1996; Harness and Wilson 2001; APLIC 2005), and long-eared owl *(Asio otus)* (APLIC 1996). Harness and Wilson (2001) documented [illegible] western screech-owls among avian species electrocuted (*n*=555) in the western United States from 1986 to 1996. Of eastern screech-owls admitted to wildlife rehabilitation centers in Florida from 1988 to 1995 (*n*=1,319), <1% was electrocuted (Forrester and Spalding 2003). In Germany (*n*=567) and France (*n*=686), <5% of raptor electrocutions were long-eared owls (Bayle 1999). Electrocution records for snowy owls *(Nyctea scandiaca)* are also uncommon (Parmalee 1972; Gillard 1977; Williams and Colson 1989; Parmalee 1992). Smith and Ellis (1989) list electrocution as a cause of death for snowy owls, yet do not quantify electrocution rates for this species. Snowy owls are found primarily in arctic regions lacking utility structures, yet birds that winter in less remote areas of the northern United States and southern Canada may encounter power lines. Electrocution was the cause of death in 5.6% of snowy owls (*n*=71) wintering in Alberta, Canada (Kerlinger and Lein 1988).

Like the snowy owl, the burrowing owl *(Athene cunicularia)* and short-eared owl *(Asio flammeus)* nest and perch on the ground and, consequently, are unlikely to be electrocuted. There are no known electrocution records for the burrowing owl. Electrocution records of short-eared owls are uncommon (Williams and Colson 1989; APLIC 1996; Harness 1997; Harness and Wilson 2001; Cartron et al. 2005). In France, <5% of raptor electrocutions (*n*=686) were short-eared owls (Bayle 1999).

VULTURES/CONDOR

Despite their large size, electrocution records for North American vultures and California condors *(Gymnogyps californianus)* are not as common as buteo and eagle electrocutions. As of 2005, 6% of California condors (*n*=144) that have been released into the wild since 1992 were killed by electrocution (Energy and Environmental Economics, Inc. 2005). Power line collisions have been a greater threat to California condors than electrocutions. Prior to the release of hacked condors, the birds undergo power pole aversion training where they are offered natural snags and simulated power poles (Snyder and Schmitt 2002). If they perch on a simulated power pole, they receive a mild shock.

Electrocutions of vultures are also uncommon, with turkey vultures *(Cathartes aura)* accounting for only 2% of electrocutions (*n*=210) in Nebraska from 1988 to 2003 (USFWS/Nebraska, unpubl. data), 2% of electrocutions (*n*=113) in Arizona from 2003 to 2004 (Dwyer 2004), and 2% of electrocutions (*n*=51) in northern California from 2001 to 2004 (PacifiCorp, unpubl. data). In the western United States, vultures accounted for 1% of electrocutions (*n*=1,428) from 1986 to 1996 (Harness and Wilson

2001). Hallinan (1922) described turkey vulture electrocutions on three-phase, 13-kV lines with metal crossarms in Florida. In southern Florida, 14 confirmed electrocutions of both turkey and black *(Coragyps atratus)* vultures were documented over a six-year period (J. Lindsay, pers. comm.). Electrocutions of turkey vultures have also been reported in Chihuahua, Mexico (Cartron et al. 2005). Turkey vulture/power line interactions, including electrocutions, were noted by Williams and Colson (1989). Both black and turkey vulture electrocutions were documented in Texas (Harness 1997).

Electrocutions of Old World vultures are much more common. In South Africa, 42% of avian electrocution records from April 1996 to November 2005 (*n*=1,0[illegible]8) were vultures (C.S. van Rooyen, unpubl. data). The large wingspans (up to 2.7 m [8.9 ft]) of these species, coupled with their behavior of perching together on a pole, accounts for this elevated electrocution risk (C.S. van Rooyen, pers. comm.).

WATERBIRDS

Electrocutions of waterbirds, such as storks, egrets, herons, ibises, pelicans, and gulls, may occur in areas where such birds perch on poles that do not provide sufficient spacing to accommodate their relatively large wingspans and/or heights (see Figures 4.12, 4.13 and Table 4.1). Although avian-safe construction and retrofitting can protect most waterbird species, increased vertical separation may be needed to accommodate their taller heights. Like other birds, waterbirds may be electrocuted as they fly into lines mid-span and touch two conductors (Lano 1927; Pomeroy 1978; PacifiCorp, unpubl. data).

Storks have large wingspans (approx. 1.5 m [5 ft]) and measure approximately 102 cm (40 in) from head to foot. The wood stork *(Mycteria americana)* occurs in the southeastern United States and is currently (2006) listed as endangered under the Endangered Species Act. Wood stork electrocutions may result from power line collisions or from contacts on power poles (Forrester and Spaulding 2003; J. Newman, pers. comm.). Electrocutions of other storks have been documented outside of North America (Pomeroy 1978; Haas 1980; Bevanger 1998; Janss 2000). In Spain, the white stork *(Ciconia ciconia)* was the second most commonly electrocuted species, accounting for 13.3% of mortalities (*n*=279) (Janss and Ferrer 1999). White storks also accounted for 6% of avian electrocutions (*n*=1[illegible]0) in southeastern France (Bayle 1999).

The great blue heron *(Ardea herodias)*, which is commonly found throughout much of sub-arctic North America, has been documented in electrocution records from numerous states (Lano 1927; O'Neil 1988; Harness 1997; Forrester and Spaulding 2003; PacifiCorp, unpubl. data). Great blue herons accounted for 3% of electrocutions (*n*=61) in Montana from 1980 to 1985 (O'Neil 1988). Roseate spoonbill *(Ajaia ajaja)* electrocutions, likely associated with power line collisions, have been identified (Forrester and Spaulding 2003; J. Roberts, pers. comm.). Electrocutions of egrets and herons have been documented outside of North America (Pomeroy 1978). Ciconiiformes, including white stork and cattle egret *(Bubulcus ibis)* accounted for nearly 10% of avian electrocutions (*n*=600) in southwestern Spain from 1990 to 1994 (Janss and Ferrer 2001).

Line investigations and avian surveys near Port Arthur, Texas, revealed that a variety of wading and shoreline birds were killed by electrocution and/or line strikes (J. Roberts, pers. comm.). Roseate spoonbills were impacted more severely than other waterbirds, with over 40 individuals killed in two years. Other birds killed or injured by lines in this area include cattle egrets, snowy egrets *(Egretta thula)*, and neotropic cormorants *(Phalacrocorax brasilianus)*. Preliminary results from an ongoing study suggest that many of the apparent collision deaths or injuries were juvenile birds with poor flight ability. However, carcass examination has indicated that some of the birds were electrocuted.

Gull electrocutions are uncommon but have been documented (Bevanger 1998). Harness (1997) reported electrocutions of 4 Franklin's gulls *(Larus pipixcan)* in a survey of electrocutions in the western United States from 1986 to 1996. In Alaska, gulls represented 3.4% of mortality records (n=264) from 2000 to 2004 (USFWS/Alaska, unpubl. data). PacifiCorp (unpubl. data) has documented gull electrocutions on poles with transformers in the western United States. Dickinson (1957) noted electrocutions of gulls at a landfill in North Carolina. In southeast France, 3% of avian electrocutions (n=100) were gulls and terns (Bayle 1999). In addition, of both electrocutions and collisions in this same region, 16% were gulls and terns, 43% were herons, and 4% were greater flamingos *(Phoenicopterus ruber)*.

Electrocutions have been reported for both sandhill cranes *(Grus canadensis)* (Harness 1997; Forrester and Spaulding 2003) and whooping cranes *(G. americana)* (Forrester and Spaulding 2003), although these are likely to have occurred as a result of mid-span collisions. Of 115 radio-tagged whooping cranes that died or disappeared between 1993 and 1999, 4.3% were electrocuted as a result of power line collisions (Forrester and Spaulding 2003). Although the North American cranes are not likely to perch on utility structures, grey crowned cranes *(Balearica regulorum)* in South Africa do perch on poles and have been electrocuted (C.S. van Rooyen, pers. comm.).

Electrocutions of brown pelicans *(Pelecanus occidentalis)* have been documented in the United States (Harness 1997; Forrester and Spaulding 2003; APLIC 2005; J. Roberts, pers. comm.). Along the Gulf Coast where large concentrations of brown pelicans occur, numerous electrocutions have been documented (J. Roberts, pers. comm.). These electrocutions occurred when young birds congregated on power lines near fish camps and caused the line to sag, allowing the birds to contact the neutral wire. The neutral wire was removed and there have not been any electrocutions since. In Georgia, an American coot *(Fulica americana)* was found inside a substation, where it was suspected to have been electrocuted as a result of contact with equipment (B. Estes, pers. comm.).

CORVIDS

Not long ago, crows, ravens, and magpies were considered pests for which some states offered bounties. The Migratory Bird Treaty Act (MBTA) of 1918 did not offer protection to corvids and birds of prey until amended in 1972. In recent years, there has been an increasing awareness that corvids are protected under the MBTA, and that they can have considerable impacts on power reliability, particularly in agricultural or suburban areas where their populations are increasing. Corvid electrocutions have received less attention than raptor electrocutions, therefore, less is known about corvid electrocution rates. Because of their large size and frequent use of power poles, ravens are likely electrocuted more often than currently documented. Although corvid mortality is unlikely to have population impacts, their electrocutions and nests can affect power reliability (Figure 4.6).

Corvid electrocutions were reported in 1921, when electrocutions of crows were documented in Florida (Hallinan 1922). Dickinson (1957) noted that crows nested on poles in North Dakota, causing faults on the line, particularly during wet weather.[15] In Montana, common ravens *(Corvus corax)*

[15] Carvings of kingbirds were mounted on the power line to deter the crows from nesting. The discouragers were considered effective, as the crows stopped building nests on the poles.

accounted for 2% of electrocution records (n=61) (O'Neil 1988).

Recent studies show an increased number of corvids in electrocution records, possibly due to enhanced reporting, increasing numbers of utility structures and/or increasing populations of some corvid species. Bridges and Lopez (1995), Harness (1997), and Boarman and Heinrich (1999) cite electrocution as a cause of death for the common raven. Common ravens were the most frequently electrocuted species in Utah and Wyoming, occurring in greater numbers than eagles and buteos and accounting for 32% of mortality (n=547) (Liguori and Burruss 2003). American (black-billed) magpies *(Pica hudsonia)* also accounted for [illegible]% of electrocutions documented in this study. Likewise, 2% of mortalities in northern California and southern Oregon from [illegible]004 to 2005 (n=103) were magpies (PacifiCorp, unpubl. data). In a survey of 3,120 poles in Colorado, corvids accounted for 7% of mortality (Harness 2001). Of 156 electrocutions in Arizona, 4% were common ravens (Dwyer 2004). Ravens accounted for approximately 40% of electrocution records for one Arizona utility (P. Jelen, pers. comm.). In Chihuahua, Mexico, the Chihuahuan raven was the most frequently electrocuted species, accounting for [illegible]9% of mortalities (n=[illegible]78) (Cartron et al. 2005). In Arkansas and Louisiana, reports of American crow *(C. brachyrhynchos)* electrocutions have been rare, although dead crows have been observed in substations on four occasions (J. Roberts, pers. comm.). The deceased crows were found in groups of two to five and the circumstances of the electrocutions have not been determined. Although uncommon, electrocutions of jays have also been documented (PacifiCorp, unpubl. data). Of APLIC-member utilities surveyed that report mortalities of all protected species (n=10), 50% listed corvids as birds of issue in their area, and 30% cited crows and ravens as the birds most frequently electrocuted in their area (APLIC 2005).

FIGURE 4.6: Common raven nest on wishbone configuration.

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Corvid electrocutions are not limited to North America (Bevanger 1998). In Spain, common ravens comprised 10% to 25% of electrocutions (n=279, Janss and Ferrer 1999; n=4[illegible]7, Janss 2000). Common raven and jackdaw *(C. monedula)* together accounted for approximately one-quarter (16% and 10.2%, respectively) of avian mortalities (n=600) found in southwestern Spain from 1990 to 1994 (Janss and Ferrer 2001). In southeast France, corvids accounted for 45% of avian electrocutions (n=100) (Bayle 1999). Corvid electrocutions are considered fairly common in South Africa (C.S. van Rooyen, pers. comm.).

SONGBIRDS AND OTHER SMALL BIRDS

Although often overlooked, electrocutions of passerines (songbirds) have been documented throughout the 1900s. Electrocution of purple martins *(Progne subis)* flocking on power lines was noted during the early twentieth century (Anderson 1933). Loggerhead shrikes *(Lanius ludovicianus)* were electrocuted in Florida when they attempted to impale prey on tie wires (Hallinan 1922). An electrocuted Baltimore oriole (*Icterus galbula*) was reported in Ohio during the 1950s (Dexter 1953). In India, rose-ringed parakeets (*Psittacula krameri*) were electrocuted when they bridged two closely spaced conductors (Dilger 1954). Their habit of climbing poles by clinging to different wires with their feet and bills made them more vulnerable to electrocution than are other small birds. Interestingly, Dilger also noted that large fruit bats, *Pteropus*, were killed on these poles as well.

Reports of songbird electrocutions are becoming more common as utilities, agencies, and the public become increasingly aware of the interactions of small birds with power lines. Records of such electrocutions, often associated with power outages, involve species such as starlings, woodpeckers, jays (mentioned with Corvids), robins, pigeons, doves, kingbirds, thrushes, shrikes, sparrows, swallows, orioles, and blackbirds (Bevanger 1998; Michigan Dept. Natural Resources 2004; APLIC 2005; PacifiCorp unpubl. data) (Figure 4.7). Although infrequent, some outages result from domestic species or pets not protected by the MBTA (PacifiCorp, unpubl. data).

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FIGURE 4.7: Western kingbird perched on power line.

In some circumstances, songbirds can cause outages when large flocks take off at once, causing lines to gallop or slap together. In Mexico, roosts of purple martins can be so large that they break electrical wires (Brown 1997). Perched flocks of small birds may span from phase to phase or ground, causing an electrical current to pass through multiple individuals. This can result in outages and electrocutions. Individual small birds may not be at risk of conductor-to-conductor contact, yet may be vulnerable to electrocution on transformers or other exposed equipment where separations between energized and grounded hardware are considerably less. On poles where protective coverings have been installed on transformer bushings, arresters, or insulators, insectivorous birds may attempt to glean insects from inside the covers.

MONK PARAKEET

Monk parakeets (*Myiopsitta monachus*) were brought to the United States from South America beginning in the late 1960s to be sold as pets. Escaped birds have since established populations throughout much of the United States and their numbers continue to grow (Pruett-Jones et al. 2005). Monk parakeets build nests in urban and suburban areas in trees and on electric utility structures (Figure 4.8; also see Chapter 6). Fires and outages can occur when monk parakeet

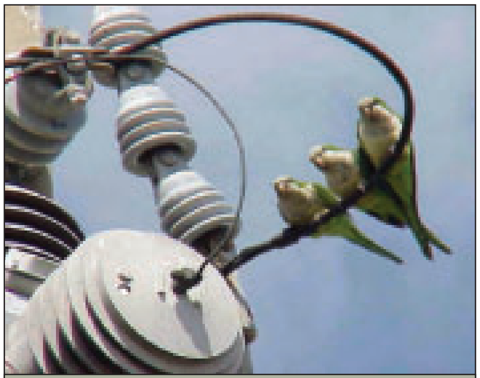

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FIGURE 4.8: Monk parakeets.

nesting material comes in contact with energized parts, or from the nesting activity of the birds themselves. Monk parakeets continually maintain their nests and, consequently, individuals have been electrocuted when attempting to weave nesting material (i.e. twigs) into the nest (J. Lindsay, pers. comm.). In addition to posing outage and fire risks, monk parakeet nests on utility structures attract predators and trespassing pet-trade trappers, potentially resulting in electrocutions of both birds and humans (Newman et al. 2004).

FACTORS INFLUENCING ELECTROCUTION RISK

AVIAN USE OF POLES

Raptors, waterbirds and small birds use power poles for hunting, resting, roosting and nesting—particularly in habitats where trees, cliffs, or other natural substrates are scarce (Figure 4.9). For waterbirds, power poles and lines can provide sites to perch while drying their feathers. Eagles and other raptors tend to use "preferred poles" that facilitate hunting success. Still-hunting conserves energy, provided suitable habitat for prey is within view. Preferred poles typically provide elevation above the surrounding terrain, a wide field of view, and easy take-off (Boeker 1972; Boeker and Nickerson 1975; Nelson and Nelson 1976, 1977; Benson 1981). When the design of a preferred pole is not avian-safe, multiple electrocutions can occur. Researchers have found up to a dozen eagle carcasses or skeletons under a single pole (Dickinson 1957; Benton and Dickinson 1966; Edwards 1969; Olendorff 1972; Nelson and Nelson 1976, 1977; Mañosa 2001).

Benson (1981) confirmed that the height of a perch above the surrounding terrain was important to the frequency of eagle electrocutions. Since pole height generally varies only 1.2 to 3 m (4 to 10 ft), there was no significant difference in the heights of poles with or without electrocuted eagles. However, poles that provided the greatest height above the surrounding terrain, e.g., those on bluffs and knolls, had a higher probability of causing electrocutions.

Habitat diversity plays an important part in pole preference. In one study (Pearson 1979), raptors used poles in heterogeneous environments more often than those in homogeneous environments. In fact, increased habitat diversity is only an indirect cause of increased use. A more direct cause is the increase in prey types and density of prey typical of greater habitat diversity. Eagles and other raptors spend more time hunting in areas that offer a greater chance of a successful capture. It is reasonable to expect that one pole will receive no more use than the next in uniform habitats, other factors notwithstanding (Ansell and Smith 1980). The "preferred pole" concept, therefore, may not apply when addressing an electrocution problem in homogeneous habitats or "preferred areas."

Choice of prey can also influence electrocution risk. Benson (1981) found highly significant differences both in eagle use and

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FIGURE 4.9: In open habitats with few natural alternatives, power poles can provide perching, nesting, hunting, or roosting sites for raptors and other birds.

eagle mortalities along electric distribution lines in agricultural versus non-agricultural areas in six western states. More use and mortality occurred in native shrublands, primarily because of variations in rabbit distribution and availability. In particular, more golden eagles were electrocuted where cottontails (*Sylvilagus* spp.) occurred than where only jackrabbits (*Lepus* spp.) occurred. In jackrabbit habitat, about 14% of poles had raptor carcasses under them, compared to nearly 37% in cottontail habitat. Where both cottontails and jackrabbits were present, about [illegible]% of poles had raptor carcasses under them. The most lethal 25% of lines studied were in sagebrush-dominated areas where both types of rabbits occurred in large numbers. No correlation was found in this study between rodent population densities and the incidence of raptor electrocutions.

Other studies have also documented a correlation between prey populations and raptor electrocution risk. The attraction of eagles to areas with high rabbit populations and increased electrocution risk was noted by Olendorff (1972a) near the Pawnee National Grassland in Colorado. Kochert (1980) concluded that the incidence of eagle electrocutions in the Snake River Birds of Prey Area in southwestern Idaho was a function of mid-winter eagle density that was in turn strongly related to the density of jackrabbits. The highest densities of jackrabbits in southwestern Idaho occur in native shrublands (Smith and Nydegger 1985); accordingly, more eagles were electrocuted in such habitats.

In the Butte Valley of northern California, irrigated agricultural fields support ground squirrels and other small mammals that, in turn, attract large numbers of raptors. In these habitats, particularly on dead-end poles with transformers lacking avian protection, raptors are at risk of electrocution. Prior to extensive retrofitting efforts in this region, numerous eagles, hawks, and owls had been electrocuted (PacifiCorp, unpubl. data).

Concentrations of wintering raptors, including ferruginous hawks and golden eagles, are attracted to the continent's largest prairie dog complex in Chihuahua, Mexico, where numerous birds had been electrocuted prior to retrofitting efforts (Manzano-Fischer 2004; Cartron et al. 2005).

In Alaska, an abundance of food sources from municipal waste facilities, canneries, and fish cleaning stations attract bald eagles that have been electrocuted on nearby power poles (Harness 2004).

Research on the proximity of nesting bald eagles to human activity in Florida suggest that fledging eagles from "suburban" nest sites have a higher risk of mortality from human activities, including electrocution, than do their "rural" counterparts (Millsap et al. 2004).

Agricultural areas attract pigeons, blackbirds, and starlings. Large flocks of these birds perching on wires can weigh down conductors, causing lines to gallop when they flush. As with raptors, these smaller species are vulnerable to electrocution on transformer poles, and related outages can disrupt farming activities.

SIZE

Birds with large wingspans, such as eagles, may bridge the distance between conductors on horizontal crossarms, while tall birds, such as herons or storks, may simultaneously contact different conductors on poles with vertical construction. Golden eagles have large wingspans, ranging from 1.8 to 2.3 m (6 to 7.5 ft) (Figure 4.10, Table 4.1). The height of a golden eagle ranges from 46 to 66 cm (18 to 26 in) from head to foot. Bald eagles are similar in size to golden eagles, with wingspans ranging from 1.7 to 2.4 m (5.5 to 8 ft) and heights ranging from 46 to 71 cm (18 to 28 in). As with most other raptors, female eagles are larger than males.

Because dry feathers provide insulation, birds must typically contact electrical equipment with conductive fleshy parts for electrocution to occur. Fleshy parts include the feet, mouth, bill, and the wrists from which the primary feathers originate. For a large golden eagle with a 2.3-m (7.5-ft) wingspan, the distance from the fleshy tip of one wrist to the tip of the other can measure 107 cm (42 in). These distances are important when considering phase-to-phase or phase-to-ground separations of power lines and the susceptibility of eagles to electrocution (see Chapter 5).

The 150-cm (60-in) standard for separation between energized and/or grounded parts is intended to allow sufficient clearance for an eagle's wrist-to-wrist span (APLIC 1996; see Chapter 5). Applying this standard will also protect birds with wingspans smaller than eagles, (see Table 4.1 and Figures 4.10, 4.11, 4.12). In areas where eagles do not occur, a standard of 102 cm (40 in) may provide adequate separation for raptors other than eagles. In areas with condors, a 150-cm (60-in) separation may not be adequate. The wingspans of California condors range from 2.5 to 3 m (8.2 to 9.8 ft)[16] and condors measure 120 to 130 cm (46 to 53 in) in height (Snyder and Schmitt 2002; Wheeler 2003). Utilities in areas with condors should consider the large size of this endangered species when designing or retrofitting power lines.

"60 inches"...Where Did It Come From?

The 1981 edition of *Suggested Practices* recommended 150 cm (60 in) of separation to provide adequate space for a large eagle with a wrist-to-wrist distance of 140 cm (54 in). This measurement was calculated by subtracting the lengths of the outer primary feathers (estimated at 46 cm [18 in] each) from the total wingspan of a large, female golden eagle measuring 230 cm (90 in).

In the preparation of the 2006 edition of *Suggested Practices*, the dimensions of numerous bird species were obtained from the literature and from measurements of live birds. This research has raised some interesting questions and has identified the need for further investigation. Measurements of live birds have shown that subtracting primary feather length from total wingspan is not an accurate measure of wrist-to-wrist distance (APLIC, unpubl. data). Although sample sizes are small, the wrist-to-wrist measurements of golden eagles obtained from live birds were much shorter than the 140-cm (54-in) distance identified in previous editions of *Suggested Practices*. Even on birds with wingspans of 200 cm (80 in) or more, wrist-to-wrist measurements were less than 110 cm (43 in). Wrist-to-wrist measurements were much smaller on bald eagles; although bald eagles may have larger wingspans than golden eagles, their primary feathers are longer and account for a greater proportion of the wingspan.

APLIC continues to recommend 150 cm (60 in) horizontal separation for eagle protection in this edition of *Suggested Practices*. This edition also recommends 100 cm (40 in) vertical separation for eagles. However, utilities may choose to implement design standards using different separations based on the species or conditions at issue. To improve avian protection on power lines, APLIC encourages researchers to collect vertical and horizontal flesh-to-flesh separation measurements of large birds. This information will help utilities tailor their avian protection efforts. For example, in areas without eagles or in urban locations, a utility could design power lines to protect large birds such as red-tailed hawks and great horned owls; in areas with California condors, utilities could design structures to accommodate these large birds; and in coastal areas, utilities could consider the tall heights of wading birds when designing lines.

[16] Wrist-to-wrist measurements could not be documented for California condor.

For tall species, vertical distance can play a role as important as horizontal distance. Because the height (head to foot) can reach up to 66 cm (26 in) for a golden eagle and 71 cm (28 in) for a bald eagle, vertical separation sufficient to accommodate perching eagles is recommended in areas with these species. Long-legged wading birds, such as herons, egrets, ibises, and storks, may also be electrocuted on poles where there is insufficient vertical separation between conductors or conductor and ground. In areas where such species are at risk, vertical separation of 120 cm (48 in) or more may be needed to accommodate the heights of some species.[17] The heights of selected species are provided in Table 4.1 and Figure 4.13.

TABLE 4.1: Wrist-to-wrist, wingspan, and height measurements for selected birds.*

Species	Wrist-to-wrist cm (in) [sample size]†	Wingspan cm (in)	Height cm (in) [sample size]§
Turkey Vulture	58–61 (23–24) [*n*=2]	165–178 (65–70)	36–53 (14–21) [*n*=3]
Black Vulture		137–160 (54–63)	
California Condor		24[illegible]–300 (98–118)	120–130 (46–53)
Osprey		1[illegible]0–180 (59–71)	
Bald Eagle	79–86 (31–34) [*n*=4]	168–244 (66–96)	46–71 (18–28) [*n*=5]
Harris' Hawk	43 (17) [*n*=1]	1[illegible]–119 (41–47)	28–43 (11–17) [*n*=2]
Swainson's Hawk	[illegible]–58 (16–23) [illegible]	1[illegible]2–13[illegible] (4[illegible]–54)	3[illegible]–41 (13–16) [*n*=2]
Red-tailed Hawk	36–58 (14–23) [*n*=10]	107–142 (42–[illegible])	34–56 (13.5–22) [*n*=9]
Ferruginous Hawk	56 (22) [*n*=1]	135–152 (53–60)	48 (19) [*n*=1]
Rough-legged Hawk		[illegible]22–[illegible]42 ([illegible]–56)	
Golden Eagle	[illegible]9–10[illegible] (31–[illegible]2) [[illegible]=10]	[illegible]83–[illegible]29 (7[illegible]–90[illegible]	[illegible]6–66 (18–26) [*n*=11]
American Kestrel	20–25 (8–10) [*n*=4]	51–61 (20–24)	15–20 (6–8) [*n*=4]
Merlin		53–69 (21–27)	
Peregrine Falcon	33–51 (13–20) [*n*=2]	94–117 (37–46)	28–38 (11–15) [*n*=3]
Prairie Falcon	41 (16) [*n*=1]	91–112 (36–44)	33 (13) [*n*=1]
Barn Owl	38–51 (15–20) [*n*=4]	104–117 (41–46)	25–38 (10–15) [*n*=4]
Great Horned Owl	43–64 (17–25) [*n*=8]	114–130 (45–51)	31–41 (12–16) [*n*=8]

Continued

[17] This distance is based on the height of a great blue heron, approximately 1.2 m (46 in).

TABLE 4.1: Wrist-to-wrist, wingspan, and height measurements for selected birds.* (cont.)

Species	Wrist-to-wrist cm (in) [sample size]†	Wingspan cm (in)	Height cm (in) [sample size]§
Roseate Spoonbill		127 (50)	81 (32)
Wood Stork		155 (61)	102 (40)
White Pelican		244–290 (96–114)	157 (62)
Brown Pelican		203 (80)	130 (51)
Egrets		91–130 ([illegible]6–51)	[illegible]–100 (20–39)
Great Blue Heron		[illegible]8[illegible] (7[illegible])	117 (46)
Other Herons		66–112 (26–44)	46–66 (18–26)
Ibis		91–97 (36–38)	58–64 (23–25)
Cormorants		132–160 (52–63)	
Common Raven		135 (53)	41 (16) [*n*=1]
Chihuahuan Raven		112 (44)	
American Crow		99 (39)	
Magpies		64 ([illegible]5)	
Jays		[illegible] (19)	
Woodpeckers		31–53 (12–21)	
Blackbirds		[illegible]–58 ([illegible]3)	

* Sources: Johnsgard 1988, 1990; Sibley 2000; Wheeler 20[illegible]; *Birds of North America* species accounts; City of Lawrence (KS) Prairie Park Nature Center (unpubl. data); HawkWatch International (unpubl. data); Kansas Department of Wildlife and Parks Milford Nature Center (unpubl. data); Operation WildLife, Inc. (unpubl. data); Oregon Zoo (unpubl. data); PacifiCorp (unpubl. data); Rocky Mountain Raptor Program (unpubl. data); Stone Nature Center (unpubl. data); and Utah Wildlife Rehabilitation (unpubl. data).

† Because wrist-to-wrist and head-to-foot measurements of most species are not typically available in the literature, measurements were obtained from wildlife rehabilitators and handlers as well as from deceased birds. Sample sizes are given for birds that were measured and blanks in this field indicate that these data are currently unavailable. Avian researchers are encouraged to record these measurements when collecting other morphometric data.

§ Height given is from the top of the head to the feet. See also footnote †, above.

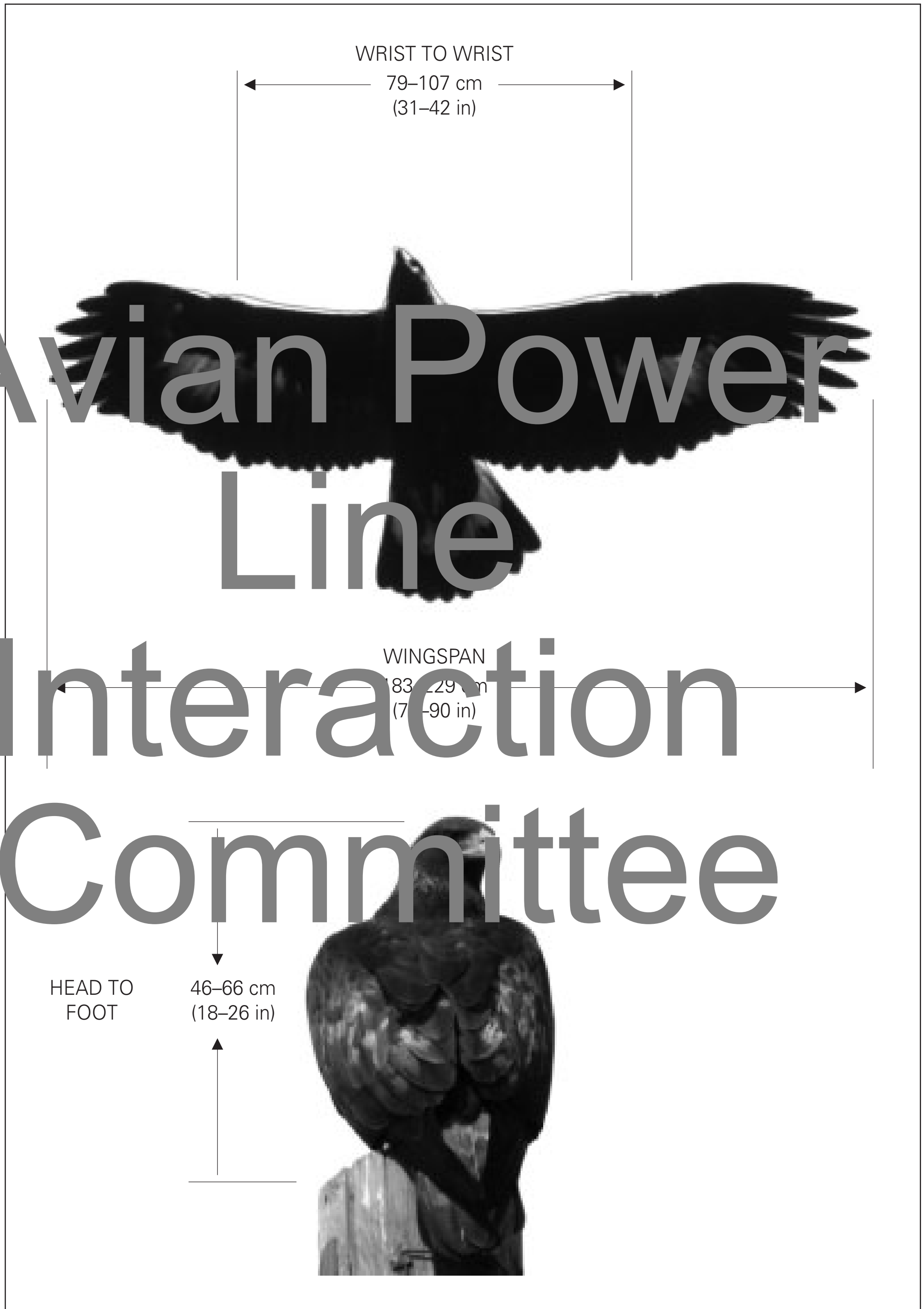

FIGURE 4.10: Critical dimensions of a golden eagle.

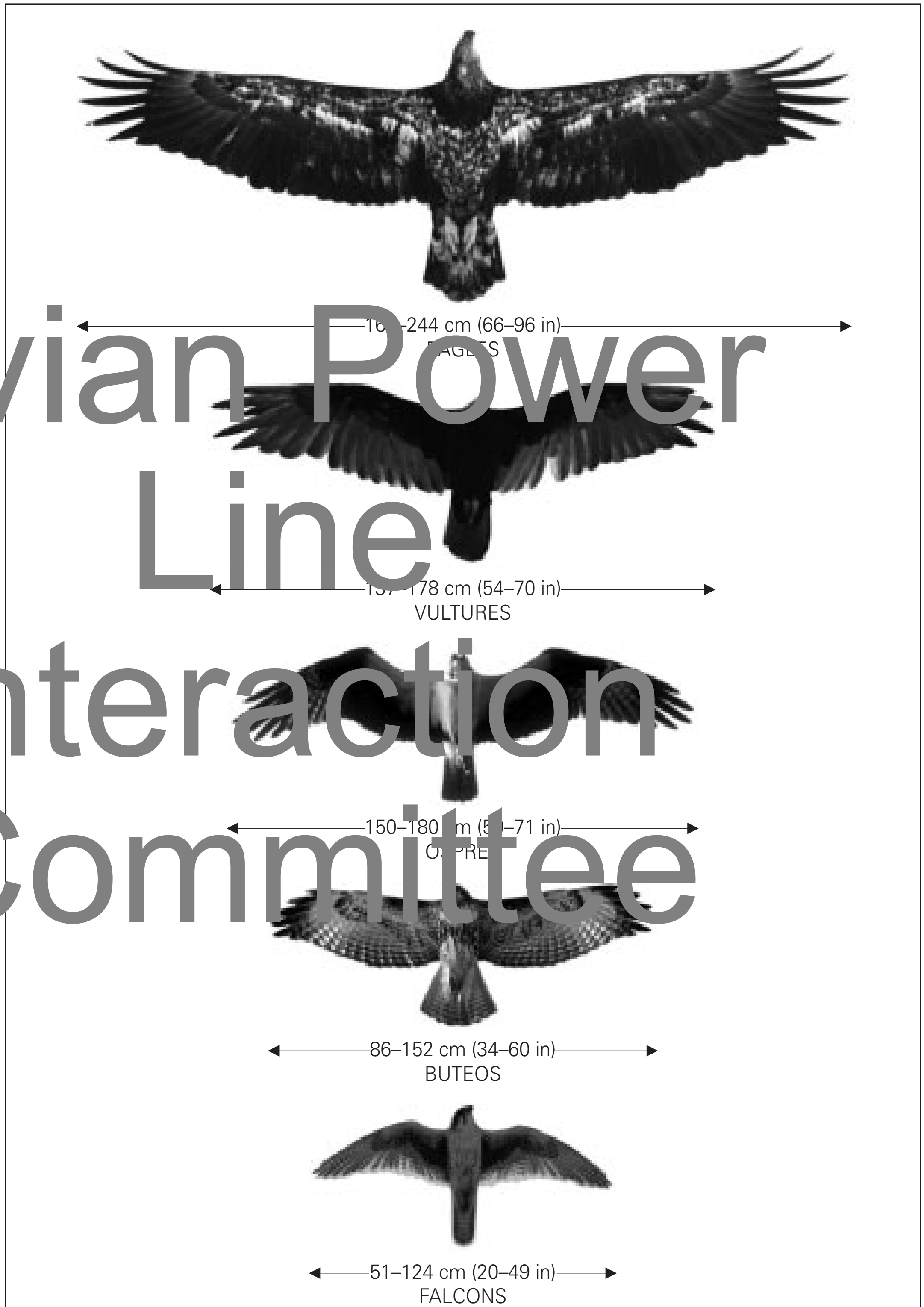

FIGURE 4.11: Wingspan comparisons of selected raptors.

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FIGURE 4.12: Wingspan comparisons of selected birds.

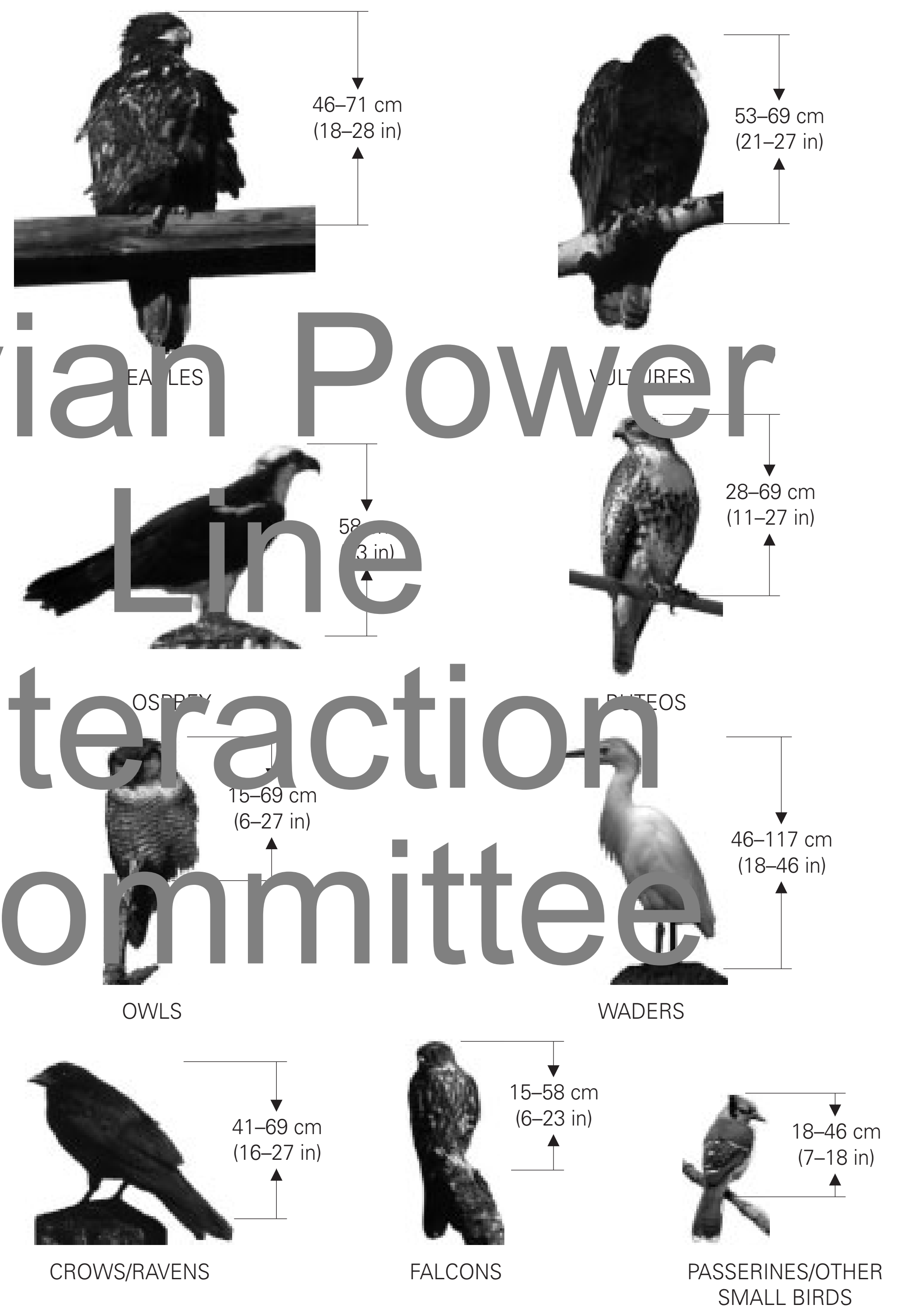

FIGURE 4.13: Height comparisons of perched birds.[18]

[18] Height ranges shown are from various sources and may include both head-to-foot and head-to-tail measurements. See Table 4.1 for additional information on height measurements.

TABLE 4.2: Percent of juvenile golden eagles in electrocution studies.

Study	Percent juvenile	Sample size
Benson (1981)	94.2%	52
Boeker and Nickerson (1975)	90.0%	419
Schomburg (2003)	87.9%	132
Harness and Wilson (2001)	66%	90
USFWS/Nebraska (unpubl. data)	63%	27

AGE

Research on golden eagles suggests that juvenile birds may be more susceptible to electrocution than adults (Table 4.2). Birds that nest on power poles may be electrocuted, particularly if the combined wingspans and simultaneous flapping behavior of several young birds cause them to bridge energized phase conductors and/or bridge between conductor and grounded equipment. Post-fledging, juvenile birds may continue to experience increased risk compared to adults because they are less agile at landing on and taking off from poles. Regardless of an electrocuted bird's age, corrective actions to prevent electrocutions remain the same.

Susceptibility of juvenile golden eagles to electrocution involves several factors, but none seems more important than experience. Inexperienced birds may be less adept at landing and taking off, which increases their risk. Inexperience may also affect how juvenile birds hunt. Juvenile birds may learn to fly and hunt from a perch, particularly in flat country, where updrafts are less common. Learning to fly involves frequent short flights from perch to perch. The first attempts to hunt involve frequent changes of perches following unsuccessful chases. One juvenile golden eagle was observed making over 20 unsuccessful hunting sorties after cottontails from a distribution pole (Benson 1981). Had the line been unsafe for eagles and weather conditions been poor, the likelihood of electrocution would have been high.

Hundreds of hours of actual observations and analyses of slow-motion, 16-mm movies made by Nelson in the early 1970s demonstrated that juvenile eagles are less adept at maneuvering than adults, especially when landing and taking off (Nelson 1979b, 1980b; Nelson and Nelson 1976, 1977). Trained golden eagles were filmed landing on un-energized, mockup power poles of various configurations in both calm and inclement weather. The eagles did not perch on wires (conductors) and seldom perched on pole-top porcelain insulators that tended to be too small, smooth, or slick for comfortable gripping. Instead, they used pole tops and crossarms that offered firmer footing. When an adult eagle approached a three-wire power pole crossarm, for instance, the bird typically swooped in under the outside wire, swung up between wires with wings folded, and stalled onto the perch. The landing, when made into a headwind, was skilled and graceful, with very little flapping.

Juvenile birds, by contrast, often tried to settle onto a crossarm from above, using outstretched wings to slow their descent. They sometimes approached diagonally, flew to the highest point—pole-top pin insulator—and tried to land. The birds often slipped off the insulator or tried in mid-flight to change to the crossarm—maneuvers accomplished by much wing flapping that increased their electrocution risk. Sometimes, juvenile birds began corrective action at a distance from the poles, particularly when the approach was too swift or at an improper angle. If they approached parallel to the lines, they often settled down across two conductors or tried to fly up between the conductors, increasing their electrocution risk (Figure 4.14). During landings, juvenile birds contacted the wires of the dummy poles making skin-to-skin contact near the wrists. Occasionally, contact also occurred on downward wing beats during

FIGURE 4.14 Juvenile golden eagle about to land on a distribution pole that is not avian-safe.

take-offs. On energized lines, simultaneously touching differing phase wires or a phase and a ground with fleshy parts of the body or with wet feathers can result in electrocution.

Juvenile eagles may rely on poles as hunting perches more than adults. Benson (1981) attributed differences in electrocution risk of adult and juvenile birds to the fact that aerial hunting (as opposed to still hunting from a perch) was the principal tactic used by adult golden eagles to capture jackrabbits. Catching jackrabbits with any consistency requires experience and tenacity in long, in-flight chases. Young birds find more success in pouncing on cottontails or other prey from stationary perches such as power poles. This increases their exposure to electrocution risk.

Florida has the largest breeding bald eagle population in the lower 48 states, with over 1,000 known nesting pairs (Nesbitt 2003). From 1963 to 1994, 16% of known bald eagle deaths in Florida (n=309) were due to electrocution. Contrary to previously mentioned data for golden eagles, these electrocutions were nearly evenly distributed between adult (55%) and juvenile (45%) birds. Likewise, 45% of known age bald eagle electrocutions in Nebraska (n=22) were juvenile birds (USFWS/Nebraska, unpubl. data).

Overall mortality rates (considering all causes of death) are greater for juvenile birds than for adults. Recoveries of banded golden eagles showed mortality in 50% of the population by an age of 31 months (Harmata 2002). Although age-related differences in electrocution risk are typically poorly understood for species other than eagles, it is likely that juvenile individuals of other species may be at greater risk than adults due to inexperience and overall higher mortality rates. For example, juveniles accounted for 61% of Harris' hawk electrocutions (n=75) in Tucson, Arizona (Dwyer 2004).

SEASONAL PATTERNS

Electrocution risk can vary with season. Many golden eagle mortalities along power lines (nearly 80% in the Benson 1981 study) occur during the winter. Of eagle electrocutions in the western United States with known mortality dates (n=96), 39% occurred from January to March; of eagle

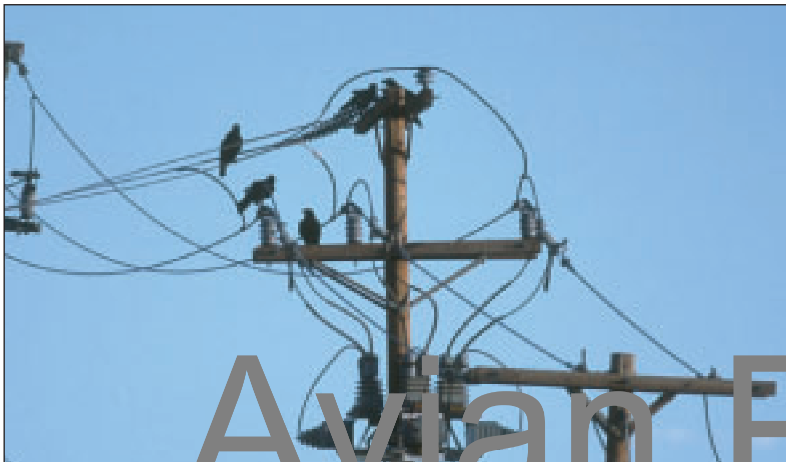

FIGURE 4.15: Numerous birds perched on a pole can increase electrocution risk. Pictured: common ravens during breeding season.

carcasses discovered for which the date of mortality was unknown (n=516), 55% were found from January to April (Harness and Wilson 2001). Likewise, the majority (65%) of eagle mortalities reported during routine utility activities from 2001 to 2004 in the western United States by PacifiCorp (unpubl. data) occurred from December to April. The increased frequency of eagle electrocutions during the winter may be attributed to greater concentrations of these birds in proximity with power lines during the winter months. Likewise, eagles may be attracted to high seasonal prey concentrations that may, coincidentally, occur near non-avian-safe lines. In addition, eagles probably hunt from perches more during the winter than at other times of the year. In Florida, where bald eagles occur year-round, electrocutions occurred during every month of the year (Forrester and Spaulding 2003). However, most occurred from October through April, the period that encompasses the breeding season when eagle abundance is greatest in Florida and when dispersal and migration occur.

Electrocution rates of other species may also increase seasonally due to breeding behavior and the presence of young. Increased raptor electrocutions, particularly of Harris' hawks, corresponded with nesting activity in Tucson, Arizona (Dwyer 2004). Of known electrocution dates for hawks (*n*=119) in the western United States from 1986 to 1996, 57% occurred from July to September (Harness and Wilson 2001). In Chihuahua, Mexico, red-tailed hawk mortality peaked from September to November (Cartron et al. 2005). Similarly, electrocutions of hawks in the western United States from 2001 to 2004 were greatest from July to November, with 16% of annual mortalities occurring in both July and August, 14% in September, 11% in October, and 7% in November (PacifiCorp, unpubl. data). These seasonal peaks likely correspond with increases in hawk populations due to dispersal of fledglings during the breeding season and influxes of birds during fall migration. This dataset also showed a slight increase in hawk electrocution mortality during March and April (each with 8% of annual mortality), probably correlated with spring staging.

As with hawks, mortalities of owls in the western United States were greatest in late summer, particularly August and September (Harness and Wilson 2001). Likewise, electrocutions of eagle owls *(Bubo bubo)* in the Italian Alps were greatest during the period of juvenile dispersal in September (Rubolini et al. 2001). In the western United States, owl electrocutions from 2001 to 2004 were greatest during summer and early fall, with June, July, August, and September accounting for 26%, 24%, 7%, and 12%, respectively, of annual mortality (PacifiCorp, unpubl. data).

Electrocutions of other species also exhibit seasonal patterns. Records of corvid electrocutions in the western United States from 2001 to 2004 were greatest from April to August, with highest numbers in June (16%), July (22%), and August (15%) (PacifiCorp, unpubl. data). These months correlated with the local breeding season of these species, particularly the times when nestlings and/or fledglings are present (Figure 4.15). Raven electrocutions also peaked in August and September in Chihuahua, Mexico (Cartron et al. 2005). Electrocutions of songbirds in the western United States were correlated with the summer months, as 69% of electrocutions occurred from June to August (PacifiCorp, unpubl. data). The APLIC-member utilities surveyed documented seasonal differences in electrocution rates and noted overall increases during nesting and fall migration (APLIC 2005). In addition, species-specific seasonality was noted for eagles (winter) and passerines (spring).

BEHAVIOR

Nesting, courtship, and territorial behavior can make raptors and other birds susceptible to electrocution (Figure 4.16; also see Chapter 6). The gregarious social behavior of some birds, such as Harris' hawks or vultures, can also increase electrocution risk as multiple birds perch together on a pole.

Benson (1981) found that nearly 46% of red-tailed hawk electrocutions occurred during courtship and nesting. Most of these birds were adults. Benson also noted that nearly 30% of the hawks electrocuted during the late spring and early summer were fledglings.

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FIGURE 4.16: Swainson's hawk pair perched on distribution pole.

Dawson and Mannon (1994) reported that 37% of 112 electrocuted Harris' hawks in southern Arizona were birds that had recently fledged. Likewise, Dwyer (2004) found that 63% of electrocuted juvenile Harris' hawks (*n*=46) were killed within three weeks of fledging. Of raptor and raven electrocutions in Tucson, 79% were within 300 m (1,000 ft) of a nest (*n*=56) (Dwyer 2004). A young Swainson's hawk was found electrocuted in south-central Washington soon after it fledged (Fitzner 1978), and 2 fledgling great horned owls were found electrocuted near nests in Saskatchewan (Gillard 1977). Groups of 2 to 3 common ravens have been electrocuted in Utah and Wyoming, likely due to multiple birds simultaneously spanning conductors (PacifiCorp, unpubl. data).

Several instances of electrocution of birds carrying prey or nest material have been reported. A dangling prey item or stick can help span the gap between phase conductors or between an energized conductor and a grounded conductor, electrocuting a bird returning to the nest (Switzer 1977; Fitzner 1978). A young great horned owl was found electrocuted with a freshly killed snowshoe hare *(Lepus americanus)* lying nearby (Gillard 1977). Similar incidents were noted by Brady (196[illegible]) and H[illegible] (1970). In Utah, an electrocuted great horned owl was discovered with four nestling western kingbirds *(Tyrannus verticalis)* in its talons, likely retrieved from a kingbird nest behind the transformer that killed the owl (S. Liguori, pers. obs.). Golden eagles carrying large prey have been electrocuted on otherwise avian-safe poles in Wyoming (PacifiCorp, unpubl. data). Two adult red-tailed hawks were electrocuted at separate nests in Wyoming, possibly while carrying nesting material (Benson 1981). A pair of electrocuted red-tails was found below a pole in Utah, both birds with nesting material in their talons (S. Liguori, pers. obs.). Ospreys have been electrocuted when carrying seaweed (*New York Times* 1951) and barbed wire

(Electric Meter 1953) to their nests. Nests and nestlings can also be destroyed if nesting material lies across conductors, resulting in a flashover and fire (Vanderburgh 1993).

During the nesting period, birds often engage in courtship and territorial defense. In such displays, raptors often lock talons, greatly increasing their effective wingspans. If these activities take place near a power line, the birds can be electrocuted. For example, in Montana, the electrocution of a subadult golden eagle was witnessed during an aggressive encounter with an adult eagle (Schomburg 2003). Benson (1981) documented a pair of electrocuted eagles below a pole, the talons of each bird imbedded in the breast of the other. In Oregon, two electrocuted red-tailed hawks were found below a pole with the foot of the adult imbedded in the chest of the juvenile (S. Liguori, pers. obs.). Aggression between species may also have similar results, e.g., in Wyoming the foot of a great horned owl was found grasping the body of a red-tailed hawk (S. Liguori, pers. obs.). Likewise, in Arizona, a Harris' hawk and red-tailed hawk were electrocuted together during an aggressive encounter (Dawson and Mannan 1994). In areas of Montana where large concentrations of eagles winter, aggressive interactions between birds have led to the electrocution of two birds at once (S. Milodragovich, pers. comm.). In the Northern Cape Province of South Africa, vultures were electrocuted on vertically configured poles when aggressive interactions caused birds to slip off the insulators and fall onto conductors (Kruger et al. 2003).

