BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF PUBLIC SERVICE COMPANY OF NEW MEXICO'S APPLICATION FOR A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY TO CONSTRUCT, OWN, AND OPERATE, LOCATION APPROVAL, AND RIGHT-OF-WAY DETERMINATION FOR THE MID-STATE 345 KV TRANSMISSION PROJECT	)	
	)	**Docket No. 26-0000XXX**
PUBLIC SERVICE COMPANY OF NEW MEXICO,	)	
Applicant.	)	

DIRECT TESTIMONY

OF

IAN EVANS

October 30, 2026

NMPRC DOCKET NO. 26-0000XXX
INDEX TO THE DIRECT TESTIMONY OF IAN EVANS

WITNESS FOR
PUBLIC SERVICE COMPANY OF NEW MEXICO

I. INTRODUCTION AND PURPOSE 1

II. POTENTIAL ENVIRONMENTAL IMPACTS AND DEVELOPMENT APPROACH 6

III. PROJECT DESCRIPTION AND ENVIRONMENTAL ANALYSIS 14

IV. LOCATION CONTROL STATUTE, NMSA 1978, § 62-9-3 21

V. LOCATION RULE, 17.9.592 NMAC 24

VI. THE APPLICANT WILL ASSURE THAT THE TRANSMISSION LINE DOES NOT UNDULY IMPAIR IMPORTANT ENVIRONMENTAL VALUES 27

VII. LAND USE, LAND OWNERSHIP, AND COMPLIANCE WITH LAND USE STATUTES AND ADMINISTRATIVE REGULATIONS 40

VIII. COMPLIANCE WITH THE LOCATION RULE 41

IX. CONCLUSION 44

SPONSORED EXHIBITS

PNM Exhibit IE-1 Educational Background and Relevant Employment Experience

PNM Exhibit IE-2 Transmission Project and Transmission Study Corridor Mapbook

PNM Exhibit IE-3 Reducing Avian Collisions with Power Lines

PNM Exhibit IE-4 Environmental Report

PNM Exhibit IE-5 Best Management Practices

PNM Exhibit IE-6 Consulted Agencies

Affidavit

DIRECT TESTIMONY
OF IAN EVANS
NMPRC DOCKET NO. 26-0000XXX

I. INTRODUCTION AND PURPOSE

Q. Please state your name, position, and business address.

A. My name is Ian Evans. I am an Environmental Senior Manager for Pattern Energy Group LP ("Pattern"). My business address is 888 Westheimer Road, Suite 350, Houston, Texas, 77006. I am responsible for environmental due diligence and permitting activities for Mid-State Transmission LLC, which is an affiliate company of Pattern. Mid-State Transmission LLC is developing the project described in this application and will transfer it to the Public Service Company of New Mexico ("PNM"). I am providing testimony on behalf of PNM.

Q. Please summarize your educational background and professional qualifications.

A. I received an undergraduate degree in Conservation Biology from Middlebury College, which is a joint major program between the Environmental Science and Biology departments. I spent the early years of my career in various field technician roles researching gray wolves, monitoring endangered shorebirds, performing biological assessments for a small land trust, and reviewing environmental components of residential development applications for a county. I then spent 7 years working for environmental non-profit organizations based in Washington, DC, most notably in various roles at the Renewable Energy Wildlife Institute where

I managed research program and stakeholder engagement initiatives to support scientific research and environmentally responsible development of wind energy projects. I joined Pattern in 2019 as an Environmental and Natural Resources Associate. Since then, I have led environmental and permitting efforts for many of Pattern's projects in New Mexico and across the United States. I work closely with federal, state, and local regulatory agencies with jurisdiction where Pattern builds its projects to ensure projects adhere to all requirements and receive necessary approvals. Please refer to PNM Exhibit IE-1 for my educational background and relevant employment experience.

Q. Have you previously provided testimony before the New Mexico Public Regulation Commission?

A. Yes. I submitted pre-filed testimony as the environmental lead for the proposed Corona Wind North II Project which is the subject of the proceeding in NMPRC Docket No. 26-0000111.

Q. Please describe the Mid-State Transmission Project and its components.

A. The Mid-State Transmission Project ("Mid-State", "the Transmission Project" or "the Project") is a new, approximately 102.8-mile, 345 kilovolt ("kV") transmission line and related facilities extending from PNM's Western Spirit Switchyard (Torrance County, New Mexico) to the Hidden Mountain Substation

(Valencia County, New Mexico). Portions of the new 345 kV line are expected to share rights-of-way ("ROW") and structures with the existing 115 kV line that connects Willard Substation to Belen Substation, known as the WL 115 kV line.

Q. What is the Applicant seeking in this proceeding with respect to the location approval for the Project?

A. The Applicant seeks approval to locate the Transmission Project within a one-mile-wide corridor that is referred to in my testimony as the "Transmission Study Corridor." The Transmission Project and the associated Transmission Study Corridor for which Commission approval is sought is more specifically depicted in PNM Exhibit IE-2, which is attached to my testimony.

Q. Are you sponsoring any exhibits with your testimony?

A. Yes. I am sponsoring the following Exhibits:

- PNM Exhibit IE-1: The aforementioned Exhibit IE-1 describes my relevant employment experience and professional background.
- PNM Exhibit IE-2: The aforementioned depiction of the Transmission Project and Transmission Study Corridor
- PNM Exhibit IE-3: Guidelines to reduce avian collisions with power lines developed by the Avian Powerline Interaction Committee ("APLIC").

- PNM Exhibit IE-4: The Project's Environmental Report ("Environmental Report"), which is a comprehensive analysis of the potential environmental impacts of the Project that was prepared by WSP USA, Inc. under my supervision.
- PNM Exhibit IE-5: A list of the Best Management Practices ("BMPs") established by Pattern and other stakeholders, which have been implemented on multiple generation and transmission projects previously approved by the Commission. The Applicant has agreed to incorporate these BMPs as commitments for this Project, as discussed in PNM witness Kelsey Martinez's direct testimony.
- PNM Exhibit IE-6: A list of federal, state, and local government agencies consulted to date about the Project.

Q. Please provide a summary of your testimony.

A. As a representative of Mid-State Transmission LLC, an affiliate of Pattern, I am submitting this testimony in support of the location approval sought in the Application for the Project. I am responsible for assessing and mitigating environmental impacts of the