Raptors and other birds may use power poles to provide protection from the elements. During hot weather in open, arid environments, birds seeking shade may perch on power crossarms or perch close to the pole (Figure 4.17). Birds may also use the lower portions of power poles during rain or snow. Although power poles do not appear to offer much protection from the elements, they can provide some cover, particularly in habitats lacking natural shelter.

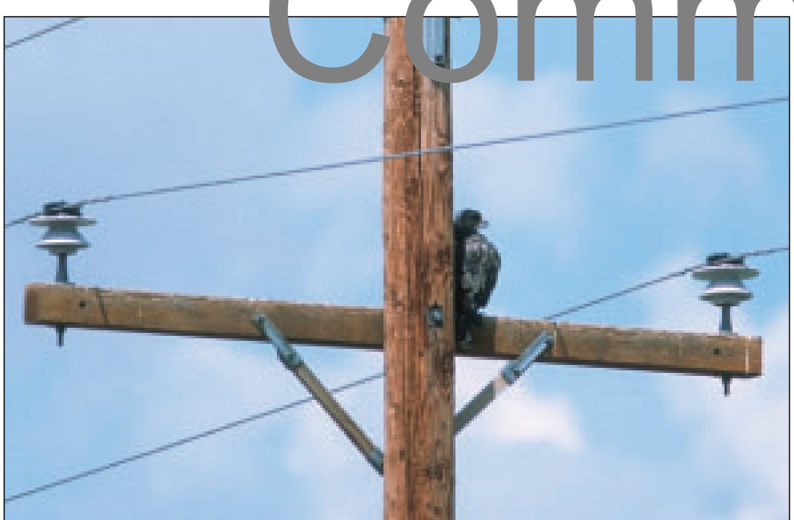

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FIGURE 4.17: Swainson's hawk using power pole for shade.

WEATHER AND THE INFLUENCE OF WET FEATHERS

Inclement weather (particularly rain, snow, and wind) increases the susceptibility of birds to electrocution. Wet feathers increase conductivity, and birds have greater difficulty landing on power poles in high winds. Because dry feathers provide insulation, most electrocutions are caused by simultaneous skin-to-skin, foot-to-skin, or bill-to-skin contact with two energized conductors or a conductor and a ground.

Nelson (1979b, 1980b) conducted experiments to determine the conductivity of a live eagle by attaching electrodes to the skin of the wings and to the toes. Although lethal voltages and currents were not determined, these experiments demonstrated that, at 280 volts (V) and a current of 6.3 milliamperes (mA), the eagle's respiration increased. At 400 to 500 V and a current range of 9 to 12 mA, the eagle convulsed. Wet feathers burned at 5,000 to 7,000 V, but there was no measurable current through a dry feather at 70,000 V. Skin-to-skin contacts were on the order of ten times more dangerous than contacts between a wet eagle and two conductors, and about 100 times more dangerous than contacts between conductors and dry feathers. A dry feather is almost as good an insulator as air, but a wet feather has demonstrably greater conductivity. Major conclusions from Nelson (1979b, 1980b) were as follows:

- For voltages of up to 70,000 V and with electrodes at least 17.8 cm (7 in), apart, there is no measurable current flow (no conductivity) through a dry feather. There is little or no possibility of electrocution of dry eagles from wingtip contacts with two electric conductors.
- Wet feathers conduct current more readily than dry ones, and become capable of conducting amperages dangerous to eagles starting at about 5,000 V.
- The hazard to wet birds is much greater than that to dry ones, and is increased even more so when wet birds lose some flight capability and control.

The amount of current conducted through wet feathers also depends on the concentration of salts and minerals in the water. Increased electrolyte content results in increased conductivity. Feather wetting further posed a risk because it elicited wing-spreading behavior in the birds studied (Nelson 1979b), presumably to dry the feathers. Although this research was conducted on eagles, it has implications for other species. Birds that spend much of their time in or near water, such as herons, egrets, ibises, storks, pelicans, cormorants, and ospreys, may be at increased risk of electrocution. In addition, wing-spreading behavior commonly exhibited by cormorants or vultures may increase electrocution risk. A utility's Avian Protection Plan (APP) should include design standards appropriate for the species and conditions at issue. However, electrocutions will never be eliminated during wet conditions because feathers and wood can be conductive when wet, potentially causing electrocutions on normally benign poles.

Finally, the direction of the prevailing wind relative to the crossarm can also influence electrocution risk. Poles with crossarms perpendicular to the prevailing wind produced fewer eagle mortalities (Boeker 1972; Nelson and Nelson 1976, 1977). About half as many birds were found below poles with crossarms perpendicular to the wind, when compared to poles with crossarms diagonal or parallel to the wind (Benson 1981). This difference was probably related to the effect of wind on the ability of juvenile eagles to land on poles without touching energized parts.

IDENTIFYING EVIDENCE OF ELECTROCUTION

Because not all dead birds below power lines may have died from electrocution, it is important to accurately determine the cause of death so that appropriate action can be taken. In winter surveys of raptor mortality in Montana, Olson (2001) found 126 carcasses along roadsides, 88 of which were submitted for necropsy. Of these birds, only 9% were electrocuted, while the majority (84%) had been shot. The majority of birds found along roadsides that were directly below power poles were also shot, with only 15% electrocuted (Olson 2001).

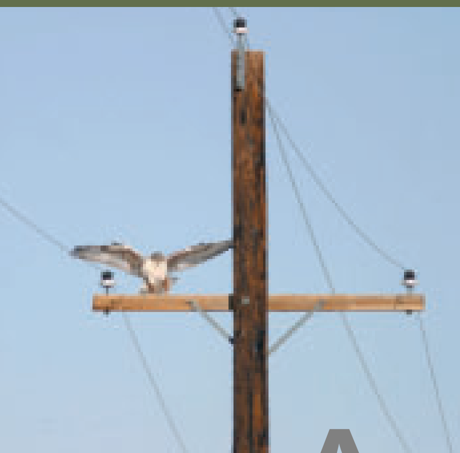
Evidence of electrocution can include burn marks on the feathers, feet, talons, flesh, or bill. Such burns may be obvious and extensive, or inconspicuous and not visible to the naked eye. Electrocuted birds may also exhibit deformed or damaged talons that appear broken, curled, or incinerated (Olson 2001). In some cases, the feet, toes, or talons are broken off during electrocution (PacifiCorp, unpubl. data). Although most victims of electrocution die, some individuals survive. Of 89 live Harris' hawks that were captured in Arizona, 9% exhibited injuries evident of electrical shock (Dwyer 2004). Likewise, 20% of Harris' hawk electrocutions documented in Arizona (n=112) were injuries rather than mortalities (Dawson and Mannan 1994).

Evidence of shooting differs from that of electrocution. Birds that have been shot exhibit sheared flight feathers rather than singed feathers (EDM International, Inc. 2004). Other signs of shooting include shattered bones, contusions, hematomas, sprayed or spattered blood, and bullet wounds (Olson 2001).

SCAVENGING RATES OF CARCASSES

Because there have been few large-scale studies that quantify avian electrocution rates, existing data have been used in some cases to extrapolate electrocution rates over large areas. Extrapolation is strongly discouraged, as electrocution risk is not uniformly distributed among all poles in all geographic areas. Carcass scavenging rates obtained from studies of non-raptors have also been used to extrapolate removal rates of electrocuted raptor carcasses. Again, caution should be used as carcass removal rates vary greatly among studies and can be influenced by scavenger populations, habitat, season, observer bias, and carcass species. In particular, raptor carcasses are less likely to be removed by scavengers than carcasses of other species. In a carcass removal study in Colorado and Wyoming, small carcasses were removed within 24 to 48 hours (Kerlinger et al. 2000). In contrast, large birds (i.e. ferruginous hawks, great horned owls, and rough-legged hawks) remained for over two months. Orloff and Flannery (1993) found no scavenging of raptor carcasses (n=14) during a single trial of seven days. Also, Howell and Noone (1992) found that carcasses of larger raptors remained longer than those of smaller raptors. Janss and Ferrer (2001) assumed the scavenging rate of eagles to be considerably lower than that of rabbits. Ellis et al. (1969) noted that, of raptor carcasses found along power lines in Utah (shooting was the primary cause of death), most carcasses had remained intact and were seldom scattered by scavengers. Olson (2001) also found little evidence of scavenging on raptor carcasses below power lines in Montana. Along a power line in Wyoming in 1992, carcasses of electrocuted eagles were removed by researchers, yet there was not a thorough effort to remove all bones and feathers (Harness and Garrett 1999). During a subsequent survey of the line in 1997, scattered, old, bleached bones of 24 carcasses were discovered and assumed to be the remains of the eagles killed several years earlier (Harness and Garrett 1999).[19] Likewise, nearly half of the carcasses found in Utah and Wyoming were old bleached bones or desiccated carcasses, many of which appeared to have been undisturbed (PacifiCorp, unpubl. data). In addition, specific cases of individual carcasses that were not retrieved or buried upon initial discovery were found again at the same poles several years later. In the urban area of Tucson, Arizona, most carcasses that were removed were taken by people, rather than scavengers (Dwyer 2004). In a study of carcass removal rates in Chihuahua, Mexico, 25% of raven carcasses (n=72) were removed within one month of their discovery (Cartron et al. 2005). In contrast, 95% of non-raven (raptor) carcasses (n=21) were present after one month, but only 63% remained after two months.

[19] A guide for identifying the remains of various raptor species (EDM International, Inc. 2004) can be obtained at www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-001.html.



CHAPTER 5

Suggested Practices: Power Line Design and Avian Safety

IN THIS CHAPTER

- Introduction to Electrical Systems
- Avian Electrocutions and Power Line Design
- Suggested Practices
- Summary

This chapter address avian electrocution concerns from the engineering perspectives of design, construction, operations, and maintenance. It describes ways of designing new facilities and retrofitting existing facilities to be "avian-safe."

As communities grow, their demand for electricity increases. Additional power lines must be built to supply the additional power. The more miles of power lines there are, the greater the potential for birds to interact with electrical facilities and their inherent hazards.

Biologists and planners must have a basic understanding of power systems, power line designs, and related terminology to identify and implement successful solutions to bird electrocutions. This chapter discusses North American power lines, and the designs and configurations that present avian electrocution risks. For further reference, a glossary of terms is provided in Appendix D.

This 2006 edition of *Suggested Practices* supersedes the recommendations incorporated in the 1996 edition and includes updates based on growing field experience and product performance testing. Despite efforts to present "state-of-the-art" recommendations, users of this manual should be aware that many wildlife protection products have not been tested or rated from an engineering perspective.[20] An IEEE Working Group under project P1656 is writing a guide entitled *Guide for Testing the Electrical, Mechanical, and Durability Performance of Wildlife Protective Devices Installed on Overhead Power Distribution Systems Rated up to 38 kV.* The guide will provide technical guidance for testing wildlife guards and should be available in 2006. Utilities are encouraged to share or publish information regarding avian-safe power line construction and retrofitting experience that can be used to refine future editions of *Suggested Practices*.

[20] However, the recommendations provided in this manual have been field tested by utilities and some results have been published in scientific and engineering journals.

INTRODUCTION TO ELECTRICAL SYSTEMS

DISTINCTIONS BETWEEN TRANSMISSION AND DISTRIBUTION LINES

Power lines are rated and categorized, in part, by the voltage levels to which they are energized. Because the magnitudes of voltage used by the power industry are large, voltage is often specified with the unit of kilovolt (kV) where 1 kV is equal to 1,000 volts (v). Generally, from the point of origin to the end of an electric system, line voltage is used to designate four classes or types of power lines (Table 5.1).

TABLE 5.1: Voltage ranges of different power line classes.

Designation	Voltage Range
Generation plant	12 V to 22 kV
Transmission	60 kV to 700+ kV
Distribution	2.4 kV to 60 kV
Utilization	120 V to 600 V

In addition to the voltage level, power line classification is dependent on the purpose the line serves (as shown in Figure 5.1). This publication is concerned with electrocution hazards that electric distribution and transmission lines may pose to birds. In this manual, lines that are energized at voltages ≥60 kV are considered transmission lines, and lines energized at voltages <60 kV are considered distribution lines, however, this may vary with different utilities. Performance experience indicates that low voltage (secondary) lines—also called *utilization facilities* (≤600 v)—are not often involved in avian electrocutions.

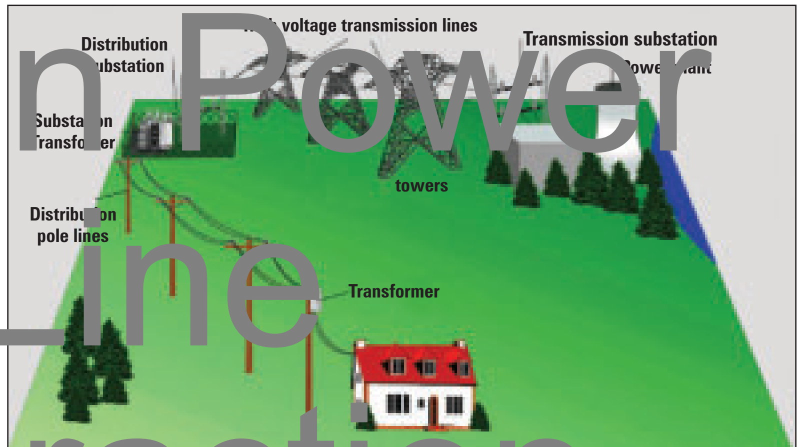


FIGURE 5.1: Schematic of power system from generation to customer.

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DIRECT CURRENT AND ALTERNATING CURRENT SYSTEMS

Although there are some direct current (DC) power systems where current flows in system conductors in only one direction, most commercial power systems in the United States use alternating current (AC). In AC systems, current flows in system conductors in one direction for 1/120th of a second, going from zero amperes to a peak ampere value and back to zero amperes. It then reverses direction and, for another 1/120th of a second flows in the opposite direction in system conductors, again going from zero amperes to a peak magnitude and back to zero amperes. It then changes direction again and the cycle repeats. If projected on a graph, the current would appear as a sinusoidal curve as depicted in Figure 5.2, that shows at least two complete cycles of current flow on phases A, B, and C of a three-phase circuit. In the United States, there are 60 such cycles each second (also referred to as 60 hertz). There are more AC systems than DC systems because utilities can transmit large amounts of power over long distances on high voltage transmission lines and can take advantage of the alternating magnetic fields associated with AC systems.

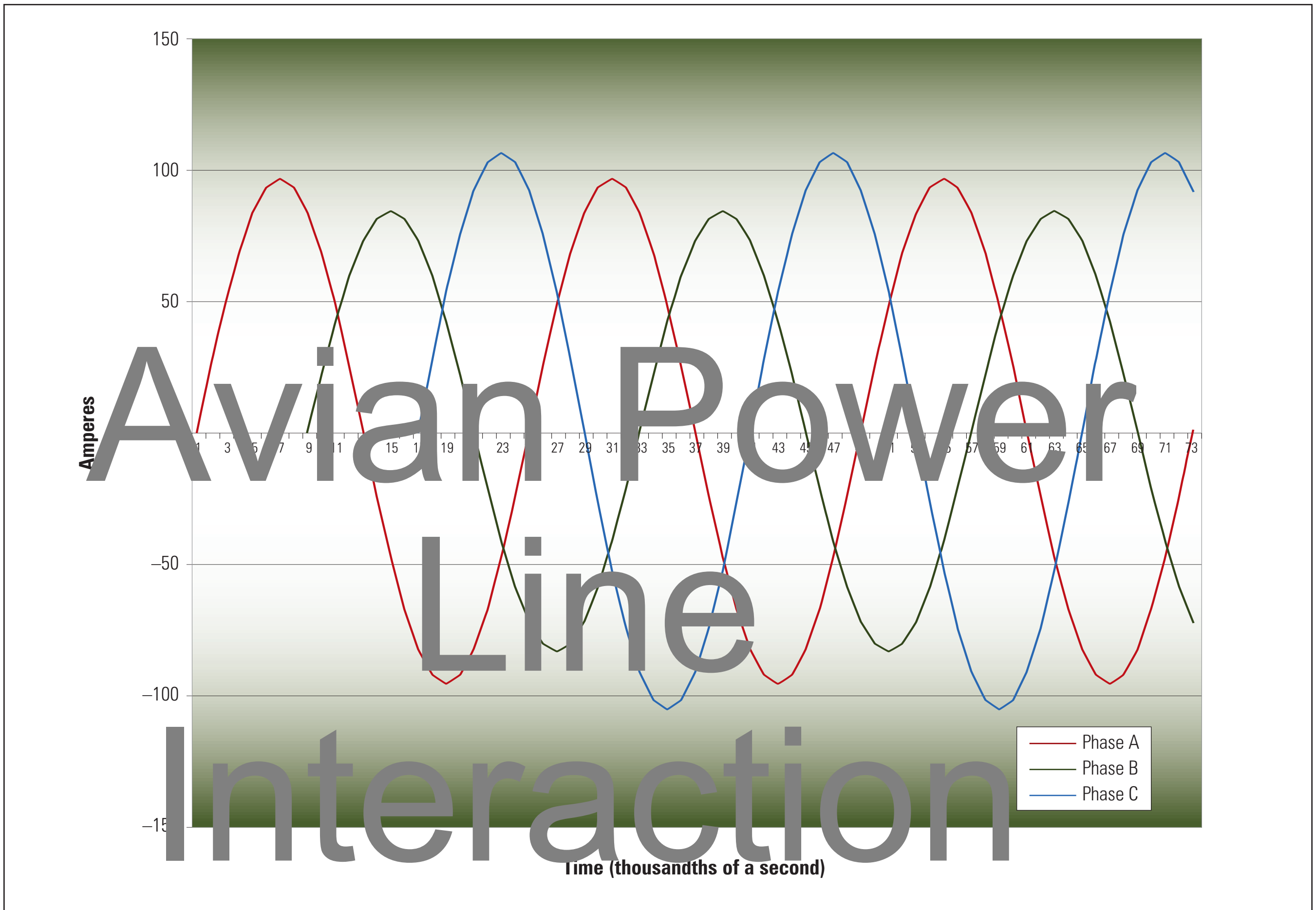

FIGURE 5.2: Three-phase current waveform.

OVERHEAD VERSUS UNDERGROUND

Utilities install facilities either overhead or underground, depending upon numerous factors and concerns. Some key factors include customer needs, terrain and environment restrictions, costs, and code requirements. Cost is a major concern as utilities have a responsibility to serve customers with high quality, reliable electric service at the most reasonable cost possible. Although facilities are installed underground in many areas throughout the country where utilities have found it technically and financially feasible to do so, there are many more areas where utilities have determined that installing facilities underground is not feasible, leaving lines to be installed overhead. If all lines could be installed underground, birds would have little exposure to electrocution hazards and there would be little need for this publication. However, it is neither practical nor feasible to install or convert all overhead lines to underground and it becomes less practical as the voltage of the line increases. The focus of this publication, therefore, is to provide overhead power line designs and modifications that minimize electrocution risk for birds.

SINGLE, TWO, AND THREE-PHASE OVERHEAD SYSTEMS

Most AC commercial overhead power lines utilize some form of support structure from which insulators and electrical conductors are attached. Support structures may consist of preservative-treated wood poles, hollow or lattice steel structures, steel-reinforced concrete poles, or composite poles made from fiberglass or other materials. Insulators are made of porcelain or polymer materials that do not normally conduct electricity. Electrical conductors are usually manufactured from copper or aluminum.

The basic workhorse of the electric utility is the three-phase circuit that consists of structures, as described above, that support at least three electrical phase conductors with or without a neutral (or grounded) conductor. The separate phase conductors are energized at the same voltage level but are electrically 120° out of phase with one another (see Figure 5.3 for a diagram of the three phase voltages and their time relationships). Because of this electrical phase difference, the conductors are called phase conductors. In electrical engineering, the term "phase" has several significant meanings, however, for this publication, it is used to mean an energized electrical conductor with the electrical characteristics described above. Three-phase systems are used for both distribution and transmission lines. One of the primary benefits of three-phase systems is the ability to deliver large amounts of power over long distances. Most electric systems originate as three-phase facilities and,

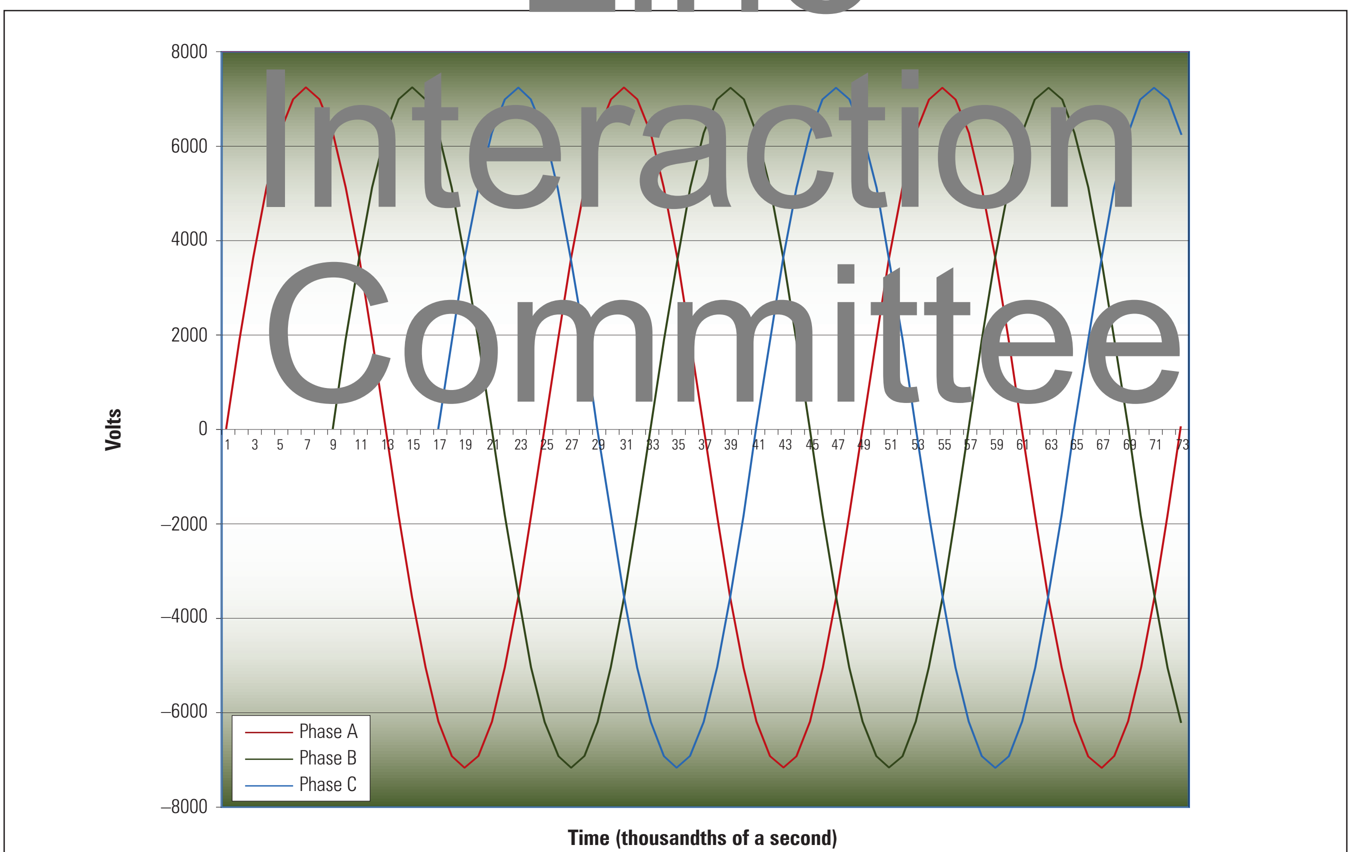

FIGURE 5.3: Three-phase voltage waveform.

out on the power line route, change from three-phase to two-phase (i.e., V-phase) facilities or to single-phase facilities.

Because of limited rights-of-way (ROW) availability and the need to deliver significant amounts of power, some power line structures may carry several three-phase circuits. In some cases, the structure supports two or more three-phase transmission circuits high on the structure while the lower portion supports several three-phase distribution circuits. Structures could also support low voltage utilization circuits for street lighting or electric service to homes and businesses. Distribution circuits installed on the lower portion of a transmission structure are commonly referred to as "underbuilt" distribution.

Transmission line structures always support at least one three-phase circuit. They have three energized conductors (more if bundled), and may have one or two grounded conductors (usually referred to as *static wires*) installed above the phase conductors for lightning protection. Again, there may be more than one three-phase circuit supported on the same structures.

Distribution line structures may support a variety of conductor configurations. A distribution line could consist of three phase conductors only, or three separate phase conductors and a single neutral (grounded) conductor. The neutral conductor could be the top-most conductor on the supporting structure or it could be placed below or even with the phase conductors. Distribution lines could also consist of two phase conductors alone or two phase conductors and a neutral conductor, again with the neutral conductor being above, below, or even with the phase conductors. A distribution line may also have just a single phase conductor and a neutral conductor with the neutral being above, below, or even with the phase conductor. Most distribution lines throughout the United States have the neutral conductor placed below the phase conductors. The neutral conductor is used to complete the electrical circuit and serves as part of the conducting path for phase current flowing from the customer back to the substation where the circuit originates. The earth itself serves as the other part of the return current path.

AVIAN ELECTROCUTIONS AND POWER LINE DESIGN

Birds can be electrocuted by simultaneously contacting energized and/or grounded structures, conductors, hardware, or equipment. Electrocutions may occur because of a combination of biological and electrical design factors. Biological factors are those that influence avian use of poles, such as habitat, prey, and avian species (see Chapter 4). The electrical design factor most crucial to avian electrocutions is the physical separation between energized and/or grounded structures, conductors, hardware, or equipment that can be bridged by birds to complete a circuit. As a general rule, electrocution can occur on structures with the following:

- Phase conductors separated by less than the wrist-to-wrist or head-to-foot (flesh-to-flesh) distance of a bird (see Chapter 4, Size)[21];
- Distance between grounded hardware (e.g., grounded wires, metal braces) and any energized phase conductor that is less than the wrist-to-wrist or head-to-foot (flesh-to-flesh) distance of a bird.

In the 1970s, Morley Nelson evaluated electrocution risk of eagles to identify configurations and voltages that could electrocute birds (Nelson 1979b, 1980b; Nelson and Nelson 1976, 1977; see Chapter 4).

[21] The wrist is the joint toward the middle of the leading edge of a bird's wing. The skin covering the wrist is the outermost fleshy part on the wing.

Because bird feathers provide insulation when dry, contact must typically be made with fleshy parts, such as the skin, feet, or bill. Nelson determined that 150-centimeter (cm) (60-inch [in]) spacing is necessary to accommodate the wrist-to-wrist distance of an eagle. As a result, a 150-cm (60-in) separation has been widely accepted as the standard for eagle protection since the 1975 edition of *Suggested Practices*. Although wingspans can measure up to 2.3 meters (m) (7.5 feet [ft]) for golden eagles (*Aquila chrysaetos*) and 2.4 m (8 ft) for bald eagles (*Haliaeetus leucocephalus*), the distance between fleshy parts (wrist-to-wrist) is less than 150 cm (60 in) for both species (see Chapter 4, Size). Therefore, under dry conditions, a 150-cm (60-in) separation should provide adequate spacing for an eagle to safely perch. Larger birds such as condors or storks may warrant special consideration by utilities. Utilities in areas without eagle populations may choose to develop separate species-specific construction standards as may utilities in regions with wet climates or increased airborne contaminants. A utility's Avian Protection Plan (APP) should identify protected species within the utility's operations area and include design standards appropriate for the species and conditions at issue (see Chapter 8). An APP should also identify circumstances where avian-safe construction is to be used (i.e., in bird use areas, as part of ROW permit conditions, etc.).

Although avian-safe construction minimizes electrocution risk, electrocutions can never be completely eliminated. Because wet feathers and wet wood are conductive, birds can be electrocuted during wet weather on normally benign poles.

With an understanding of how birds can be electrocuted on power lines, utilities can select designs that are avian-safe and help to avoid and/or mitigate electrical hazards to birds. Voltage, conductor separation, and grounding practices are a particular concern when designing avian-safe structures, however, public safety, governed throughout the United States by the current National Electric Safety Code (NESC), is the primary design consideration. State and local governments also may have codes that govern power line design and construction.[22]

SEPARATIONS

The NESC and the codes of some local jurisdictions dictate power line phase-to-phase separations and the clearances of line components above ground. In accordance with the NESC, both the distance between phase conductors and the distance that conductors are hung above ground is based on the line voltage and the activity that does and could take place in the area of the power line. These code requirements are considered the minimum distances and separations needed to be certain that the facilities will not be harmful to the general public or the line crews that have to operate and maintain them. The code requirements are not intended to provide safety to birds and other animals that come into contact with assemblies at the tops of electrical structures.

Distribution lines are built with smaller separations between energized conductors and between energized conductors/hardware and grounded line components than are transmission lines. Consequently, avian electrocution risk is greater on distribution lines.

Transmission conductors are generally spaced 1 to 9.1 m (3 to 30 ft) apart, and are supported on poles or towers that range from 15.2 to 36.6 m (50 to 120 ft) in height. A single transmission tower can accommodate more than one circuit. See Figure 5.4 for examples of transmission structures.

[22] For example, California Public Utility Commission (CPUC) General Order 95 establishes the rules for overhead line construction in California.

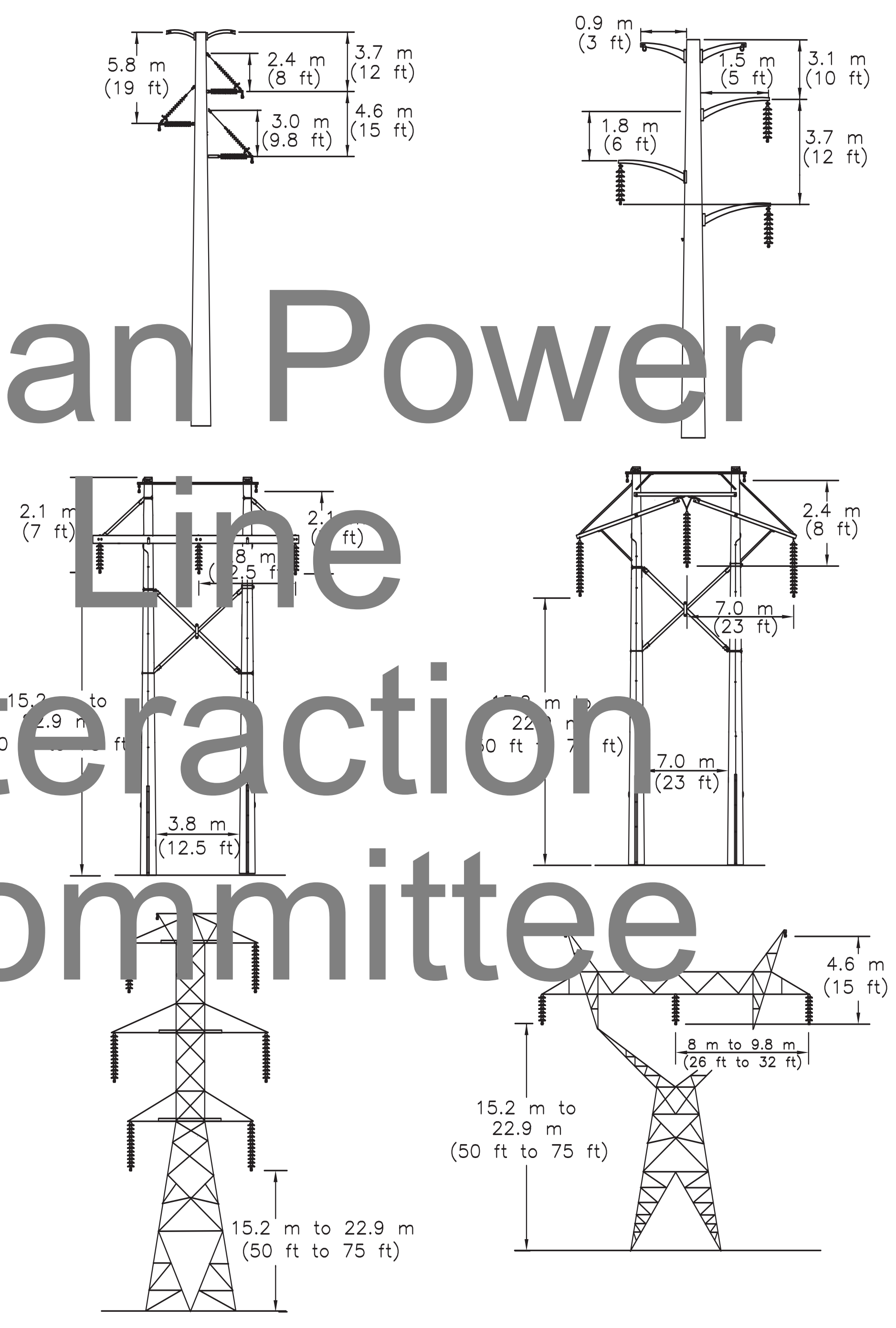

FIGURE 5.4: Examples of transmission structures.

Distribution line conductors are generally spaced 0.6 to 1.8 m (2 to 6 ft) apart, and are supported on wood, steel, composite or concrete poles that range from 9.1 to 19.8 m (30 to 65 ft) in height (Figure 5.5). As with transmission poles and towers, distribution poles can accommodate more than one circuit (Figure 5.5). The addition of jumper wires, transformers, switches, and electrical protective devices (fuses, reclosers, and other circuit sectionalizing equipment), as well as grounded hardware included on pole-top assemblies, increase the potential for avian electrocutions due to close separation of energized and grounded parts.

BONDING AND GROUNDING

Bonding electrically interconnects all metal or metal-reinforced supporting structures—including lamp posts, metal conduits and raceways, cable sheaths, messengers, metal frames, cases, equipment hangers or brackets,

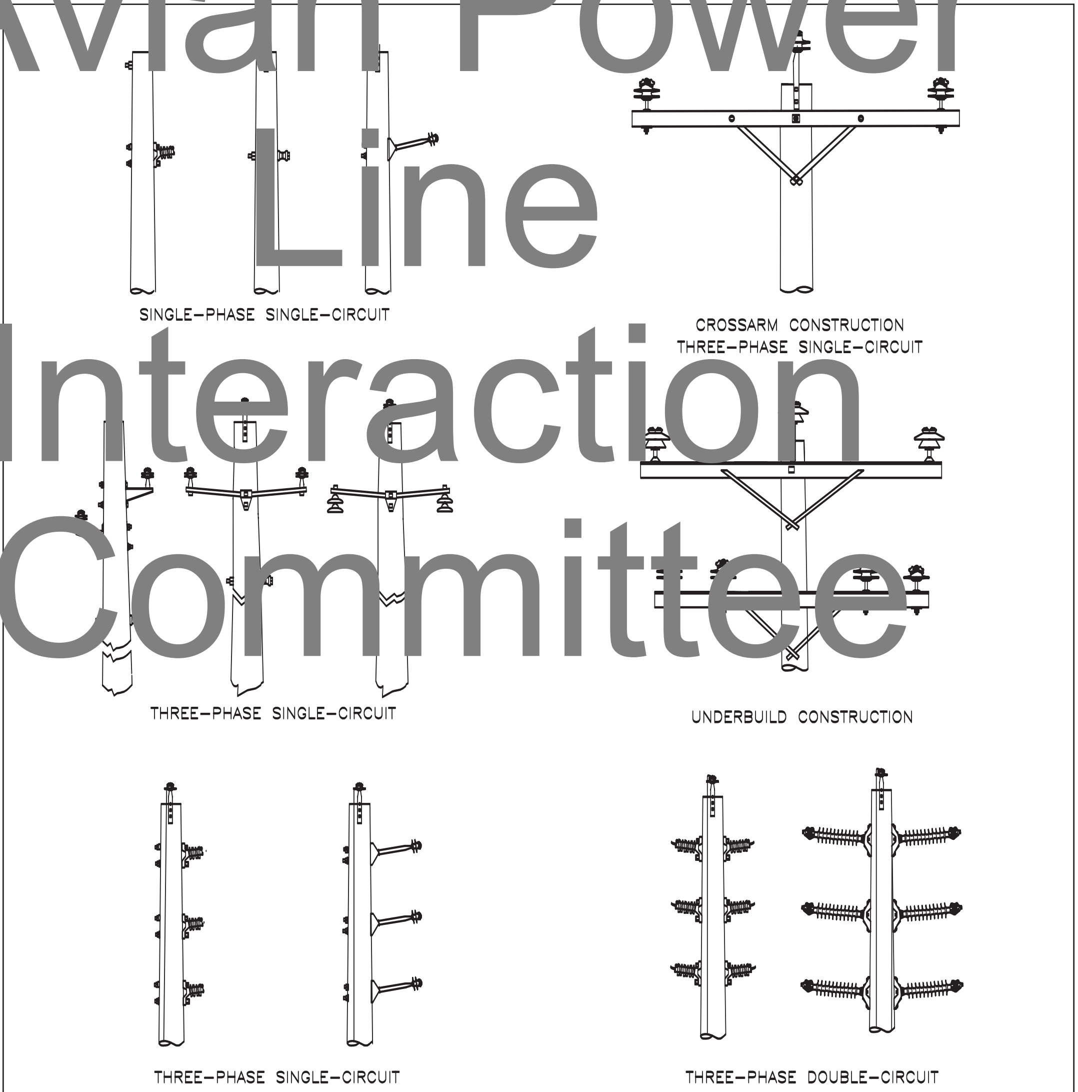

FIGURE 5.5: Examples of typical distribution configurations.

and metal switch handles and operating rods. In most cases these bonded hardware items are grounded in accordance with NESC Rule 215 C1.[23] The NESC requires the grounding of these metallic items to help keep the metal at the same voltage as the earth to which it is grounded. Bonding is particularly necessary in areas (industrial, agricultural, or coastal locations with salt, particulates, or other matter in the air) where excessive leakage currents may cause burning around metal items in the presence of moisture. On multi-grounded neutral power systems, the neutral is grounded by connecting it to a grounding electrode (ground rod) installed in the earth at the base of a pole at least four times in each mile of line. For birds, bonding and grounding provide pathways for contacts from energized conductors or energized hardware to metal items that are grounded.

The position of the neutral depends on the area's isokeraunic level and/or the practices of the utility. For some utilities, the neutral serves as an overhead ground wire (static wire) for lightning protection. If this type of construction is used, the designer should provide avian-safe separation and ensure that appropriate coverings are used on the grounding conductors and bonded hardware.

SUGGESTED PRACTICES

The remainder of this chapter presents configurations that can pose avian electrocution risks and suggested practices for modifying those problem configurations (Table 5.2). Recommendations are based on providing 150 cm (60 in) separation for eagle protection. Other avian species may require more or less separation, depending on the size and behavior of the bird (see Chapter 4, Size). Recommendations are provided for avian-safe modifications of existing facilities, and avian-safe designs for new facilities. These practices either provide birds with a safer place to land or attempt to discourage birds from perching on parts of the structure where optimal separation cannot be provided.

Two basic principles should be considered when attempting to make a structure avian-safe: *isolation* and *insulation*. The term *isolation* refers to providing a minimum separation of 150 cm (60 in) between phase conductors or a phase conductor and grounded hardware/

TABLE 5.2: Summary of figures and pages for problem configurations and suggested solutions.

Configuration	Problem Figure	Solution Figure	Pages
Single-phase	Figures 5.6, 5.8	Figures 5.7, 5.9, 5.10	61–66
Three-phase	Figures 5.11, 5.15, 5.17, 5.20	Figures 5.12, 5.13, 5.14, 5.16, 5.18, 5.19, 5.21	66–76
Corner poles	Figure 5.22	Figures 5.23, 5.24, 5.25	76–80
Steel/concrete distribution poles	Figures 5.27, 5.29	Figures 5.28, 5.30, 5.31, 5.32, 5.33	81–88
Problem transmission designs	Figures 5.34, 5.36, 5.40, 5.42	Figures 5.35, 5.37, 5.38, 5.39, 5.41, 5.43	88–99
Transformers and other equipment	Figures 5.44, 5.45	Figures 5.46, 5.47	99–102

[23] In some jurisdictions, bond wires are not grounded if the facilities comply with the exceptions of NESC Rule 215 C1.

conductor.[24] Using the principle of isolation may be most applicable for new or rebuilt structures in areas where avian electrocution risk is a concern. The term *insulation* refers to covering phases or grounds where adequate separation is not feasible. Although equipment that is covered with specifically designed avian protection materials can prevent bird mortality, it should not be considered insulation for human protection. Examples of such coverings are phase covers, bushing covers, arrester covers, cutout covers, jumper wire hoses, and covered conductors. In addition, perch discouragers may be used to deter birds from landing on hazardous (to birds) pole locations where isolation, covers, or other insulating techniques cannot be used. Many equipment poles necessitate using a combination of techniques to achieve avian safety.

Both avian-safe modifications of existing structures and avian-safe new construction should be employed if circumstances indicate they are necessary. In areas with known populations of raptors or other birds of concern, new lines should be designed with adequate separations for birds. Given the diversity of line designs and voltages used by power companies, across-the-board standards and guidelines are not possible. It is not realistic to expect to eliminate all hazards to birds. However, it is feasible to reduce known and potential hazards.

MODIFICATION OF EXISTING FACILITIES

In recommending remedial actions for a particular problem, the following generalizations can be made:

- In areas with vulnerable avian populations, power lines built to past construction standards may present serious threats to birds. Such lines are characterized by closely separated, energized components including bare conductors, equipment bushings, primary transition terminations, arresters, and cutout tops. In addition, all of these energized sources may be close to grounded steel brackets, metal crossarm braces, conductors, or guy wires.
- The phase-to-phase and phase-to-ground separation of most transmission lines is typically greater than 150 cm (60 in) and, therefore, the likelihood of electrocutions occurring at voltages greater than 60 kV is low.
- Priority should be given to poles preferred by raptors or other birds that have a high electrocution risk.
- Raptors may use any pole located in homogenous areas of suitable habitat. In these areas, poles of like configuration may pose similar electrocution risks. These areas can be assessed to prioritize structures for corrective actions.
- Electrocutions that have occurred on distribution lines with crossarm construction should be evaluated closely. Although remedial actions should be made at structures with avian mortalities, modifications of entire line sections are generally not recommended in response to an electrocution, which may be an isolated event. Risk assessments should be conducted to determine the likelihood of multiple electrocutions on a given section of line and to identify the poles that pose that risk. Criteria could include electrocuted birds found near a pole, prey availability, proximity to active nests, terrain advantage, and/or consistent use of preferred poles for perching or still-hunting.
- Poles supporting additional electrical equipment (e.g., transformers and switches)

[24] The drawings and text in this chapter refer to providing 150-cm (60-in) separation for eagle protection. Dimensions can be modified for other species (see Table 4.1 for measurements of other avian species). A utility's APP may include approved construction standards for avian protection; this may be particularly necessary for designs that do not provide 150-cm (60-in) separation.

in avian use areas are more likely to cause electrocution (Olendorff et al. 1981; APLIC 1996; Harness and Wilson 2001; Liguori and Burruss 2003; Idaho Power Co., unpubl. data). Retrofitting these structures can reduce avian electrocution risk and improve power reliability.

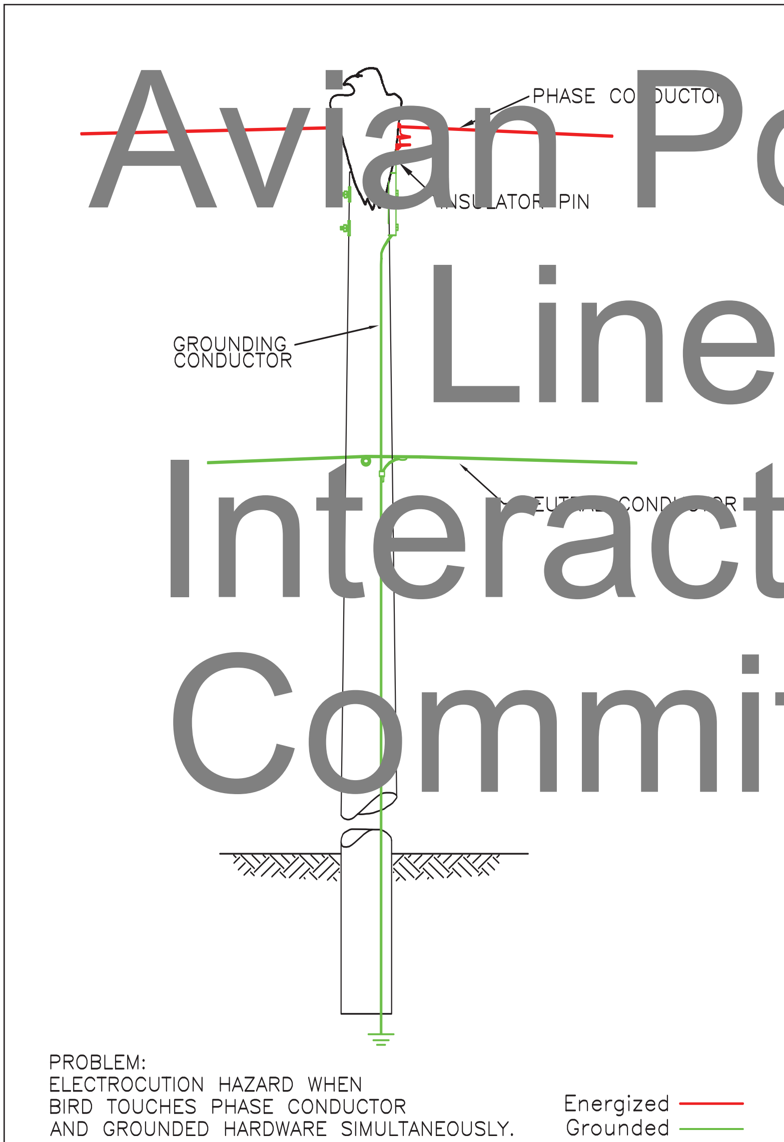

FIGURE 5.6: Problem single-phase with grounded pole-top pin.

AVIAN-SAFE DESIGN OF NEW FACILITIES

Concepts used to modify existing power lines also apply to new construction. Again, two basic considerations are conductor separation and grounding procedures. As with retrofitting, the objective is to provide a 150-cm (60-in) separation between energized conductors or energized hardware and grounded conductors/hardware. If enough separation is not possible, appropriate covers can be used to prevent simultaneous contact between energized and/or grounded facilities.

When planning the construction of new power lines, it is important to consider the safety of the public and utility personnel, biological aspects, ROW permit requirements, service reliability, and other economic and political factors. Although biological significance cannot be overlooked, it may not be possible to site lines outside high-quality bird habitat. In many instances, ROW permits will require avian-safe construction on federal lands. Biologists and engineers should cooperatively consider all factors when developing recommendations for preventing avian mortality problems.

SPECIFIC DESIGN PROBLEMS AND SOLUTIONS

Distribution

WOODEN POLES

Single-Phase Lines

Figure 5.6 shows a typical single-phase line with the phase conductor mounted on the top and the neutral mounted on the side of the pole.[25] In this example, the pole bond (grounding conductor) extends up to the top of the pole to ground the metal bracket. With this configuration, the feet of a large bird perched on the pole top could touch the grounding conductor or grounded insulator pin, while its breast or other body parts contact the phase conductor. In 1971, 17 dead

[25] Note that in this and subsequent figures, grounded conductors and hardware are shown in green and energized conductors and hardware in red. The designs presented in this section apply to poles of a non-conducting nature (i.e. wood or fiberglass). See Steel/Concrete Poles for avian-safe designs of steel/concrete poles.

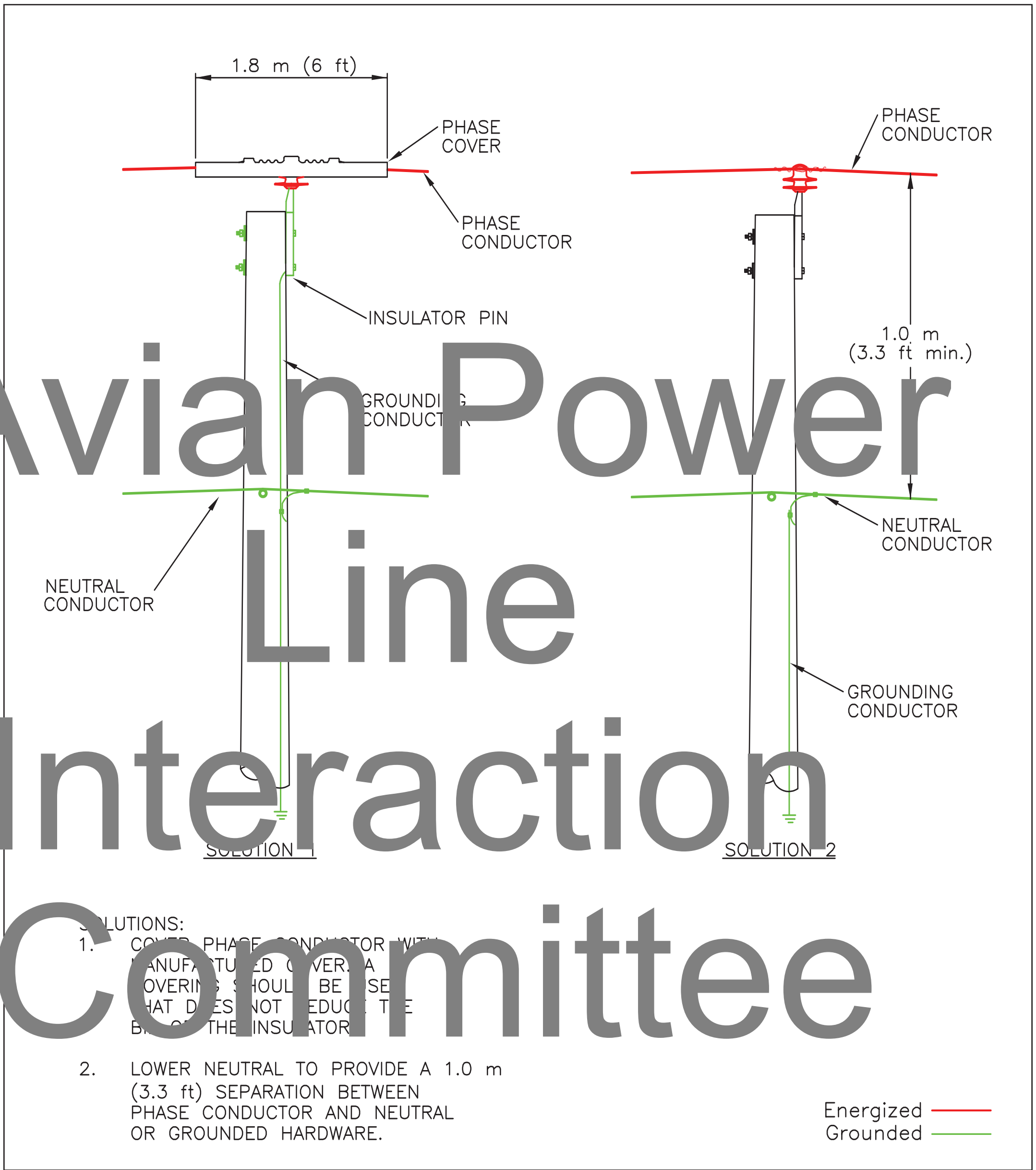

FIGURE 5.7: Solutions for single-phase with grounded pole-top pin.

eagles were found below poles of this configuration in the Pawnee National Grasslands and adjacent areas in Colorado, where habitat and prey attracted wintering eagles (Olendorff 1972a). One retrofitting option for this configuration is to place a cover manufactured for this purpose over the phase conductor to help prevent simultaneous phase-to-ground contact (Figure 5.7, Solution 1). For further information on the use of cover-up products see Precautions (page 102).

If the pole bond or grounding conductor does not extend above the neutral conductor and there is at least 100 cm (40 in) of vertical

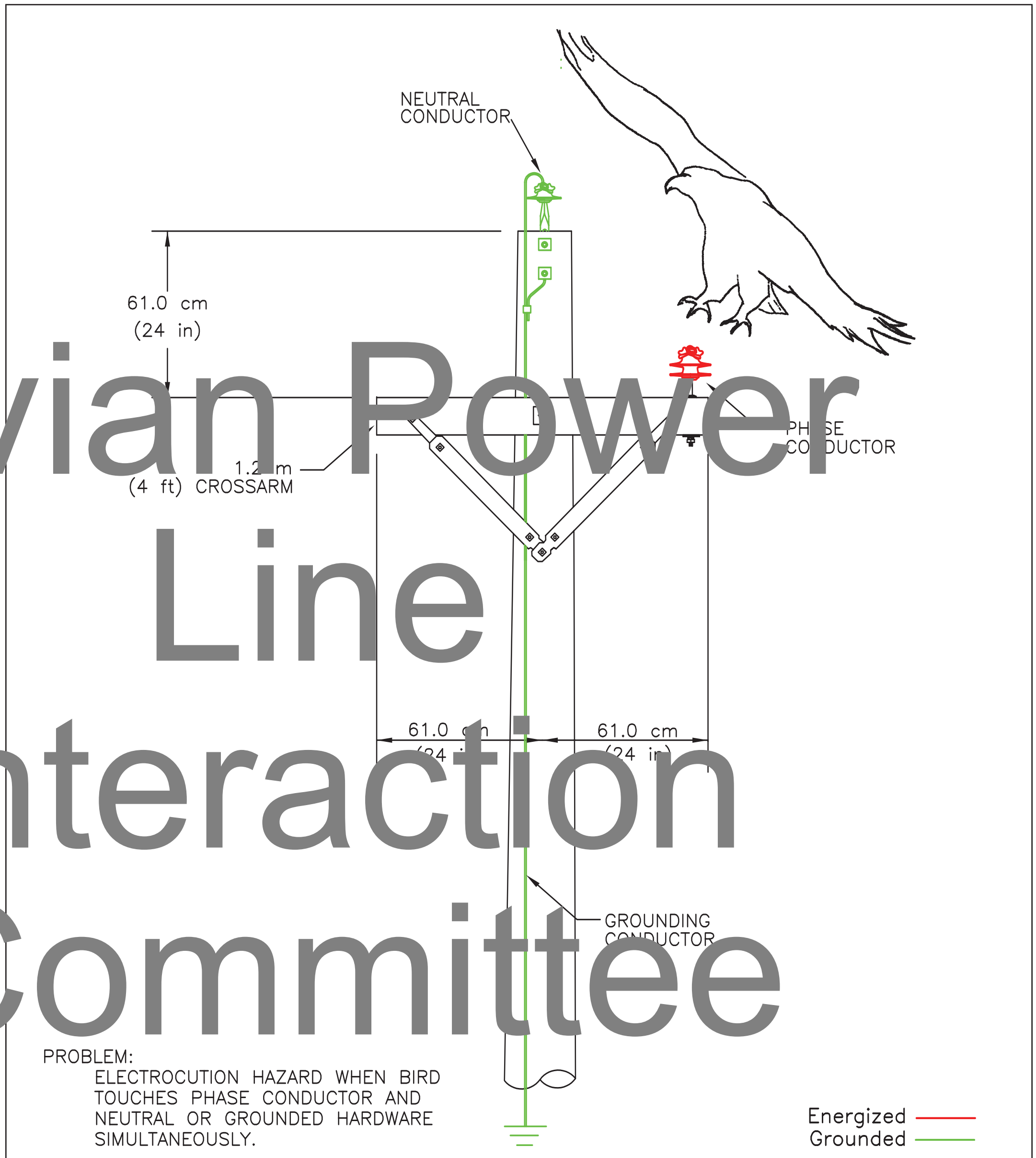

FIGURE 5.8: Problem single-phase configuration with crossarm and overhead neutral.

separation between the phase and neutral conductors, then no further avian protection action should be needed (Figure 5.7, Solution 2).

Figure 5.8 shows another problem single-phase power line, where a pole-top neutral conductor was mounted 61 cm (24 in) above an energized conductor that was supported on a 1.2-m (4-ft) crossarm. In 1992, 17 dead eagles were found below poles with such a configuration along a 24-kilometer (km) (15-mile [mi]) stretch of distribution line in central Wyoming (PacifiCorp, unpubl. data). When the eagles tried to perch on the

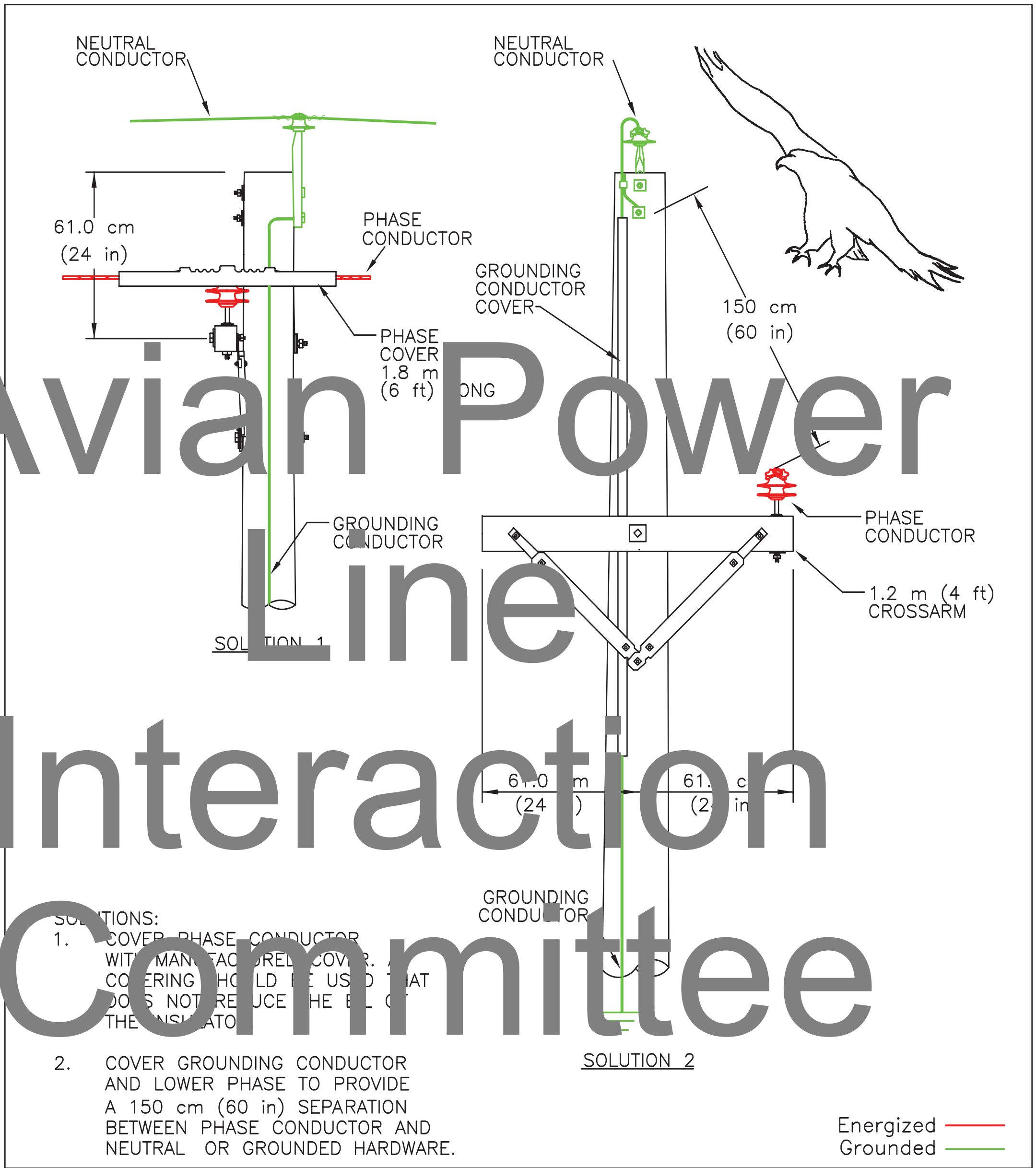

FIGURE 5.9: Solutions for single-phase configuration with crossarm and overhead neutral.

conductor end of the crossarm where there was less than the wrist-to-wrist separation between the phase and neutral conductors, the birds were electrocuted. Surveys conducted in 2002 found that, although this configuration is now uncommon (only 3.9% of 10,946 poles surveyed), it accounted for a disproportionate number (6.4%) of raptor mortalities (n=94) (PacifiCorp, unpubl. data). For this single-phase crossarm configuration (Figure 5.8), the phase conductor can be covered to prevent avian electrocutions (Figure 5.9, Solution 1). Another option is to lower the crossarm and cover the grounding conductor

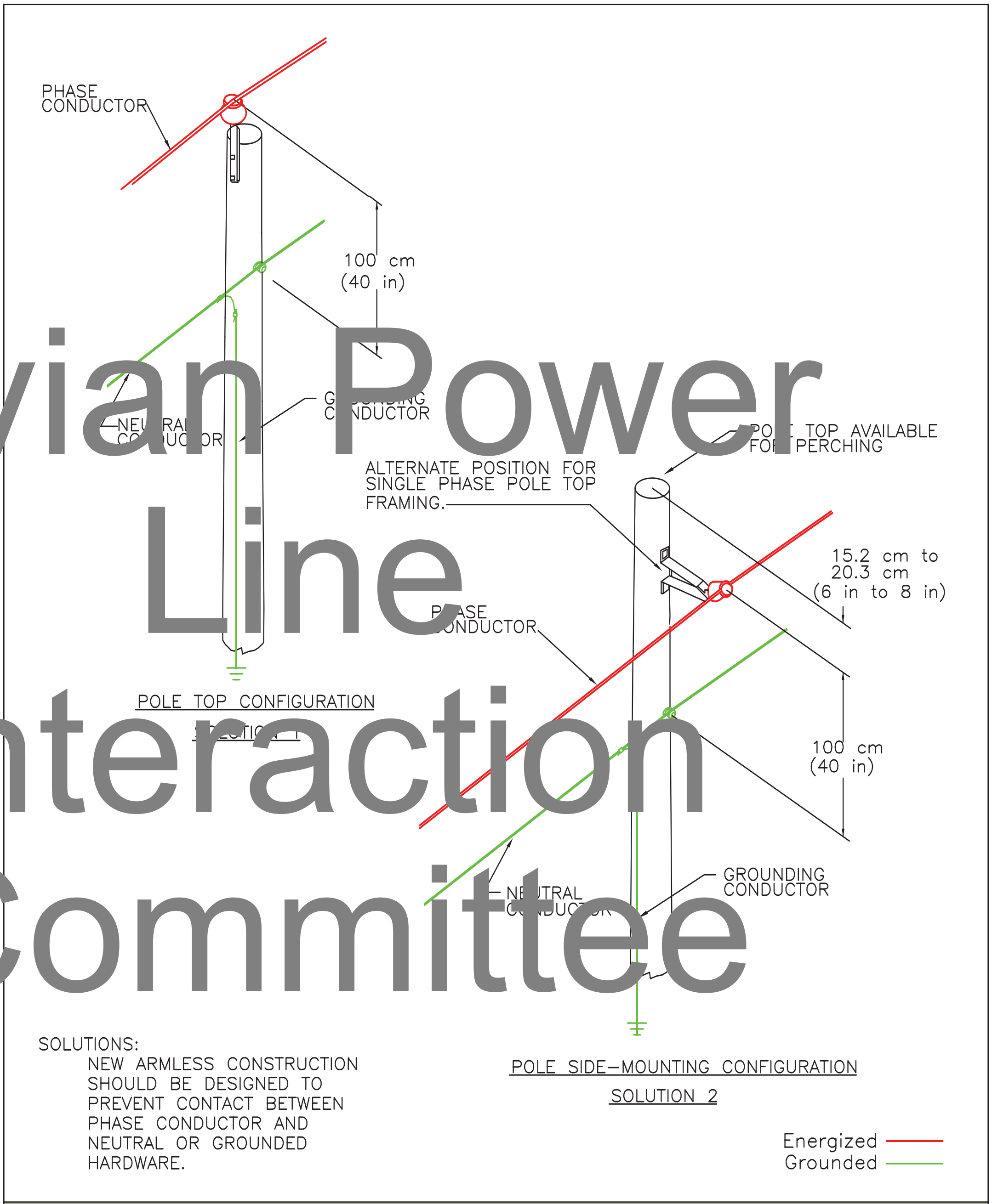

FIGURE 5.10: Single-phase avian-safe new construction.

for avian-safe phase-to-ground separation (Figure 5.9, Solution 2).

When constructing new armless single-phase lines in bird concentration areas, structures should be designed to prevent contact between energized phase conductors/hardware and grounded conductors/hardware (Figure 5.10). If the pole bond and grounding conductor do not extend above the neutral conductor and there is a 100-cm (40-in) spacing between the phase conductor and the neutral conductor, then no further avian protection should be needed (Figure 5.10, Solution 1). Figure 5.10 (Solution 2) shows a single-phase configuration with the phase conductor mounted on the side of the pole. This provides the pole top as a perch.

Three-Phase Lines

Crossarms of 1.8 or 2.4 m (6 or 8 ft) are typically used for most single-pole, three-phase configurations (Figure 5.11). For raptors, the crossarms can provide excellent perching opportunities between phases, but the phase conductor separation is often insufficient to safely accommodate wrist-to-wrist distances of large birds. Utility use of grounded steel crossarm braces[26] may further reduce ground-to-phase separation, increasing the risk of avian electrocution. Although the Rural Electrification Administration (REA)[27] specifications were changed in 1972 to increase conductor separation and include the use of wooden crossarm braces (U.S. REA 1972; see Appendix B) many pre-1972 poles are still in use today. The center phase is supported either on a pin insulator on the crossarm (Figure 5.11, Problem 1) or with a pin insulator attached to the pole top (Figure 5.11, Problem 2).

Several remedial measures are available to achieve avian-safe separation between phases

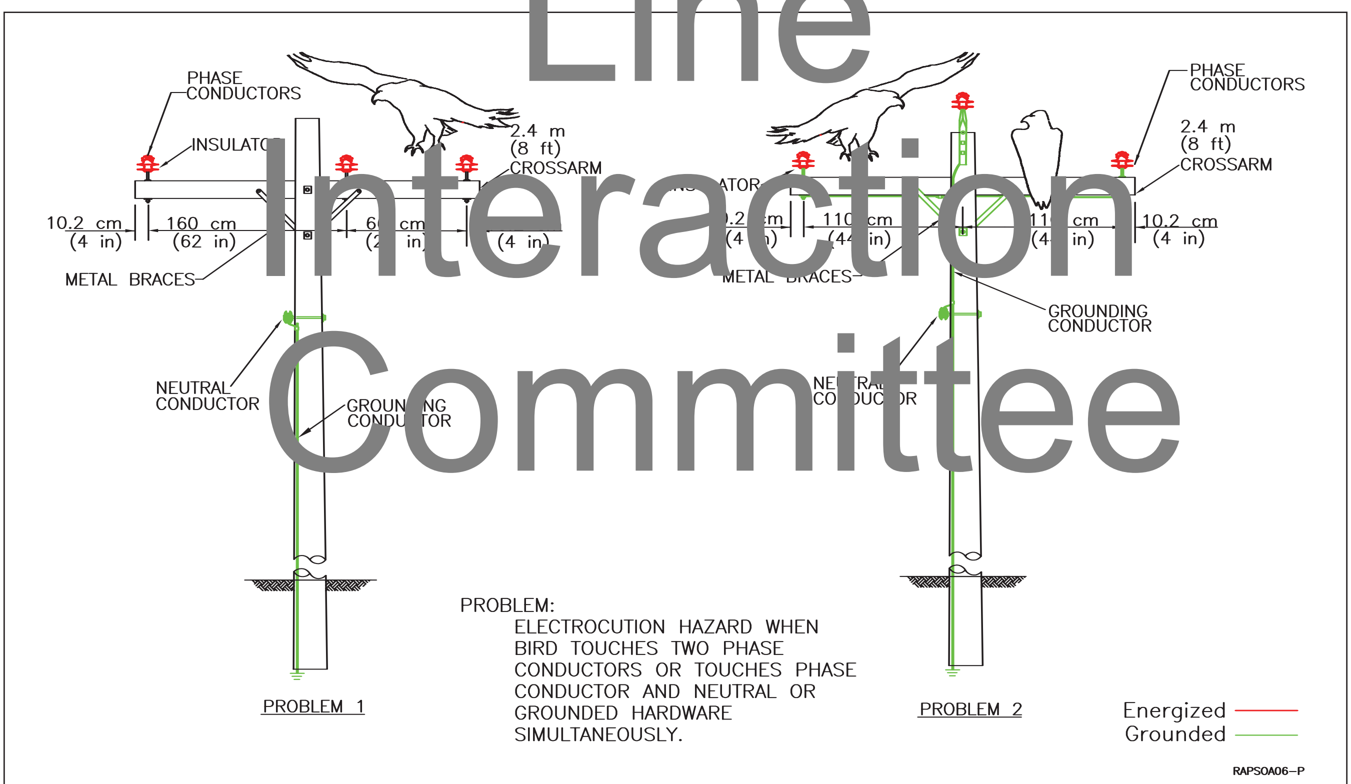

FIGURE 5.11: Problem three-phase crossarm designs with and without grounded hardware.

[26] Grounded to prevent pole fires resulting from insulator leakage currents.

[27] REA, the predecessor to the Rural Utilities Service (RUS), provides financing assistance to rural electric utilities that agree to install facilities in accordance with the standards and specifications established by REA/RUS.

or between phase and ground where all hardware is bonded (as shown in Figure 5.11):

- Install covers over the insulator and conductor on the center phase and remove bonding down to the neutral (Figure 5.12, Solution 1). For further information on the use of cover-up products, see Precautions (page 102).
- If bonds are not removed, install phase covers over all three insulators and conductors (Figure 5.12, Solution 2).
- For pole-top pin construction, the crossarm can be lowered and/or replaced with a longer crossarm (Figure 5.13).[28] A 2.4-m (8-ft) crossarm should be lowered 104 cm (41 in) to achieve 150-cm (60-in) conductor separation. A 3-m (10-ft)

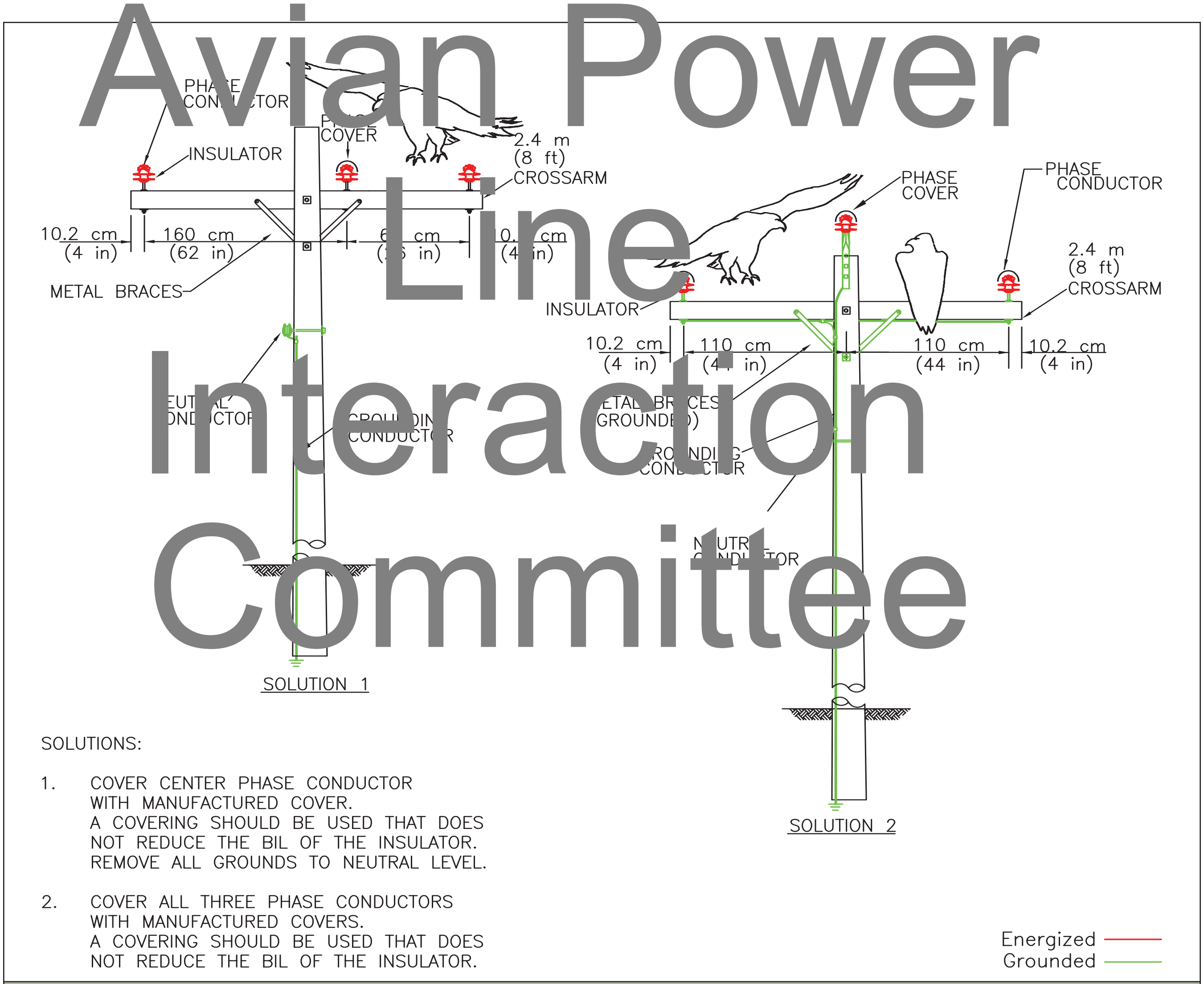

FIGURE 5.12: Solutions for three-phase crossarm designs with and without grounded hardware.

[28] Provided that NESC requirements can be met.

crossarm could be mounted 55 cm (21.5 in) below the top of the pole to provide 150 cm (60 in) of conductor separation between the center and outer phase conductors. In addition, the bond wire must be lowered to the neutral position. This lowered arm configuration can also be used for avian-safe new construction.

On three-phase crossarm construction where there is no grounding conductor above the neutral and the center phase is on the crossarm, a perch discourager may be installed to deter perching between closely separated phase conductors (Figure 5.14). If there is less than a 150-cm (60-in) spacing between the center and outer phases (opposite the perch discourager), a phase cover should be installed on the center phase instead of using a perch discourager. Design consideration must be given to meet minimum NESC clearances on the supporting structure (pole, crossarm, insulator and perch discourager).[29] Proper distance between the perch discourager and the phase conductor is required and increases as the system voltage increases. In addition, to prevent birds from perching between the discourager and phase conductor, no more than a 12.7-cm (5-in) space should be allowed between a perch discourager and the insulator skirt. When these two parameters conflict, the perch discourager

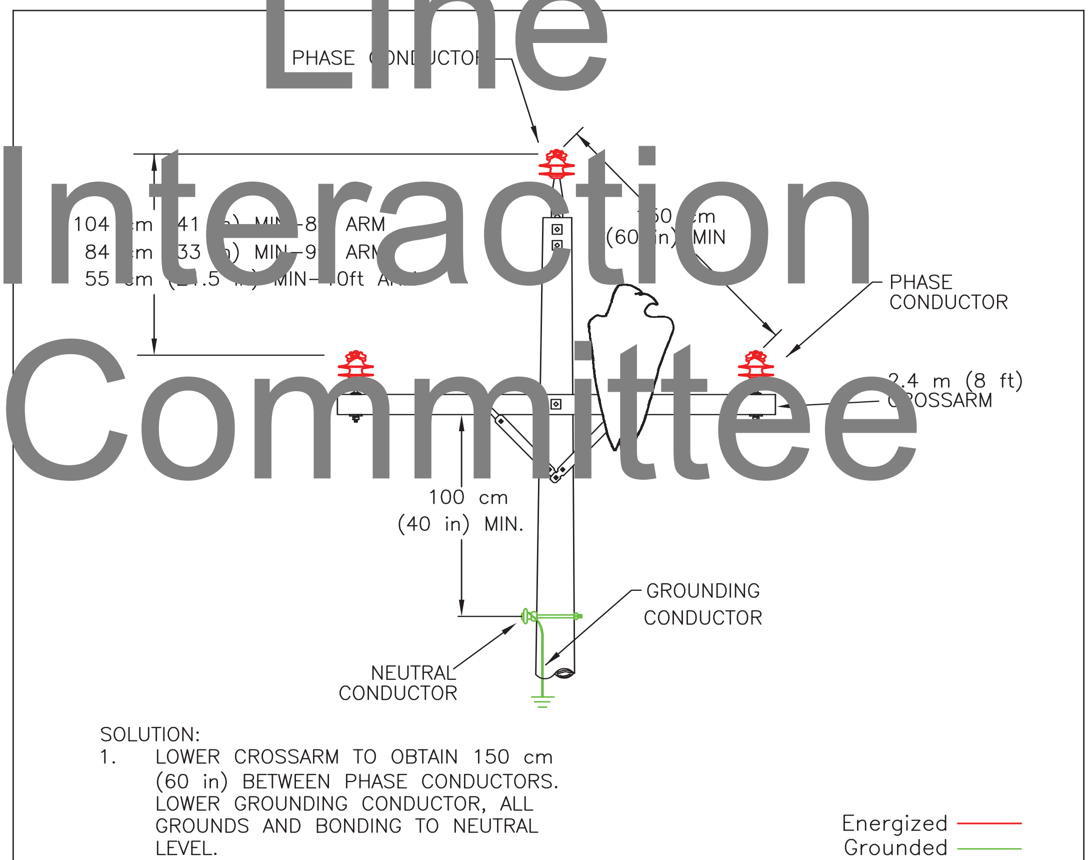

FIGURE 5.13: Avian-safe three-phase construction for different length crossarms.

[29] NESC Rule 235E, Table 235-6.

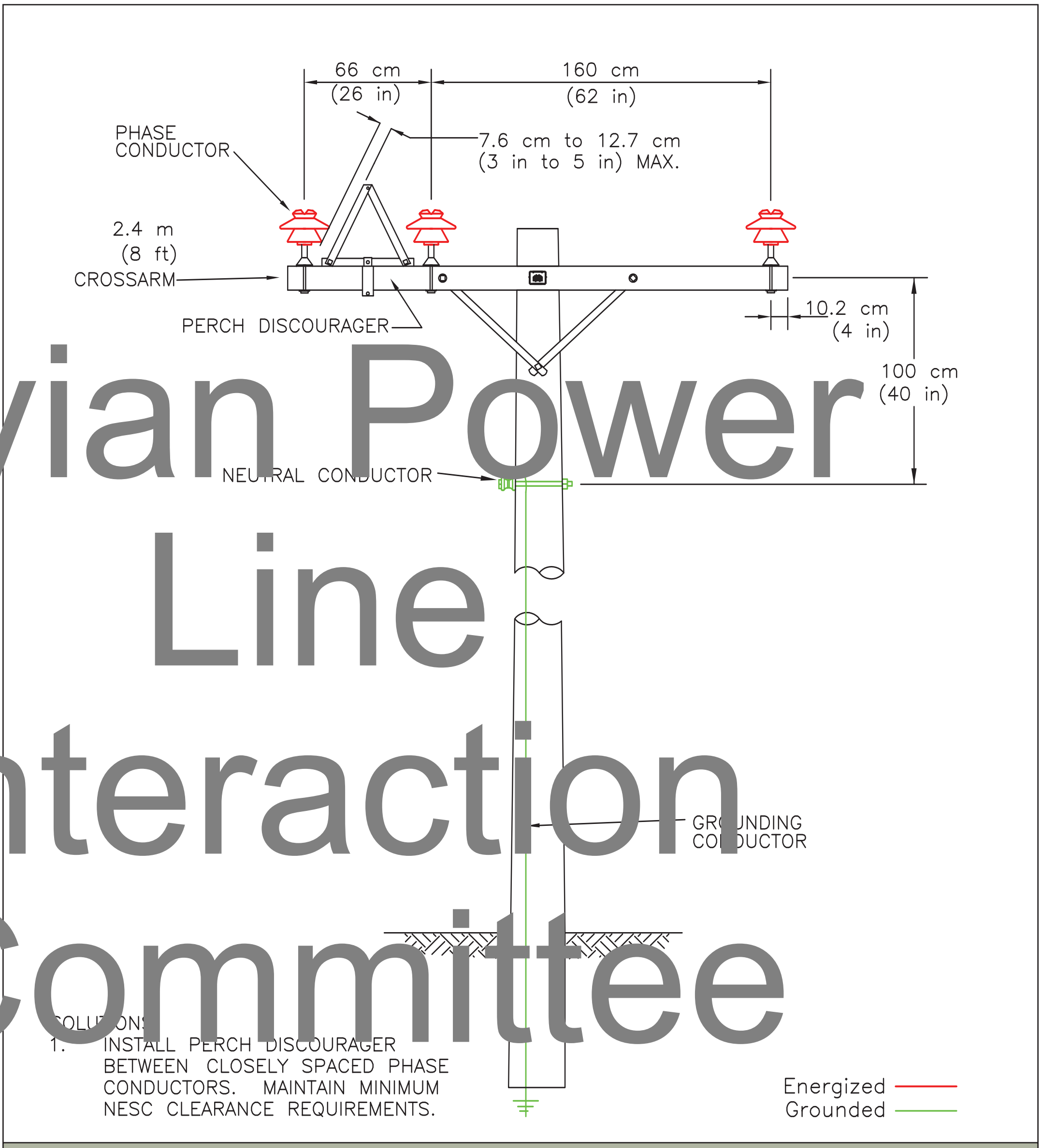

FIGURE 5.14: Solution for three-phase crossarm using perch discourager.

is not an acceptable mitigation tool. For example, on system voltages exceeding 18.7 kV phase to phase, electrical clearance will require greater than 12.7 cm (5 in), which exceeds the maximum avian-safe physical spacing and would not be effective. If spacing and system voltage are not compatible with a perch discourager, a phase cover should be used instead. See page 17 for a discussion of appropriate uses of perch discouragers for deterring birds.

Dead-end distribution structures accommodate directional changes, line terminations, and lateral taps. These structures handle greater loads, usually use anchor and guy wire assemblies, and have energized jumper wires.

These characteristics can pose electrocution risks to birds. Figure 5.15 depicts a three-phase, double dead-end pole in which jumper wires extend over the crossarm. On such a configuration, a bird can be electrocuted by simultaneously touching two of the phase jumpers. To reduce this risk, use dead-end covers on both sides of the center conductor

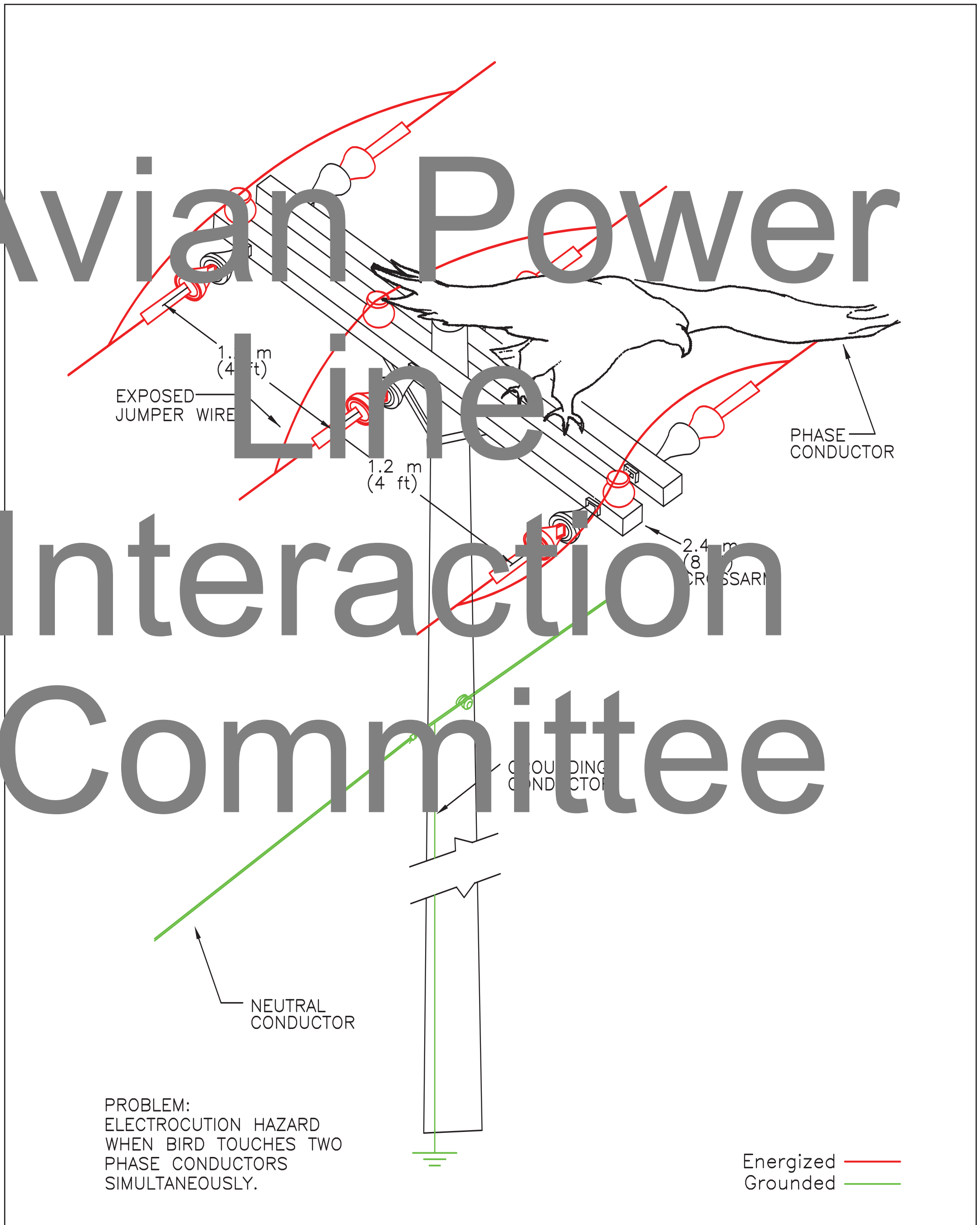

FIGURE 5.15: Problem three-phase double dead-end with exposed jumper wires.

and cover the center phase jumper wire with a material designed for the purpose. A covered conductor can also be used (Figure 5.16), as can insulated links or insulators that move the energized conductor 91 cm (36 in) from the center of the pole.

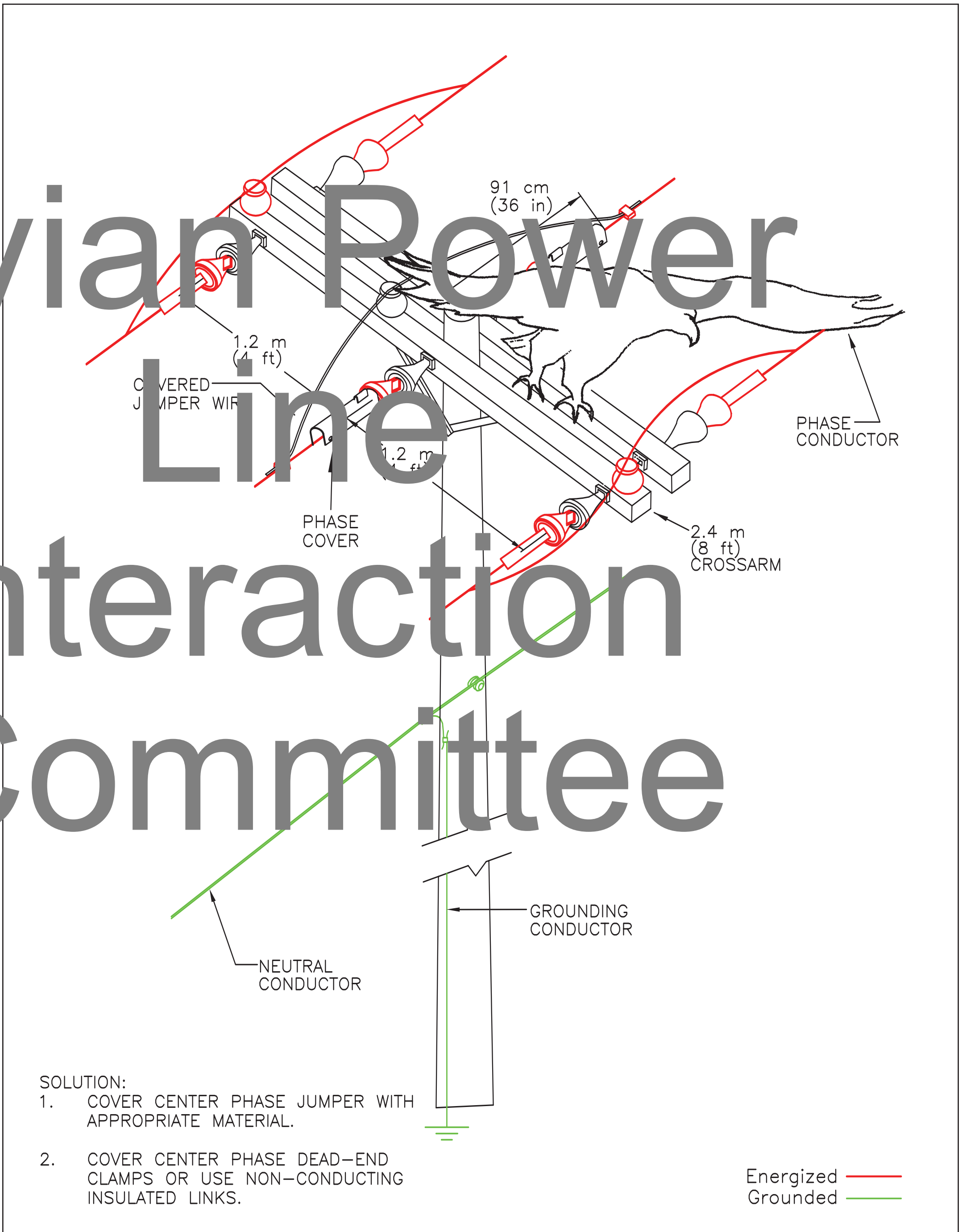

FIGURE 5.16: Solution for three-phase double dead-end with exposed jumper wires.

Compact Designs

The three-phase compact design shown in Figure 5.17 was not originally considered a high-risk configuration (Olendorff et al. 1981; APLIC 1996). However, raptors and other large birds may be electrocuted when flying in to perch on the short fiberglass arms that support the phase conductors. Interestingly, this configuration presented a significant eagle electrocution problem on a line in southern Utah, while a nearby line of the same construction did not electrocute any eagles (PacifiCorp, unpubl. data). Overall, streamline poles comprised 10% of poles surveyed in Utah and Wyoming from 2001 to 2002 (*n*=74,020) and accounted for 13%

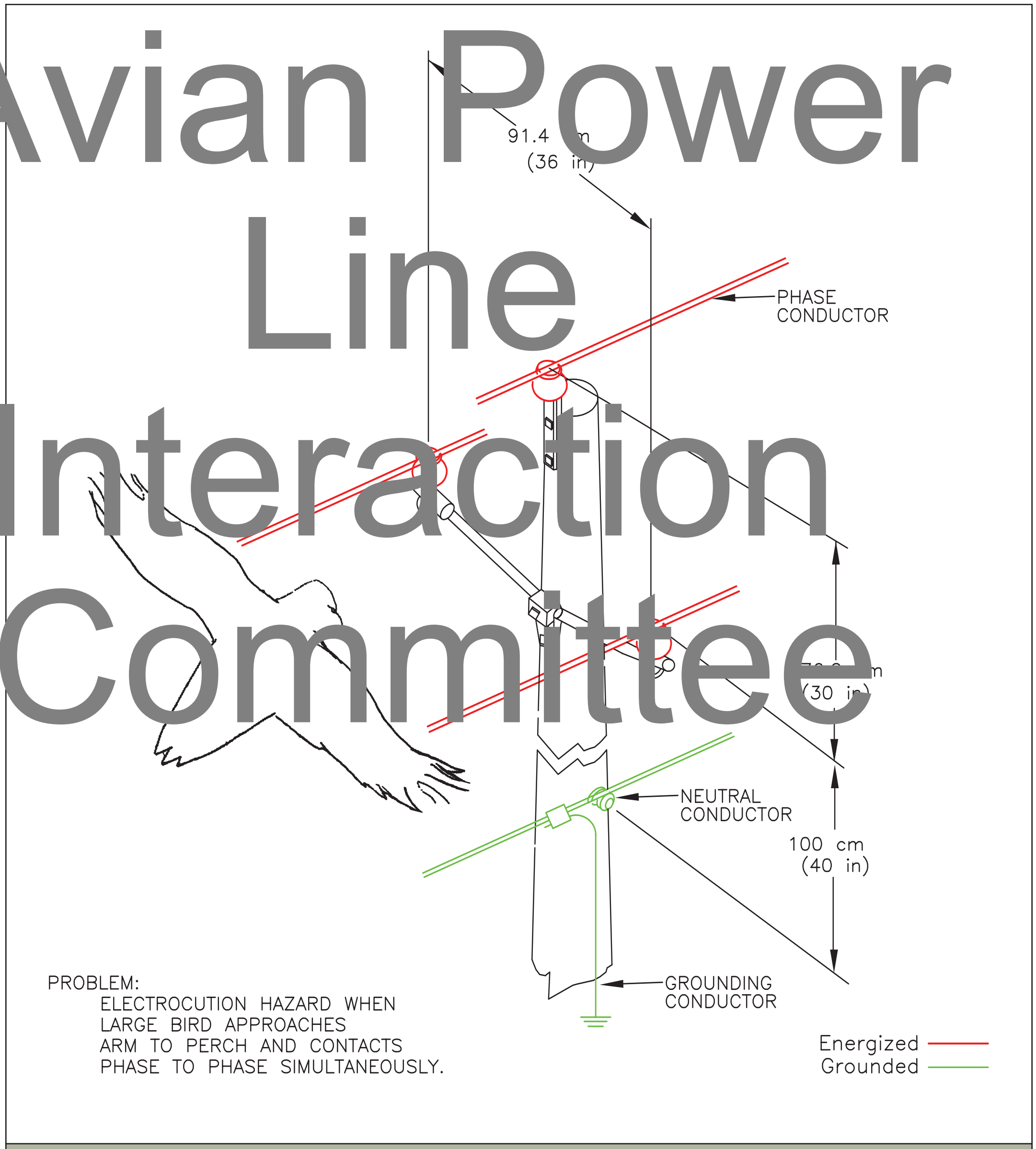

FIGURE 5.17: Problem compact three-phase design.

of avian mortality (*n*=547) (Liguori and Burruss 2003).

Solutions for the problem compact design shown in Figure 5.17 include the following:

- Install phase covers over the lower, outer phase conductors (Figure 5.18). Note that phase covers may not fit on compact designs with side-tied conductors or angled insulators.
- Replace the existing epoxy bracket with a longer bracket and lower it to achieve a 150-cm (60-in) phase separation (see Figure 5.19, Solution 3).

In addition, there are several avian-safe design options for new construction that may

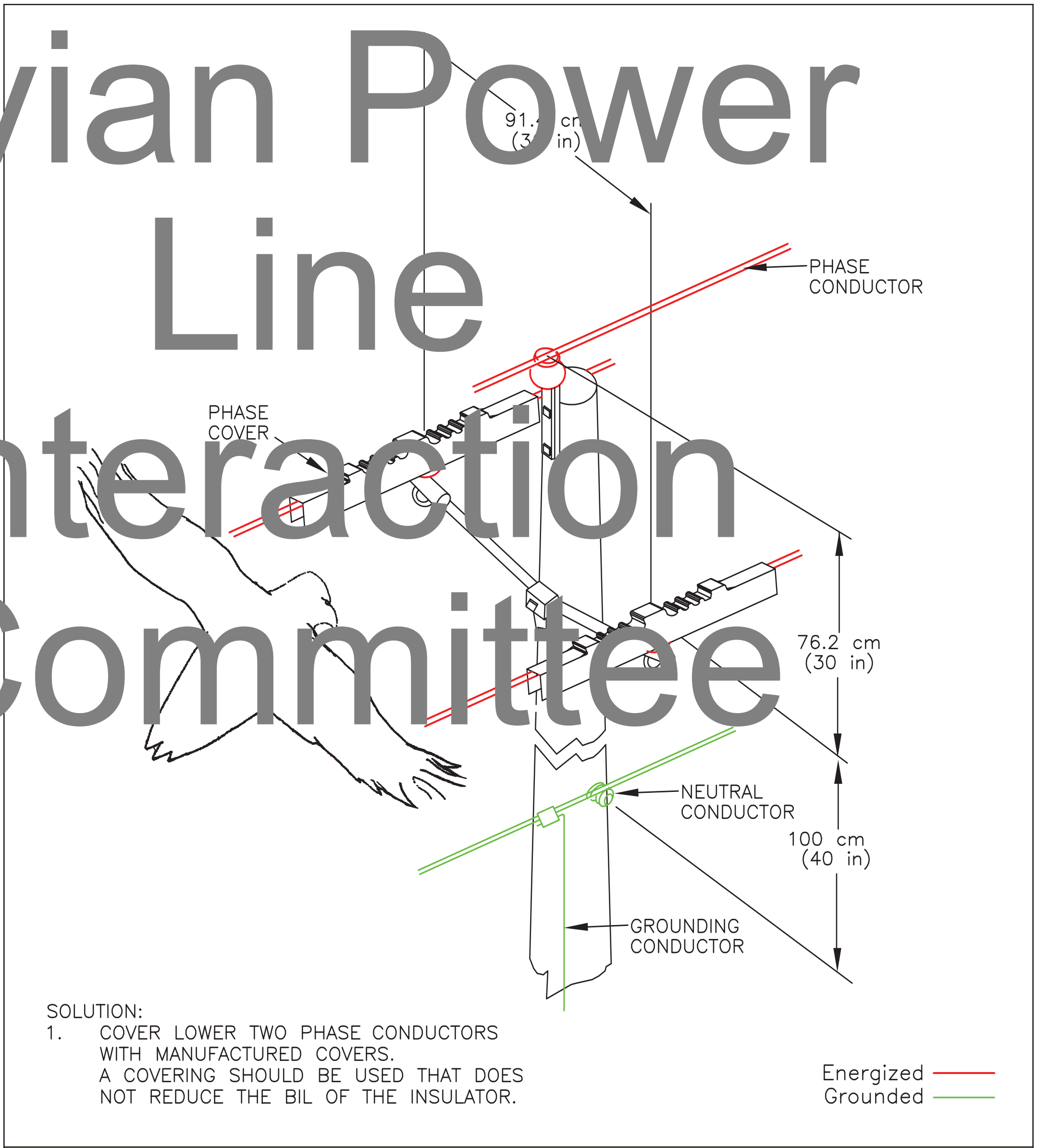

FIGURE 5.18: Solution for compact three-phase design.

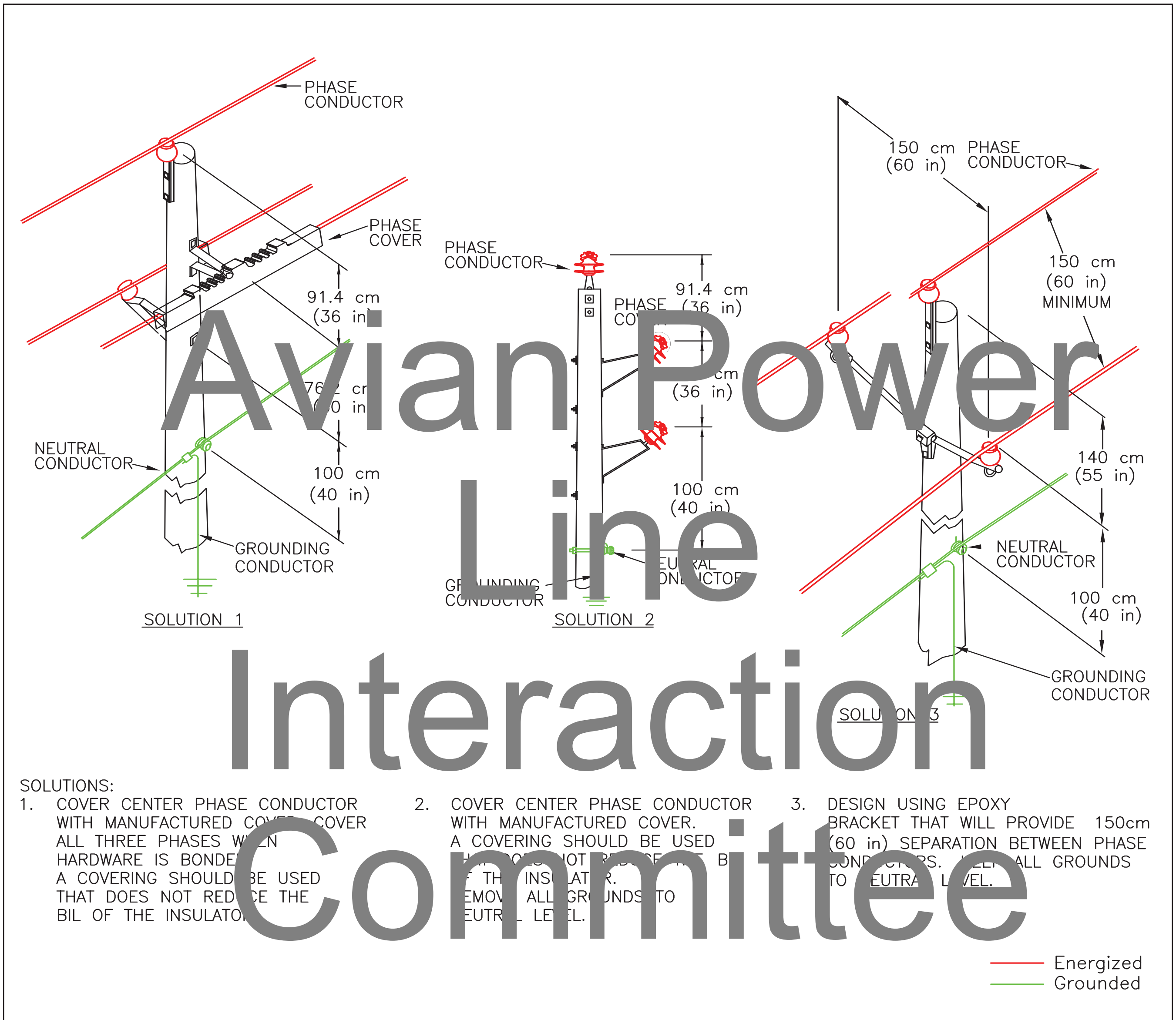

FIGURE 5.19: Avian-safe compact three-phase designs for new construction.

be used where ROW restrictions require compact configurations in areas that attract large birds (Figure 5.19). Inventories of avian populations, food sources, locations preferred by birds, alternative configurations, electrical reliability requirements, and other data should be obtained before determining the final design.

The armless configuration, in which conductors are mounted on horizontal post insulators, can be used for distribution lines (Figure 5.20). In utility service areas subject to high lightning levels, lightning protection on such lines may include an overhead conductor that must be grounded. On some installations with wood poles, utilities, particularly in salt spray or other contaminated areas, may bond the bases of the post insulators to the pole-grounding conductor to prevent pole fires. A bird perched on the insulator can be electrocuted if it comes in contact with the energized conductor and either the grounded insulator base or the bonding conductor. Solutions for avian-safe horizontal post designs are provided in Figure 5.21. Solution options include:

- Covering the vertical grounding conductor from the overhead grounding conductor clamp to 30 cm (12 in) below the lowest phase and disconnecting insulator bracket bonds (Figure 5.21, Solution 1);

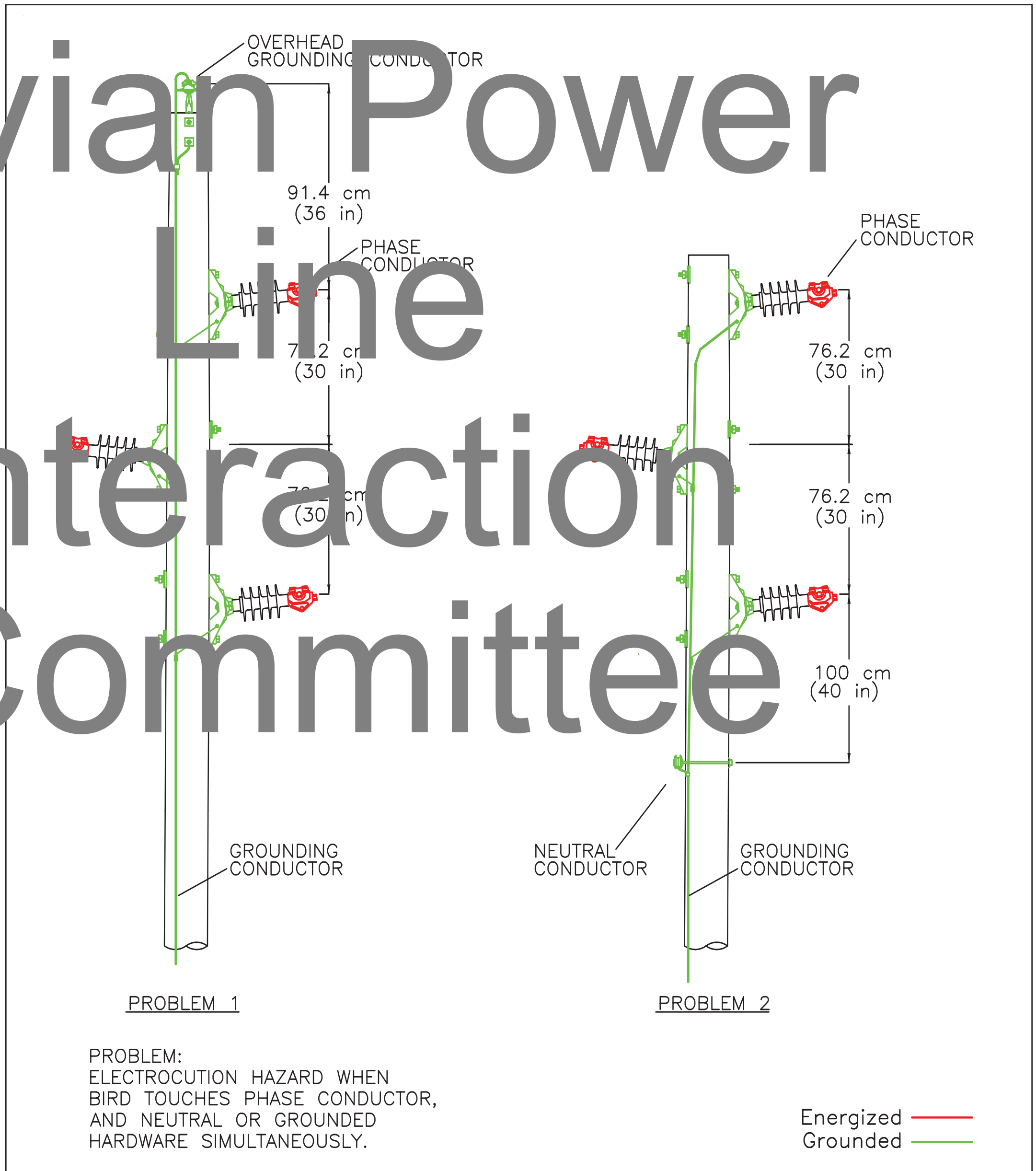

FIGURE 5.20: Problem distribution horizontal post insulator designs.

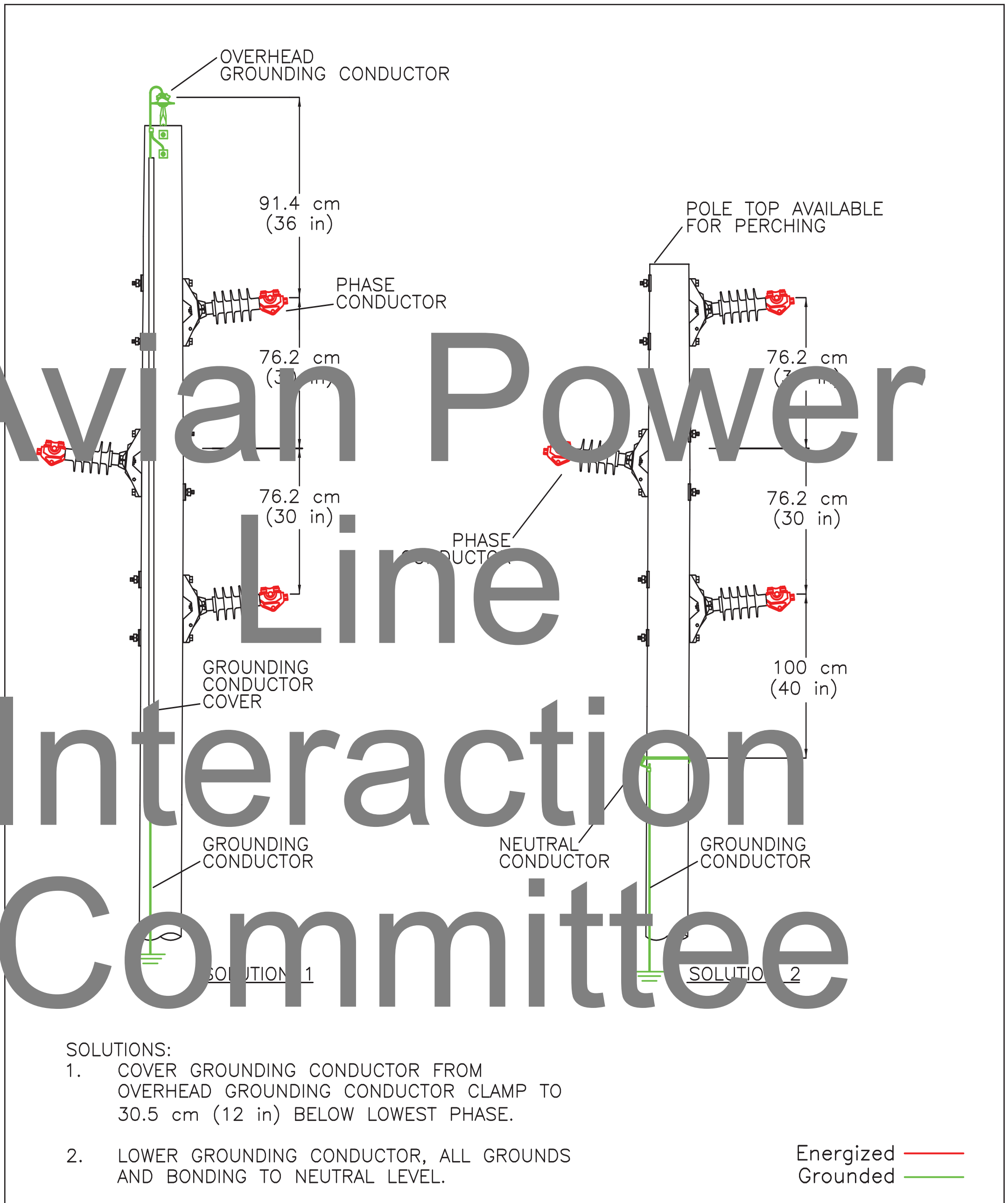

FIGURE 5.21: Solutions for distribution horizontal post insulator designs.

- Removing all bonds and the grounding conductor to the neutral (Figure 5.21, Solution 2); or
- Installing phase covers on all three phases if hardware is bonded and grounding conductor is uncovered.

Corner Poles

Poles designed to accommodate directional changes in power lines (Figure 5.22) can create hazards for birds. On these poles, uncovered jumper wires are normally used to complete electrical connections and connect the phase conductors. In this case, the typical 110-cm (42-in) or less horizontal separation between conductors is insufficient to protect large birds. If grounded metal crossarm braces, grounded guying attachments, and uncovered grounding conductors are present, the avian electrocution risk may be further increased.

On corner poles, the center phase conductor can be attached to the top set of crossarms with additional insulators or

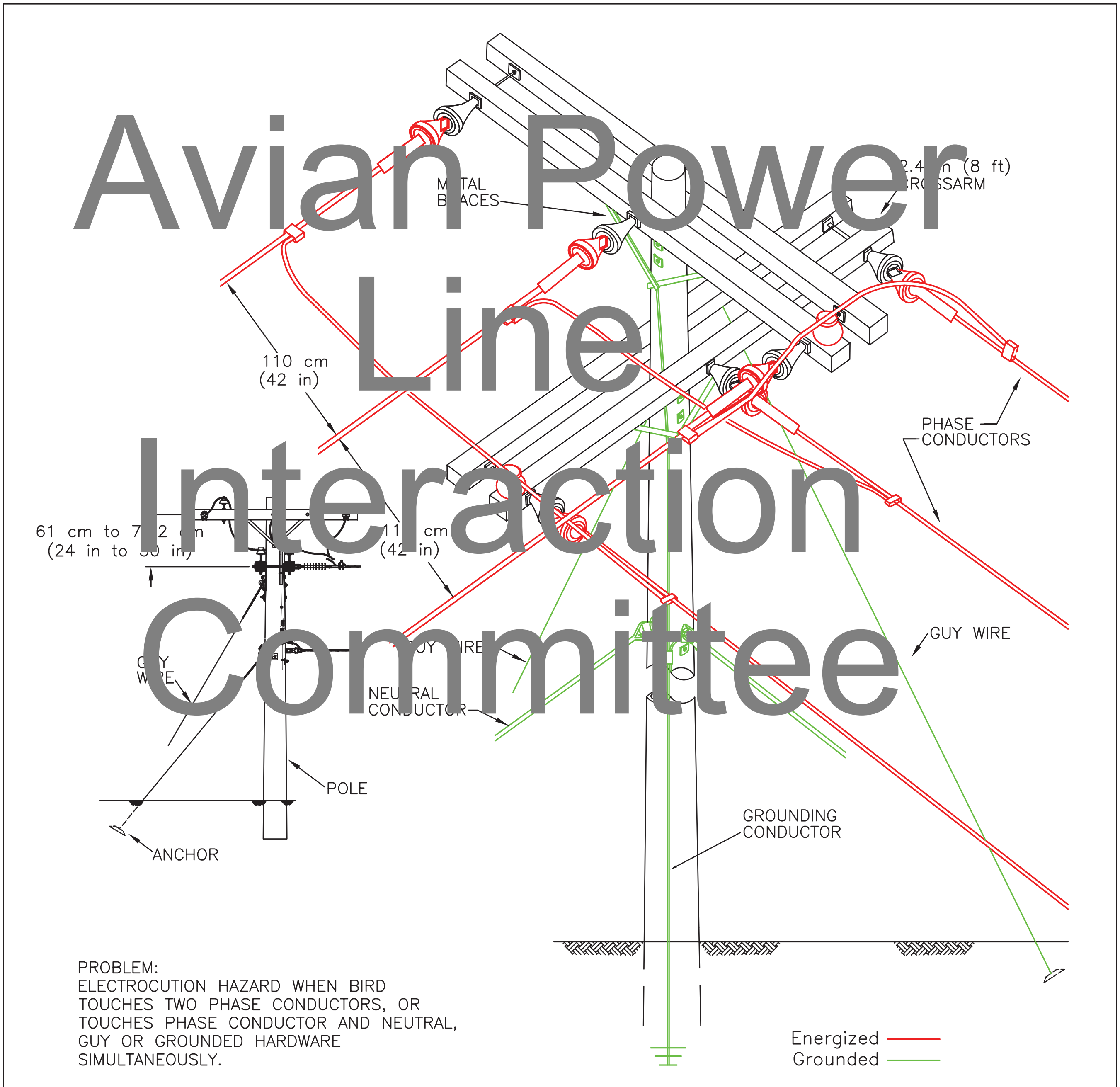

FIGURE 5.22: Problem three-phase distribution corner configuration.

with a non-conducting extension link to prevent contact by birds. An alternative to using an extension link may be to install a phase cover on the center phase (Figure 5.23). The extension link or phase cover should extend 91 cm (36 in) from the pole to the conductor. Bare jumper wires should be covered with a material designed for the purpose or replaced with covered conductors. In addition, all down guy-wires should have guy strain

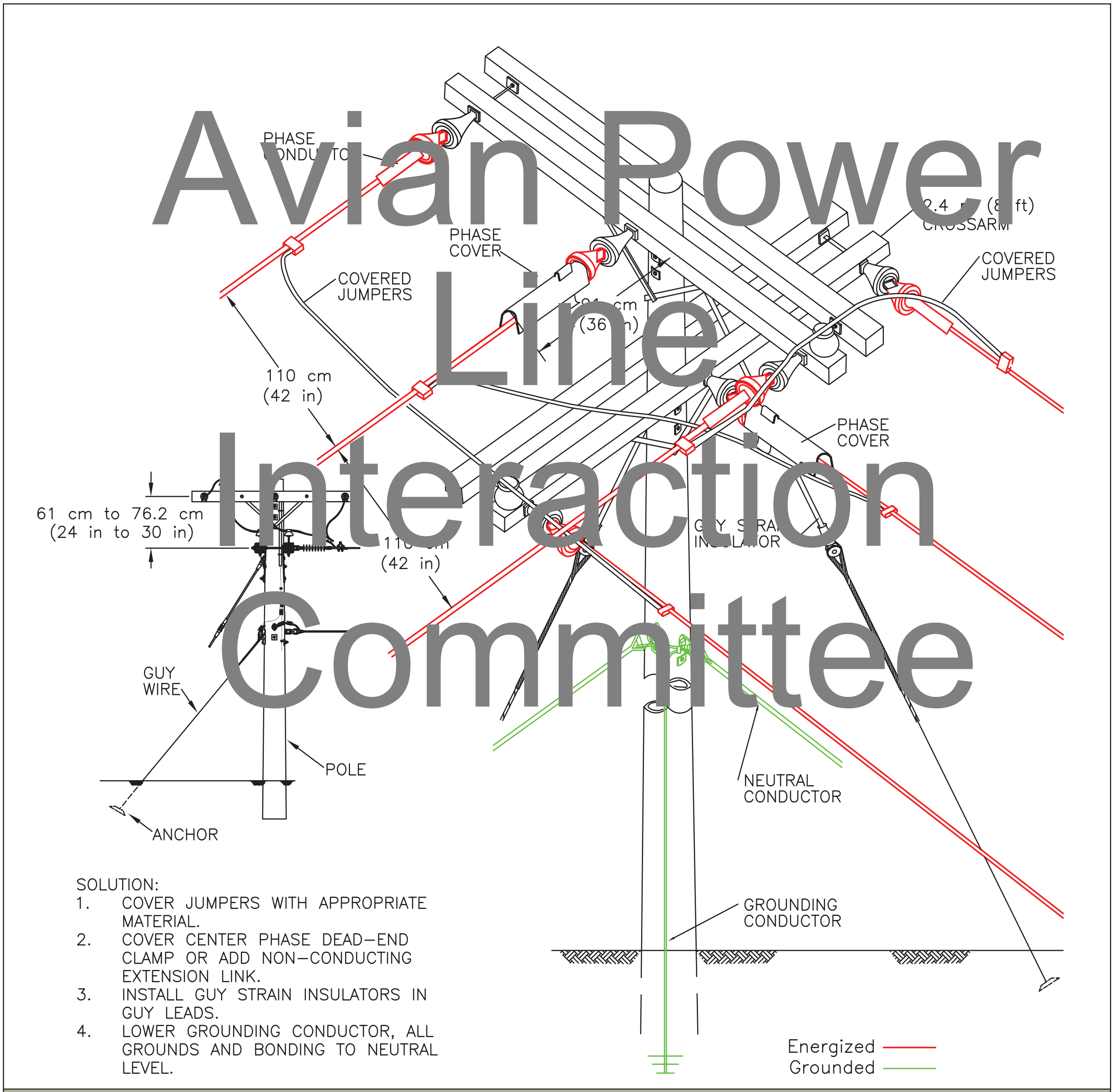

FIGURE 5.23: Solution for three-phase distribution corner configuration.

insulators to prevent them from acting as grounds.

For new structures, corner poles can be constructed with lowered crossarms (i.e. 104 cm [41 in] from the pole top if using 2.4-m [8-ft] arms) that provide 150 cm (60 in) of phase-to-phase separation. Conventional corner poles can be constructed in the manner depicted in Figure 5.23. Other alternatives are the vertical designs shown in Figures 5.24

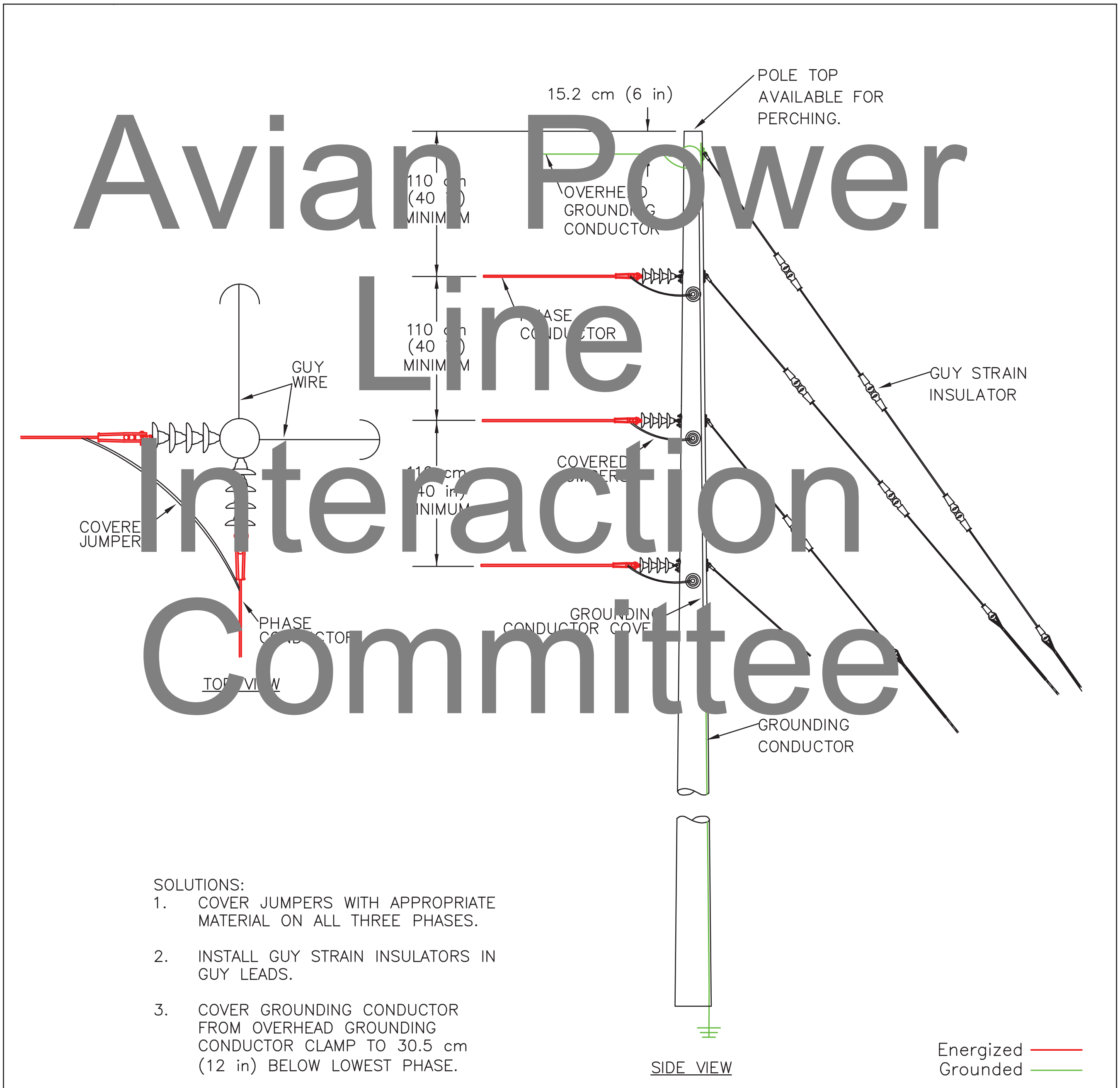

FIGURE 5.24: Three-phase vertical corner configuration—overhead grounding conductor on pole top.

and 5.25, which prevent simultaneous contact by birds. In Figure 24, the grounding conductor should be covered with a material appropriate for avian protection. Taller poles are usually required, but vertical avian-safe corner designs eliminate crossarms and unwieldy jumper wire arrangements. They can also accommodate overhead grounding conductors.

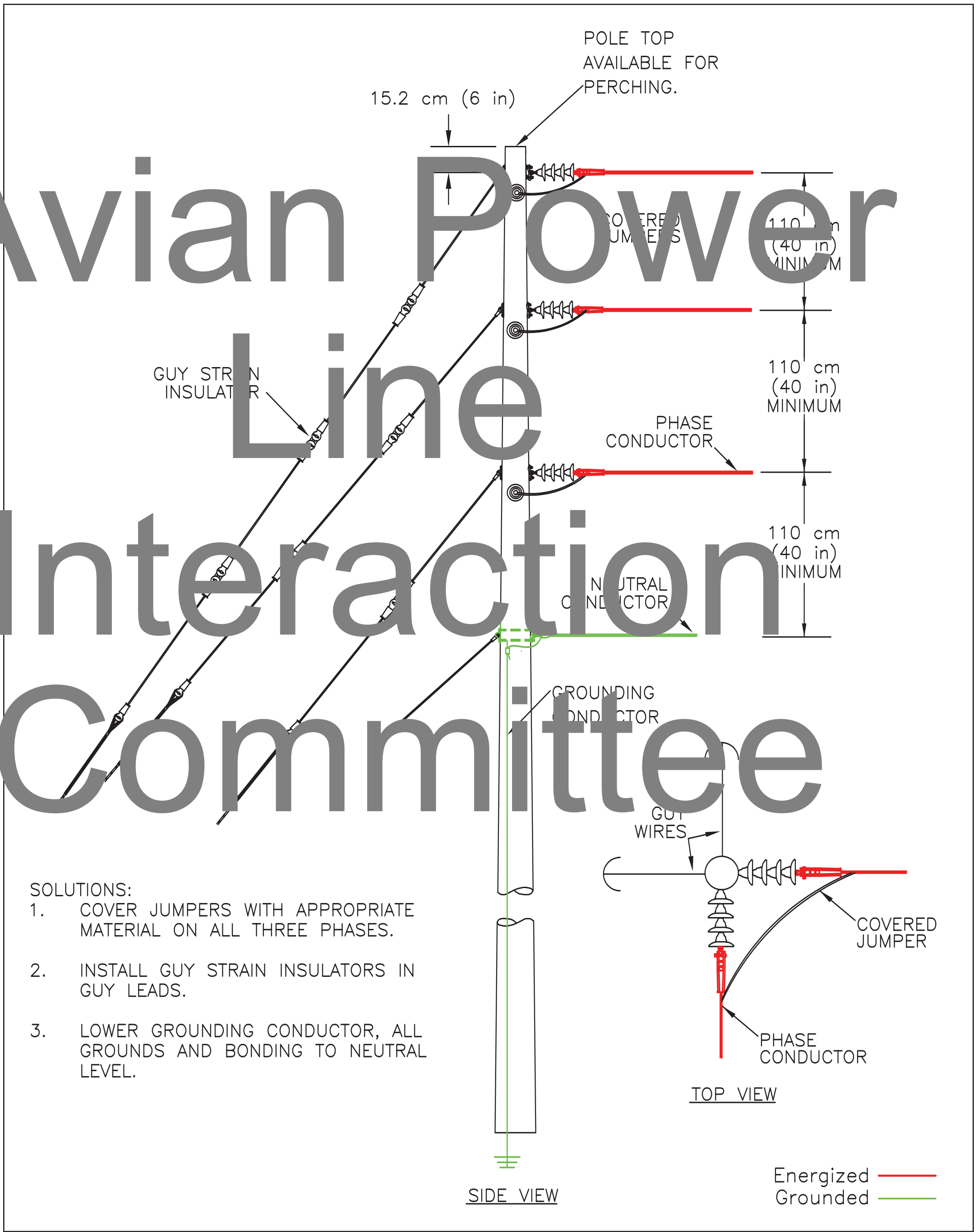

FIGURE 5.25: Three-phase vertical corner configuration—neutral below phases.

STEEL/CONCRETE POLES

Steel/Concrete Pole Construction Worldwide

Most distribution power poles in the United States are made of wood, a nonconductive material.[30] In contrast, steel and concrete poles are commonly used in distribution line construction in Europe and other parts of the world. In Western Europe, it is estimated over 90% of the distribution poles are metal with grounded metal crossarms (Janss and Ferrer 1999). On such configurations, electrocutions can occur from phase conductor to pole or phase conductor to metal crossarm, placing both large and small birds at risk (Bayle 1999; Negro 1999; Janss and Ferrer 1999). Accordingly, European electrocution mitigation methods differ from those of the United States because measures effective on wooden power poles have not solved electrocution problems on conductive poles (Janss and Ferrer 1999). However, covering conductors with a dielectric material appropriate for avian protection is typically more effective in preventing electrocutions than is perch management, regardless of whether the pole is wooden, steel, or concrete (Negro 1999). Covering conductors is the preferred method on new or retrofitted steel and concrete poles in Europe (Janss and Ferrer 1999).

Concrete poles, with their internal metal rebar support structure, pose similar electrocution risks to metal poles. Concrete poles also provide a pathway to ground, further increasing their electrocution risk, especially when wet or when fitted with conductive crossarms. The largest remaining black-tailed prairie dog *(Cynomys ludovicianus)* colony complex in North America is in northwestern Chihuahua, Mexico (Ceballos et al. 1993). This complex supports a high density of raptors and nearby power lines are constructed with reinforced concrete poles with steel crossarms. In 2000, 1,826 power poles were surveyed and 49 electrocuted birds were found, including Chihuahuan ravens *(Corvus cryptoleucus)*, ferruginous hawks *(Buteo regalis)*, red-tailed hawks *(B. jamaicensis)*, prairie falcons *(Falco mexicanus)*, American kestrels *(F. sparverius)*, and golden eagles. The number of electrocutions led researchers to conclude that these poles represent a serious risk for wintering raptors (Cartron et al. 2000). The subsequent replacement of steel crossarms with wooden arms on over 200 poles in this area significantly reduced the electrocution risk of these structures (Cartron et al. 2005).

Steel/Concrete Pole Construction in the United States

Historically, utilities in the United States have primarily used wood for distribution poles and crossarms. Accordingly, many avian retrofitting techniques today are designed for use on wood structures. Fiberglass, concrete, and steel poles are now being used more in distribution line construction for a variety of reasons. Sometimes non-wood poles are used because they are not susceptible to damage by woodpeckers. In some regions of the United States, woodpecker damage is the most significant cause of pole deterioration (Abbey et al. 1997). Steel poles and concrete poles are harder for animals such as squirrels, raccoons, and cats to climb. By keeping these animals off structures, utilities can help reduce outages. Non-wood poles may also be used because they are not susceptible to fungal, bacterial, or insect damage.

Distribution power lines constructed with steel or concrete poles using standard utility configurations can significantly reduce phase-to-ground separations. Fiberglass poles have a higher insulation resistance than steel, concrete, and wood poles.

Single-phase lines are usually constructed without crossarms and support a single energized phase conductor on a pole-top insulator.

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[30] The insulation value of wood poles and crossarms is variable based on age, condition, contamination, and wetness.

Wood or fiberglass distribution structures, without pole-top grounds or pole-mounted equipment, generally provide adequate separation for birds (Figure 5.26).

When steel or concrete poles are used (Figure 5.27), a bird perched on the pole top can touch its body to the conductor while simultaneously contacting the grounded pole

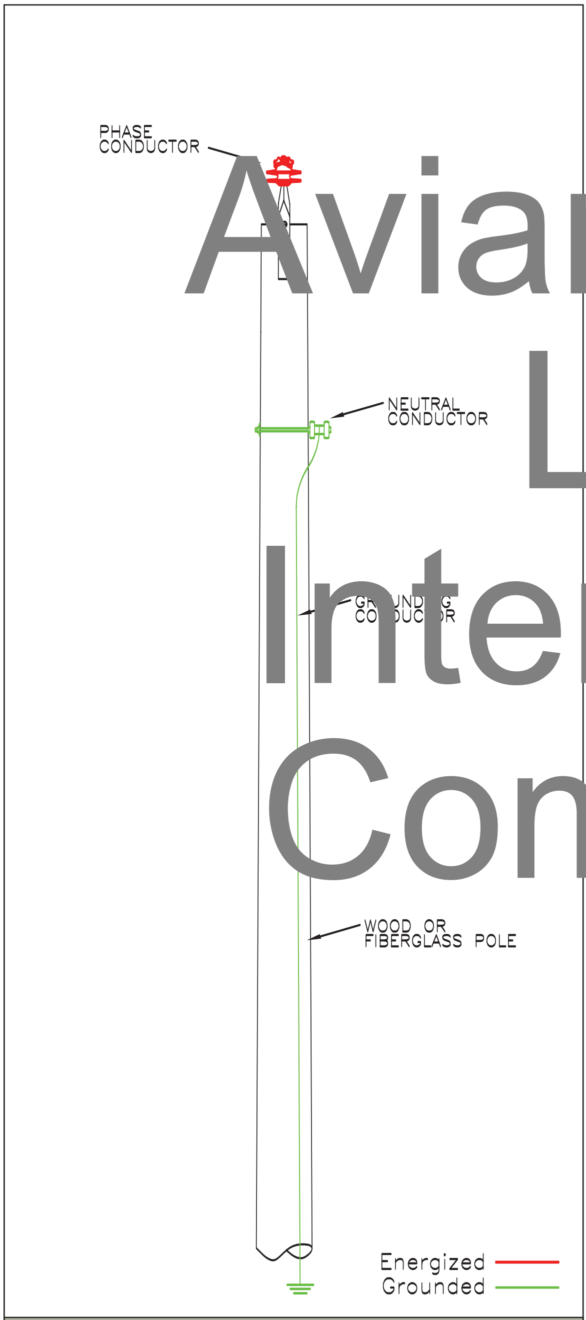

FIGURE 5.26. Typical single-phase distribution configuration on a wood or fiberglass pole.

FIGURE 5.27: Problem single-phase configuration on a steel or reinforced concrete pole.

top or hardware with its feet, resulting in electrocution. One solution to this problem is to install a phase cover (Figure 5.28, Solution 1). Another solution is a two-step process: (1) place the phase conductor on an insulator installed on an extended fiberglass-reinforced pole-top pin to increase the separation between the phase conductor and the pole top, (2) install a pole cap to deter birds from perching on top of the pole (Figure 5.28, Solution 2). In tests with captive raptors at the Rocky Mountain Raptor Program, a pole cap's slick surface discouraged birds from perching (Harness 1998).

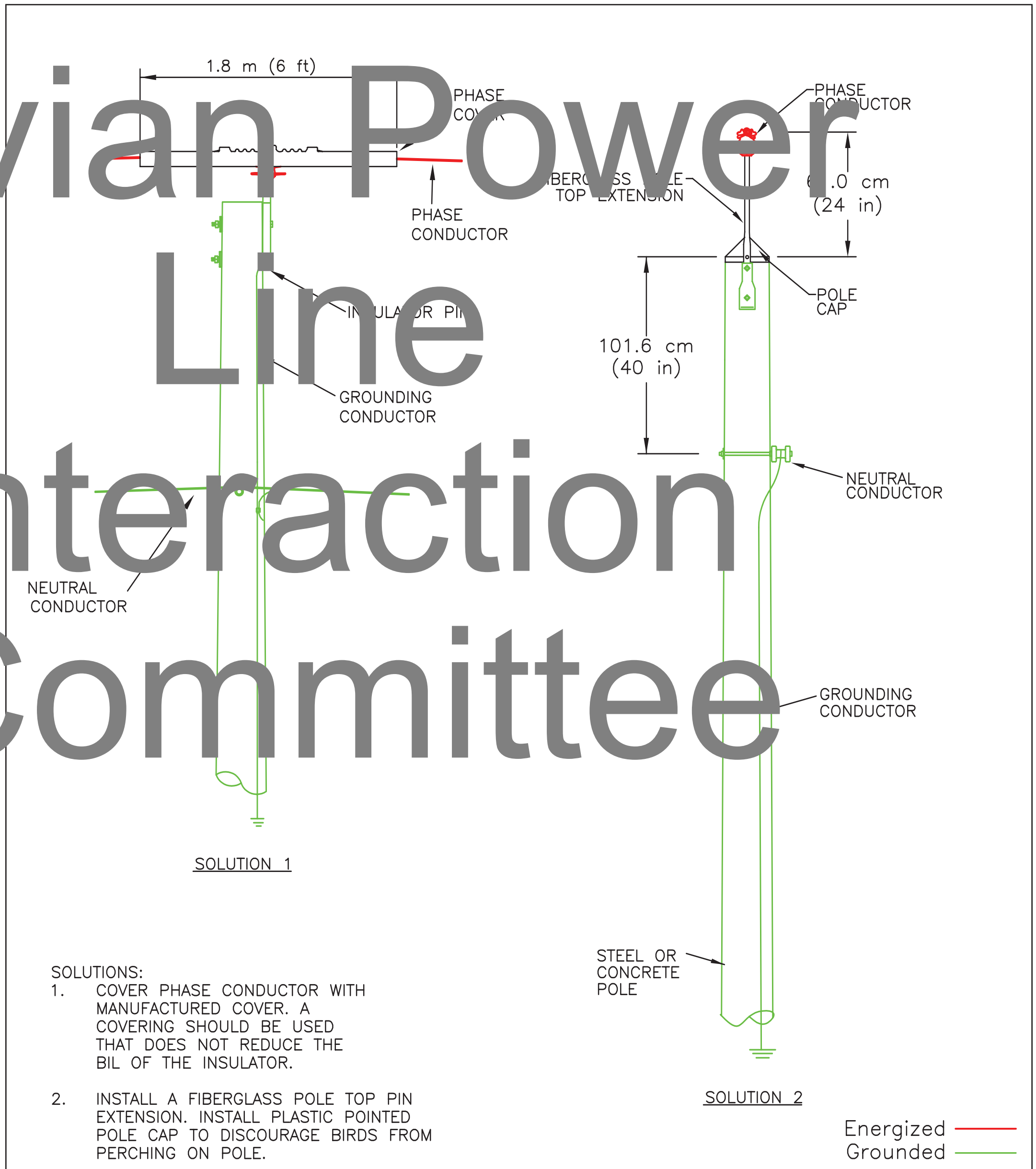

FIGURE 5.28: Solutions for single-phase configuration on a steel or reinforced concrete pole.

When steel or concrete poles are used for multi-phase structures, the critical separations for birds are both the phase-to-phase and the phase-to-pole (i.e., phase-to-ground) separation (Figure 5.29). Although the phase-to-phase issues are the same as encountered on wood poles, the phase-to-pole issue is not.

As on the single-phase structure (Figure 5.28, Solution 2), additional separation should be provided for the center pole-top phase conductor by placing it on an extended fiberglass reinforced pole-top pin and adding a pole cap to discourage perching. Additionally, wood or fiberglass crossarms should be used. Steel crossarms mounted on steel poles should be avoided because their minimal phase-to-ground separations make them extremely hazardous. Birds landing on grounded steel arms become grounded and need only touch one energized conductor or piece of hardware to be electrocuted.

The reduced phase-to-ground separations found on existing steel or concrete poles can be mitigated in several ways. One method is

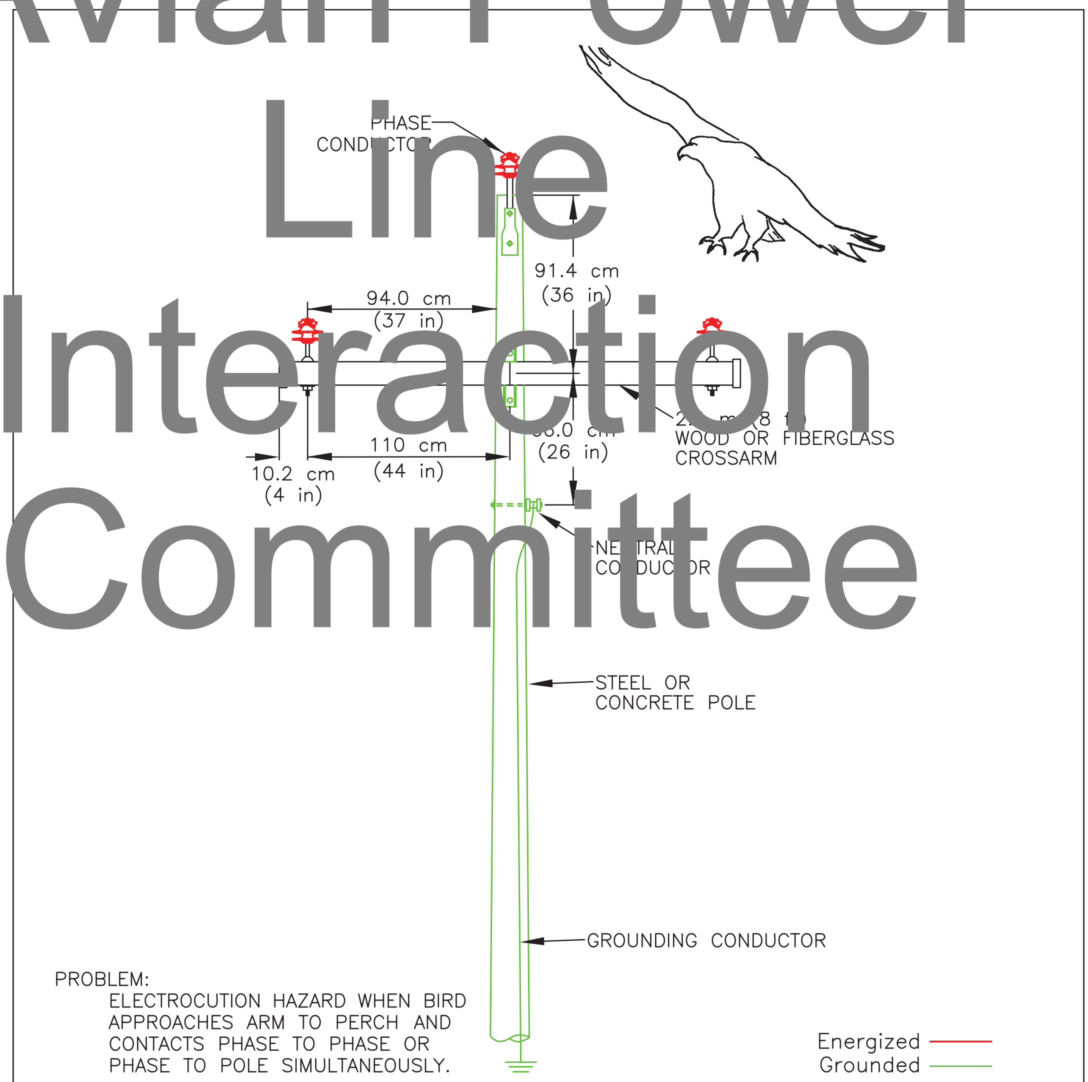

FIGURE 5.29: Problem three-phase configuration on a steel or reinforced concrete pole.

to cover the pole from the crossarm to the pole top with a material designed for this purpose (Figure 5.30). This can be achieved by wrapping a band of 40-mil thermoplastic polymer membrane backed with a pressure-sensitive adhesive around the pole from the crossarm up to and including the top of the pole, or by spraying the same area with a protective coating that has sufficient dielectric strength. A utility performed a dielectric test of a thermoplastic wrap, and determined that a 46 x 167-cm (18 x 66-in) piece allows no appreciable current leakage at 35 kV for a three-minute duration. The thermoplastic wrap also can effectively increase phase-to-ground separations on narrow profile configurations.

As an alternative to wrapping the pole top, perch discouragers can be mounted on the crossarm to deter birds from perching on the crossarm (Figure 5.31). Crossarms fitted with perch discouragers are effective in reducing

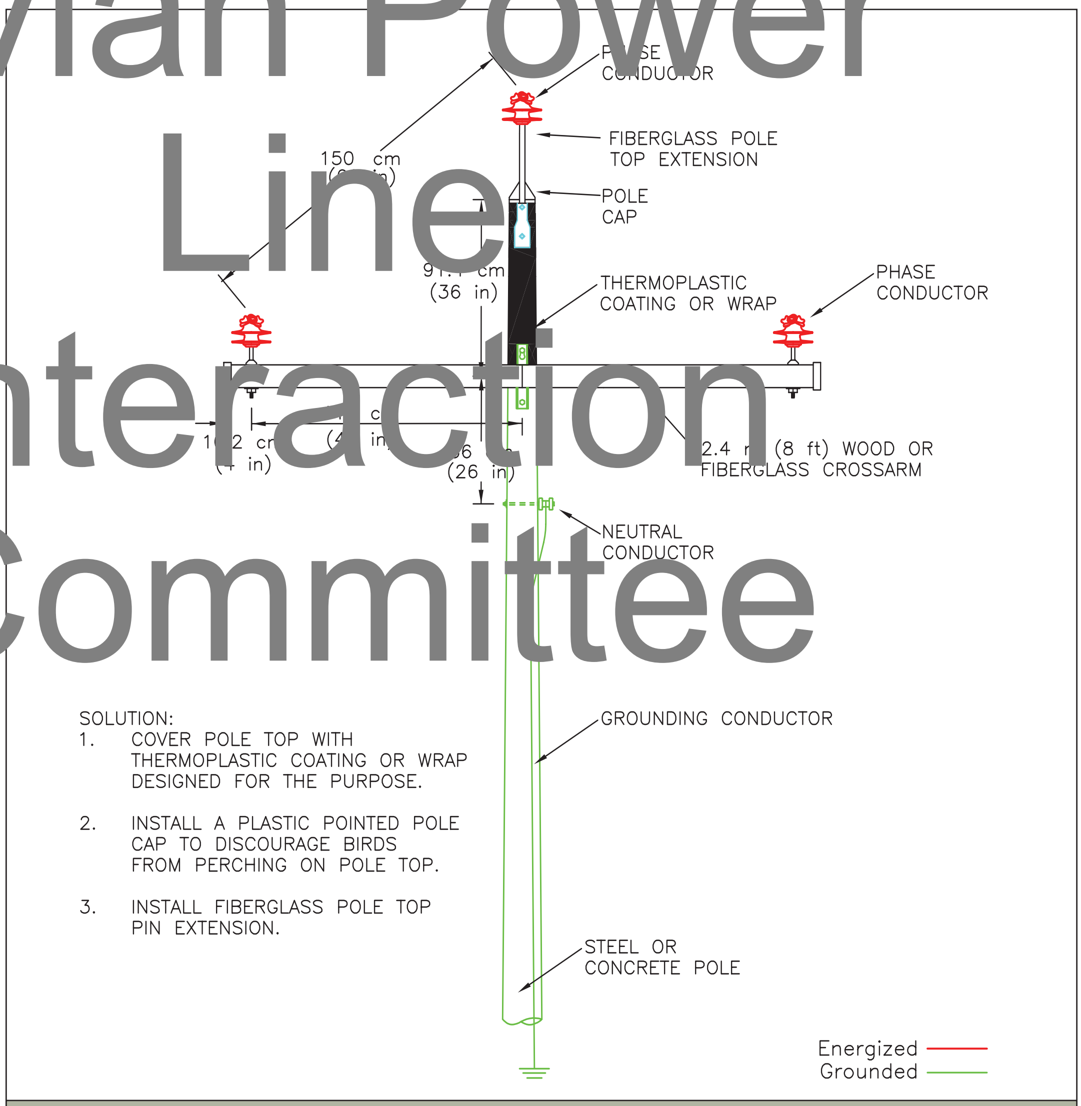

FIGURE 5.30: Solution for three-phase configuration on a steel or reinforced concrete pole using thermoplastic wrap.

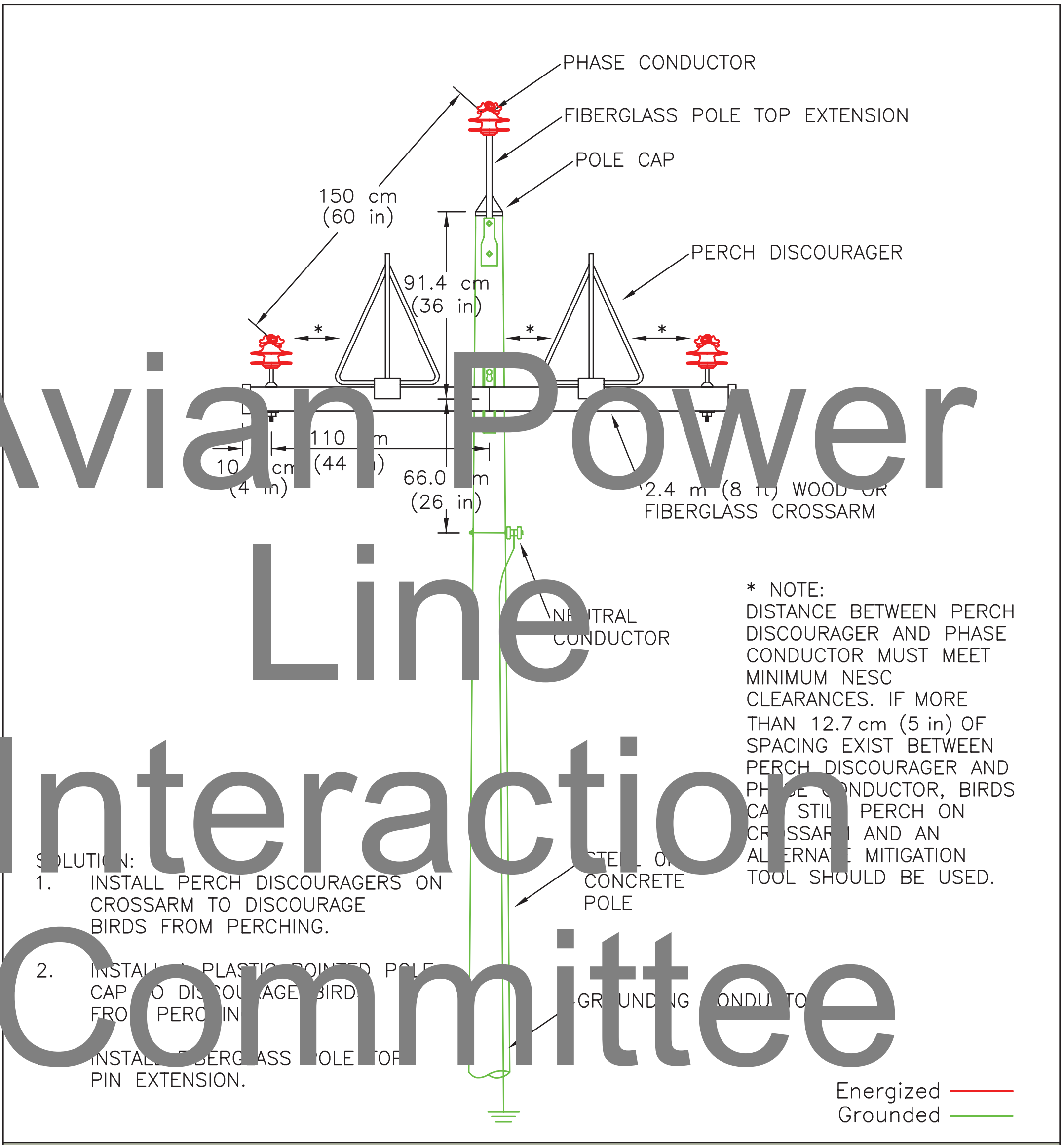

FIGURE 5.31: Solution for three-phase configuration on a steel or reinforced concrete pole using perch discouragers.

some but may not eliminate all avian mortality (Harness and Garrett 1999). Perch discouragers also may shift birds to other nearby poles that might not be any safer. For guidance on the use of perch discouragers from both biological and engineering perspectives, see page 17 and page 68.

Another suitable method for reducing avian electrocution risk is covering the outer two phase conductors to prevent phase-to-pole (i.e., phase-to-ground) contacts (Figure 5.32). On the center phase, a phase cover or a pole cap with extension pin should also be installed.

Another option is to suspend two of the energized conductors from the crossarm, instead of supporting them on the arm (Figure 5.33). Suspending the conductors allows birds to perch on the crossarm without contacting energized conductors. A pole cap and extended fiberglass reinforced insulator pin should still be used to discourage perching on the pole top to prevent contact with the center phase. Suspending the insulators and conductors will also allow utilities to achieve 150-cm (60-in) separation with 1.8 or 2.4-m (6 or 8-ft) crossarms (as shown in Figure 5.33). If vertical construction is used with steel or reinforced concrete poles, phase covers should be installed on all three conductors.

Avian-safe separation can be achieved on steel and reinforced concrete dead-end or corner poles by installing fiberglass extension links or adding additional insulators between the primary dead-end suspension insulators and the pole. This solution is similar to those recommended for three-phase distribution dead-end and corner configurations using wooden poles and crossarms (Figures 5.16 and 5.23). Bare jumper wires are commonly used to connect incoming conductors to the

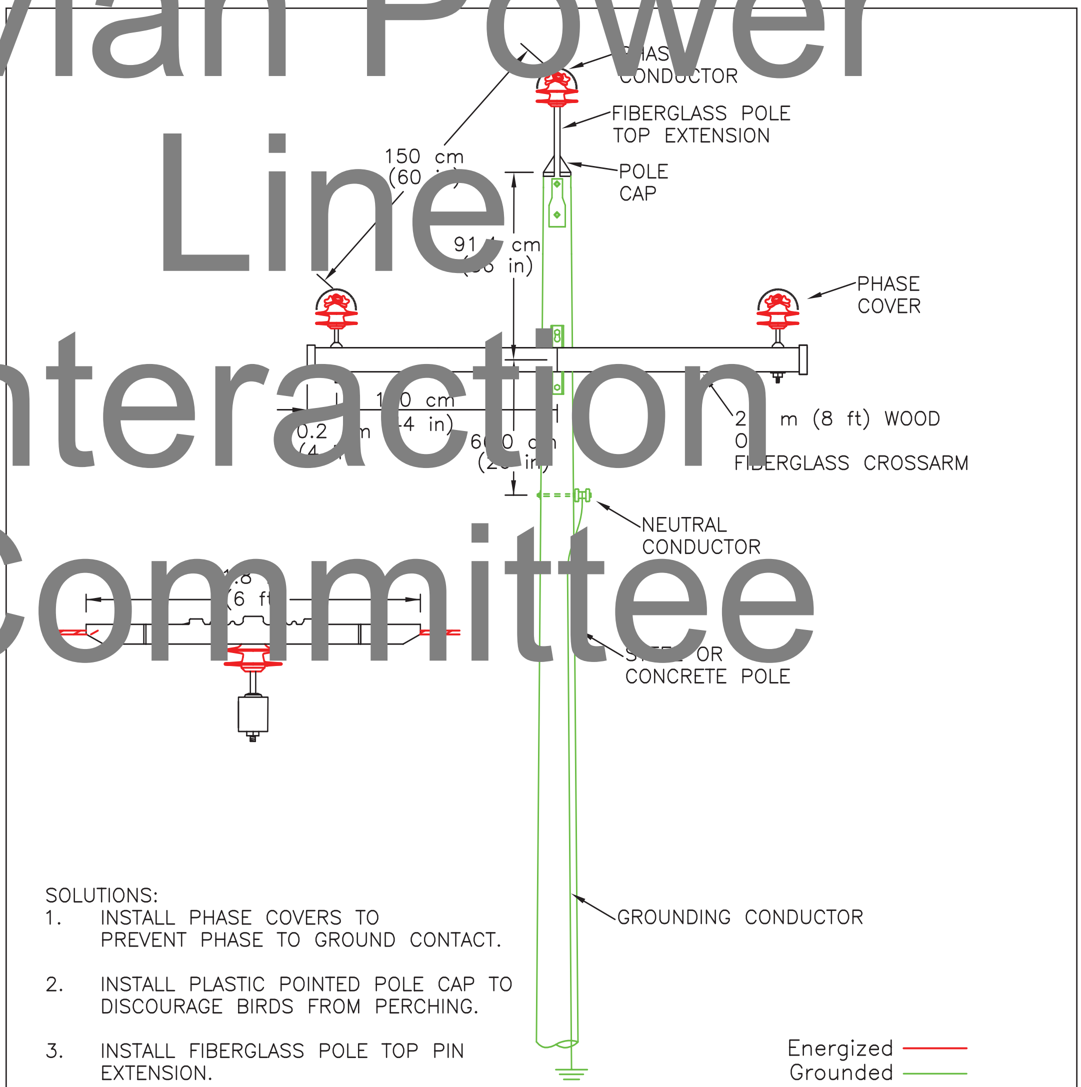

FIGURE 5.32: Solution for three-phase configuration on a steel or reinforced concrete pole using phase covers.

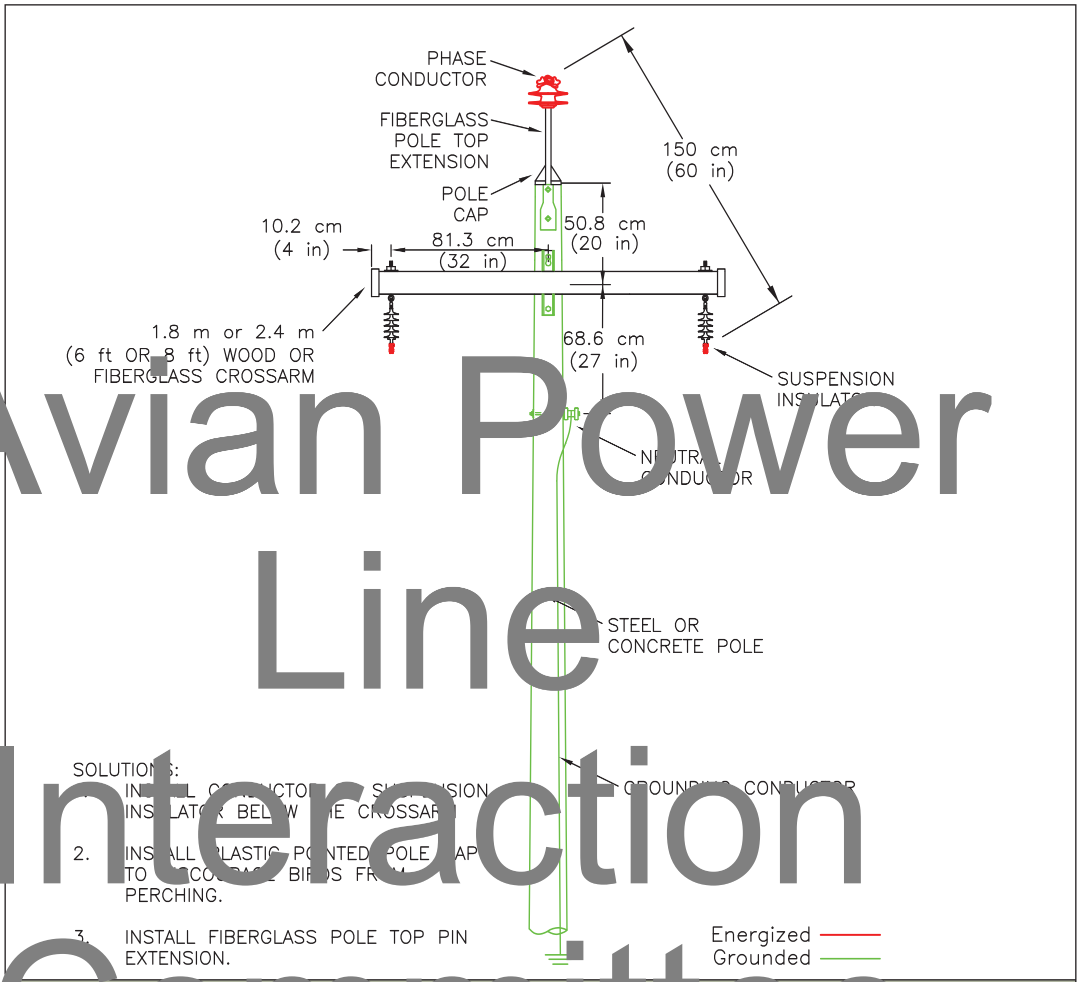

FIGURE 5.33: Three-phase configuration on a steel or reinforced concrete pole with suspended insulators.

outgoing conductors, making the line turn or tapping off the main circuit. Covering the jumper wires with a material suitable for avian protection or replacing them with covered conductor will reduce electrocution risk.

Problem Transmission Designs

Although transmission lines rarely electrocute birds, there are a few exceptions, particularly on lower voltage transmission lines (i.e., 60 kV or 69 kV).[31] The armless configuration, in which conductors are mounted on horizontal post insulators, commonly used for distribution lines (see Figures 5.20 and 5.21), may also be used for some transmission lines below 115 kV (Figure 5.34). In areas subject to high lightning levels, lightning protection may include an overhead static wire that must be grounded. On installations with wood poles, utilities, particularly in salt spray or other contaminated areas, may bond the bases of the post insulators to the grounding conductor to prevent pole fires. A bird perched on the insulator can be electrocuted if it comes in

[31] If distribution underbuild is present on a transmission structure, the recommendations shown previously for distribution configurations should be used to make the underbuild avian-safe.

contact with the energized conductor and either the grounded insulator base or the bonding conductor. From 1991 through 1993, more than 30 golden eagles were electrocuted along approximately 32 km (20 mi) of a 69-kV line with this configuration in central Wyoming (PacifiCorp, unpubl. data).

This configuration was once thought to be avian-safe because it was anticipated that birds would perch on the pole top rather than on the insulators. The 1996 edition of *Suggested Practices* recommended installing perch discouragers on the insulators to prevent electrocutions. However, because birds were still able to fit between the perch discourager and the conductor, the use of perch discouragers alone has been determined ineffective (PacifiCorp, unpubl. data).

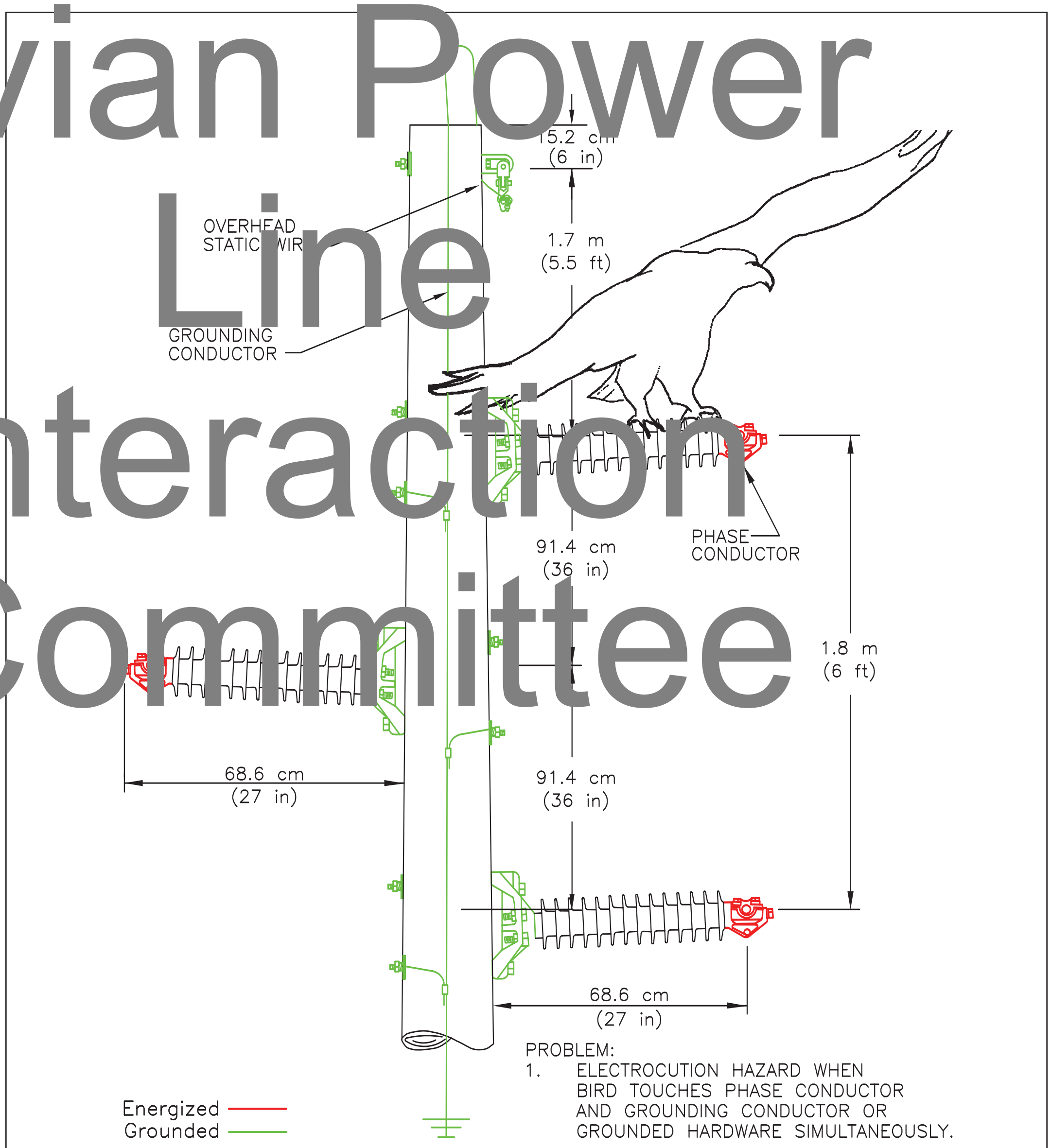

FIGURE 5.34: Problem 69-kV horizontal post insulator design.

Utilities are testing different options (Figure 5.35) for reducing electrocution risk on horizontal post construction. These options include:

- Covering the insulator bases and bolts with cover-up material designed for this purpose. Installing an insulated pole grounding conductor or covering the pole grounding conductor with appropriate cover-up material, or wood or plastic moldings. The grounding conductor should be covered at least 30.5 cm (12 in) below the lowest energized conductor.

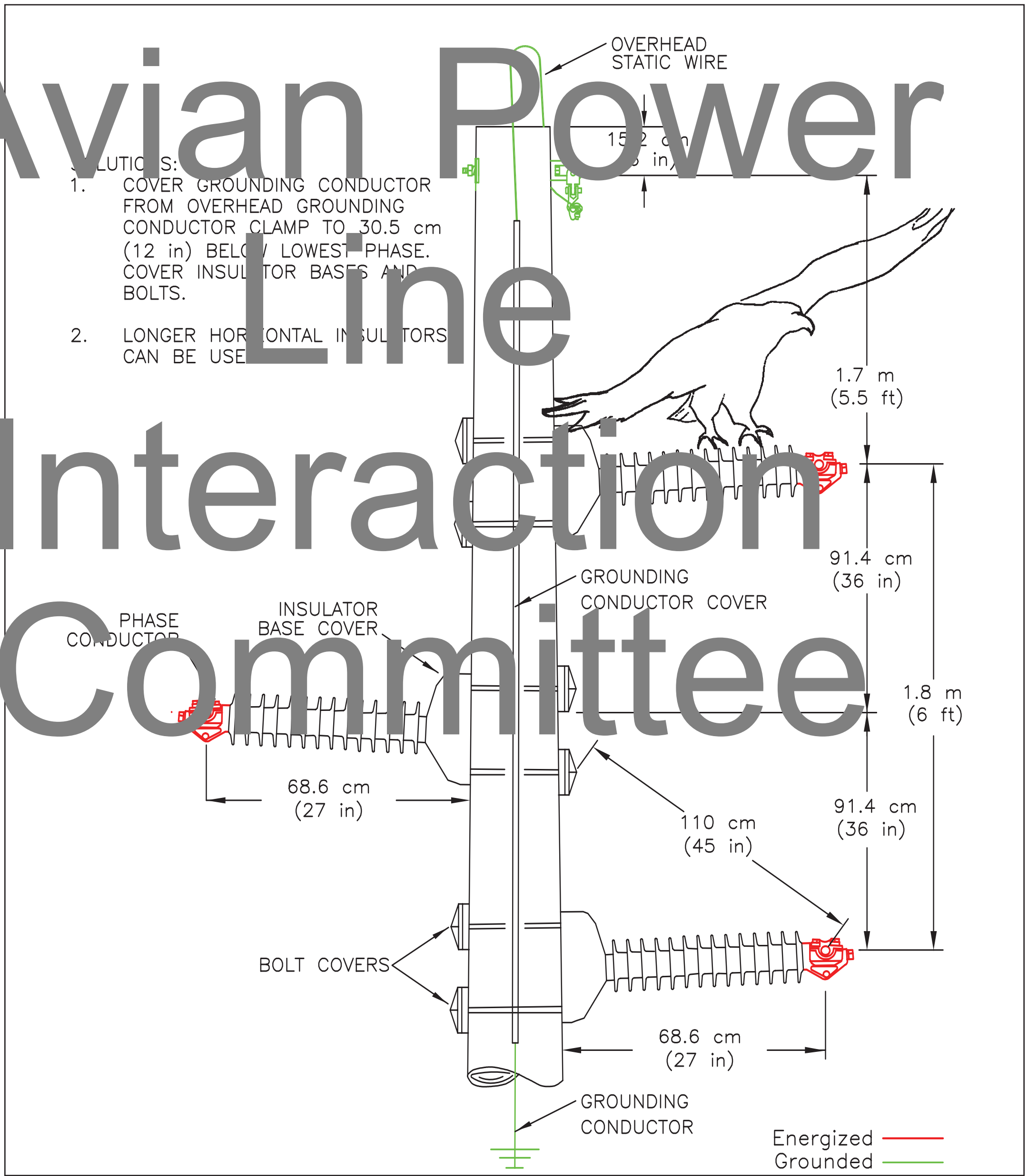

FIGURE 5.35. Solutions for 69-kV horizontal post insulator design.

- Replacing 60-kV or 69-kV post insulators with longer insulators (i.e., 115 or 138 kV) to provide the necessary 150-cm (60-in) separation. Although this may be a costly retrofit option, it can be used for new construction.

The wishbone configuration (Figure 5.36) is commonly used for 34-kV to 69-kV lines. The distance from the top phase to the lower arm can be less than 1 m (3.3 ft), which presents an electrocution hazard when large birds such as eagles or waders touch their heads to the energized conductor while

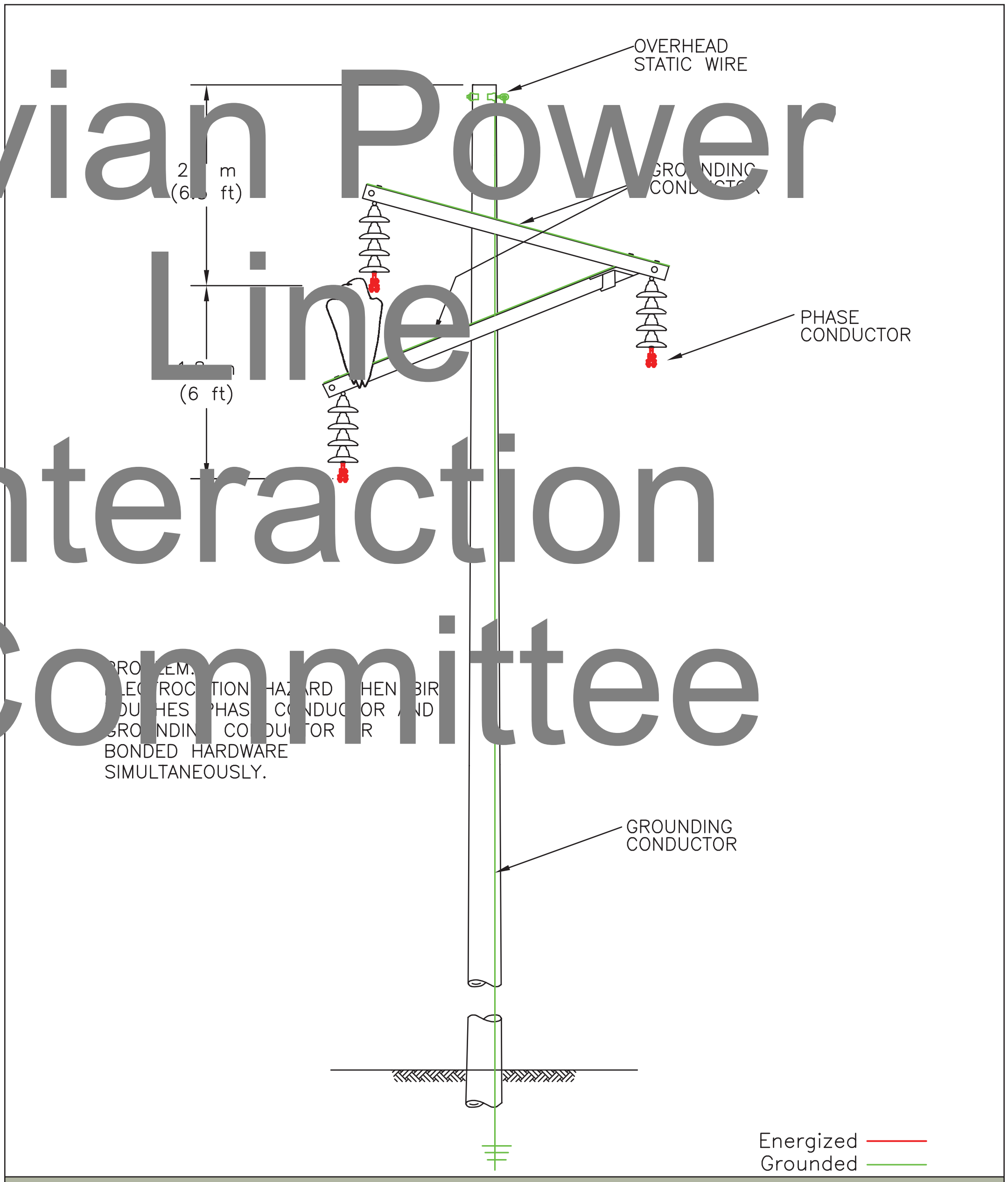

FIGURE 5.36: Problem wishbone design.

perched on the grounding conductor or bonded hardware on the crossarm.

To prevent phase-to-ground contact on the wishbone design, the grounding conductor and bonded hardware should be covered. This can be accomplished by:

- installing a dielectric cover on the lower crossarm (Figure 5.37), and
- covering the grounding conductor with plastic or wood molding or plastic tubing. A covered ground wire may also be used. The grounding conductor should be

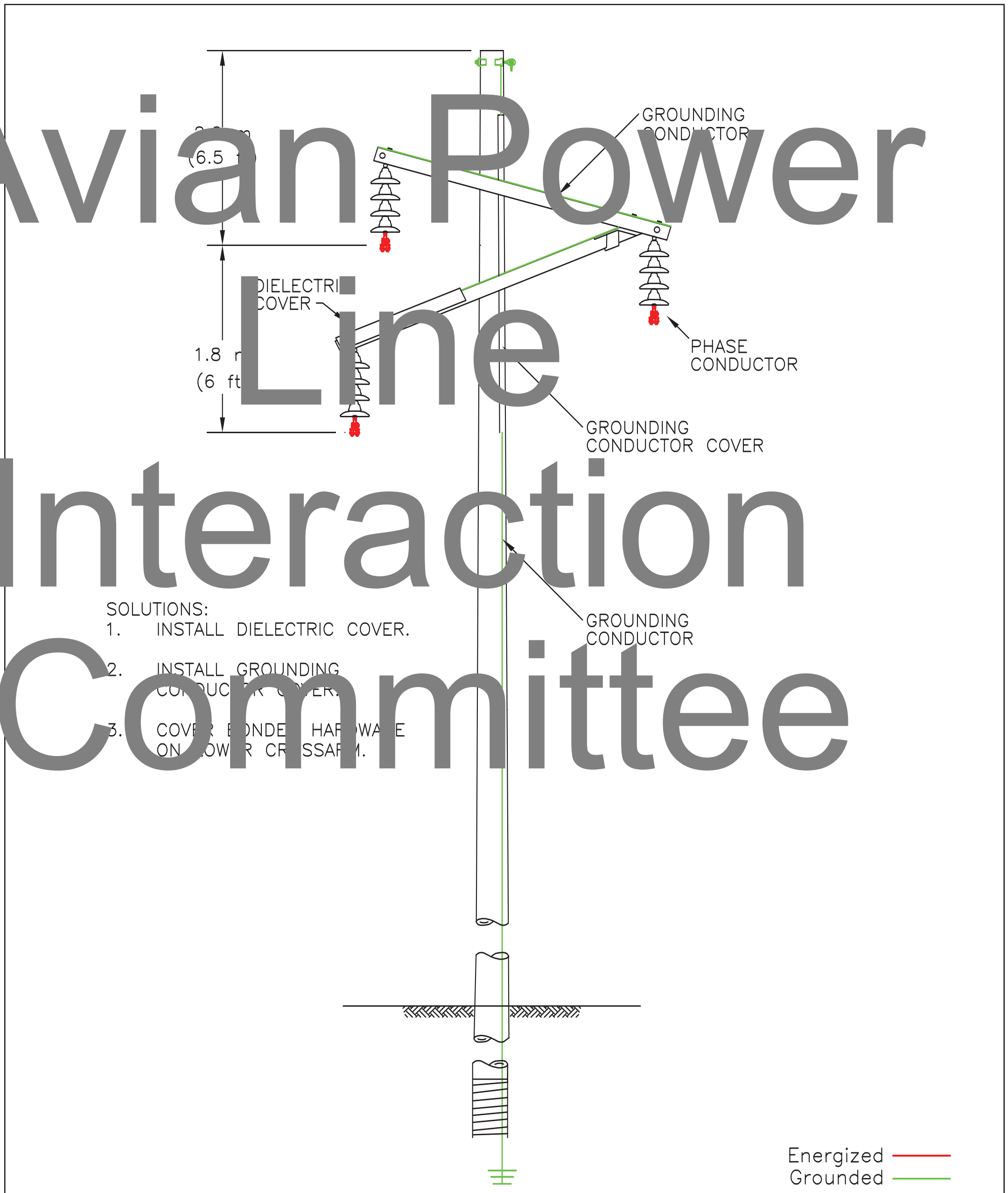

FIGURE 5.37: Solution for the wishbone design.

covered at least 30.5 cm (12 in) below the lowest energized conductor. Bonded hardware on the lower crossarm should also be covered with a material appropriate for avian protection.

For new construction, a wishbone design that provides adequate separation for large birds can be used (Figure 5.38). An avian-safe suspension configuration (Figure 5.39) can also be used for new construction as an

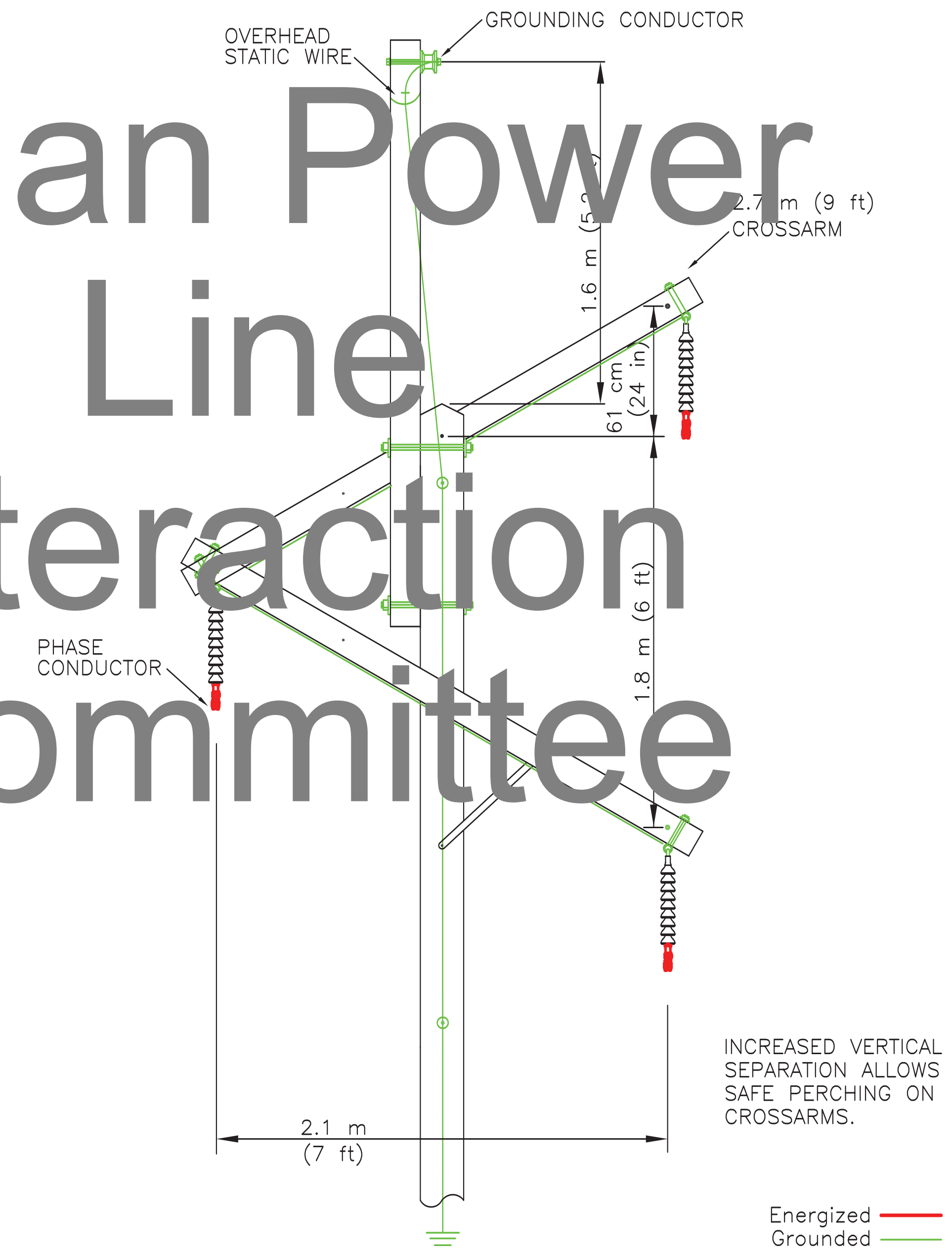

FIGURE 5.38: Avian-safe wishbone construction.

alternative to the wishbone or horizontal post designs. This suspension configuration provides adequate separation between phases and accommodates perching on the davit arms. The ridge pin overhead-grounding conductor attachment may also be replaced with a side-mounted suspension arrangement so the pole top is also available for perching. Although this construction can reduce electrocutions, it may contribute to streamer problems from

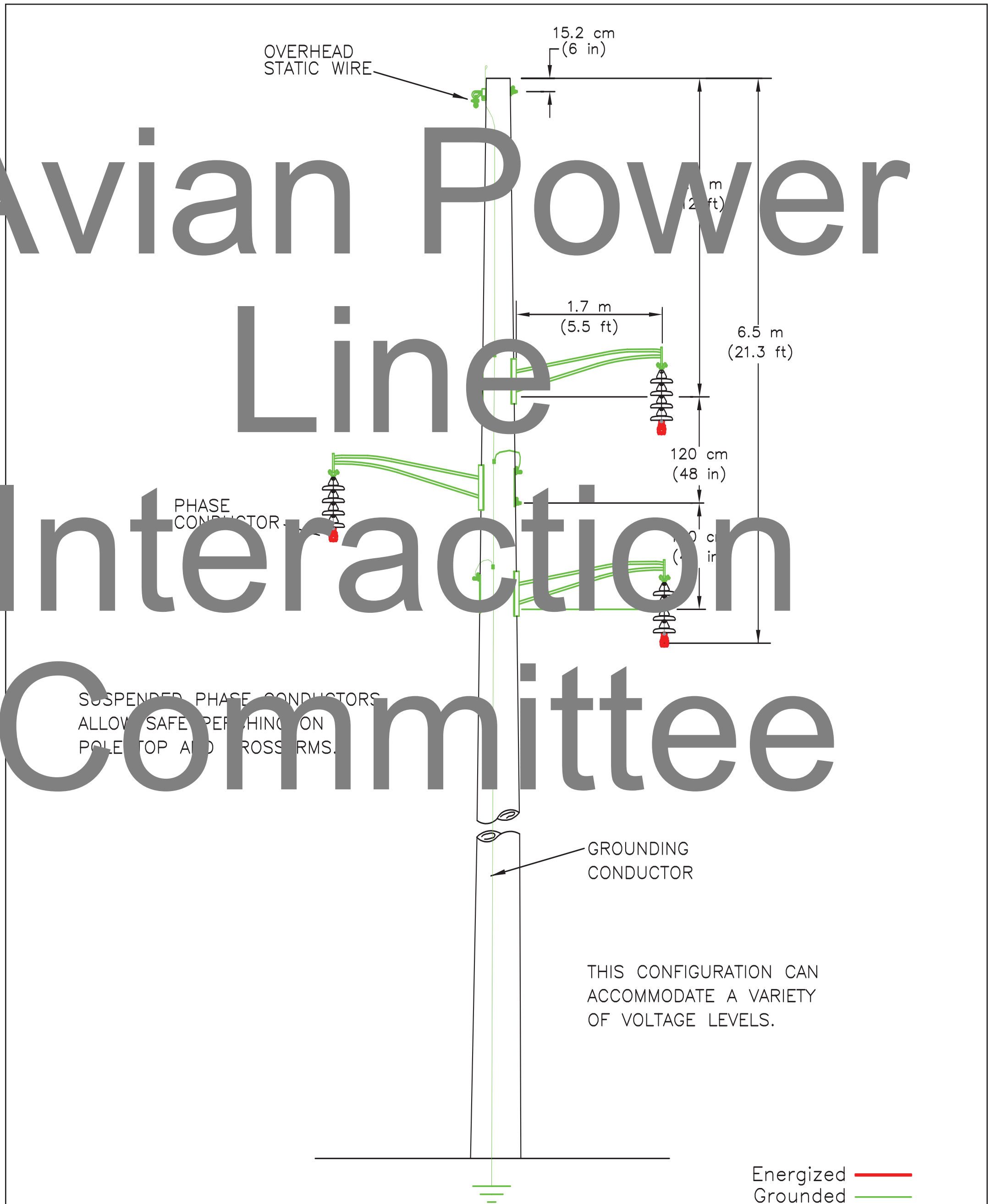

FIGURE 5.39: Avian-safe suspension configuration.

birds perching on a davit arm and defecating on the conductor or insulator below.

Figure 5.40 depicts a 69-kV design with a steel bayonet added as a lightning rod. This rod is grounded and significantly reduces separation between energized hardware and itself. This configuration can pose a phase-to-ground electrocution risk for birds that attempt to land or perch on the crossarms. In one year, 69 raptor carcasses were recovered from under a line of this configuration in southern Idaho (Idaho Power Co., unpubl. data). If

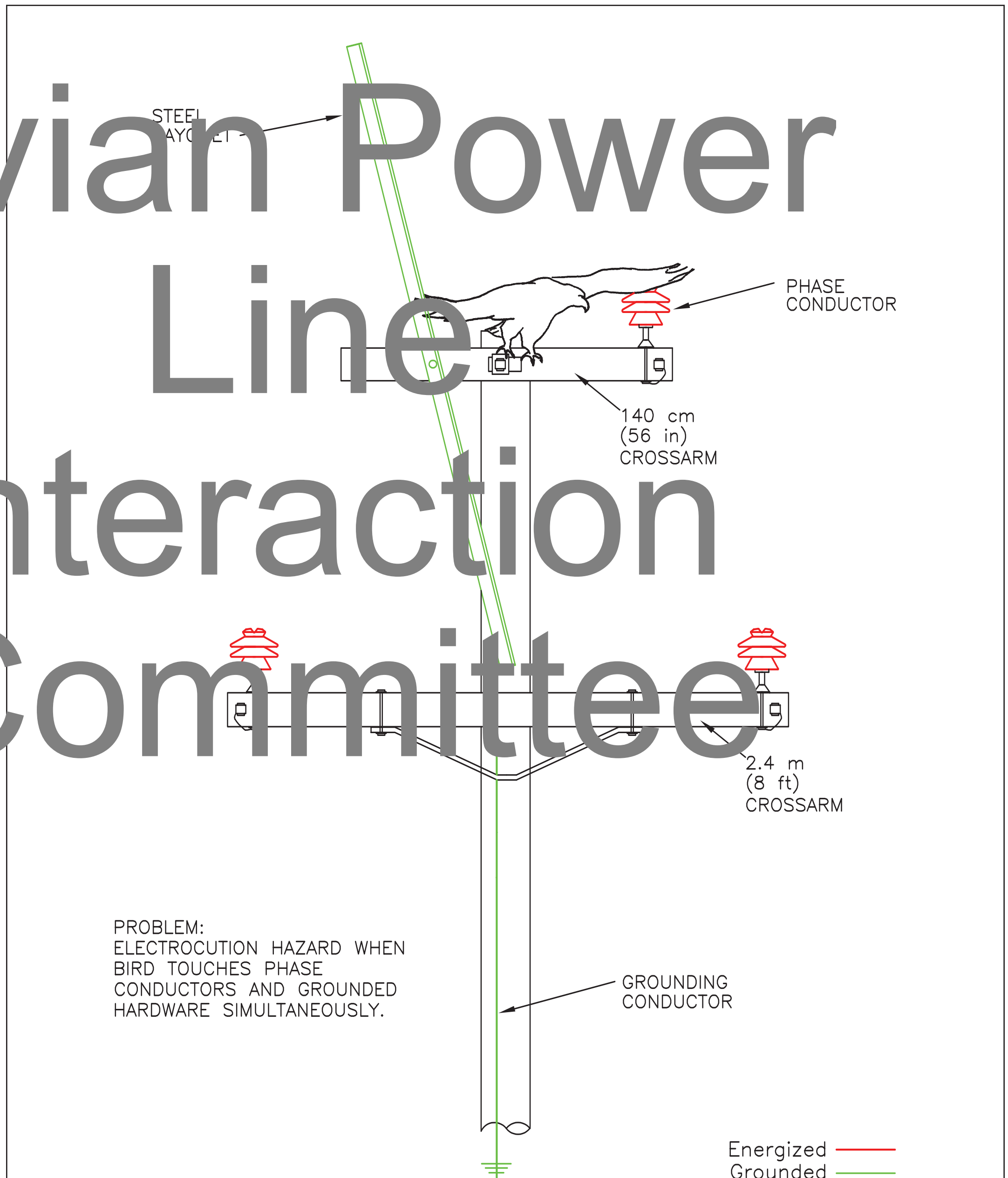

FIGURE 5.40: Problem design with grounded steel bayonet.

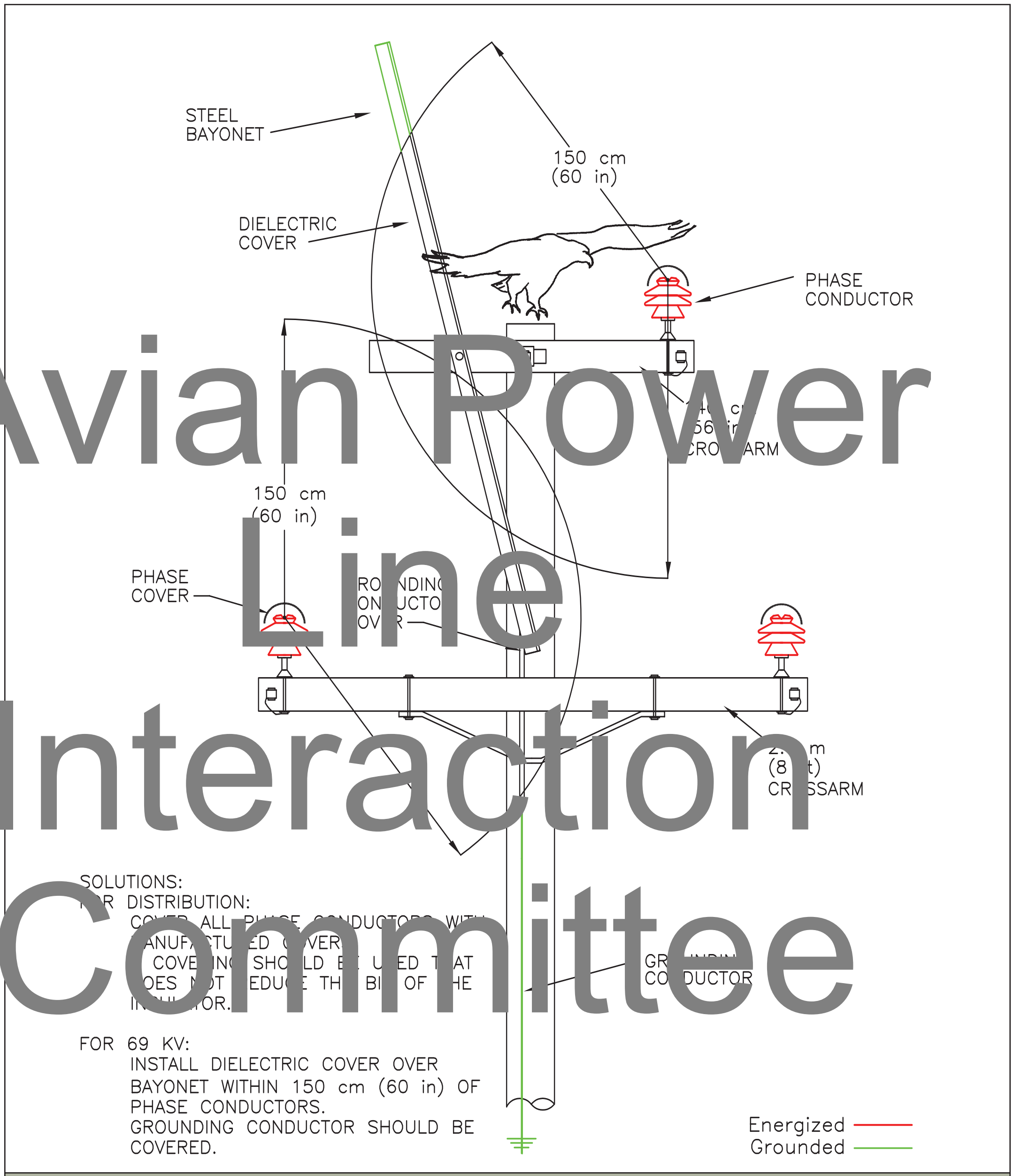

FIGURE 5.41: Solutions for design with grounded steel bayonet.

this configuration is used for a distribution line, phase covers can be installed on all three phases to prevent electrocutions (Figure 5.41). If mitigating a transmission line of this configuration, the bayonet should be covered with a dielectric cover within 150 cm (60 in) of the phase conductors. The grounding conductor should also be covered.

On the corner structure shown in Figure 5.42 (Problem 1), large birds may be electrocuted by making simultaneous contact with uncovered phase jumpers and the grounded structure. A solution to this problem is to install horizontal post insulators to move the phase jumpers further from ground (Figure 5.43, Solution 1).

Raptor mortalities have occurred on double-circuit transmission tower designs with insufficient clearance for perching raptors from the grounded center crossarm brace (also called grounded tension member or wind brace) to the top phase (E. Colson, Colson and Associates, pers. comm. in APLIC 1996) (Figure 5.42, Problem 2). Electrocutions on this configuration may be remedied by covering grounded tension members with dielectric material (Figure 5.43, Solution 2). It may also be possible to replace the tension

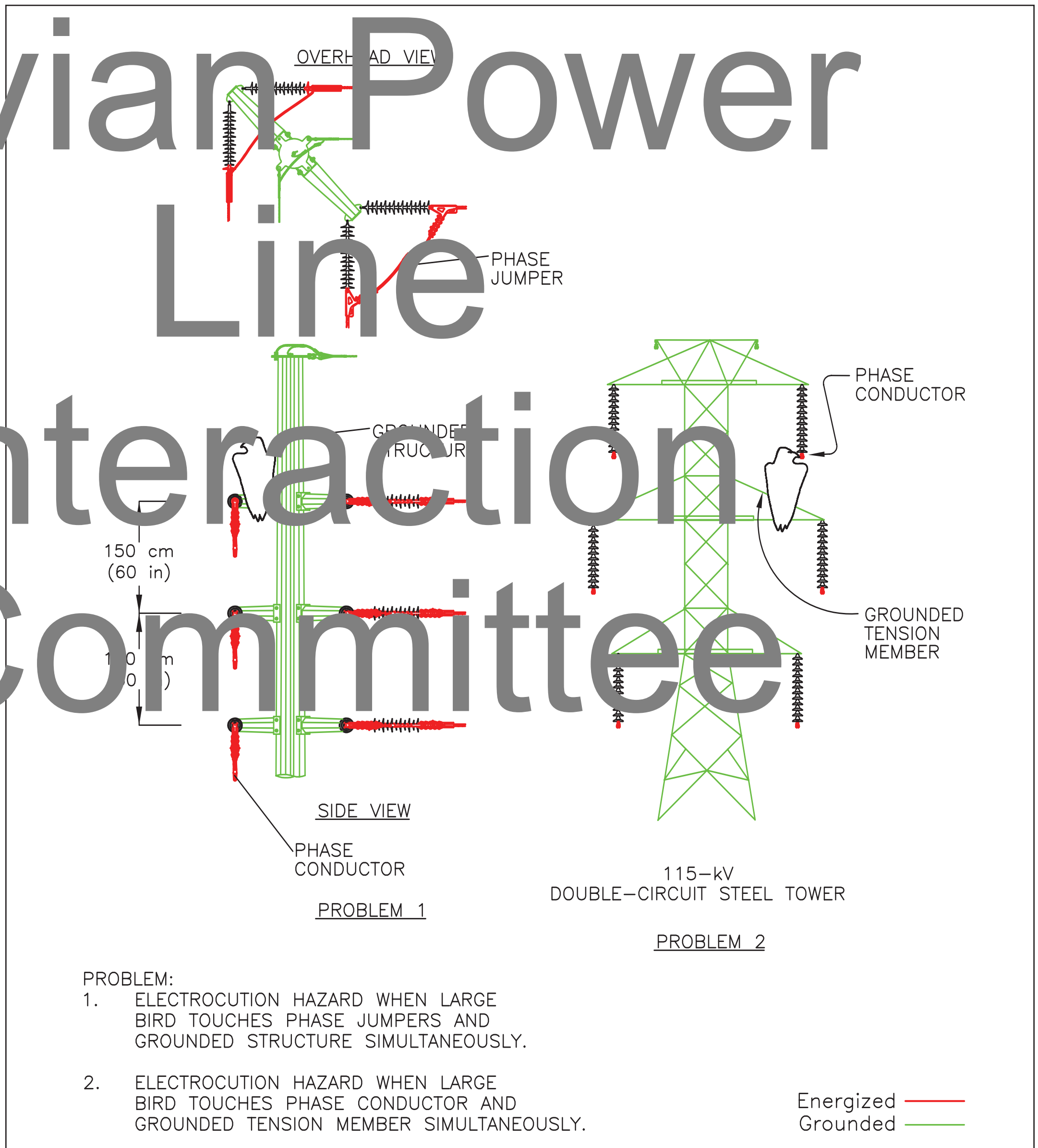

FIGURE 5.42: Problem transmission designs.

member with a non-conducting material (e.g., fiberglass) that meets structural requirements.

Transmission lines may produce arcing, where current jumps, or arcs, from a conductor to a bird on the structure. Though the conductor separation on higher voltage lines is sufficient to avoid this, it can occur on the more closely spaced lower voltage transmission lines. To prevent bird-induced arcing on more closely spaced transmission lines, conductor separation should be increased from 152 cm (60 in) by 0.5 cm (0.2 in) for each kV over 60 kV (see Table 5.3).

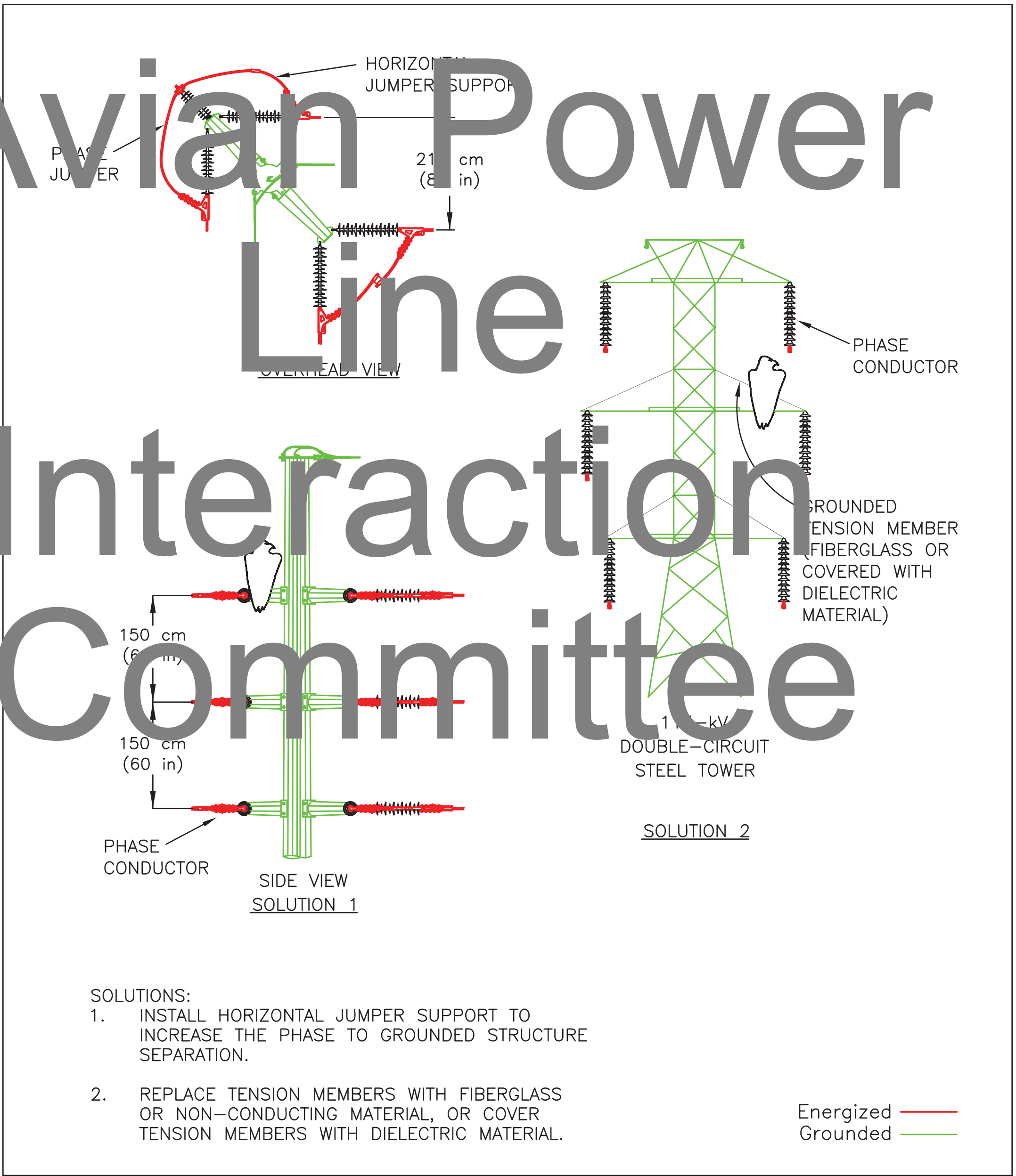

FIGURE 5.43: Solutions for transmission designs.

TABLE 5.3: Recommended conductor separation for transmission lines >60 kV.		
kV	**Horizontal Spacing**	**Vertical Spacing**
69 kV	157 cm (62 in)	106 cm (42 in)
115 kV	180 cm (71 in)	130 cm (51 in)
138 kV	192 cm (76 in)	141 cm [illegible]

Equipment Poles

TRANSFORMERS AND OTHER EQUIPMENT

Equipment poles are poles that have transformers, capacitor banks, reclosers, regulators, disconnect switches, cutouts, arresters, or overhead-to-underground transitions (often referred to as *riser poles*). Equipment poles pose increased electrocution risks to birds of all sizes because of close separations between both phase-to-phase and phase-to-ground (Figures 5.44, 5.45).

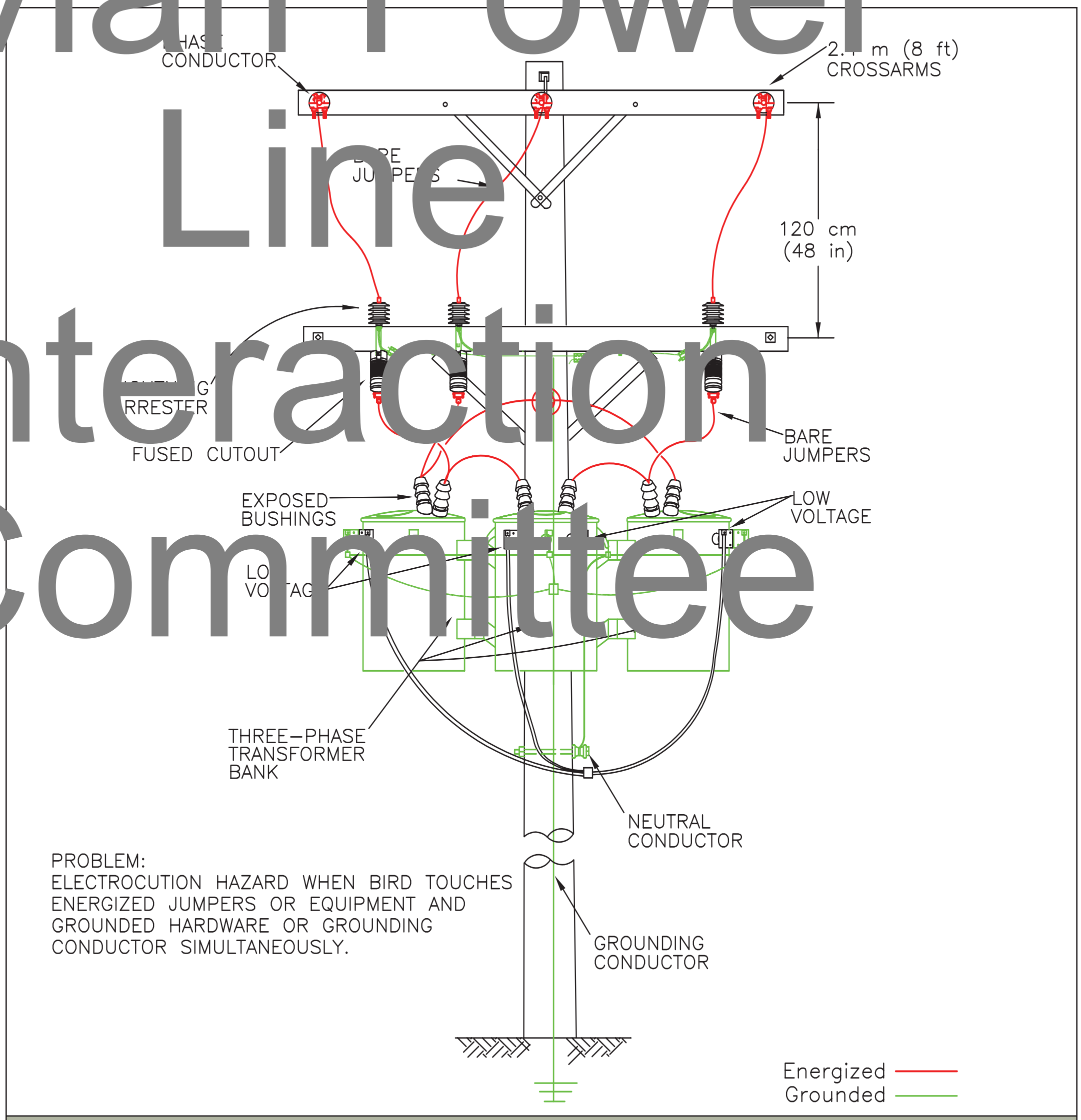

FIGURE 5.44: Problem three-phase transformer bank.

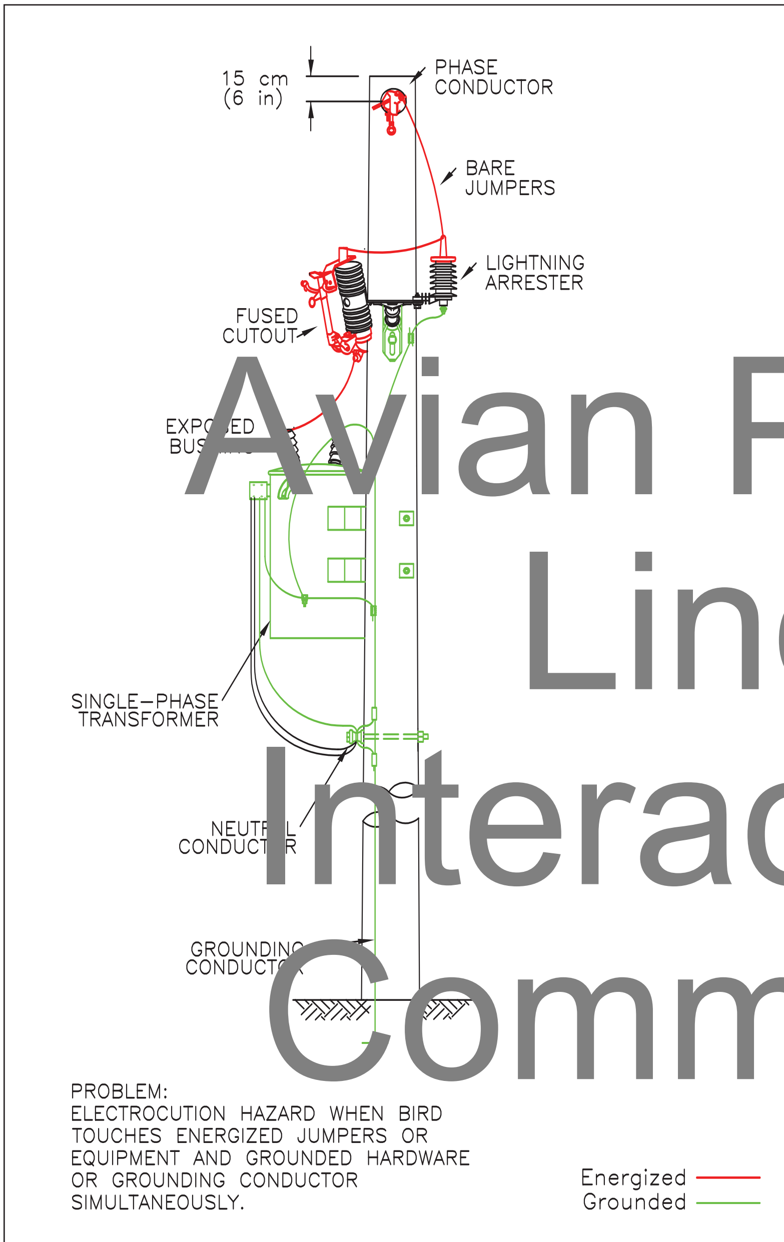

FIGURE 5.45: Problem single-phase transformer bank.

If a line is located in an area of high lightning activity, some utilities may install an overhead (grounded) static wire, requiring the installation of a grounding conductor all the way to the top of some or all structures. To assure the safety of line personnel and the general public, the NESC requires that all electrical equipment such as transformers, switches, lightning arresters, etc., must also be grounded. This grounding usually reduces the separation between energized and grounded parts of the system.

In a review of raptor electrocutions from 58 utilities in the western United States between 1986 and 1996, more than half were associated with transformers (Harness and Wilson 2001). Fifty-three percent of confirmed electrocutions (*n*=421) were associated with transformers, yet only one-quarter of the poles in these areas were transformer poles. Single or three-phase transformer banks were associated with 41% of eagle mortalities (*n*=748), 59% of hawk mortalities (*n*=278), and 52% of owl mortalities (*n*=344). In Utah and Wyoming, poles with exposed equipment accounted for only 32% of all structures surveyed (*n*=74,020), yet 53% of poles with mortalities (*n*=457) had exposed equipment (Liguori and Burruss 2003). In particular, transformers were present on 16% of structures surveyed, yet were found on 36% of poles with mortalities. Small birds (including starlings, magpies, and songbirds), ravens, and owls were more frequently electrocuted at poles with transformers or other equipment than at poles without equipment.

Utilities should seek to address electrocution risk on the entire pole when retrofitting or designing equipment poles. Electrocution risk on new or retrofitted equipment poles can be reduced by using a variety of cover-up materials including covered conductors, moldings, covered jumper wires, arrester covers, bushing covers, cutout covers, phase covers, and other covers to prevent birds from making simultaneous contact between grounded and energized conductors or hardware (Figures 5.46, 5.47). See the *Precautions* section (below) for a discussion of cover-up materials. When lightning arresters are installed on a wooden crossarm in combination with fused cutouts, the arrester ground wire is normally attached beneath the arm connecting the base of the arresters to ground without bonding or contacting the arrester brackets.

The use of perch discouragers alone on or near equipment poles is not recommended, as perch discouragers may deter birds from landing on the crossarm, leaving equipment arms or transformers as perching alternatives. However, perch discouragers may be used if an alternative perch is provided and exposed equipment is covered with appropriate avian protection devices.

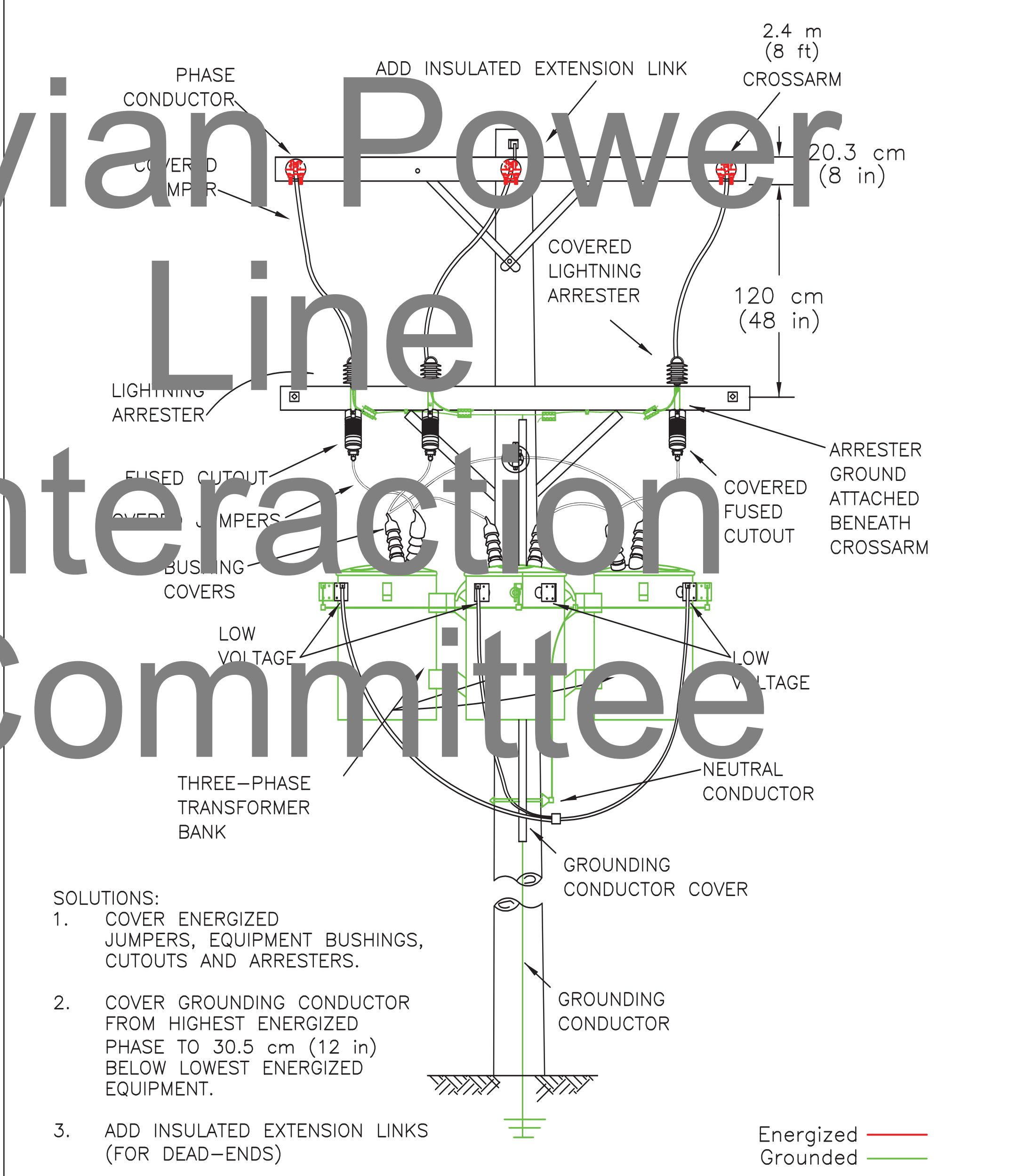

FIGURE 5.46: Solution for three-phase transformer bank.

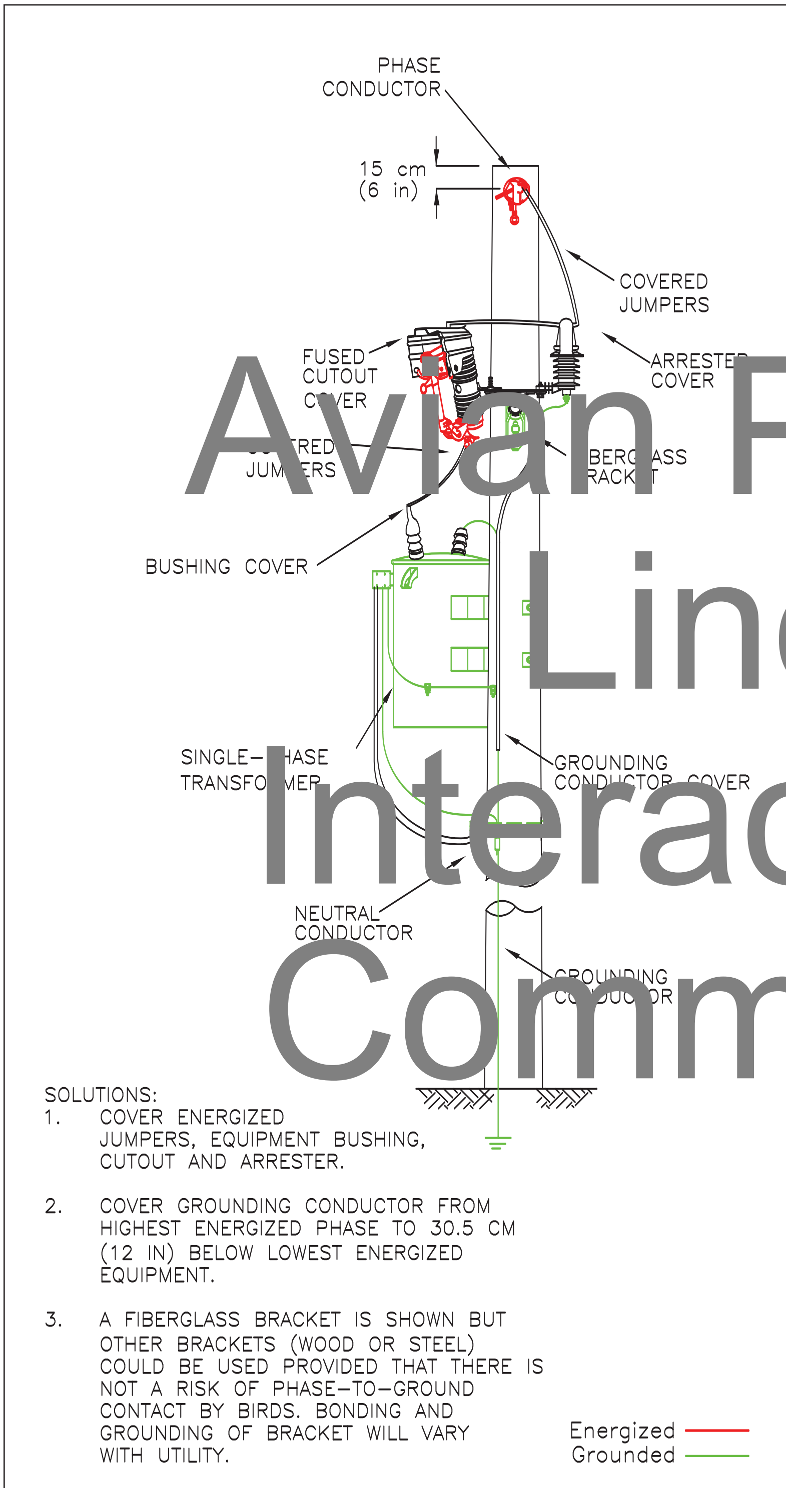

FIGURE 5.47: Solution for single-phase transformer bank.

PRECAUTIONS

When using cover-up products on equipment, a utility should be aware of several important points. First, these products are intended only for wildlife protection; **they are not intended for human protection**. Second, there are currently no standard protocols for testing such products (see page 51 for further information on testing). Utilities are advised to evaluate the products that they select for durability, effectiveness, ease of installation, etc. Finally, wildlife protection products may not be effective or can cause problems if installed improperly. Bushing covers and arrester covers should fit between the first and second skirts of the bushing or arrester. Likewise, phase covers should sit on the top skirt of the insulator and not extend to the crossarm. If covers are pushed down too far, they can cause tracking, outages, or fires. Cutout covers should also be evaluated to ensure that they will not interfere with the operation of the cutouts or the use of a load-break tool. Coverings on jumper wires should cover the entire jumper, because exposed gaps can pose an electrocution risk. See the APLIC website (www.aplic.org) for a current list of avian protection product manufacturers.

SWITCHES

Many types of switches are used to isolate circuits or redirect current for the operation and maintenance of a distribution system. Several examples are shown in Figures 5.48, 5.49, and 5.50. Because of the close separation, it may be difficult to mitigate electrocutions on switch poles. Efforts can be made to either provide birds with safe perch sites on adjacent poles or to make switch poles less hazardous to birds. The installation of unprotected switch poles is discouraged in raptor use areas due to the electrocution risk and difficulty of making these poles avian-safe. Where switches are installed, offset or staggered vertical switch configurations with an

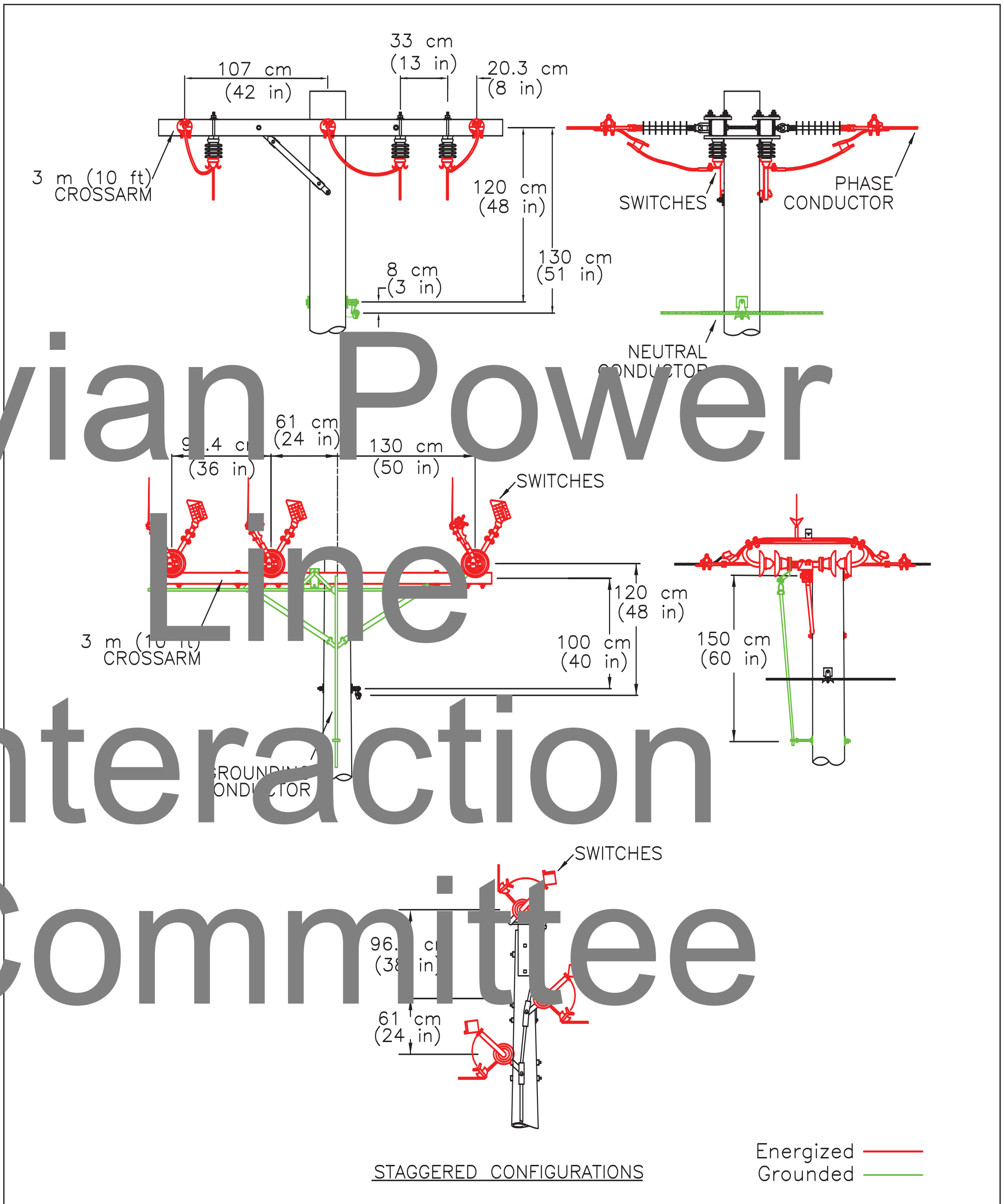

FIGURE 5.48: Pole-mounted switches.

alternate perch above the top switch may provide a safer perching site (see Figure 5.49). Separation is key to making these structures safer for birds. Coverings designed for the purpose should be used on as many of the energized components as possible. Using fiberglass arms for switches may also help reduce electrocutions.

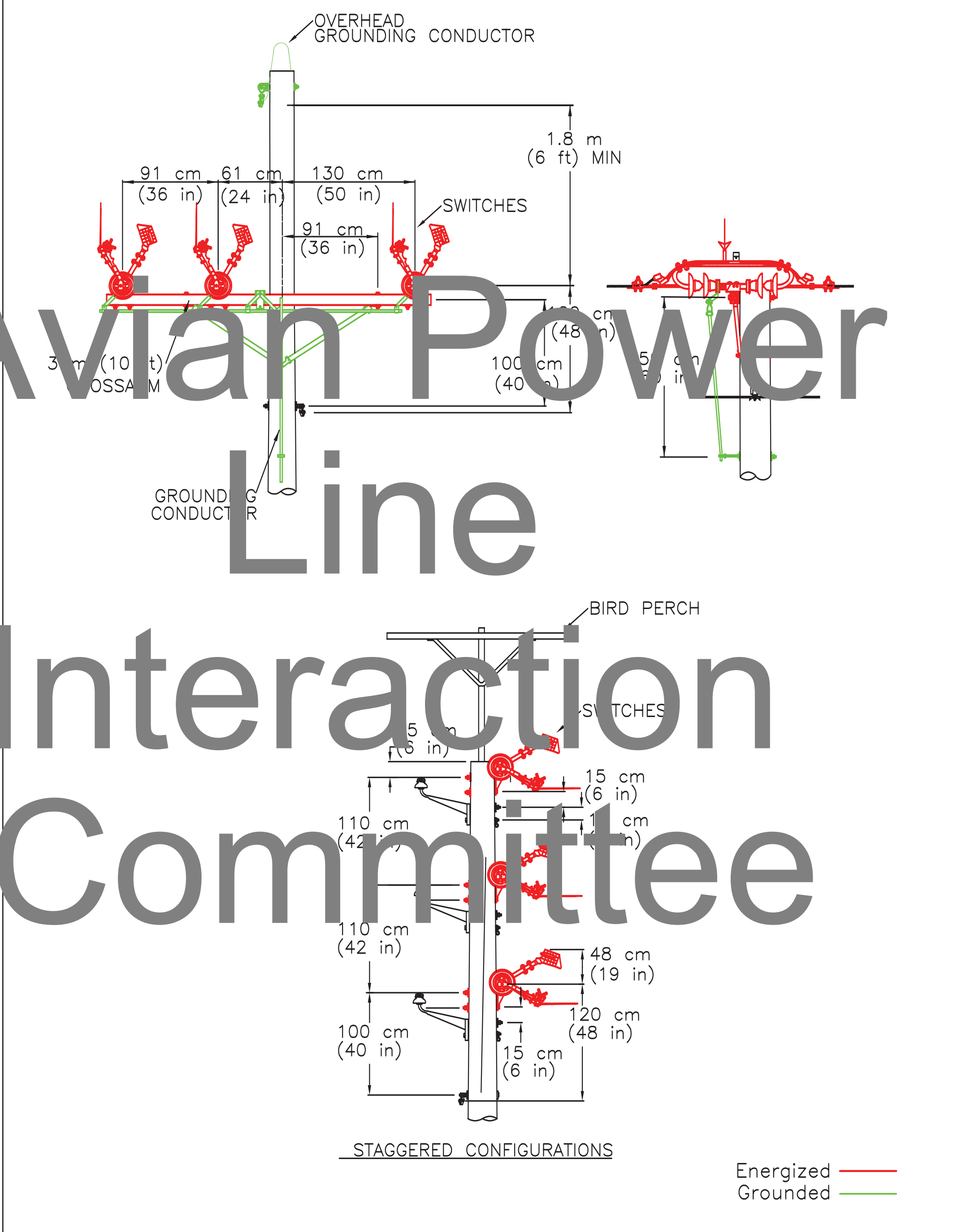

FIGURE 5.49: Pole-mounted switches.

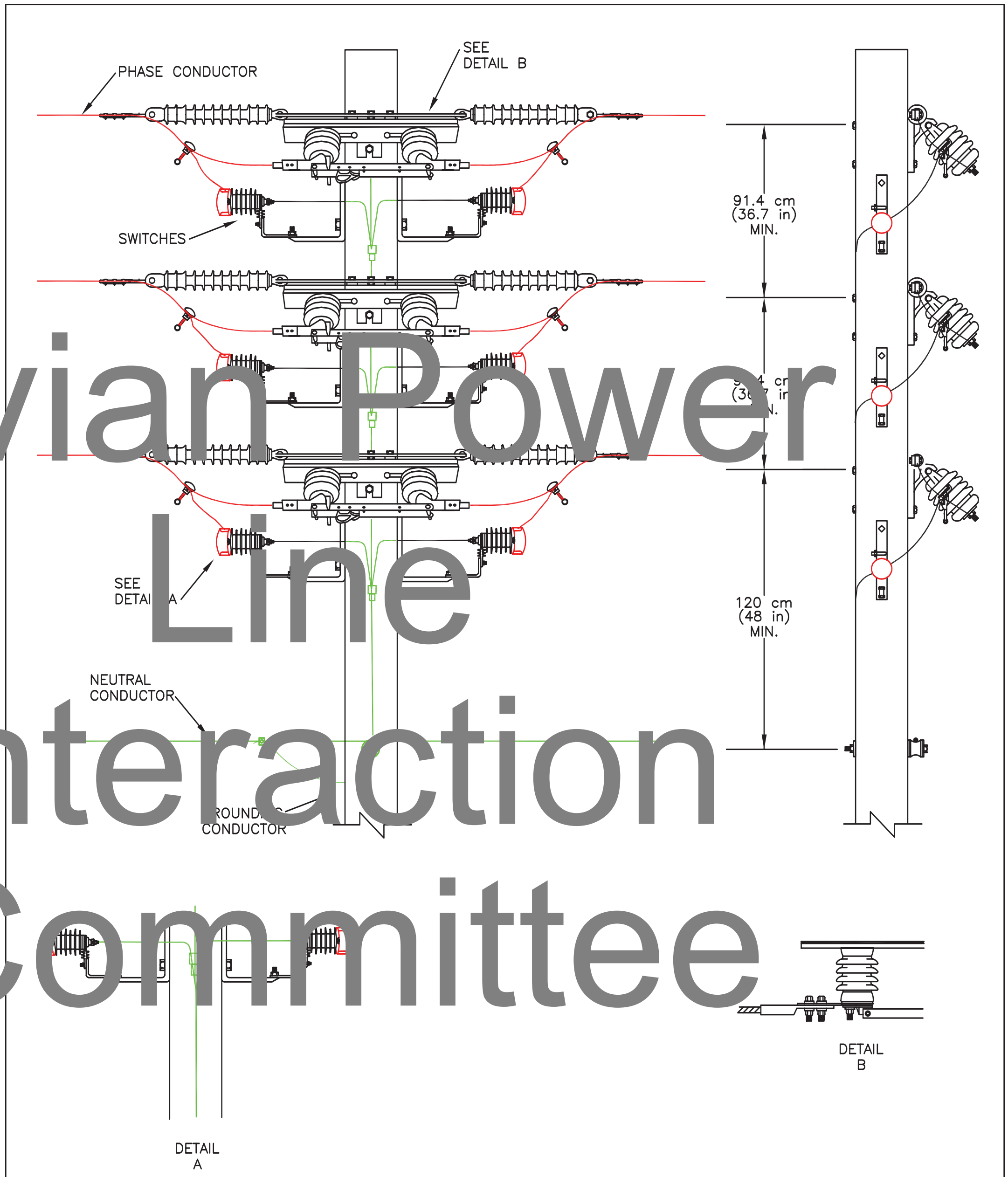

FIGURE 5.50: Pole-mounted switches.

SUBSTATION MODIFICATION AND DESIGN

Substations are transitional points in the transmission and distribution system. While raptor electrocutions at substations are uncommon, smaller birds such as songbirds and corvids may perch, roost, or nest in substations, causing electrocution and outage risks. Numerous bird species have caused substation outages, including great horned owl *(Bubo virginianus)*, American kestrel, black-billed magpie *(Pica hudsonia)*, European starling

(Sturnus vulgaris), golden eagle, and monk parakeet *(Myiopsitta monachus)* (PacifiCorp, unpubl. data; Florida Power and Light, unpubl. data). Over an 18-month period, 18 bird-caused outages were documented in substations in six western states, which affected over 50,000 customers (PacifiCorp, unpubl. data).

Over the years, numerous techniques have been used to prevent bird and animal contacts in substations. Such techniques include habitat modification, physical barriers, auditory, visual, olfactory, and pyrotechnic discouragers, and physically removing animals. Many of these practices have had limited success, or are cost-prohibitive or impractical. The most effective method for preventing bird contacts in substations employs the practices used for distribution and transmission structures, "insulate" or isolate (see page 59). For new substations, a combination of framing and covering can prevent contacts by birds and other animals. For existing substations, cover-up materials designed for the purpose can be installed to make substations avian-safe.

SUMMARY

Power line structures can present electrocution hazards to birds when less than adequate separation exists between energized conductors or between energized conductors/hardware and grounded conductors/hardware. This document recommends 150 cm (60 in) separation for eagles. Other separations may be used based upon the species impacted. Avian-safe facilities can be provided by one or more of the following:

- increasing separations to achieve adequate separation for the species involved
- covering energized parts and/or covering grounded parts with materials appropriate for providing incidental contact protection to birds
- applying perch management techniques.

A utility's Avian Protection Plan (see Chapter 7) should identify new construction designs, retrofitting options, approved avian protection devices, proper installation techniques, and other procedures related to avian protection.

CHAPTER 6

Perching, Roosting, and Nesting of Birds on Power Line Structures

IN THIS CHAPTER

- Avian Use of Power Lines
- Nest Management
- Reliability Concerns

This chapter examines how birds use power line structures. It considers the advantages and disadvantages that utility structures present to birds as well as the effects birds have on power reliability.

Power line structures provide perching, roosting, and nesting substrates for some avian species. This is particularly true of raptors that inhabit open areas where natural substrates are limited. Nest management, including platforms installed on or near power structures, can provide nesting sites for several protected species while minimizing the risks of electrocution, equipment damage, or outages. Nest management might also include the control of the monk parakeet (*Myiopsitta monachus*), a species introduced from South America, which constructs large, communal nests, often on power line structures, causing significant reliability problems.

AVIAN USE OF POWER LINES

RAPTORS

Perching

Power line structures in relatively treeless areas have made millions of kilometers of suitable habitat available to perch-hunting raptors (Olendoff et al. 1980). Power poles offer raptors an expansive view of the surrounding terrain while they inconspicuously watch for prey below (see Figure 4.9). Perch-hunting also allows raptors to conserve energy by minimizing flight activity (Figure 6.1). Ospreys (*Pandion haliaetus*) readily perch-hunt from power poles that have been placed near treeless wetlands or other water bodies.

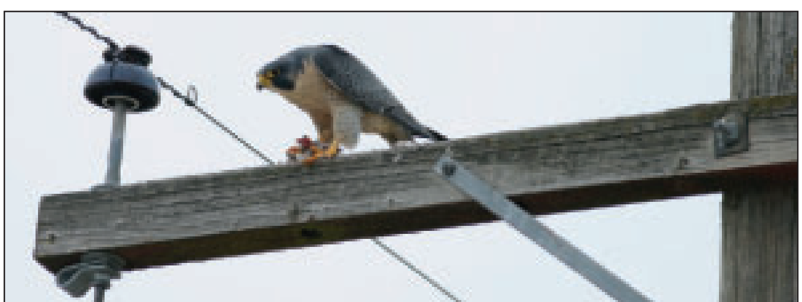

FIGURE 6.1: Peregrine falcon with prey on distribution pole.

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There is a strong association between raptor activity and utility rights-of-way (Williams and Colson 1989). Following the 1974 construction of a 230-kV transmission line in Colorado, raptor density near the line increased from 4 to 13 raptors per square kilometer (km^2) (10 to 34 per square mile [mi^2]) to 21 to 32 raptors/km^2 (54 to 83/mi^2) after construction (Stahlecker 1978).

Although transmission towers comprised only 1.5% of available perches in this area, 81% of raptors seen during surveys used them as perches. Rough-legged hawks *(Buteo lagopus)*, golden eagles *(Aquila chrysaetos)*, and prairie falcons *(Falco mexicanus)* used towers more than any of the other available perches (e.g., distribution poles, fence posts, trees, windmills, etc.). Craig (1978) noted that almost 7[illegible]% of all raptors perched along a 187-km (116 mi) survey route in Idaho were perched on power poles or wires. During a three-year study in southern New Mexico, Kimsey and Conley (1988) found that open terrain traversed by transmission towers received more use by raptors than similar areas without towers. In Wyoming, golden eagles and other raptors perched on distribution poles during winter to exploit a locally abundant food source (Harness and Garrett 1999).

Roosting

Raptors also use power line structures for roosting. Roosts may be selected for protection from predators and inclement weather, or for their proximity to food sources. Raptors that nest on utility structures often use those nests as nocturnal roosts as well. They can roost singly (e.g., osprey or buteos), or communally (e.g., Harris' hawks *[Parabuteo unicinctus]* or wintering bald eagles *[Haliaeetus leucocephalus]*). When perched side-by-side, birds can span the distance between phases or phase and ground, which increases the risk of an electrocution as well as an outage. Excrement from multiple birds can also create outage risks by contaminating equipment.

Craig and Craig (1984) found that golden eagles wintering in Idaho often roosted communally on several types of power line structures. These structures allowed eagles to exploit local populations of jackrabbits, and provided shelter from inclement weather. Eagles and hawks may use the lower portions of transmission towers, which provide some degree of cover for night roosting in barren areas (Smith 1985). In Spain, transmission substations serve as summer roost sites for congregations of lesser kestrels *(Falco naumanni)*. These sites may play an important role in the conservation of this declining species (Arevalo et al. 2004).

Nesting

Casual observation attests, and many studies have documented, that raptors nest on distribution and transmission structures (see Table 6.1). Although most species that nest on power line structures inhabit open, arid areas, one notable exception is the osprey (Figure 6.[illegible]). Ospreys use utility structures for nesting more than any other North American raptor. They typically select poles that are located near or over waters where fish are abundant. To protect ospreys and the power system, nest platforms have been installed on or near transmission towers and distribution poles so nest material and excrement will not contaminate lines. In addition, power poles that are left standing when lines are decommissioned can provide both nest and perch sites. During an 11-year period in Michigan, an average of 55% of the osprey platforms available were occupied (Postupalsky 1978). On Lake Huron in Canada, 82% of artificial platforms were occupied within one year of installation (Ewins 1996). In 1995, nearly 46% of osprey nests studied in Finland (n=951) were located on artificial structures and, in southern Finland, up to 90% of occupied nests (n=79) were on artificial platforms (Saurola 1997).

TABLE 6.1: Accounts of raptor species nesting on transmission structures (T), distribution poles (D), and substations (S).*

Species	Reference
African hawk-eagle *(Hieraaetus faciatus)*	Tarboton and Allan 1984 (T); Allan 1988 (T)
American kestrel *(Falco sparverius)*	Illinois Power Company 1972 (T); Blue 1996 (P); Georgia Power Company, unpubl. data (T)
Aplomado falcon *(Falco femoralis)*	The Peregrine Fund 1995 (T); D. Bouchard, pers. comm. (T)
Bald eagle *(Haliaeetus leucocephalus)*	Keran 1986 (T); Bohm 1988 (T); Hanson 1988 (T); Marion et al. 1992 (T); J. Swan, pers. comm. (T)
Black-breasted snake eagle *(Circaetus gallicus)*	Brown and Lawson 1989 (T)
Black eagle *(Aquila verreauxii)*	Boshoff and Fabricius 1986 (T); Ledger et al. 1987 (T); Jenkins et al. 2005 (T)
Brown snake eagle *(Circaetus cinereus)*	Brown and Lawson 1989 (T)
Crested caracara *(Caracara cheriway)*	J. Lindsay, pers. comm. (S)
Eurasian kestrel *(Falco tinnunculus)*	Boshoff et al. 1983 (T)
Ferruginous hawk *(Buteo regalis)*	Nelson and Nelson 1976 (T); Gilbertson 1982 (T); Gilmer and Stewart 1983 (T); Gaines 1985 (T); Bridges and McConnon 1987 (T); Electric Power Research Institute 1988 (T); Fitzner and Newell 1989 (T); Steenhof et al. 1993 (T); Olendorff 1993a (T); Bechard and Schmutz 1995 (P); Blue 1996 (T); Erickson et al. 2004 (T)
Golden eagle *(Aquila chrysaetos)*	Anderson 1975 (T); Nelson and Nelson 1976 (T); Herron et al. 1980 (T); Electric Power Research Institute 1988 (T); Steenhof et al. 1993 (T); Blue 1996 (P); Kochert et al. 2002 (T); PacifiCorp, unpubl. data (S, T)
Great horned owl *(Bubo virginianus)*	Gilmer and Wiehe 1977 (T); Steenhof et al. 1993 (T); Blue 1996 (P); PacifiCorp, unpubl. data (D, S)
Greater kestrel *(Falco rupicoloides)*	Kemp 1984 (T); Hartley et al. 1996 (P)
Harris' hawk *(Parabuteo unicinctus)*	Ellis et al. 1978 (D); Whaley 1986 (T); Bednarz 1995 (T); Blue 1996 (P)
Lanner falcon *(Falco biarmicus)*	Tarboton and Allan 1984 (T); Hartley et al. 1996 (P)
Martial eagle *(Polemaetus bellicosus)*	Dean 1975 (T); Boshoff and Fabricus 1986 (T); Hobbs and Ledger 1986 (T); Boshoff 1993 (T); Jenkins et al. 2005 (T)
Mountain caracara *(Phalcoboenus megalopterus)*	White and Boyce 1987 (P)

** Note that some studies refer only to nesting on power line structures (P).*

Continued

TABLE 6.1: Accounts of raptor species nesting on transmission structures (T), distribution poles (D), and substations (S).* (cont.)	
Species	**Reference**
Osprey *(Pandion haliaetus)*	Melquist 1974 (D); Detrich 1978 (T); Henny et al. 1978 (T, D); Prevost et al. 1978 (T); Henny and Anderson 1979 (D); van Daele et al. 1980 (D); Jamieson et al. 1982 (D); Austin-Smith and Rhodenizer 1983 (T); Fulton 1984 (T); Keran 1986 (T); Hanson 1988 (T); Vanderburgh 1993 (D); Blue 1996 (P); Ewins 1996 (T, D); Henny and Kaiser 1996 (T, D); Meyburg et al. 1996 (P); Poole et al. 2002 (P); Henny et al. 2003 (T, D); Henny and Anderson 2004 (D)
Pale chanting goshawk *(Melierax canorus)*	Brown and Lawson 1989 [illegible]
Peregrine falcon *(Falco peregrinus)*	Bunnell et al. 1997 (T); White et al. 2002 (T); PacifiCorp, unpubl. data (T)
Prairie falcon *(Falco mexicanus)*	Roppe et al. 1989 (T); Blue 1996 (P); Bunnell et al. 1997 (T)
Red-tailed hawk *(Buteo jamaicensis)*	Nelson and Nelson 1976 (T); Ellis et al. 1978 (T); Fitzner 1980a (T); Gilbertson 1982 (T); Brett 1987 (T); Electric Power Research Institute 1988 (T); Fitzner and Newell 1989 (T); Steenhof et al. 1993 (T); Knight and Kawashima 1993 (P); Blue 1996 (T); Stout et al. 1996 (D); Brubaker et al. 2003 (P)
Rough-legged hawk *(Buteo lagopus)*	Bechard and Swen 2002 (P)
Swainson's hawk *(Buteo swainsoni)*	Olendorff and Stoddart 1974 (D); Fitzner 1978 (D); Fitzner and Newell 1989 (T); Blue 1996 (P); England et al. 1997 (P, T)
Tawny eagle *(Aquila rapax)*	Dean 1975 (T); Tarboton and Allan 1984 (T); Jenkins et al. 2005 (T)
White-backed vulture *(Gyps africanus)*	Ledger and Hobbs 1985 (T)
Zone-tailed hawk *(Buteo albonotatus)*	Blue 1996 [illegible]
** Note that some studies refer only to nesting on power line structures (P).*	

Nest location on a power structure can vary by species and structure type. On natural substrates, ospreys typically nest on the flat tops of dead trees and broken tops of live trees. Likewise, on power structures, ospreys prefer the upper portions of transmission towers or the tops of distribution poles. Red-tailed, Swainson's *(Buteo swainsoni)*, and ferruginous hawks *(B. regalis)* generally prefer nest heights that are relatively high, moderate, and low, respectively. Tower sections where steel latticework is relatively dense are generally preferred, as this provides more support for nests (Figure 6.3). The configuration of two poles supporting four paired sets of crossarms was most often used by raptors in New Mexico (Brubaker et al. 2003). Double dead-end and dead-end distribution poles (see Figures 5.15, 5.16, 6.2, 6.23, 6.24, 6.25, and 6.26 for examples) are the distribution configurations most commonly used by osprey and some other raptors throughout North America.

Steenhof et al. (1993) reported an 89% success rate for ferruginous hawk nests on

FIGURE 6.2: Osprey nest on double crossarm of non-energized pole.

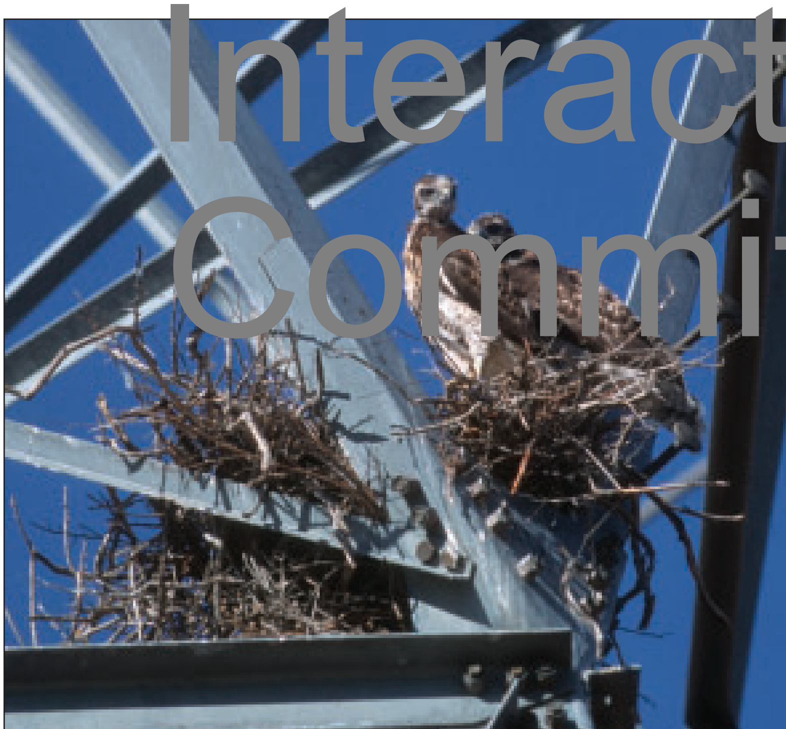


FIGURE 6.3: Red-tailed hawk nest on steel lattice transmission tower.

platforms (*n*=19), which was higher than nesting success on cliffs (58%, *n*=38) or other natural substrates (20%, *n*=5). Likewise, ferruginous hawk nesting success was higher on artificial platforms in Wyoming than on natural substrates (Tigner et al. 1996). [illegible] and Schmutz (1995) stated that nesting platforms could be beneficial for ferruginous hawks, especially in previously occupied habitats where the number of natural nest sites is in decline. They recommend spacing nest platforms out-of-sight of other buteo nests.

Nest platforms for bald eagles provide support for weak or collapsed nests, attract birds searching for a breeding site, encourage the reuse of historic sites, and support nests moved from areas of pending human activity or development (Postupalsky 1978; Hunter et al. 1997). In Florida an increased number of bald eagle nests on man-made structures has been reported. In 2003, there were 24 bald eagle nests on man-made structures with

46% on transmission towers (J. Swan, pers. comm.). In 2004 and 2005, the number of nests on towers increased due to the loss of nesting trees to hurricanes in 2004 (S. Nesbitt, pers. comm.).

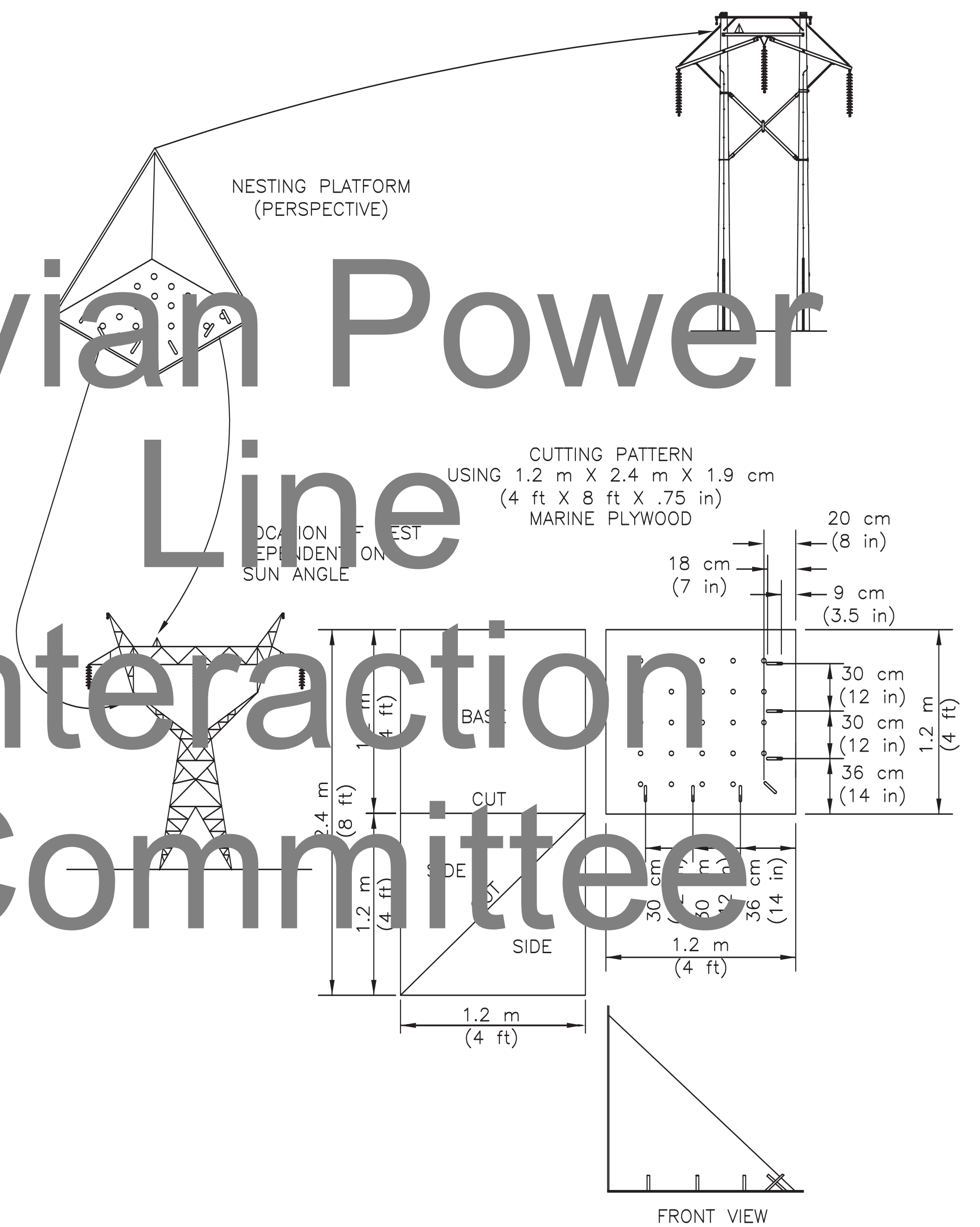
ADVANTAGES TO RAPTORS NESTING ON UTILITY STRUCTURES

Utility structures can provide nesting substrates in habitats where natural sites are scarce, facilitate the range expansion of some species, increase the local density of some species, and offer some protection from the elements. In addition, some raptors have increased their nest success and productivity on power line structures.

In New Mexico, decommissioned telephone poles and energized electrical poles were used by nesting raptors (Brubaker et al. 2003). Thirty-two of 338 poles were used by nesting raptors, including 27 pairs of Swainson's hawks, 3 pairs of red-tailed hawks, and 2 pairs of great horned owls *(Bubo virginianus)*. In Wisconsin, red-tailed hawks nested on artificial structures, including transmission towers, as the availability of natural nest sites declined in human-altered landscapes (Stout et al. 1996). New 230-kV and 500-kV lines on the Hanford Reservation in Washington were monitored between 1979 and 1988 (Fitzner and Newell 1989). After construction of the lines in 1979, only one red-tailed hawk nest appeared on these structures. By 1988, 19 Swainson's, ferruginous, and red-tailed hawks' nests were found on the structures. Red-tailed hawks and common ravens *(Corvus corax)* in southern California nested on utility structures in greater numbers than expected based on the availability of potential nest substrates (Knight and Kawashima 1993). In 1980 and 1981, the PacifiCorp Malin-to-Midpoint 500-kV transmission line was constructed across eastern Oregon and southern Idaho (Steenhof et al. 1993). In cooperation with the BLM, PacifiCorp installed 37 nesting platforms designed by Morley Nelson (Figure 6.4) (Nelson and Nelson 1976; Olendorff et al. 1981; Nelson 1982). Within one year, raptors and ravens began nesting on these platforms. Although only 2% of the towers had platforms, 72% (*n*=29) of the golden eagle and 48% (*n*=52) of the ferruginous hawk nesting attempts were made on the artificial platforms. Nineteen (51%) of the platforms were used at least once. Steenhof et al. (1993) suggested that the needs of nesting raptors should be considered and assistance encouraged during the construction of transmission lines, especially when the line traverses treeless habitat and the disturbance of a sensitive prey species is not an issue.

The construction of artificial nesting platforms, including those on power poles, has contributed to the ospreys' population growth and range expansion in North America (Houston and Scott 2001; Henny and Anderson 2004). Although the number of ospreys nesting on natural substrates remained constant in the Willamette Valley, Oregon, from the 1970s to 1990s, the number of active nests on power line structures increased from 1 in 1977 to 66 in 1993 (Henny and Kaiser 1996). In 2001, 234 osprey pairs were nesting in this area, with 74% of the nests located on power poles or platforms erected by electric utilities (Henny et al. 2003).

Power line structures may also help local raptor populations increase (Olendorff et al. 1981). Within ten years after construction of a 500-kV transmission line across eastern Oregon and southern Idaho, 53 pairs of raptors and ravens nested on line structures while their nesting densities on nearby natural substrates remained at pre-construction levels (Steenhof et al. 1993). In South Africa as well, raptor nests are not removed unless they pose a threat to the power supply. Consequently, many raptor species regularly nest on transmission towers (Ledger et al. 1993).



Adapted from Nelson and Nelson (1977).

FIGURE 6.4: The Morley Nelson raptor nest platform.

Transmission towers may afford nesting raptors some protection from the elements. Beams and cross-braces provide shade and windbreaks for nesting birds (Anderson 1975). Compared to cliffs, towers allow more air circulation and lower heat absorption. Raptors nesting on transmission towers are also more protected from range fires (Steenhof et al. 1993).

Some studies have documented greater nest productivity on artificial nesting substrates than on natural substrates (van Daele et al. 1980; Gaines 1985; Olendorff 1993a). Martial eagles (*Polemaetus bellicosus*) in southern Africa had higher breeding success on electrical transmission towers than elsewhere (Boshoff 1993). Ospreys using artificial sites in Germany produced more young than those nesting in trees (Meyburg et al. 1996). Similar rates of raptor nesting success have been found between natural and man-made substrates in the Canadian Great Basin and in southern Wisconsin (Ewins 1996; Stout et al. 1996). Improved productivity on poles, towers and other artificial structures can usually be attributed to nest stability and protection from mammalian predators.

DISADVANTAGES TO RAPTORS NESTING ON UTILITY STRUCTURES

Raptors that nest on power poles face disadvantages that include: increased risk of electrocution and collision, susceptibility to nest damage from wind and weather, disturbance from line maintenance or construction, and vulnerability to shooting. Raptors nesting on power line structures may also impact some prey species and can reduce power reliability by contaminating equipment with excrement or nesting material (see Reliability Concerns). Another possible disadvantage is that raptors, specifically ospreys, reared from power pole nests may only select power poles as nest substrates when they nest as adults (Henny and Kaiser 1996).

Raptors nesting on utility structures have an increased electrocution risk if nearby poles are not avian-safe (see Chapter 5). Entanglement in wires and other utility hardware can also occur (Olendorff et al. 1981). In the United States, raptor collisions with power lines do occur, but not as frequently as electrocutions (Oldendorff and Lehman 1986; Kochert and Olendorff 1999). Although raptors may become familiar with power lines in their breeding territory, repeated flights across power lines increases the risk of collision, especially in bad weather or in the pursuit of prey (Manosa and Real 2001). In Europe, transmission lines near nests were associated with high turnover rates of breeding Bonelli's eagles *(Hieraaetus fasciatus)*. Collisions with power lines were the suspected cause (Manosa and Real 2001).

The dense latticework of transmission towers offer some protection from the elements, but relatively open distribution poles do not. Consequently, nests on distribution poles are more often damaged or destroyed by strong winds (Gilmer and Wiehe 1977; Postovit and Postovit 1987). Raised edges on nesting platforms can help stabilize and protect nests during high winds. Destruction of nests by wind was a common cause of nest failures (14%) on transmission towers in Idaho. Poles with artificial platforms afforded more protection from wind than poles without platforms (Steenhof et al. 1993). A bald eagle nest on an H-frame structure in Florida repeatedly fell during windstorms until an artificial platform was erected to support it (Marion et al. 1992).

Although short-lived, the activity and alteration of surrounding habitat that occurs during power-line construction can disturb raptors. Maintenance operations may also temporarily disrupt normal bird nesting, hunting and roosting behavior (Williams and Colson 1989).

Indiscriminate shooting of raptors may

be higher along power lines than at natural nest sites because poles are often highly visible and close to access roads (Williams and Colson 1989).

The addition of artificial raptor nests can have negative impacts on others animals (Fitzner 1980a). For example, burrowing owls *(Athene cunicularia)*, which are preyed upon by larger raptors, can be more susceptible to predation if nest platforms are erected in their territories. The introduction of great horned owls into an area via nest platforms can threaten nestlings of diurnal raptors.

FIGURE 6.5: Loggerhead shrike *(Lanius ludovicianus)* perched on conductor.

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OTHER BIRDS

Perching

Many other bird species use distribution poles, transmission towers, and conductors for perching, particularly where suitable foraging or nesting habitat is nearby (e.g., Yahner et al. 2002). As they do for raptors, power line structures provide a view of the surroundings, and facilitate hunting. From these perches, kingfishers pursue fish in lakes or streams, and shrikes seek their prey along power line corridors (Figure 6.5). Utility structures, especially conductors, are commonly used as perches by flocking birds, such as blackbirds, swallows, and European starlings *(Sturnus vulgaris)*.

Roosting

Species such as cormorants, vultures, ravens, and crows use power line structures for roosting. Poorly adapted to cold environments, vultures often seek roosts that are protected from harsh weather. Cape Griffons, or Cape vultures *(Gyps coprotheres)* and, to a lesser extent, white-backed vultures *(Gyps africanus)*, roost in large numbers on transmission towers in southern Africa (Ledger and Hobbs 1999). Likewise, turkey vultures *(Cathartes aura)* and black vultures *(Coragyps atratus)* use transmission towers for roosting in North America.

Some corvid species roost communally or congregate on power line structures. Engel et al. (1992b) documented the largest known communal roost of common ravens in the world. There were as many as 2,103 ravens on adjoining 500-kV transmission towers in southwestern Idaho. The towers appeared to present an attractive alternative to natural roost sites by offering increased safety from predators and close proximity to food sources.

Nesting

A number of non-raptor species also nest on utility structures. Transmission tower latticework can provide suitable nesting substrate for ravens, herons, cormorants and other large birds. Distribution poles are used by smaller birds that build their nests on support brackets, transformers, or capacitors. Table 6.2 presents a list of non-raptor species that have nested on power line structures. This list is not comprehensive, but it illustrates the variety of species attracted to utility structures.

Birds that build stick nests may find areas on transmission and distribution structures suitable for nesting sites. In Europe, the white stork *(Ciconia ciconia)* commonly nests on distribution and transmission towers (Janss 1998). Double-crested cormorants *(Phalacrocorax auritus)* and great blue herons *(Ardea herodias)* nest on steel-lattice transmission towers along the Great Salt Lake in Utah (PacifiCorp,

TABLE 6.2: Examples of non-raptor species nesting on power line structures.*	
Species	**Source**
Double-crested cormorant *(Phalacrocorax auritus)*	PacifiCorp (unpubl. data)
Great blue heron *(Ardea herodias)*	PacifiCorp (unpubl. data)
Hadeda ibis *(Bostrychia hagedash)*	C.S. van Rooyen (pers. comm.)
White stork *(Ciconia ciconia)*	Janss 1998
Egyptian goose *(Alopochen aegyptiaca)*	C.S. van Rooyen (pers. comm.)
Canada goose *(Branta canadensis)*	J. Burruss (pers. comm.)
Monk parakeet *(Myiopsitta monachus)*	J. Lindsay (pers. comm.)
Eastern kingbird *(Tyrannus tyrannus)*	The Maryland Ornithological Society (http://www.mdbirds.org/atlas/spnotes.html)
Western kingbird *(T. verticalis)*	M. Fiedler (pers. comm.); PacifiCorp (unpubl. data)
Scissor-tailed flycatcher *(T. forficatus)*	Georgia Ornithological Society (http://www.gos.org/rbas/ga2000/2000-05.html)
Pied crow *(Corvus albus)*	C.S. van Rooyen (pers. comm.)
Cape crow *(C. capensis)*	C.S. van Rooyen (pers. comm.)
Common raven *(C. corax)*	Knight and Kawashima 1993; Steenhof et al. 1993
Chihuahuan raven *(C. cryptoleucus)*	Bednarz and Raitt 2002; Brubaker et al. 2003
Sociable weaver *(Philetairus socius)*	C.S. van Rooyen (pers. comm.)

* *This table includes species that have constructed nests or used existing nests on poles, not those which may nest in cavities within poles, e.g. woodpeckers, chickadees, etc.*

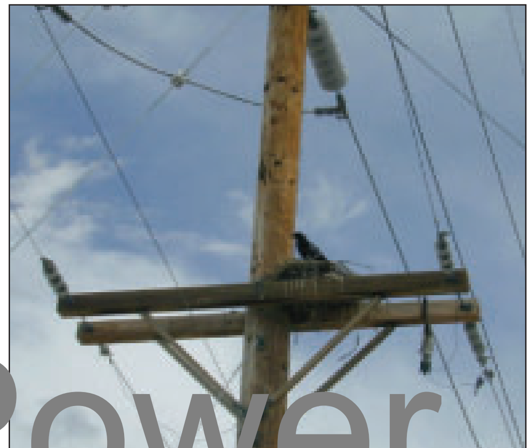

FIGURE 6.6: Common raven nest on distribution underbuild of transmission structure.

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FIGURE 6.7: Western kingbird nest (see highlighted area) on transformer.

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unpubl. data). In the western United States, Canada geese *(Branta canadensis)* have nested on platforms erected for raptors (J. Burruss, pers. comm.).

Common ravens often nest on utility structures (Figure 6.6). Within ten years of the construction of a 500-kV transmission line across Oregon and Idaho, 81 pairs of common ravens nested on the transmission structures (Steenhof et al. 1993). Their success was similar to or greater than nest success in natural substrates. In New Mexico, ravens preferred to nest on the configuration with two poles supporting four paired sets of crossarms (Brubaker et al. 2003).

Throughout a 45,000-km^2 (17,375-mi^2) area of the Mojave Desert in southern California, 26 pairs of common ravens used power line structures for nesting. There were more nests than expected based on the availability of natural nest substrates

(Knight and Kawashima 1993).

Some species exhibit preferences for nest location on a structure. For example, 98% of raven nests (n=408) were found on the uppermost portion of towers (Steenhof et al. 1993). Western kingbirds often nest on transformer brackets, riser poles, switches, and transmission structures (Figure 6.7) (M. Fiedler, pers. comm.; PacifiCorp, unpubl. data).

The use of non-raptor nests by raptors on power line structures has been reported. For example, prairie falcons have been documented using common raven nests (DeLong and Steenhof 2004), and a pair of peregrine falcons *(Falco peregrinus)* occupied a common raven nest on a transmission tower along the Great Salt Lake, Utah (J. Burruss, pers. comm.). In south Texas, a pair of aplomado falcons *(Falco femoralis)* used a common raven nest on an H-frame, 138-kV tower (D. Bouchard, pers. obs.). Although the nest was destroyed by wind, a platform was installed in the same place and was also successful.

MONK PARAKEETS

Though native to South America, monk parakeets were brought to the United States in the late 1960s as pets. Escaped birds have adapted well and established populations from Florida to New York, Texas to Oregon, and in parts of southern Canada. Populations in some states have grown exponentially in the last 10 to 15 years (Pruett-Jones et al. 2005). Monk parakeets build bulky stick nests on trees, power poles, and substations (Spreyer and Bucher 1998; Newman et al. 2004). The number of nests can range from several on distribution or transmission poles to more than 50 in a single substation (Figures 6.8, 6.9). Since monk parakeets are colonial breeders, the size

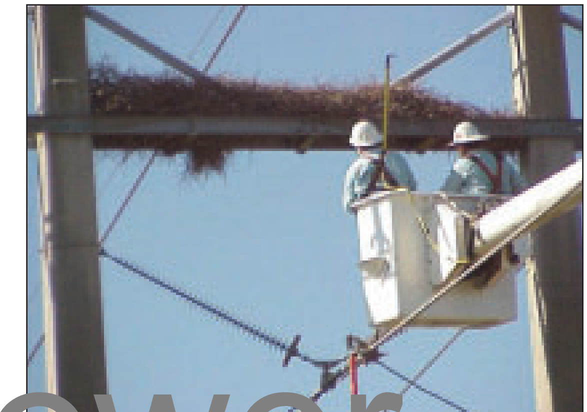

FIGURE 6.8: Monk parakeet nests on transmission tower.

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FIGURE 6.9: Monk parakeet nest on distribution pole.

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of their nests can increase each year and may reach several meters in diameter. Examination of the monk parakeet's annual nesting patterns in south Florida suggests an increasing preference for both power line structures and substations (Newman et al., in press).

Monk parakeet nest site selection on power line structures in Florida is quite predictable, and they show similar behavior in other states as well (Newman et al. 2004). In south Florida, 82% of nests occurred on distribution poles with transformers and capacitor banks. Most of these nests were built on the brackets that attach the equipment to poles. On the transmission towers surveyed, most nests were located on the secondary arms, followed by the primary arms (Newman et al., in press). A commonality between nests on substations and transmission lines is the parakeet's apparent preference for nesting on 45°-angled braces. On transmission towers, 93% of nests occurred on 45°-angle braces. In substations 44% of nesting occurred on 45°-angle crossbeams, followed by switches (18%) and vertical supports (18%) (Newman et al., in press). The remaining 20% were on 90° primary supports, insulator/switches, and substation support structures.

Monk parakeet nests have caused power reliability, fire and safety problems, especially when they contact energized portions of a utility structure. This problem is compounded when one structure supports multiple nests. Safety concerns related to monk parakeet nests include loss of power to critical care facilities, risk of injury to maintenance crews, and risk of electrocution to trespassers attempting to capture wild birds. In service areas such as New York City, some distribution poles have signs indicating that continuous power is necessary for a resident on life-support. Nests on these poles or nearby distribution feeders pose a serious risk to these residents.

Psitticosis is a rare disease that can be transmitted from psitticine birds (parrots) to humans. Thus, nest removal activities associated with colonial psitticines can present a risk to utility workers. Utility crews should also protect themselves from nest materials that may contain mites and insects that can cause discomfort.

MONK PARAKEET NEST MANAGEMENT

The significant increase in monk parakeet population and associated power reliability problems, management costs, and safety concerns warrant short- and long-term nest management strategies. Short-term objectives include removing high-risk nests from utility structures and preventing birds from re-nesting on them. Long-term objectives include reducing population size and growth, and enacting legislation to aid in the control of this species. Because of structural and operational differences between transmission lines, distribution lines, and substations, specific nest management and control strategies need to be developed for each (Newman et al. 2004). Much of what is known about monk parakeet management has been developed through field-testing in Florida where the species has been a challenge for utilities for over a decade ([illegible]. Lindsay, pers. comm.; Newman et al. 2004). Monk parakeets are not protected by the Migratory Bird Treaty Act, however removal of nests and birds can be received negatively by the public.

Short-term control of monk parakeets by nest removal alone is ineffective and can actually increase the number of new nests. Often, multiple pairs of monk parakeets occupy a single nest. When a nest is destroyed, the pair that started the nest will not rejoin its neighbors. Instead, it will build a separate nest on the same or nearby structure. Simultaneously removing the parakeets **and** the nest has proven successful in reducing the number of high-risk nests and in preventing re-nesting in the short-term. Birds are removed from the nests at night and the nests are removed later.

Nets have been designed for trapping monk parakeets on distribution poles, but because monk parakeets are vigilant and astute, the trapping efficiency per nest is approximately 50% (Tillman et al. 2004). Trapping and nest removal are labor intensive and also have public acceptance issues. Trapping may be effective as a long-term strategy for reducing populations if these efforts are continued until all nesting ceases at a particular location (Newman et al. 2004). Passive trapping with a cage is somewhat effective for substations. Trapping techniques for transmission towers have not been developed.

Florida Power & Light has investigated a wide range of other strategies including physical, behavioral, chemical and biological controls. Presently, only one potential long-term control has been identified. In the laboratory, Diazacon, a chemical sterilant, has been effective in reducing the number of eggs laid. However, additional research is needed to determine if its use is practical and effective in the field.

NEST MANAGEMENT

ENCOURAGING BIRDS TO NEST IN DESIRED AREAS

Distribution Poles

Installing nest platforms in safe areas on or near utility structures is effective for both nest management and line maintenance. Of 88 utilities that responded to a survey regarding raptors nesting on their utility structures, 66% had raptor nest enhancement projects (Blue 1996). Artificial nest platforms were most commonly used (n=40) and 95% of these companies erected platforms for ospreys. Generally, there is a greater need for nest platforms on distribution poles than on transmission structures because the closer separation between distribution conductors increases the risk of electrocutions and outages.

An osprey nest structure erected above a power pole should have a well-supported platform with some nest material added to entice the birds to the new site (Figure 6.10). A perch, situated above the nest (Figure 6.11) or extending from the platform (Figures 6.12

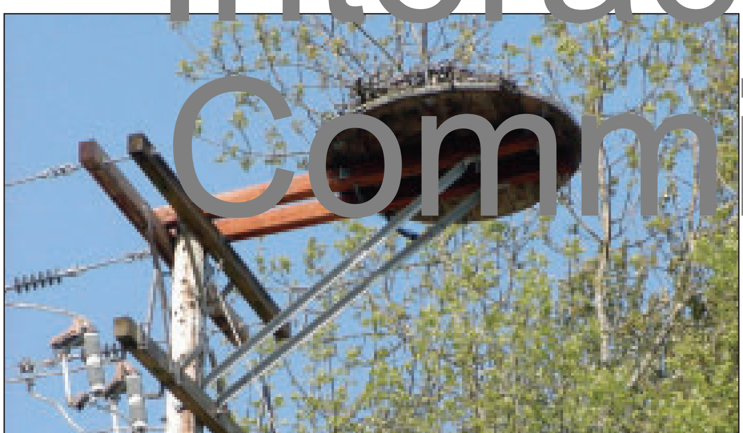

FIGURE 6.10: Osprey nest platform design developed by Portland General Electric. The platform is constructed from the end of a 1.5-meter (m) (5-foot [ft]) diameter wooden cable spool with coated cable along the edge to contain nest material. Utilities should ensure energized parts and equipment below the nest are covered to prevent electrocution of birds or outages from nest material. Consumer's Power, Inc. retrofitted this pole to their avian-safe standards.

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FIGURE 6.11: A nest platform built atop a pole using crossarms to extend the platform above the conductors. This design also includes an optional elevated perch to attract ospreys. The perch should be perpendicular to the prevailing wind.

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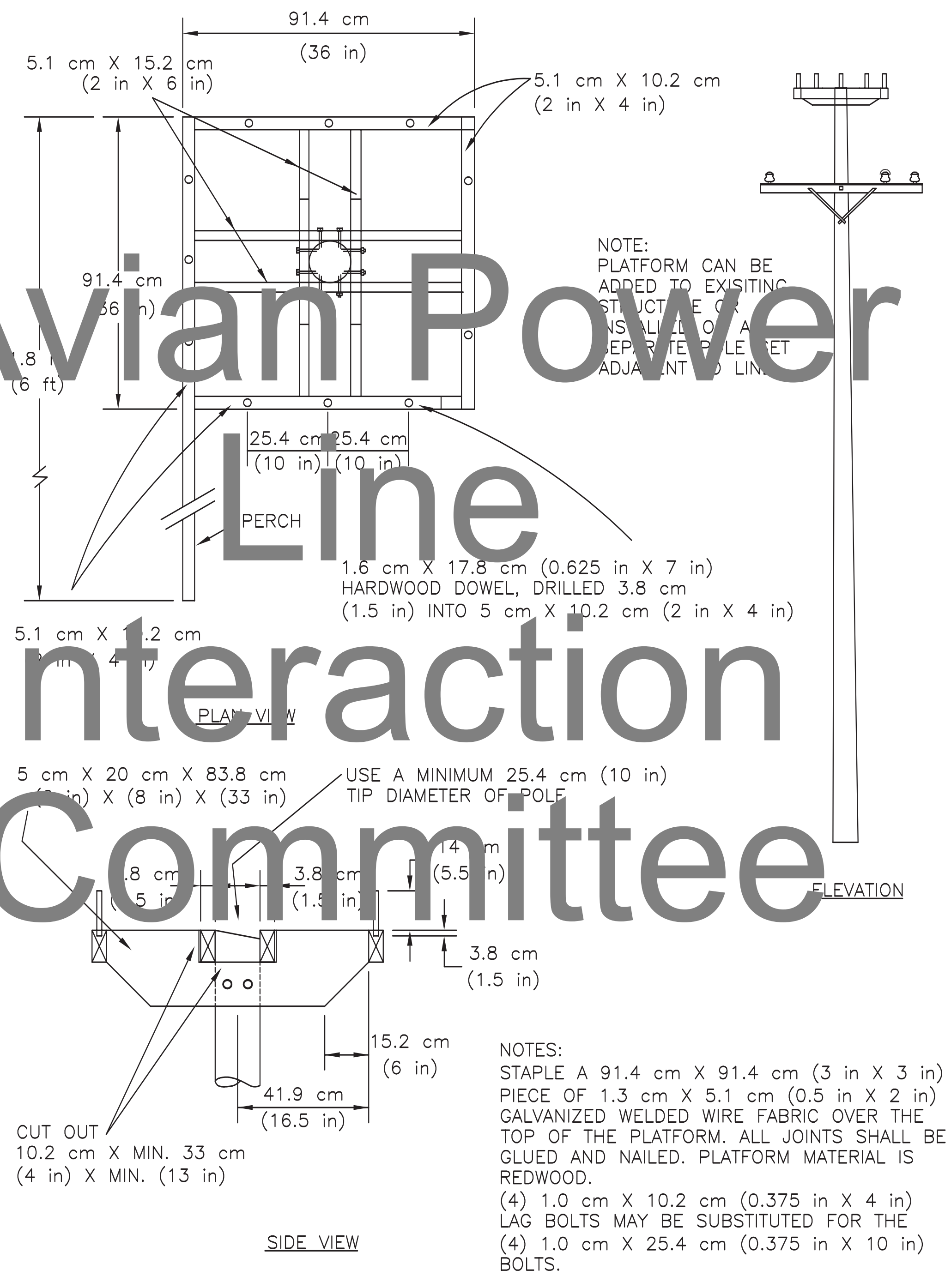

Figure 6.12: Osprey nest platform details (Idaho Power Company, PacifiCorp).

FIGURE 6.13: Photo of nest platform depicted in Figure 6.12.

FIGURE 6.14: A simple and cost-effective offset nesting platform built for ospreys in Washington. Pallets can be used as platforms, providing ospreys with a flat nesting area.

and 6.13) may increase its desirability. Perches should be perpendicular to the prevailing wind. Care should be taken to arrange sticks and other nest materials so they mimic the size and form of a natural nest. Various nest platform designs are used by utility companies throughout the United States, Canada, and Europe (van Daele et al. 1980; Ewins 1994).

Platforms made from discarded wooden cable spools have been used by nesting ospreys (Austin-Smith and Rhodenizer 1983) (see Figure 6.10). The offset-pallet-platform design developed in Ontario (Ewins 1994:13) is simple and cost-effective (Figure 6.14). Figure 6.15 depicts another nest platform design that may be used for some buteos and ospreys. Grubb (1995) provides a guide for eagle nest designs.

Osprey nest management may include building alternate nest platforms above power lines, installing a nearby taller non-energized pole with a nest platform, or leaving the nest intact but retrofitting the pole (Henny et al. 2003).[32] However, utilities should be aware that installing a nest platform above lines or leaving a nest on a crossarm may result in outages from nesting material, excrement, or

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32 See Chapter 5 for retrofitting recommendations.

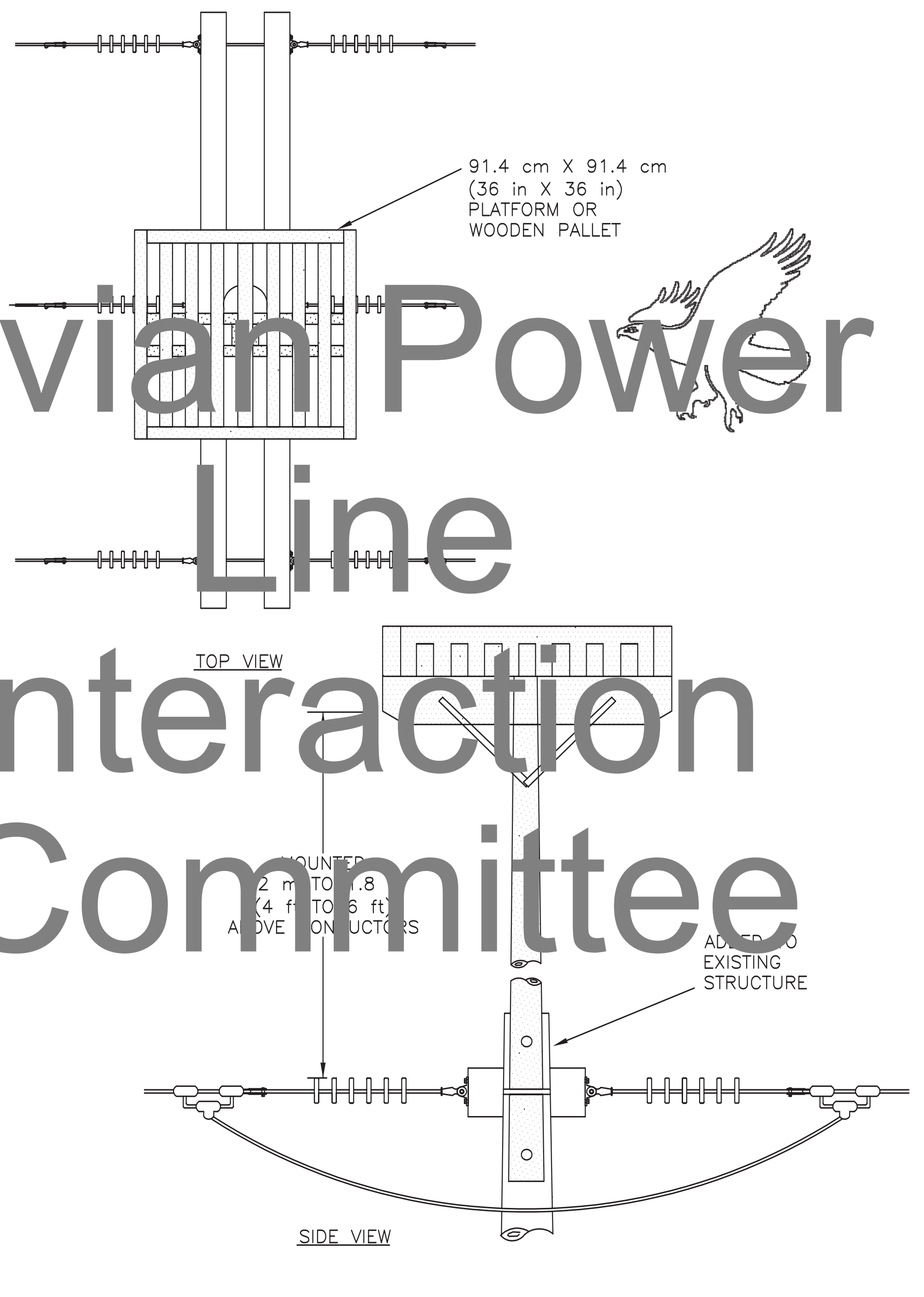

FIGURE 6.15: Raptor nest platform used by ospreys and some buteos (PacifiCorp). This design is recommended when a new nest pole cannot be erected.

prey remains dropping onto conductors or energized equipment (Figure 6.16). Installing a platform on a nearby non-energized pole reduces these risks.

Transmission Structures

The greater separation between conductors on transmission towers generally allows raptors and other birds room to nest without causing problems for electric operations (e.g., Hobbs and Ledger 1986). The latticework of some steel transmission towers provides adequate support for nests without the aid of platforms (Figure 6.17). However, a nest situated above insulator strings may cause equipment failures due to contamination with excrement, prey remains, or nest materials.

In Spain, 11 nesting platforms were placed on transmission towers, where they would not interfere with electrical operations, to draw white storks away from sites elsewhere on the towers (Janss 1998). The storks accepted the platforms, but the original nests remained in use as well.

The location of a nest platform can also influence roosting behavior, and either increase or decrease the risk of streamer-caused faults (C.S. van Rooyen, pers. comm.). In South Africa, outages caused by streamers from roosting martial eagles *(Polemaetus bellicosus)*, tawny eagles *(Aquila rapax)*, and Verreaux's eagles *(A. verreauxii)* were concentrated within a ten-transmission tower radius of active nests. These outages occurred on configurations that were both preferred for nesting and susceptible to streamer contamination (Jenkins et al. 2005). Conversely, eagles with nests located below phase conductors also roosted below conductors, reducing the outage incidence and risk.

Progress Energy reduced its osprey nest problem on double-crossarm structures by installing fiberglass nest platforms above the conductors (D. Voights, pers. comm.) (Figure 6.18).

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FIGURE 6.16: Osprey nest in Wyoming atop double dead-end pole. Nesting material that may drop onto the conductors or equipment poses fire, outage, and equipment damage risks.

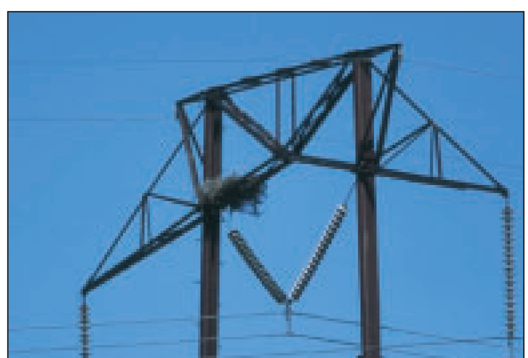

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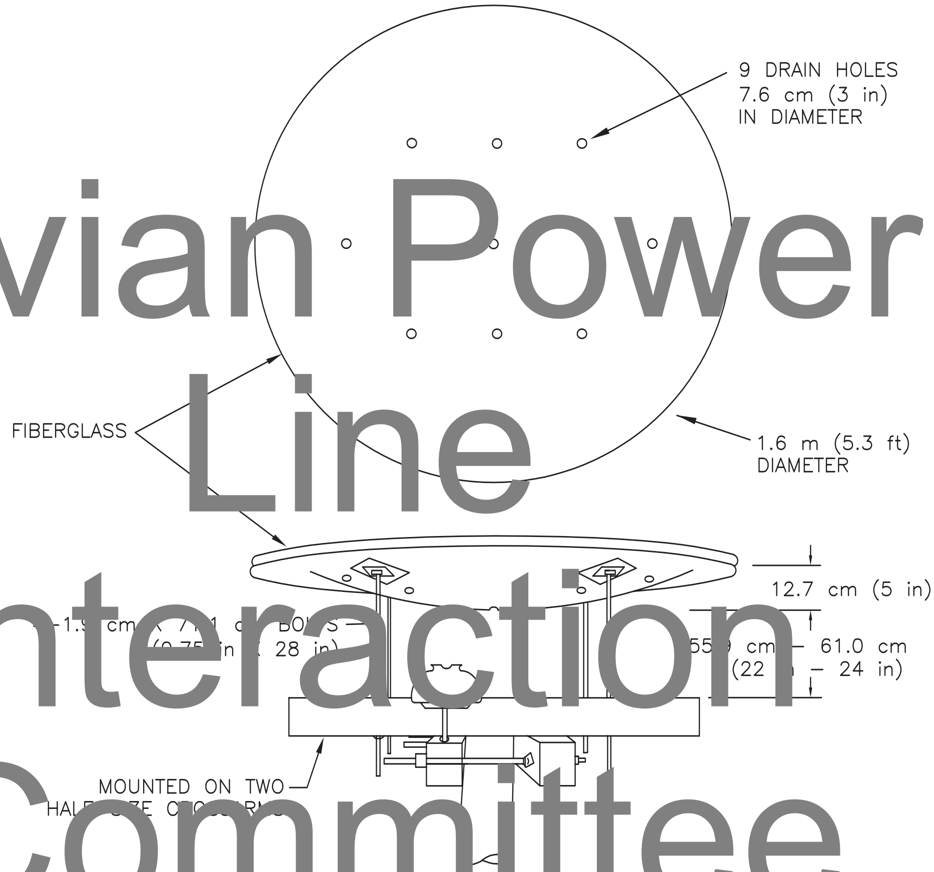
FIGURE 6.17: Golden eagle nest on transmission tower.



NOTE:
RAISING PLATFORM ABOVE ENERGIZED CONDUCTORS PREVENTS INJURIES TO OSPREYS AND ALSO REDUCES OUTAGES AND EQUIPMENT DAMAGE. PLATFORM SHOULD BE LARGE ENOUGH TO COVER ANY ENERGIZED EQUIPMENT AND PREVENT CONTACT WITH NEST MATERIALS.

FIGURE 6.18: Osprey nest platform (Progress Energy).

Georgia Southern University and Georgia Power Company have erected nest boxes and tubes on transmission structures in Georgia for American kestrels (J. Parrish, pers. comm.). The nesting tubes were constructed of 30.5-cm (12-in) diameter, UV-resistant PVC pipe cut at lengths of either 46 or 91 cm (18 or 36 in). All tubes were drilled with drain holes in the bottom and vents on the sides, and lined with several inches of pine straw. The entrance of each nest tube was positioned to face east or south. The 91-cm (36-in) long tube included 30.5-cm (12-in) end caps with a 7.6-cm (3-in) hole cut in the middle of one of them (Figure 6.19). In 2003 and 2004, two of these tubes were mounted horizontally on transmission towers at a height of 30.5 m (100 ft). The tube mounted in 2003 was used in 2004, and both were used by nesting kestrels in 2005. The 46-cm (18-in) tube, which can be mounted either horizontally or vertically, includes a 7.6-cm (3-in) hole in either the end or the top of the tube (Figure 6.20). These tubes were installed both vertically and horizontally at a height of 4.5 m (15 ft). Kestrels used one of the four vertically mounted tubes in 2005, but did not use either of the horizontally mounted tubes that year.

FIGURE 6.19: Kestrel nesting tube (91-cm [36-in] length) installed on transmission tower in Georgia.

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FIGURE 6.20 Kestrel nesting tube (46-cm [18-in] length) installed on transmission tower in Georgia.

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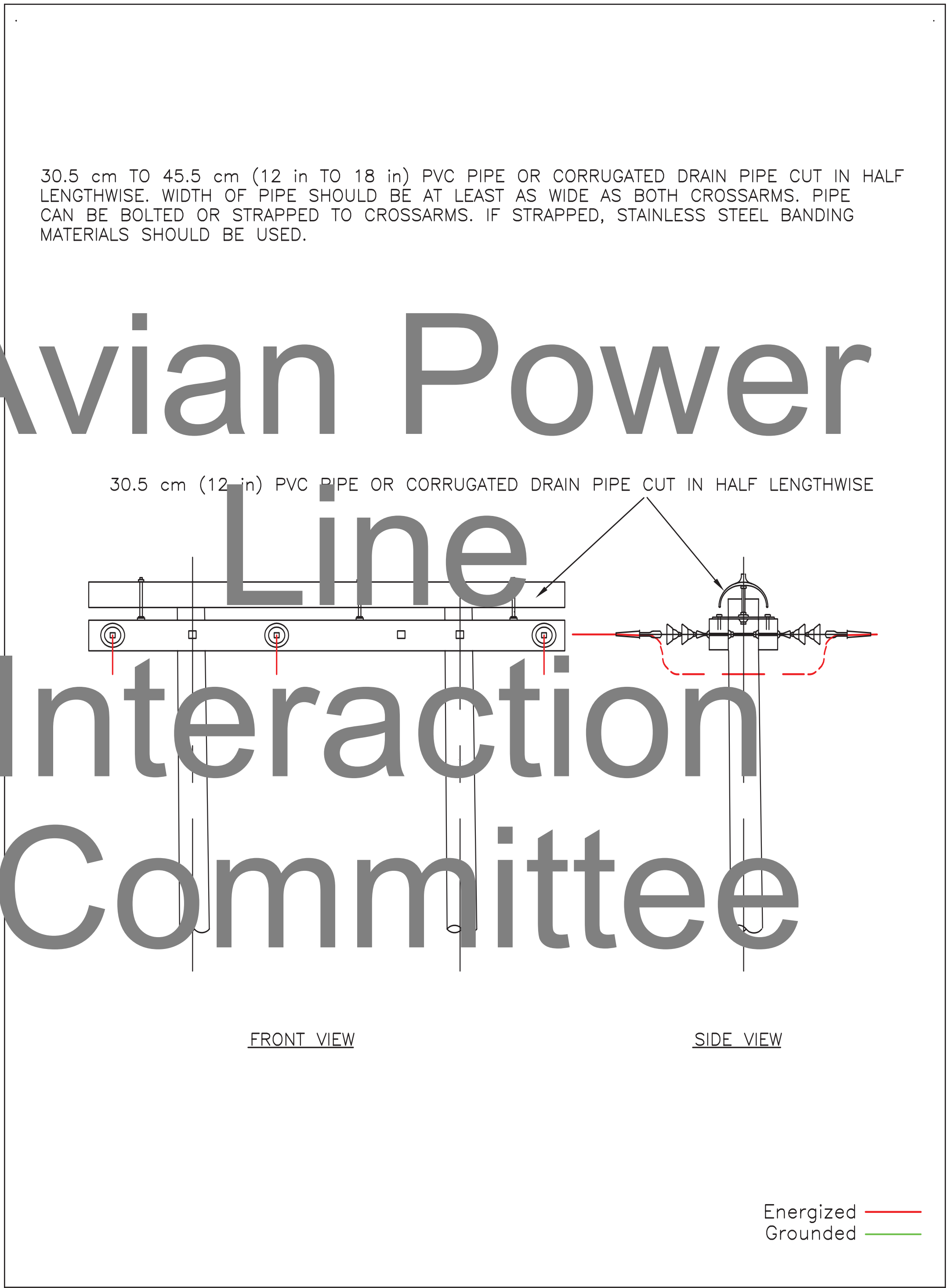

FIGURE 6.21: Nesting discourager (PacifiCorp).

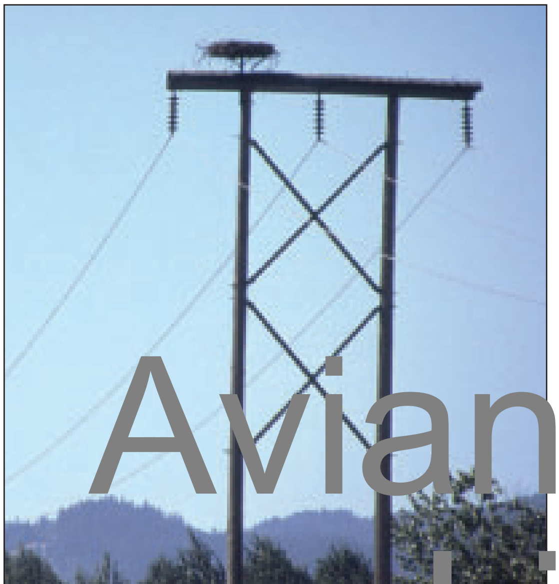

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FIGURE 6.22: This osprey nest was originally located on the crossarms above the center conductor where contamination from fallen nest material and excrement accumulated. It was relocated to the platform shown. A halved, corrugated pipe was installed to prevent renesting on the crossarms. Relocating problem nests to a nest platform on an adjacent non-energized pole is preferred. However, if pole cost, rights-of-way restrictions, or limited access prevent installation of a new structure, it is best to install a safe nest platform on the existing structure.

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FIGURE 6.23: A segment of plastic pipe was installed on a dead-end pole in Oregon to discourage osprey nesting. However, the osprey pair continued nest construction after the pipe was installed.

DISCOURAGING NEST CONSTRUCTION

Nesting should sometimes be discouraged due to the risks to people, nesting birds, or the power system. PVC pipe or corrugated drain pipe banded to the crossarms can prevent birds from nesting on "H" frame transmission structures (Figure 6.21). A nest platform can then be placed above the arm and away from the insulators (Figure 6.22) or on a nearby non-energized pole. To discourage nest rebuilding on distribution poles where nests have been removed, a large plastic pipe can be installed above the crossarm (van Daele et al. 1980). In Montana, this has been effective in deterring nesting ospreys (S. Milodragovich, pers. comm.). However, in other areas, this nest discourager has been ineffective (Figure 6.23). Poles with conductors and insulators above the crossarms require a more complicated design. A PVC tube positioned above and extending the length of the crossarm with diagonal tubes extending toward the crossarms can deter nesting (Figure 6.24) (Henny et al. 2003). Such nest

FIGURE 6.24: A pipe mounted above the conductors can be used as a nest discourager on distribution poles with insulators mounted on the crossarm. The use of triangles is cautioned against, as they may aid in the accumulation of nesting material. This design may pose an electrocution risk if exposed equipment and conductors are not covered or adequately spaced.

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discouragers should be installed close enough to the crossarm to prevent birds from nesting under them. They should be mounted securely on the arm, and should be installed so they do not reduce the BIL of the design.

Triangles, plastic owls, and small spikes have also been used to discourage nesting on power poles. However, these devices are often unsuccessful. For example, birds may nest in open spaces adjacent to triangles (Figure 6.25), birds may initially react to plastic owls, but over time they can become habituated to them (Figure 6.26), and plastic spikes may aid in the accumulation of nest material (Figure 6.27). As discussed in Chapter 5, materials placed on poles to discourage birds from perching or nesting degrade over time, particularly in areas with extreme weather conditions. Utilities should consult with their standards and engineering personnel to identify company-approved devices prior to installation.

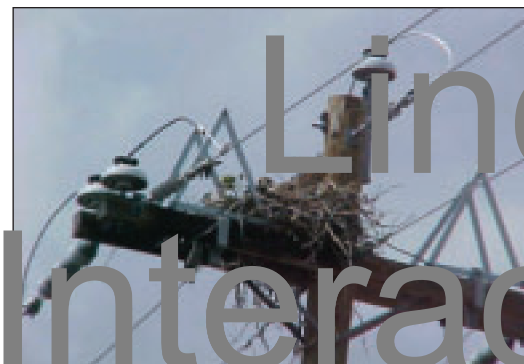

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FIGURE 6.25: Red-tailed hawk nest on pole with triangle perch discouragers.

RECOMMENDATIONS FOR DESIGNING AND INSTALLING NEST PLATFORMS

When designing and installing nest platforms, biologists, engineers, and line workers should consider the following:

- Platforms should be placed where conductors and energized equipment will not be fouled by dropped nest material, prey remains, or excrement.
- To prevent electrocutions, avian-safe designs and retrofitting materials and methods (see Chapter 5) should be applied to poles with or near nest platforms. However, the use of perch discouragers should be avoided near nests. If a nest fails, the pair may attempt to nest on a nearby

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FIGURE 6.26: Osprey nest constructed on pole with plastic owl intended to haze birds.

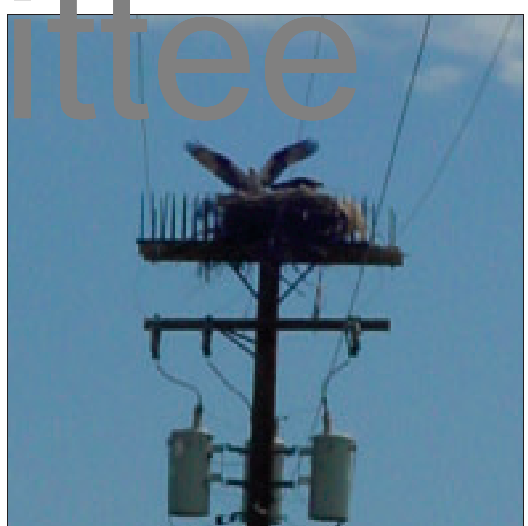

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FIGURE 6.27: Osprey nest on pole with plastic spikes.

pole, possibly selecting a pole with perch discouragers because it more easily accumulates sticks (S. Milodragovich, pers. comm.).

- Platforms should be located in areas with adequate habitat and prey for the target species.
- Discretion should be used when placing nest platforms near sites with sensitive wildlife such as sage grouse, prairie chickens, or prairie dogs that may fall prey to nesting raptors.
- Nest platforms may not be needed on all types of transmission towers. For example, the metal latticework of certain steel towers and the double crossarms of H-frame construction typically provide adequate nest substrates (Lee 1980; Steenhof et al. 1993).
- If possible and appropriate, nesting platforms can be installed on decommissioned poles to draw nesting activity away from energized structures.
- For ospreys, a 1.2-m (4-ft) square or 1.5-m (5-ft) diameter platform (see Figure 6.18) can be more effective than a 0.9-m (3-ft) square platform (see Figures 6.12 and 6.15) in preventing nest material from sloughing off (J. Kaiser, pers. comm.). A lip or pegs along the edge several inches high also helps prevent nest sticks from falling off the platform. Carriage bolts, which may already be carried on line-trucks, can be used as alternative to a lip or pegs. The addition of sticks to a newly-constructed platform may help entice nesting birds. Birds may also be more likely to use a new nest platform if it is higher than adjacent substrates or a reasonable distance away from other alternative(s).
- The weight of a nest platform under wet or snowy conditions should be considered. If it is too heavy for an existing pole, the platform should be installed on a nearby, suitable pole.
- Federal and/or state permits are required for managing active nests of protected species (see Chapter 3). No active nests (nests with eggs or young) may be altered, moved, or destroyed without proper authorization from appropriate agencies. Nests of eagles and endangered species cannot be altered, moved, or destroyed at any time without proper authorization from appropriate agencies. Because of the biological/behavioral characteristics of some birds (e.g., colonial- and ground-nesting birds), destruction of an inactive nest could also result in a take (USFWS 2003).
- If platforms are used to relocate problem nests, relocation distances should not be excessive; success is directly related to proximity. Distances between 20 and 100 m (66 and 328 ft) are most common for ospreys (J. Kaiser, pers. comm.). Golden eagle nests have been successfully moved as far as 2.6 km (1.6 mi), but in incremental steps (Phillips and Beske 1982). The new location should be in line-of-sight to the old location. A biologist should be consulted to provide guidance, and appropriate permits must be obtained.
- On poles with platform nests, predator guards can be used to prevent raccoons and other predators from climbing to the nests. A commonly used device is a 1.5-m (5-ft) length of sheet metal wrapped completely and tightly around the pole at about 1 to 1.5 m (3 to 5 ft) above the ground. However, predator guards should not be used on poles that utility personnel are required to climb.
- Maintenance of platforms and platform supports will extend the life of the structures and will minimize future conflicts with utility operations. Maintenance activities should take place before the breeding season to avoid disturbing nest building efforts, eggs, or nestlings.

RELIABILITY CONCERNS

Unfortunately, despite the benefits utility structures provide nesting birds, there are some negative effects as well. For example, nesting material, electrocuted birds, streamers, or prey debris can cause interruptions and outages. During the nest building process, birds may drop sticks onto conductors causing flashovers (Ledger and Hobbs 1999). Likewise, nests located over exposed, energized equipment can cause flashovers or nest fires during wet conditions. Osprey nests in agricultural areas may contain baling wire or twine that could cause power outages or entangle nestlings (Blem et al. 2002; PacifiCorp, unpubl. data). Dangling or falling prey can also contact energized wires (EDM International 2004).

Utility companies have dealt with bird-caused power reliability problems in a number of ways. One management concept is to maintain nests when they are in desirable locations (Henny et al. 2003; J. Kaiser, pers. comm.). Nest material can be trimmed away from conductors (Hobbs and Ledger 1986; Toner and Bancroft 1986). Occupied nests are well maintained by raptors, but abandoned nests may partially or completely collapse, thereby threatening electrical equipment (Ledger and Hobbs 1999). The use of perch or nest discouragers alone may not be effective in preventing nesting. In Florida, monk parakeets began using raptor perch discouragers as nest substrates in areas where they had not previously nested (J. Lindsay, pers. comm.). In the western United States, red-tailed hawks, ospreys, and common ravens have built nests around perch discouragers that were installed to discourage nesting on equipment or double dead-end poles (J. Burruss, pers. comm.) (see Figures 6.23, and 6.25 through 6.27).

Suspending a vulture carcass or decoy by its feet in a tower was an effective means of ridding the structure of communally roosting black and turkey vultures for many months (Avery et al. 2002). However, before using a carcass for this, a utility must consult with federal and state wildlife resource agencies regarding permits, and should closely evaluate the public response. Shields attached below the latticework on transmission towers with roosting ravens have been used to prevent the accumulation of excrement on insulators (Engel et al. 1992a). In South Africa, high-density polyethylene (HDPE) welded rod bird guards have been effective in reducing line faults (Vosloo and van Rooyen 2001; van Rooyen et al. 2003).

BIRD-RELATED OUTAGES

Bird-related outages are a concern for many utilities. Although outages may occur as the result of an electrocution or collision, there are several other causes that do not result in avian mortality, for example:

- Nest material contact,
- Conductor-to-conductor contact caused by the line gallop started by a large flock of birds flushing,
- Prey falling on energized conductors or equipment,
- Bird streamers or contamination of equipment from accumulated bird feces, and
- Bird collisions with conductors that cause outages but do not kill the birds.

Bird electrocutions do not necessarily result in outages. Of eagle electrocutions in the western United States with known mortality dates (n=612), only 16% were associated with an outage (Harness and Wilson 2001). Likewise, only 16% of known bald eagle mortalities in western Washington from 2000 to 2005 (n=62) caused outages (M. Walters, pers. comm.). Less than 10% of raptor electrocutions documented in Arizona were associated with outages (Dwyer 2004). However, higher proportions of mortalities have been associated with outages in other areas of the western United States. For example, 55% of bird electrocutions (*n*=327) resulted in outages in Utah, Wyoming, Idaho, California, Oregon, and Washington (PacifiCorp, unpubl. data).

Momentary short circuits, which do not cause outages, can cause disruptions for customers with high power quality requirements, and can also result in electrocutions. During these disturbances, the cause of the fault is cleared from the circuit before circuit protection devices trip the line, making it difficult to identify the cause. Some utilities have begun tracking this class of disruption, which might yield important bird mortality information.

Collection of Outage Data

Two key aspects of quantifying bird-caused outages are tracking and verification. Utilities should collect data to quantify outage numbers and causes. These data may include outage location, duration, cause, associated equipment, and pole type. Outage data can help identify outage locations, quantify the impact of birds on system reliability, identify the species associated with outages, and guide retrofitting and new construction efforts for preventing outages.

To accurately address an outage, its cause(s) must be verified. Local regulations require some utilities to list the causes of all outages. In some cases, birds are just speculatively recorded as the cause. In others, their carcasses are not discovered for various reasons: scavengers or people removed them, the victim fell into dense vegetation, or a systematic search was not conducted. Identifying the causes of outages is critical to developing corrective plans. Utilities should recognize that the number of bird-caused outages reported may increase after a tracking or verification program is implemented simply because the causes of more outages are properly identified. On the other hand, the total number of bird-related outages on record may decrease when erroneous reports are corrected.

Although the causes of bird-related outages are well documented, few studies quantify bird-related outage rates. The National Rural Electric Cooperative Association (NRECA) listed animals as the third leading cause of power outages nationwide (Southern Engineering Company 1996). Of Avian Power Line Interaction Committee (APLIC) utility members surveyed in 2005 (*n*=12), 58% tracked bird-caused outages (APLIC 2005). Of utilities that provided data, bird-caused outages ranged from <1 to <10% of their total outages. Half of these utility respondents reported major outages due to birds. In California, wildlife-related incidents accounted for 10 to 25% of all outages (Energy and Environmental Economics, Inc. 2005). Wildlife was considered a contributing cause in up to 20% of outages in Wisconsin during 2003 (Kysely 2004). Birds accounted for 23.5% of substation outages for a Canadian utility in 2002–2003 (BC Hydro 2004). In an assessment of 2,174 bird-related outages documented in the western United States, 60% were caused by federally unprotected species (i.e. starlings or pigeons), 21% were associated with protected bird deaths, 12% were reported as bird-caused although no carcasses were found (e.g., flocks flushing from lines), and 7% were due to bird nests not associated with a mortality (PacifiCorp, unpubl. data). Within this study, seasonal outage trends were also documented, and revealed that outages peaked during summer and fall (likely due to nesting activity and fall migration).

Costs of Outages

Costs associated with bird-related outages include those related to:

- Lost revenue,
- Power restoration,

- Equipment repair,
- Nest removal and other animal damage-control measures,
- Administrative and managerial time,
- Lost service to customers and negative public perception, and
- Reduced electrical system reliability.

Stocek (1981) estimated that the annual cost of bird-related damage to Canadian utilities was $374,600. Recent data from a Canadian utility estimated that wildlife outages (n=2,500 to 3,500) cost $2 million annually (BC Hydro 1999). Wildlife-related outages are estimated to cost up to $3 billion each year in California (Hunting 2002; Singer 2002; Energy and Environmental Economics, Inc. 2005). One utility documented that bird-related outages cost them $2 million annually (APLIC 2005). During a five-month period in 2001 in south Florida, 198 outages affecting over 10,000 customers were related to monk parakeets. Lost revenue from electric power sales due to these outages was $24,000 (Florida Power & Light, unpubl. data). Outage repair was a much more significant cost, estimated at $221,000 annually. The total estimated cost associated with the 198 outages in this small part of the service area was $245,000.

FIGURE 6.28: Red-tailed hawk expelling streamer.

BIRD STREAMERS

Large raptors, vultures, and herons can expel long streams of excrement (Figure 6.28). These "streamers" can cause flashovers and short-outs when they span energized conductors and other line structures. Flashovers are faults that originate on live hardware and travel through the streamer to the structure. Although bird streamers were first thought to be a cause of unexplained transmission line faults in the 1920s (Michener 1924), this hypothesis has been difficult to verify because flashovers are rarely witnessed, and the resulting evidence is difficult to find. Yet, Burnham (1995) estimated that bird streamers might cause as many transmission outages in Florida as lightning, dust, fecal, or industrial contamination. Recent studies in South Africa have emphasized the role of bird streamers as a cause of line faults (van Rooyen et al. 2003).

Evaluating streamer-related faults has often relied upon indirect evidence. Studies conducted by Burnham (1995), van Rooyen and Taylor (2001), Vosloo and van Rooyen (2001), Vosloo et al. (2002), and Acklen et al. (2003) documented patterns that are indicative of streamer-related transmission faults and described methods for preventing outages of this kind. There are several indicators of streamer-caused faults; e.g., the presence of large birds along transmission lines that are subject to faulting (Burnham 1995; van Rooyen et al. 2003; van Rooyen and Smallie 2004). Streamer-related faults are not normally lethal to birds, as streamers are often released as a bird departs from a structure. However, in some cases flashover mortalities do occur. Streamer-related faults occur most frequently

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FIGURE 6.29: Burn marks on transmission structure associated with streamer-caused flashover.

on horizontally configured, steel transmission structures that provide perching space above the conductors. Structures with small windows and shorter air-gaps are especially fault-prone (van Rooyen et al. 2003), although faults can also occur on wooden or concrete structures (Burnham 1995). Faults are most prevalent on the highest phase of the tower, or the phase closest to a preferred perching space on a tower. Such faults are less frequent on vertically configured structures that generally provide little perching space above the conductors. Streamer-related flashovers have been simulated in the laboratory and flash marks on structures and insulators were recognizable (West et al. 1971; Burger and Sardurksi 1995).

Flashovers are generally indicated by burn marks on the insulator string, or the corona ring and tower top. Burn marks may occur as pitting. They are shiny on aluminum structures and black on steel structures (Figure 6.29). Streamer-caused faults typically occur during the late evening and early morning. A late night peak, usually around 11 p.m., occurs as birds finish digesting their last meal. Likewise, an early morning peak occurs when birds leave their roosts (Burnham 1995; van Rooyen et al. 2003). Faults often occur in clusters, indicating that concentrations of large birds have been attracted by a favorable prey base or suitable habitat, or that there is a seasonal population increase.

Devices designed to prevent excrement build-up on insulator strings have had limited success because they fail to prevent the air-gap breakdown caused by streamers. The most successful devices create a barrier that keeps birds from roosting over the conductors. Examples of such devices include welded-rod bird guards and cones. The most comprehensive application of bird-guarding devices for preventing streamer-related faults is practiced in South Africa by Eskom Transmission Group through its National Bird Guard Project. Eskom has installed thousands of HDPE welded-rod bird guards, which has dramatically reduced faults (Vosloo and van Rooyen 2001; van Rooyen et al. 2003). In addition, perch discouragers installed over insulators on lines in Florida have been effective in reducing streamer-related faults (Burnham 1995).

Avian Power Line Interaction Committee

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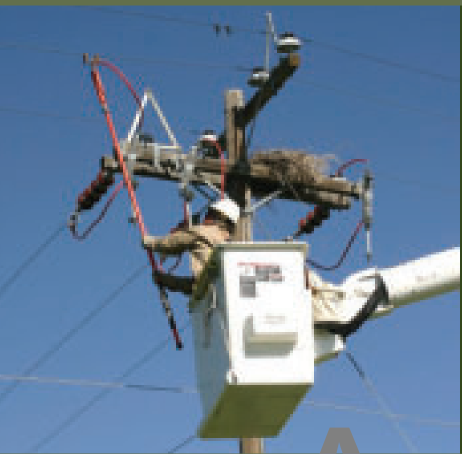

CHAPTER 7

Developing an Avian Protection Plan

IN THIS CHAPTER

- Choosing the Right Tool—MOUs and APPs
- Components of an APP
- Implementing an Avian Protection Plan

In 2005, the Avian Power Line Interaction Committee (APLIC) and the U.S. Fish and Wildlife Service (USFWS) announced their jointly developed Avian Protection Plan Guidelines (Guidelines) that are intended to help utilities manage their avian/power line issues. The Guidelines offer resources for developing avian protection plans (APPs). An APP should provide the framework necessary for implementing a program to reduce bird mortalities, document utility actions, and improve service reliability. The components that a utility may wish to include in its APP are summarized in this chapter.

The 1996 edition of *Suggested Practices* included a final chapter, "Cooperative Management of the Electrocution Issue," that focused on relationships among utilities and agencies and offered recommendations for mortality reporting, training, and prioritizing remedial actions. Since 1996, utilities and agencies have continued to advance the understanding of avian electrocutions. Efforts between the Avian Power Line Interaction Committee (APLIC) and the U.S. Fish and Wildlife Service (USFWS) have culminated in the Avian Protection Plan Guidelines (Guidelines) (see Appendix C). The Guidelines are a "toolbox" from which utilities may select and tailor components to fit their needs. In this chapter, an overview of the Guidelines is presented, along with recommendations for developing and implementing an Avian Protection Plan (APP). There is an abbreviated version of the Guidelines in Appendix C. The complete version can be obtained from either the APLIC (www.aplic.org) or USFWS (www.fws.gov) website.

CHOOSING THE RIGHT TOOL—MOUs AND APPs

When developing a bird protection program, two tools, the Memorandum of Understanding (MOU) and the APP, have been used effectively. Historically, MOUs have been initiated by the USFWS when it finds a utility has violated bird protection laws and has not implemented or abided by the law or an APP. MOUs are signed by both the utility and the USFWS and establish the program's requirements. They generally include a statement of purpose, the contract's duration, definitions, a requirement to develop an APP, and requirements for permitting, possessing, retrieving, salvaging, reporting, and record keeping.

Although APPs are typically a component of MOUs, they may be initiated voluntarily and signed only by the utility. This can allow for greater flexibility in developing timetables and enables a utility to tailor components to match its specific needs.

Because an APP represents a utility's commitment to reducing its avian impacts and is shared with the USFWS, it is understood to be binding. Since they emanate from the utility, APPs are more easily modified for addressing newly developing problems and unforeseen needs. Despite the fact that APPs are generally initiated by utilities, a cooperative dialog between the utility and the USFWS during development is strongly encouraged. This sets the tenor for those conversations that will inevitably follow, as the APP is implemented and refined over time.

A utility that implements the principles contained in the Guidelines will greatly reduce avian electrocution risk. Developing and implementing an APP makes good business sense because animal- and bird-caused outages can be costly. A utility that creates an APP to address its specific avian issues can benefit through reduced regulatory risk, reliability improvements, cost savings, and positive recognition from regulators, employees, and customers.

COMPONENTS OF AN APP

An APP is a utility-specific program to reduce the operational and avian risks that result from avian interactions with electric utility facilities. Although each utility's APP will be different, the overall goal of reducing avian mortality is the same. The Guidelines provide a framework along with principles and examples to help a utility craft its own APP to best fit its needs while furthering avian conservation and improving reliability and customer service. Because of utility-specific circumstances, some of the elements of the Guidelines may not be applicable. The Guidelines present a comprehensive overview of the elements that should be considered when a utility develops its own APP. An APP should also be a "living document" that is modified over time to improve its effectiveness. The following are the principles of an APP:

- Corporate policy
- Training
- Permit compliance
- Construction design standards
- Nest management
- Avian reporting system
- Risk assessment methodology
- Mortality reduction measures
- Avian enhancement options
- Quality control
- Public awareness
- Key resources

CORPORATE POLICY

An APP typically includes a statement that balances the company's commitment to minimizing its impact on migratory birds and complying with bird-protection regulations with its goal of providing reliable, cost-effective electrical service. To do this, it will comply with all necessary permits, monitor avian mortality incidents, and make reasonable efforts to construct and alter infrastructure to reduce the incidence of avian mortality.

TRAINING

Training is an important element of an APP. All appropriate utility personnel, including managers, supervisors, line crews, engineering, dispatch, and design personnel, should be properly trained in avian issues. This training should encompass the reasons, needs, and methods for reporting avian mortalities, following nest management protocols, disposing of carcasses, and complying with applicable regulations, and understanding the potential consequences of non-compliance. Supplemental training also may be appropriate when there are changes in regulations, permit conditions, or internal policies. APLIC-sponsored short-courses on avian electrocutions, collisions, and nest issues are conducted annually at locations throughout the United States. In addition, a two-hour overview presentation of avian issues that can be used for internal company training is available from APLIC (see www.aplic.org).

PERMIT COMPLIANCE

An APP can describe the process through which a company will obtain and comply with all necessary avian-related permits. The activities that may require permits include, but are not limited to, nest relocation, temporary possession, depredation, salvage/disposal, and scientific collection.

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FIGURE 7.1: Utility crew installing raptor nest platform.

CONSTRUCTION DESIGN STANDARDS

Avian interactions with electrical facilities can cause outages and reduce system reliability. To improve system reliability, avian interactions should be considered when designing and siting new facilities, as well as when operating and maintaining existing facilities. For those reasons, inclusion of accepted standards for both new construction and retrofitting techniques should be included in an APP. Companies can either rely upon construction standards recommended in this document or may develop their own standards that meet or exceed these guidelines. These standards may be used in areas where new construction should be avian-safe, and where existing infrastructure should be retrofitted for avian safety.

NEST MANAGEMENT

An APP may include procedures for managing nests on utility structures (Figure 7.1). This could include procedures for problem nests (ones that need to be relocated or removed) as well as for safe nest sites. These procedures should be explained to company employees during training to ensure consistent treatment of avian nest issues and compliance with regulations or permits related to nest management.

AVIAN REPORTING SYSTEM

Although avian mortality reports may be required as a condition of federal or state permits, a utility may also voluntarily monitor relevant avian interactions, including mortalities, by developing an internal reporting system. A well-implemented system can help pinpoint the locations of mortalities and the extent to which they are occurring. These data can be limited to avian mortalities or injuries, or could be expanded to track avian nest problems, problem poles or line configurations, and the remedial actions taken. All data should be regularly entered into a searchable database compatible for use in additional analyses (see Risk Assessment Methodology below). Some companies have developed their own bird interaction reporting systems, and the USFWS has created an online bird electrocution reporting system for utilities (see Appendix C, Avian Reporting System).

RISK ASSESSMENT METHODOLOGY

A utility can most effectively reduce avian mortalities by focusing its efforts on the areas of greatest risk to migratory birds. Therefore, an APP should include a method for evaluating the specific risks a company poses to migratory birds. A risk assessment will often begin with a review of available data that address areas of high avian use, avian mortality, problem nests, established flyways, preferred habitats, prey populations, perch availability, effectiveness of existing procedures, remedial actions, and other factors that can increase avian interactions with utility facilities. The avian reporting system discussed in the previous section is an integral component of this risk assessment, as is the use of avian experts, birders, and biologists who can provide additional information on avian distribution. A risk assessment can be used to develop models that will enable a company to use biological and electrical design information to prioritize poles most in need of modification. A risk assessment may also provide data about the various causes of avian mortality as well as the benefits that birds receive from utility structures.

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FIGURE 7.2: Reframing a crossarm to prevent avian electrocutions.

MORTALITY REDUCTION MEASURES

After completing a risk assessment, a company can focus its efforts on areas of concern, ensure that its responses are not out of proportion to the risks presented to migratory birds, and determine whether avian mortality reduction plans need to be implemented (Figure 7.2). Risk reduction measures may be implemented through the APP by using risk assessment results to direct monitoring and retrofitting activity in the existing system, and to direct attention to avian issues encountered during new construction projects. If a utility finds that avian protection measures are appropriate, it also may choose to develop an implementation schedule for these measures.

AVIAN ENHANCEMENT OPTIONS

In addition to reducing avian mortality risk, an APP also may include opportunities for a utility to enhance avian populations and/or habitat. This may include installing nest platforms, managing habitats to benefit migratory birds, or working with agencies or organizations in these efforts (Figure 7.3).

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FIGURE 7.3: Volunteers and utility personnel work together to create nesting platforms.

Where feasible, new ideas and methods for protecting migratory birds should be encouraged and explored.

QUALITY CONTROL

An APP also may include a mechanism for reviewing existing practices and ensuring their efficiency and effectiveness. For instance, a utility may examine its reporting system's performance, or evaluate the techniques and technologies it uses for preventing collisions, electrocutions and problem nests.

PUBLIC AWARENESS

An APP may include a method for educating the public about the avian electrocution issue, the company's avian protection program, and its successes in avian protection.

KEY RESOURCES

An APP should identify key resources that address avian protection issues including a list of experts who may be called upon when resolving avian-related problems. Experts could include company specialists, consultants, state and federal resource agents, university faculty, or other conservationists. Engineers may find that company personnel such as environmental specialists can help find creative solutions to avian interaction problems, and that members of external organizations like APLIC can also serve as helpful resources through workshops, materials, and contacts. An understanding of avian behavior can influence how and when avian protection should be provided. An APP that connects biologists with utility decision-makers may reduce bird mortality and improve system reliability.

IMPLEMENTING AN AVIAN PROTECTION PLAN

Integrating an APP into an electric utility's operations will help the utility meet demands for reliable, cost-efficient, and environmentally compatible power delivery. A utility that creates and manages an APP will quickly become familiar with avian-related science, engineering, law, and politics. It will also need to establish a program that satisfies the law, utility employees, utility customers, investors, and other interests.

The ease of implementing an APP will depend on the size of a utility's transmission and distribution system, the range of avian species in the service area, and the frequency of bird/power line interactions. The extent of bird/power line interactions may not be realized until several years into a fully implemented reporting program. Thus, APP implementation and operation is a long-term commitment and a process of continual evaluation and improvement.

An APP may be the first species-oriented environmental compliance initiative to which utility employees are exposed. Depending on the company's culture, the rate of adoption may vary. High-profile endorsements by corporate officers and managers can facilitate a program's adoption. Some larger utilities have effectively linked APP compliance with financial incentives, similar to more common budget, schedule, and safety goal incentives. Compliance with an APP will reduce utility costs in the long term through improved reliability and reduced regulatory risk.

Management support is critical for a successful program. However, even with management support, successful implementation is unlikely unless all the affected organizations within the utility also support it. An effective way to build a broad consensus during APP preparation is to form a team within the utility that includes representatives from standards, engineering, environmental services, vegetation management, construction and maintenance, public relations, customer service, and other departments that will be impacted by the APP. Considerable input and assistance from team members are needed to understand how APP implementation will best fit the operations of each department. Solutions to reducing avian mortality can be developed that are responsive to the work requirements of each functional unit. In this manner, individuals from each department will feel invested in the mortality reduction solutions they helped develop and will have an interest in assuring APP effectiveness.

Beyond developing and communicating corporate APP policy, the most important component of an APP is a consistent and mandatory reporting process. An electronic or paper form of documenting bird-power line conflicts (e.g., time, place, equipment) becomes the foundation for appropriate corrective action—both to correct unsafe situations and to build a dataset to guide future engineering/construction needs. Managing data for these purposes, as well as for meeting any state and federal agency reporting requirements is an important function of APP administration. Using Geographic Information System (GIS) technology to track and report bird mortalities, remedial actions, outages, and avian risks enables a utility to identify problems and to track the effectiveness of its APP.

Use of existing processes and systems (e.g., outage reporting, environmental review, asset management, and accounting) will help control costs of developing and implementing an APP. Whether an APP is driven by an environmental, engineering, or operations department, cooperation will be necessary across all departmental lines to reduce actual and potential avian-power line conflicts. As with any project, better planning yields better results. The ultimate goals of an APP are a measurable decrease in avian-power line fatalities, and an increase in electric service reliability.

A utility's APP will represent the continuation of a long-term proactive conservation partnership between the utility industry, the conservation community, and the USFWS. These voluntary plans will provide utilities with a framework for addressing electrocution hazards, and reducing the risk their power lines pose to birds, and working with the USFWS to conserve federally protected migratory birds.

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APPENDIX B

Early History of Agency Action

Chapter 2 provides a brief history of the initial agency and industry response to the raptor electrocution problems identified after a systematic campaign to kill eagles was uncovered in the early 1970s. This Appendix provides additional detail for those interested in the process and people involved in this first, cooperative response.

In May 1971, the carcasses of 11 bald eagles *(Haliaeetus leucocephalus)* and four golden eagles *(Aquila chrysaetos)* were discovered in Jackson Canyon, near Casper, Wyoming, a traditional roosting place for both species. The toll eventually reached 24 birds. External examinations revealed no gunshot wounds, and there were no power lines in the area on which the birds could have been electrocuted. It was determined that several antelope carcasses had been laced with thallium sulfate (then a widely used predator control poison), and left as bait.

Surveys in Wyoming and Colorado uncovered a major shooting campaign. During August 1971, a Wyoming helicopter pilot told the Senate Environmental Appropriations Subcommittee that he had piloted several eagle hunts in the preceding seven months where roughly 560 eagles were killed. The shooting was commissioned by the father-in-law of the sheep rancher who had poisoned the eagles in Jackson Canyon. Revised testimony by the helicopter pilot set the estimate of eagle kills at nearly 800, and implicated at least 12 other Wyoming ranching companies. During the surveys in Wyoming and Colorado, more than 300 eagles were found dead near power lines (Turner 1971; Laycock 1973).

When the Jackson Canyon, Wyoming, incident and subsequent investigation revealed a close connection between raptor deaths and power lines, individuals, agencies, and concerned groups collaborated to study the problem and begin corrective action. On 19 January 1972, agency representatives met in Washington, D.C. to discuss the electrocution problem (U.S. Fish and Wildlife Service 1972). Agencies included the Rural Electrification Administration (REA; now the Rural Utilities Service), U.S. Forest Service (USFS), Bureau of Land Management (BLM), the U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and Bureau of Indian Affairs (BIA). The USFWS coordinated the search for lethal lines, while the REA began developing line modifications to minimize eagle electrocutions.

In January 1972, Robert K. Turner, Rocky Mountain Regional Representative of the National Audubon Society, wrote to Thomas Riley of the Pacific Gas and Electric Company drawing attention to the raptor electrocutions in Colorado and Wyoming (R. Turner, National Audubon Society, pers. comm. in APLIC 1996). The letter, forwarded to Richards S. Thorsell of the Edison Electric Institute (EEI)[33] in New York City, became the impetus for utility company participation, fund-raising, and publications aimed at decreasing power line hazards to eagles. Thorsell coordinated representatives from a group of western utilities[34] to assess the problem. They determined that grounding practices of 4 kV- to 69 kV-distribution lines (along with certain configurations of transformer banks, fused cutouts, lightning arresters, and conductor phase spacings) could be a substantial cause of raptor deaths. Engineering solutions were then to be developed in a cooperative public/private effort to help solve the problem of raptor electrocutions.

On 6 April 1972, EEI hosted a meeting in Denver, Colorado, the first of several workshops on eagle electrocutions and their relationship to power outages and other related issues (Olendorff 1972c). It was attended by representatives of western power companies, the REA, state and federal wildlife agencies, and conservation organizations.[35] Three concrete actions resulted:

1. The participants agreed to seek and implement power line modifications and restrictions that would be biologically and economically feasible and that would reduce raptor electrocutions.
2. A raptor mortality reporting system was established, to be administered by the USFWS.
3. Participants would document modifications with drawings and suggestions that could be used by private and public entities.

The REA, an agency of the U.S. Department of Agriculture, lends money to cooperatives that supply electricity primarily to customers in rural areas. As part of loan conditions, the REA sets minimum standards for power line design. Even before the Denver meeting, it had been determined that older three-phase and single-phase power lines presented the most serious electrocution problems for eagles. REA Bulletin 61-10, *Powerline Contacts by Eagles and Other Large Birds*, describes causes of raptor electrocutions resulting from certain grounding practices and conductor spacing (U.S. REA 1972). The bulletin included suggestions on how member companies could correct existing problem lines or design new lines that would be safe for eagles.

The USFWS raptor electrocution reporting system was instituted in 1973.[36] About 300 eagle carcasses and skeletons were found between 1969 and 1972. Subsequently, the number of reported eagle mortalities along power lines dropped to 123 in 1973, 88 in 1974, and 65 in 1975. No conclusions can be drawn from these figures, however, because other variables were involved that affect the reliability of the data. For example, during the same period, mid-winter golden eagle populations trended downward in response to a steep jackrabbit population decline one to two years earlier. The number of golden eagles electrocuted in Idaho declined during those years (Kochert 1980) when fewer golden eagles fledged. Additionally, reporting system figures are contradicted by findings of substantial numbers of eagle mortalities along power lines in some western states (Benson 1981; PacifiCorp, unpubl. data; Idaho Power, unpubl. data).

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[33] Now located in Washington, D.C., EEI is an association of investor-owned electric utility companies in the United States and provides a committee structure and coordination for the industry.

[34] Including Idaho Power Company, Pacific Gas and Electric Company, Public Service Company of Colorado, Tucson Gas & Electric, Pacific Power and Light Company and Utah Power & Light Company (both currently PacifiCorp).

[35] Including Colorado Division of Wildlife, National Audubon Society, National Wildlife Federation, and USFWS.

[36] The USFWS reporting system of the 1970s is no longer in effect, although an internet-based reporting system has been recently developed by USFWS (see APP Guidelines, Appendix C).

APPENDIX C

Avian Protection Plan Guidelines

Avian Protection Plan Guidelines (Guidelines) were developed by the Avian Power Line Interaction Committee (APLIC) and the U.S. Fish and Wildlife Service (USFWS) in 2005. This appendix contains excerpts from the Guidelines. To download the Guidelines in its entirety, see www.aplic.org or www.fws.gov.

The following appendix provides guidance for implementation of each of the Avian Protection Plan (APP) principles listed below:

1. Corporate Policy
2. Training
3. Permit Compliance
4. Construction Design Standards
5. Nest Management
6. Avian Reporting System
7. Risk Assessment Methodology
8. Mortality Reduction Measures
9. Avian Enhancement Options
10. Quality Control
11. Public Awareness
12. Key Resources

1. CORPORATE POLICY

The following is an example of a utility Bird Management Policy.

EXAMPLE 1: Bird Management Policy.

[Company] Bird Management Policy

Bird interactions with power lines may cause bird injuries and mortalities, which, in turn, may result in outages, violations of bird protection laws, grass and forest fires, or raise concerns by employees, resource agencies and the public.

This policy is intended to ensure compliance with legal requirements, while improving distribution system reliability. [Company] management and employees are responsible for managing bird interactions with power lines and are committed to reducing the detrimental effects of these interactions.

To fulfill this commitment, [Company] will:

- Implement and comply with its comprehensive Avian Protection Plan (APP).
- Ensure its actions comply with applicable laws, regulations, permits, and APP procedures.
- Document bird mortalities, problem poles and lines, and problem nests.
- Provide information, resources, and training to improve its employees' knowledge and awareness of the APP.
- Construct all new or rebuilt facilities in rural areas (outside city limits or beyond residential/commercial developments) and in areas of known raptor use, where appropriate, to [Company] avian-safe standards.
- Retrofit or modify power poles where a protected bird has died. Modifications will be in accordance with APP procedures.
- Participate with public and private organizations in programs and research to reduce detrimental effects of bird interactions with power lines.

[Company] customer service and regulatory compliance will be enhanced and risk to migratory birds will be reduced through the proactive and innovative resolutions of bird power line interactions guided by this policy.

Signature ________________________ Date ____________________

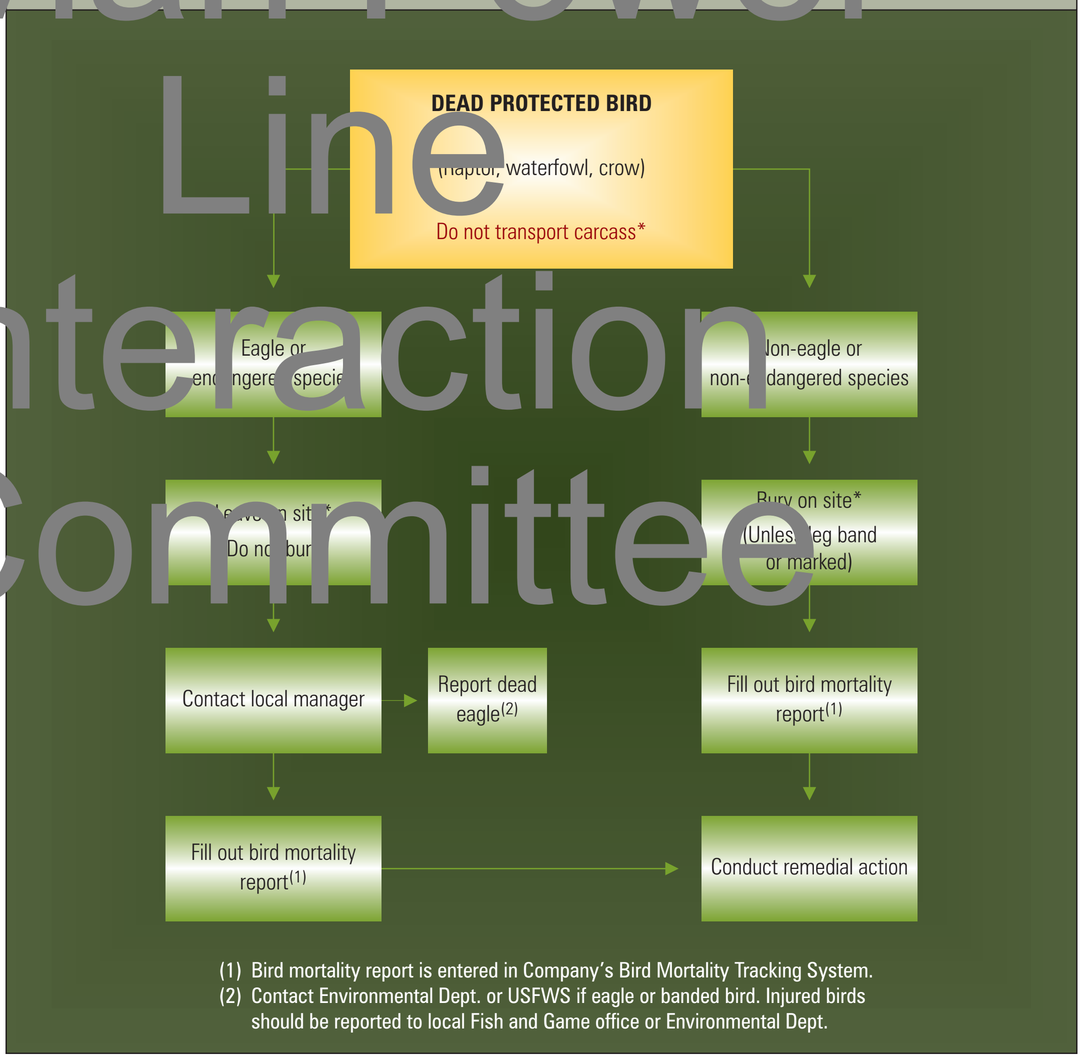
2. TRAINING

Training is an integral component of an APP. Workshops and short courses on avian/power line interactions are provided by APLIC (www.aplic.org) and the Edison Electric Institute (EEI, www.eei.org). A two-hour overview of avian electrocutions and collisions intended for training use is also available through the APLIC website as part of the APP "tool box."

The following are examples of PacifiCorp and Southern California Edison employee training materials, including:

- Flow diagrams of company procedures for bird and nest management that can be distributed to field personnel as part of employee training.
- A brochure describing electrocution and nest issues and company raptor protection procedures.
- A brochure describing nest management procedures and protection.

EXAMPLE 2 Bird mortality flow diagram based on PacifiCorp training materials.*



* Individual utility permits may contain different conditions regarding transport or salvage of protected species.

EXAMPLE 3: Nest management flow diagram based on PacifiCorp training materials.*

(1) If imminent danger exists, conduct necessary action first; then call USFWS immediately.
(2) Contact Environmental Dept. or USFWS/State agency to request necessary permit(s) for active nest or eagle nest removal/relocation.

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* Individual utility permits may contain different conditions regarding nest management of protected species.

EXAMPLE 4: "Raptor Protection Program" brochure, Southern California Edison.

SOUTHERN CALIFORNIA EDISON®

An EDISON INTERNATIONAL® Company

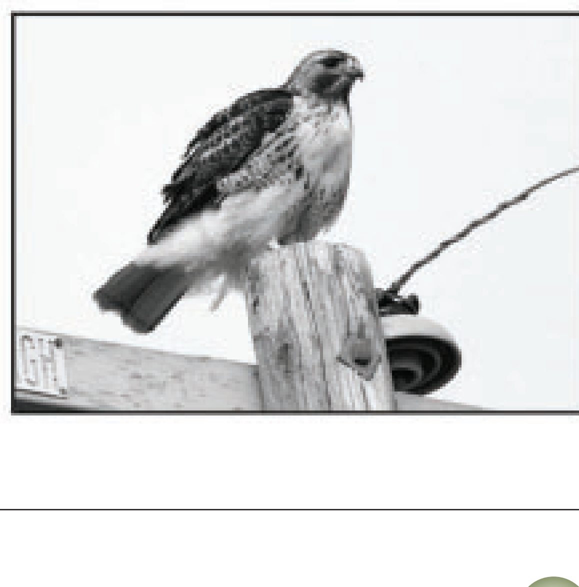
RAPTOR PROTECTION PROGRAM

Raptor Protection Program Goals

Raptors, or birds of prey, are meat-eating birds that include the hawks, eagles, and owls. Most species of raptors are protected under one or more laws and/or regulations.

Edison's Raptor Protection Program is designed to:

1. Reduce impacts to raptors.
2. Ensure compliance with state and federal laws and rules and regulations protecting these species.
3. Gather and provide information from operating divisions within Edison to Environmental Affairs on facility-caused electrocutions. This information will assist Environmental Affairs in responding to regulatory agency inquiries and provide informed responses to concerns expressed by the public.
4. Assist Company biologists in identifying problem areas where raptor protection may be required. Selectively identify and install cost-effective raptor protection devices to ensure Company compliance with existing laws and regulations.
5. Help identify and isolate where bird-caused outages occur so that these can be minimized, providing higher quality service to our customers.



EXAMPLE 4: "Raptor Protection Program" brochure, Southern California Edison. (cont.)

Raptor Protection

Electrocutions

Raptors often perch or nest on transmission or distribution towers or poles. Occasionally, the birds will make accidental contact between phases or phase and ground, causing harm to or electrocuting the bird. These electrocutions are most common on distribution or subtransmission facilities where energized conductors are close together.

The number of electrocutions can be decreased by either designing the line to minimize contact between phases, or by retrofitting existing lines where necessary with a protective device that prevents this contact. Studies have demonstrated that raptors prefer certain poles for nesting and perching. By identifying preferred poles, we can modify them, and thus greatly diminish the potential for raptor electrocutions in a cost-effective manner.

Nest Protection

In the absence of other suitable nest sites, raptors often use transmission towers and distribution poles for nesting. State and federal laws and regulations protect these nests from removal at certain times of the year without necessary permits. It is important that nests not be disturbed when eggs or young birds are in them.

Raptor Protection Program Procedures

1. All incidents of facility-related raptor mortality should be reported to your supervisor. You should then fill out the raptor mortality report form available in all district offices or from your supervisor. The completed form should be sent to Environmental Affairs in the General Office.
2. From February through June, nests should not be removed or disturbed. Under no circumstances should known eagle nests be disturbed at any time of the year.
3. If a nest is discovered during this February–June period that presents a hazardous situation for the continued safe operation of the line, try to trim the nest rather than remove it. If a nest must be removed, call Environmental Affairs. Environmental Affairs personnel will obtain the necessary permits for removing nests.
4. At any time you have questions regarding these procedures, please discuss them with your supervisor or call Environmental Affairs, Dan Pearson at PAX 29562, or Janet Baas at PAX 29541.

EXAMPLE 5: "Protection of Breeding Bird Nest Sites" brochure, Southern California Edison.

What to Do if You Are Working in Sensitive Areas or Find an Active Nest

- Avoid tree or shrub trimming to the extent feasible during the nesting season, especially in sensitive areas (riparian or sage scrub habitats).
- Limit noise during the nesting season to the extent feasible by turning off equipment when not in use and/or using equipment with mufflers.
- If a nest is found, **carefully** determine if the nest is active, that is, if it contains eggs or young. Do not touch the nest or its contents.
- If young are inadvertently knocked out of a nest or are found on the ground after trimming **call Environmental Affairs (EA) immediately.** If the young are small and the nest can be found and is intact, the young may be carefully replaced in the nest (using gloves). If the young are large and active or the nest can not be found or is not intact, the young should be protected and kept warm, if possible. EA will contact a rehabilitation expert for pick up.
- CONTACT EA IF YOU MUST WORK IN A SENSITIVE AREA DURING THE NESTING SEASON OR ENCOUNTER AN ACTIVE NEST THAT MUST BE REMOVED, TRIMMED, OR MAY BE DISTURBED BY VEGETATION CLEARING ACTIVITIES OR TO PROTECT PUBLIC HEALTH AND SAFETY. Note: eagle nests may never be removed or relocated at any time of year without clearance from the US Fish and Wildlife Service and the California Department of Fish and Game. Contact EA if it is necessary to handle an eagle nest in any way.

What to Do if You Have Questions

If you have any questions, such as whether or not you are working in a sensitive area, if there is the potential for sensitive species to be nesting where you will be working, or you find an active bird nest while you are working, contact your supervisor (first) or one of the following EA personnel:

Tracy Alsobrook PAX 27547 or (626) 302-7547
Janet Baas PAX 29541 or (626) 302-9541
[illegible] PAX 29545 or (626) 302-[illegible]
Dan Pearson PAX 29562 or (626) 302-9562

Outside of normal business hours, you may contact these people through the Edison operator. All may be contacted by pager.

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL Company

PROTECTION OF BREEDING BIRD NEST SITES

Why SCE is Concerned About Bird Nests

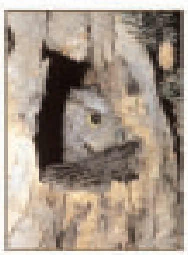
Screech-owl (Cavity Nest)

EXAMPLE 5: "Protection of Breeding Bird Nest Sites" brochure, Southern California Edison. (cont.)

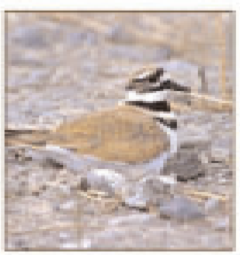
Virtually all birds in North America are protected by one or more state or federal laws. SCE must be in compliance with all laws and regulations protecting birds, their habitat, and nest sites. It is illegal to, among other things, pursue, hunt, harass, kill, or collect any migratory or listed bird species, including their eggs or nest. Fines and penalties, including jail, can be substantial for non-compliance.

When and Where Birds Nest

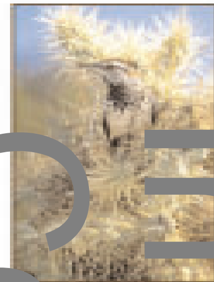
Most birds nest during the period from mid-February through August. The specific timing depends on several factors such as species of bird, its nest location (altitude and latitude), abundance of food, and weather. Birds nest in a wide variety of habitats, such as riparian areas (along streams, creeks, ponds), forests, beaches, deserts, and foothills. That is, anywhere adequate shelter and food for young can be found. Nesting sites within these habitats include trees, shrubs, holes and cavities in trees or dirt embankments, on cliff ledges, on the ground, and utility poles and towers.



Screech owl
(Cavity nest)



Killdeer
(Ground nest)

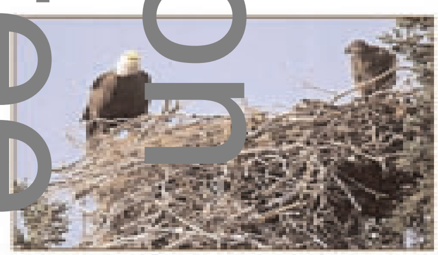


Cactus wren
(Twiggy mass in cactus or shrub)

Flycatcher
(Small cup in willow shrubs)

Red-tailed hawk
(Moderately large twiggy nest in tall trees or other structures)

Nest sites range from large, obvious structures made by eagles, to very small, inconspicuous, cup-shaped ones used by hummingbirds.



Bald eagle
(Branches in large tree or on rocky outcrop)

Hummingbird
(Tiny cup in shrub)

How to Locate and Avoid Disturbing Nesting Birds

- Be aware of when birds nest (generally February through August).
- Be aware when working in especially sensitive habitats, such as riparian and sage scrub (at least partly natural areas with somewhat woody shrubs, below about 3,000 feet).
- Look for bird activity within shrubs or trees. If a bird appears agitated or reluctant to leave an area, it may indicate a nearby nest.
- Many nests are found between the ground and 3 meters high in shrubs and trees.
- Look for small dark, generally cup-shaped masses among the branches of shrubs or both small and larger masses in trees.
- Prior to trimming or cutting down trees, look for holes or cavities that may contain nests.

3. PERMIT COMPLIANCE[37]

A company should work with resource agencies to determine if permits are required for operational activities that may impact protected avian species. Particular attention should be given to activities that may require Special Purpose or related permits, including, but not limited to, nest relocation, temporary possession, depredation, salvage/disposal, and scientific collection.

While it is recommended that each utility developing an APP familiarize itself with the different permit types and their provisions located in 50 CFR part 21 (Migratory Bird Permits) (http://www.fws.gov/permits/mbpermits/regulations/regulations.htm), it is highly recommended that the utility make initial contact with the Migratory Bird Permit Examiner located in the USFWS Region where the utility is planning to implement its APP.

To acquire a permit application, contact the Migratory Bird Permit Office in the region where your business is headquartered or in the region (if it is different) where you propose to implement your APP. Information about regional boundaries can be accessed at http://permits.fws.gov/mbpermits/birdbasics.html then click on Regional Bird Permit Offices for locations and addresses. State permits may also be required to manage protected bird nests or for temporary possession of avian species. Specific information on required permits should be obtained from your state resource agency. Both state and federal agencies should be consulted as you develop your APP.

4. CONSTRUCTION DESIGN STANDARDS

In habitats that have electrical facilities and the potential for avian interactions, the design and installation of new facilities, as well as the operation and maintenance of existing facilities, should be avian-safe. Accepted construction standards for both new and retrofit techniques are highly recommended for inclusion in an APP. Companies can either rely upon construction design standards found in this document and in APLIC's Mitigating Bird Collisions with Power Lines: The State of the Art in 1994 (or current edition), or may develop their own internal construction standards that meet or exceed these guidelines. These standards should be used in areas where new construction should be avian-safe, as well as where existing infrastructure needs to be retrofitted. An APP may require that all new or rebuilt lines in identified avian use or potential problem areas be built to current avian-safe standards. Implementing avian-safe construction standards in such areas will reduce future legal and public relations problems and will enhance service reliability.

NEW CONSTRUCTION

Distribution, transmission and substation construction standards must meet National Electric Safety Code (NESC) requirements and should provide general information on specialized construction designs for avian use areas. Avian-safe construction, designed to prevent electrocution, should provide conductor separation of 150 cm (60 in) (or a distance appropriate to the species expected in the area of the line) between energized conductors and grounded hardware, or utilities should cover energized parts and hardware if such spacing is not possible.[38]

MODIFICATION OF EXISTING FACILITIES

Modification of existing facilities is necessary when dead and/or injured birds are found,

[37] See Chapter 3 for additional information on regulations and permits.

[38] See Chapter 5 for additional information on construction design standards.

high-risk lines are identified, or legal compliance is an issue. A "problem pole" is one where there has been a documented avian collision, electrocution, or problem nest; or where there is a high risk of an avian mortality. The need for remedial action may result when "problem poles" are identified through bird mortality records, field surveys, or when the company is notified by agency representatives or concerned customers. System reliability concerns due to bird interactions may also result in requests from field operations staff.

SITE-SPECIFIC PLANS

The factors that create hazards for birds near power lines are complex and often site-specific. When a problem is identified, a site meeting with engineering and operations personnel along with company biologists or consultants brings the relevant expertise together for the most effective analysis. The timeframe for action will be based on agency requests, reliability concerns, public relations, budget, logistical and manpower constraints, and the biology of the affected species. Remediation of a few problem poles or spans often reduces problems over a wide area. Therefore, the most efficient solution for correcting a problem line is a site-specific plan that considers the local conditions (i.e., topography, avian populations, prey populations, land use practices, line configuration, habitat types, historical bird use areas). The plan should include recommendations for the most appropriate remedial action, and a timetable for job completion.

5. NEST MANAGEMENT

Raptors, and some other avian species, benefit from the presence of power line structures by using them for nesting.[39] Although electrocution of birds that nest on transmission towers is infrequent, nests themselves can cause operational problems. Nest removal generally does not solve the problem because most species are site-tenacious and rebuild shortly after the nest is removed. There are also regulatory and public relations components to nest removal (see Chapter 3). Further, companies may experience public relations and reliability benefits by providing safe nesting locations. All active nests (those with eggs or young present) of designated migratory birds are protected by the Migratory Bird Treaty Act. A permit issued by USFWS may be required before managing an active nest. If a problem with a nest is anticipated, permit requirements may be avoided by moving or removing the nest while it is inactive (excluding eagles and endangered/threatened species). The breeding season and nest activity varies by location and species, but for most North American raptors it falls between February 1 and August 31. However, a nest is considered active only when eggs or young are present. If there are questions about whether a problem nest is active or inactive, company environmental staff, USFWS, or state wildlife agencies should be consulted. A memorandum from USFWS on nest management and nest destruction is provided on the following page. This document can also be accessed online at http://permits.fws.gov/mbpermits/PoliciesHandbooks/MBPM-2.nest.PDF.

[39] See Chapter 6 for additional information on nest management.

United States Department of the Interior
FISH AND WILDLIFE SERVICE
Washington, D C 20240
MBPM-2
Date: APR 15, 2003

MIGRATORY BIRD PERMIT MEMORANDUM

SUBJECT: Nest Destruction

PURPOSE: The purpose of the memorandum is to clarify the application of the Migratory Bird Treaty Act (MBTA) to migratory bird nest destruction and to provide guidance for advising the public regarding this issue.

POLICY: The MBTA does not contain any prohibition that applies to the destruction of a migratory bird nest alone (without birds or eggs), provided that no possession occurs during the destruction. To minimize MBTA violations, Service employees should make every effort to inform the public of how to minimize the risk of taking migratory bird species whose nesting behaviors make it difficult to determine occupancy status or continuing nest dependency.

The MBTA specifically protects migratory bird nests from *possession, sale, purchase, barter, transport, import,* and *export,* and *take*. The other prohibitions of the MBTA - *capture, pursue, hunt,* and *kill* - are inapplicable to nests. The regulatory definition of *take*, as defined by 50 CFR 10.12, *means to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to hunt, shoot, wound, kill, trap, capture, or collect*. Only *collect* applies to nests.

While it is illegal to collect, possess, and by any means transfer possession of any migratory bird nest, the MBTA does not contain any prohibition that applies to the destruction of a bird nest alone (without birds or eggs), provided that no possession occurs during the destruction. The MBTA does not authorize the Service to issue permits in situations in which the prohibitions of the Act do not apply, such as the destruction of unoccupied nests. (Some unoccupied nests are legally protected by statutes other than the MBTA, including nests of threatened and endangered migratory bird species and bald and golden eagles, within certain parameters.)

However, the public should be made aware that, while destruction of a nest by itself is not prohibited under the MBTA, nest destruction that results in the unpermitted take of migratory birds or their eggs, is illegal and fully prosecutable under the MBTA.

Due to the biological and behavioral characteristics of some migratory bird species, destruction of their nests entails an elevated degree of risk of violating the MBTA. For example, colonial nesting birds are highly vulnerable to disturbance; the destruction of unoccupied nests during or near the nesting season could result in a significant level of take. Another example involves ground nesting species such as burrowing owls and bank swallows, which nest in cavities in the ground, making it difficult to detect whether or not their nests are occupied by eggs or nestlings or are otherwise still essential to the survival of the juvenile birds. The Service should make every effort to raise public awareness regarding the possible presence of birds and the risk of violating the MBTA, the Endangered Species Act (ESA), and the Bald and Golden Eagle Protection Act (BGEPA), and should inform the public of factors that will help minimize the likelihood that take would occur should nests be destroyed (i.e., when active nesting season normally occurs).

The Service should also take care to discern that persons who request MBTA permits for nest destruction are not targeting nests of endangered or threatened species or bald or golden eagles, so that the public can be made aware of the prohibitions of the ESA and the BGEPA against nest destruction.

In situations where it is necessary (i.e., for public safety) to remove (destroy) a nest that is occupied by eggs or nestlings or is otherwise still essential to the survival of a juvenile bird, and a permit is available pursuant to 50 CFR parts 13 and 21, the Service may issue a permit to take individual birds.

Steve Williams
Director

6. AVIAN REPORTING SYSTEM

An important part of an APP is a utility's system for documenting bird mortalities and nest management activities. This system should be designed to meet the needs of the utility and be compatible with other data management and analysis programs. The system could be based on paper forms like the following examples or may be an internal web-based program. The information collected should be used to help a utility conduct risk assessments to identify avian problem areas and potential or known high risk structures. To protect birds and minimize outages, these data can be prioritized for corrective actions. Avian information collected by a utility should be maintained internally. Data may be required as a condition of an annual federal permit for direct take of birds or their nests. The USFWS does not issue "accidental, incidental or unintentional" take permits under authority of the MBTA.

In 2002, USFWS created an online bird electrocution reporting system for utilities (J. Birchell, pers. comm.). Initiated in Alaska, the system was developed to provide a central data repository and to encourage utilities to voluntarily report bird electrocutions. Information is collected on how, where, when, and why a bird electrocution or collision occurred and is used to help prevent future incidents. Utilities that use this reporting system hold an account to which only they can report and access their data. The online system also offers a forum for open discussion among utilities of retrofitting measures and their effectiveness. Though its use is growing, most of this system's current users are Alaska utilities. Since the inception of the USFWS reporting system, cooperation and communication between electric utilities in Alaska and USFWS have increased. By working together to address electrocution problems, USFWS is able to better protect wildlife resources while utilities are able to mitigate avian electrocution risks.

EXAMPLE 6: Dead bird/nest reporting form.

Dead Bird/Nest Form

Operations Area:

Dead Bird (circle one) **or** **Nest (circle one)**

Dead Bird (circle one)	Nest (circle one)
Crow/magpie/raven	Active
Hawk/falcon/osprey	Inactive
Small bird (protected)	
Eagle	
Owl	
Waterfowl	
Unknown species	

Bird Count ______________________

Date Found ______________________ **Time Found** ______________________

Sign of Death (circle one)

Collision Electrocution Unknown Other ______________________

County ______________________

Finder's Name ______________________

Finder's Phone ______________________

Line Name/Circuit No. ______________________

Pole Identification No. ______________________

Recommended Action (circle)

Dead Bird Actions	*Nest Actions*
Cover transformer equipment	Install nest platform
Install insulator cover(s)	Relocate nest
Install triangle(s)	Trim nest
Reframe structure	Install nest discouragers
Replace structure	Remove nest
Remove pole	Evaluate to determine appropriate action
De-energize	No action
Install bird flight diverters/fireflies	
Continue to monitor line (Justification required)	
No action (Justification required)	

Comments ______________________

EXAMPLE 7: Dead Bird Reporting Form.

Animal/Bird Mortality Report

Date ____________________

Name ____

Work location ____________________________ Phone ____________________

Describe the species of the animal or bird that was mortally injured (electrocution/collision)

____

____

If any bands or tags please return to Environmental Department or write number and agency here

____

____

Describe how the animal or bird was mortally injured (bird contacted transformer bushings, etc.)

____

____

____

____

Weather conditions at time of death if known (e.g. rainy and cold, sunny and warm, etc.)

____

____

____

Circuit name & voltage ____

Specific problem location (e.g. pole #/address/cross streets, etc.)

____

____

____

Description of terrain and vegetation in area (e.g. near agricultural area, urban area, residential, etc.)

____

____

____

Recommended corrective action

____

____

Please attach picture of the bird or animal if possible.

EXAMPLE 8: Bird Nest Reporting Form.

Raptor/Bird Nesting Record

Date ____________________

Name ____

Work location ____________________ Phone ____________________

Species of raptor/bird (if known) ______________________________

Circuit name and voltage ______________________________

Specific nest location (pole no.) ______________________________

Condition of nest

____

____

Are eggs or young birds apparent? If so, please describe.

____

____

____

Description of terrain and vegetation in area (e.g. near agricultural area, urban area, residential, etc.)

____

____

____

History of previous nesting on this circuit

____

____

____

History of electrocutions/mortality on this circuit

____

____

____

Recommendations

____

____

____

Please attach picture of the bird and/or nest, if possible.

7. RISK ASSESSMENT METHODOLOGY

Thousands of utility poles are located in areas of suitable habitat for migratory birds. Because remedial actions on all poles in such areas are not economically or biologically necessary, a method is needed to identify configurations or locations of greatest risk. While utilities vary based on geographic scale, available data, and funding resources, risk assessment studies and models can be used by any utility to more effectively protect migratory birds.

Risk assessments may use existing data sources or new information collected specifically for the purpose. Electrocution risk assessment data may include habitat, topography, prey populations, avian nesting territories or concentration areas, avian use of poles, pole configuration, avian electrocutions, and bird-caused or unknown-cause outages. Although individual data layers alone may be inadequate for risk assessment, when all risk assessment data are overlaid, high-risk locations, configurations, or other factors may become apparent. Following a risk assessment, remedial actions can be prioritized throughout a utility's transmission and distribution system.

8. MORTALITY REDUCTION MEASURES

A utility can have its most cost-effective impact on reducing avian mortality by focusing efforts on the areas that pose the greatest risk to migratory birds. A risk assessment will often begin with an evaluation of available data that address areas of high avian use, avian mortality, nesting problems, established flyways, adjacent wetlands, prey populations, perch availability, and other factors that can increase avian interactions with utility facilities. The assessment may also include outage and circuit reliability information. Mortality reduction plans should use biological and electrical design information to prioritize poles in most need of repair. The causes of avian mortality and benefits to utility customers should be identified. A successful APP and mortality reduction plan require management support as well as the following:

- Assessment of facilities to identify risks
- Allocation of resources
- Standards for new or retrofit avian-safe construction
- Budget for operation and maintenance (O&M) and capital investment
- System for tracking remedial actions and associated costs
- Timely implementation of remedial measures
- Positive working relationship with agencies.

Mortality reduction plans may use strategies that include preventative, reactive, and proactive measures that focus on issues, risks, and reliability commitments facing a utility. The following are examples of how this multi-faceted approach may be used.

- **Preventative:** Construct all new or rebuilt lines in high avian use areas to Company avian-safe standards. Ensure that APP is in compliance with applicable laws, regulations and permits.
- **Reactive:** Document bird mortalities and problem nests; conduct assessment of problems and apply remedial measures where appropriate. Notify resource agencies in accordance with the company's permits and policy.
- **Proactive:** Provide resources and training to improve employee's knowledge and awareness. Partner with organizations that conduct research on effects of bird interactions with power lines. Evaluate electrocution and collision risks of existing lines in high avian use areas and modify structures where appropriate.

The USFWS and state agencies should be consulted on electrocutions and the remedial actions undertaken. Utilities should annually review their APPs in the context of risk assessment and electrocution and collision incidents and modify as appropriate, ideally with agency input.

9. AVIAN ENHANCEMENT OPTIONS

While an APP will include measures to reduce avian mortality associated with electrical operations, it can also include opportunities to enhance avian populations by installing nest platforms, improving habitats, and collaborating with agencies or conservation organizations. USFWS and state wildlife resource agencies, as well as other experts, can be consulted for recommendations on habitat enhancement projects. Nest platforms can be erected on poles for birds such as osprey, eagles, hawks, owls, herons, and cormorants (see Chapter 6). In addition, nest boxes can be erected for cavity-nesting species such as kestrels, owls, bluebirds, swallows, chickadees, wrens, and others. Such boxes may also benefit bats and flying squirrels.

Nest box construction, maintenance, and monitoring can be done in conjunction with volunteers, such as Boy Scouts and Girl Scouts or avian conservation organizations. These efforts are excellent opportunities to educate the public about the company's APP and its partnerships.

10. QUALITY CONTROL

A quality control mechanism can and should be incorporated into an APP to evaluate the effectiveness of a company's avian protection procedures. Some examples of quality control include assessing:

- the effectiveness of remedial action techniques in reducing avian mortality
- avian protection devices to identify products preferred for avian protection as well as ease of application and durability
- mortality reporting procedures to ensure that discoveries of avian mortalities are properly documented
- response to avian mortalities to ensure that appropriate actions are taken in a timely manner
- compliance with company procedures to ensure that personnel are consistently following company methods for avian-safe construction, mortality reporting, nest management, etc.
- public and agency opinions on system reliability and avian protection.

The quality control component of an APP is a continuous process. Information gathered during assessments of existing practices should be used to improve the effectiveness and timeliness of avian protection efforts, which, in turn, can help to reduce costs associated with such efforts.

11. PUBLIC AWARENESS

A public awareness program can be an integral part of an APP. It can be used to enhance public awareness and support for a company's APP. It allows stakeholders such as government agencies, tribes, non-profit organizations, wildlife rehabilitators, and other interested parties an opportunity to provide input to the decision-making process, enabling all parties to work openly and collaboratively towards recommendations that can be effectively implemented. This collaboration often leads to improved relationships within the community and to more efficient and positive projects. The relationships developed through this process may also encourage the public to report bird mortalities and encourage them to seek assistance for birds that have been injured in power line-related accidents.

Effectively communicating an APP can be done through a variety of public outreach tools, including fact sheets, newsletters, brochures, videos, websites, and speaker bureau presentations. These tools can also be used to record the successes of an APP, thereby documenting the utility and electric industry's efforts to reduce avian mortalities. The goal of these outreach efforts is to convey to the public that electric utilities are responsible stewards of the environment, working cooperatively with wildlife agencies towards reducing avian mortalities while continuing to provide safe, reliable, affordable electricity to their customers.

Many utilities have examples of their environmental stewardship and of the innovative ways they have reduced environmental impacts through their business decisions. A company's efforts to minimize avian mortalities should be shared with the public and resource agencies.

12. KEY RESOURCES

Key resources may include utility personnel or external contacts. Internal personnel may include representatives from environmental, engineering, operations and maintenance, standards, procurement, outage management, and other departments. External resources may include biologists and law enforcement agents from state and federal agencies as well as avian specialists from NGOs or universities, and wildlife rehabilitators. External utility industry resources include APLIC, Edison Electric Institute (EEI), Electric Power Research Institute (EPRI), Institute of Electrical and Electronics Engineers (IEEE), National Rural Electric Cooperative Association (NRECA), and Rural Utilities Service (RUS). Contact information and websites for a number of resources are available in the complete APP Guidelines (see www.aplic.org or www.fws.gov).

APPENDIX D

Glossary

adult
a bird that has acquired its final plumage.

air-gap
the empty space or "window" around conductors on a steel transmission structure. The empty space provides insulation for the conductors. A fault can occur when something bridges all or a sufficient portion of the air gap between the steel tower and an energized conductor.

ampere
unit measure of current.

avian-safe
a power pole configuration designed to minimize avian electrocution risk by providing sufficient separation between phases and between phases and grounds to accommodate the wrist-to-wrist or head-to-foot distance of a bird. If such separation cannot be provided, exposed parts are covered to reduce electrocution risk, or perch management is employed. This term has replaced the term "raptor-safe" used in the 1996 edition of *Suggested Practices*.

Basic Insulation Level (BIL)
the measure of a line's ability to withstand rapidly rising surge voltages such as those resulting from lightning strikes. It is provided by porcelain, wood, fiberglass, air, or combinations of these. Using the same insulators, a line built on wood poles will have a higher BIL than one built on concrete or steel poles unless the insulator bases are grounded on the wood poles. BIL is also affected by pole framing. For example, if the phase conductors and neutral conductors are both framed on wood crossarms, the BIL is reduced.

bushing (transformer)
an insulator inserted in the top of a transformer tank to isolate the electrical leads of the transformer winding from the tank. Bushings are usually made of porcelain, and are also used on circuit breakers and capacitor banks.

bushing cover
a covering installed over a bushing to prevent incidental contact by birds or other animals.

capacitance
the capacity of the condenser to hold an electrical charge; the property of an electrical nonconductor for storing energy.

capacitor
a device consisting of conductors isolated in a dielectric medium; each capacitor is attached to one side of a circuit only. It is used to increase the capacitance of a circuit. Capacitors are constructed in metal tanks and have bushings.

capacitor bank
a series of capacitors connected together and inserted into an electrical circuit to change the efficiency of the energy use.

circuit (single)
a conductor or system of conductors through which an electric current is intended to flow. The circuit is energized at a specified voltage.

circuit (multiple)
a configuration that supports more than one circuit.

conductivity
the capacity to transmit electrical energy.

conductor
the material (usually copper or aluminum)—usually in the form of a wire, cable or bus bar—suitable for carrying an electric current.

configuration
the arrangement of parts or equipment. A distribution configuration would include the necessary arrangement of crossarms, braces, insulators, etc. to support one or more electrical circuits.

corona ring
a device used on transmission suspension insulators to reduce the electrical field stress at the end fittings.

corvid
birds belonging to the family Corvidae; includes crows, ravens, magpies, and jays.

crossarm
a horizontal supporting member used to support electrical conductors and equipment for the purpose of distributing electrical energy. Can be made of wood, fiberglass, concrete, or steel, and manufactured in various lengths.

current
a movement or flow of electricity passing through a conductor. Current is measured in amperes.

davit arm
a formed, laminated wood or steel crossarm attached to wood or steel poles and used to support electrical conductors or overhead ground wires.

de-energized
any electrical conducting device disconnected from all sources of electricity.

dielectric strength
the ability of an insulating material to withstand the electrical voltage stress of the energized conductor.

distribution line
a circuit of low-voltage wires, energized at voltages from 2.4 kV to 60 kV, and used to distribute electricity to residential, industrial and commercial customers.

electrode

a conductor used to establish electrical contact with a nonmetallic part of a circuit. In the case of testing the conductivity of an eagle feather, electrodes were attached to both ends of the feather, and electrical current was passed through the feather.

energized

any electrical conducting device connected to any source of electricity.

fault

a power disturbance that interrupts the quality of electrical supply. A fault can have a variety of causes including fires, ice storms, lightning, animal electrocutions, or equipment failures.

fledgling

a bird that has recently left the nest and may still be dependent on its parents for food.

fused cutouts

electrical switches fitted with a fuse, so that the switch will open when the current rating of the fuse is exceeded. Fused cutouts are used to protect electrical equipment and circuits from lightning and short-circuiting caused by wires, wind, animals, or conductive equipment of all kinds.

generation plant

a facility that generates electricity.

ground

an object that makes an electrical connection with the earth.

ground rod

normally a copper-clad steel rod or galvanized steel rod, driven into the ground so that ground wires can be physically connected to the ground potential.

grounding conductor

a conductor used to bond all of the bolts and other pole/line hardware to the ground. Grounding conductors may be copper-clad, solid copper or stranded galvanized wires and are attached to poles with staples. Sometimes also called *downwire*.

guy

secures the upright position of a pole and offsets physical loads imposed by conductors, wind, ice, etc. Guys are normally attached to anchors that are securely placed in the ground to withstand loads within various limits.

hacking

the process of transitioning birds reared in captivity to independence in the wild. Hacking has been used to bolster populations of endangered species such as peregrine falcons, California condors, and bald eagles.

insulator

nonconductive material in a form designed to support a conductor physically and to separate it electrically from another conductor or object. Insulators are normally made of porcelain or polymer.

isokeraunic level
refers to the average number of thunderstorm (lightning) days per year that are present in a region. Electric lines in areas of high levels may have overhead grounding conductors (static wires) installed so that lightning strikes to the line can be diverted directly to earth away from the phase conductors.

jumper wire
a conductive wire, normally copper, used to connect various types of electrical equipment. Jumper wires are also used to make electrical conductors on lines continuous when it becomes necessary to change direction of the line (e.g., angle poles, dead-end poles).

juvenile
(plumage)—first plumage of a bird.
(bird)—a young bird in its first year of life.

kilovolt
1000 volts, abbreviated kV.

latticework
the combination of steel members connected together to make complete structures, such as transmission towers or substation structures.

lightning arrester
an electrical protection device used to divert the energy of lightning strikes to the earth.

lightning days
lightning or thunderstorm days. One or several lightning storms in the same day would be classed as a lightning day.

nest substrate
the base upon which a nest is built, e.g. cliffs, trees, ground, power poles, boxes, platforms, etc.

nestling
a young bird that has not yet reached sufficient size and maturity to leave the nest.

neutral conductor
a conductor or wire that is at ground potential, i.e., grounded.

outage
event that occurs when the energy source is cut off from the load.

phase
an energized electrical conductor.

phase-to-ground
the contact of an energized phase conductor to ground potential. A bird can cause a phase-to-ground fault when fleshy parts of its body touch an energized phase and ground simultaneously.

phase-to-phase
the contact of two energized phase conductors. Birds can cause a phase-to-phase fault when the fleshy parts of their wings or other body parts contact two energized phase conductors at the same time.

pole
a vertical structure used to support electrical conductors and equipment for the purpose of distributing electrical energy. It can be made of wood, fiberglass, concrete, or steel, and manufactured in various heights.

power line
a combination of conductors used to transmit or distribute electrical energy, normally supported by poles.

primary feathers
also called **primaries.** The ten outermost flight feathers of the wing that meet at the wrist to form the "hand" of the wing.

problem pole
a pole used by birds (usually for perching, nesting, or roosting) that has electrocuted birds or has a high electrocution risk.

raptor
bird of prey. Raptors are members of the orders Falconiformes (diurnal raptors) and Strigiformes (owls). Raptors have a sharp hooked bill and sharp talons used for killing and eating prey.

raptor-safe
see **avian-safe**

retrofitting
the modification of an existing electrical power line structure to make it avian-safe.

ridge pin
the support bracket for an insulator that is attached to the top of a pole with two or more bolts and supports energized or grounded conductors, depending on the power line design.

rights-of-way (ROW)
the strip of land that has been acquired by an agreement between two or more parties for the purpose of constructing and maintaining a utility easement.

sectionalize
refers to the practice of isolating an energy source from a load. It is sometimes necessary to isolate electric systems (using switches) for operations and maintenance.

separation
the physical distance between conductors and/or grounds from one another.

site-tenacity
strongly attached or drawn to a chosen location.

still-hunting
the practice of hunting from a perch, as opposed to hunting in flight.

structure
a pole or lattice assembly that supports electrical equipment for the transmission or distribution of electricity.

subadult
age(s) of a bird between juvenile and adult.

substation
a transitional point (where voltage is increased or decreased) in the transmission and distribution system.

switch
an electrical device used to sectionalize electrical energy sources.

tension member
the tower member on steel lattice towers that supports the crossarm from the topside.

transformer
a device used to increase or decrease voltage.

transmission line
power lines designed and constructed to support voltages >60 kV.

trust resource
wildlife, such as migratory birds, that are held in the public trust and managed and protected by federal and state agencies. These trust agencies are designated by statute and regulations as responsible for upholding the protection, conservation, and management of these resources.

underbuild
refers to a circuit that is placed on the same pole but underneath another circuit of a higher voltage. The lower circuit is often referred to as the underbuilt circuit.

volt
the measure of electrical potential.

voltage
electromotive force expressed in volts.

wrist
joint toward the middle of the leading edge of the wing. The skin covering the wrist is the outermost fleshy part on a bird's wing.

APPENDIX E

List of Acronyms

APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
BGEPA	Bald and Golden Eagle Protection Act
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BSPB	Bulgarian Society for the Protection of Birds
CFE	Comisión Federal de Electricidad
CFR	Code of Federal Regulations
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute
ESA	Endangered Species Act
EWT	Endangered Wildlife Trust
FERC	Federal Energy Regulatory Commission
GIS	Geographical Information System
HCP	Habitat Conservation Plan
IBA	Important Bird Area
IEEE	Institute of Electrical and Electronics Engineers
ITP	Incidental Take Permit
MBTA	Migratory Bird Treaty Act
MLEA	Moon Lake Electric Association
MOU	Memorandum of Understanding
NESC	National Electric Safety Code
NGO	Non-governmental organization
NMFS	National Marine Fisheries Service
NPS	National Park Service
NRECA	National Rural Electric Cooperative Association
NWCC	National Wind Coordinating Committee
REA	Rural Electrification Association
ROW	Rights-of-way
RUS	Rural Utilities Service
USC	United States Code
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

Avian Power Line Interaction Committee

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Avian Power Line Interaction Committee

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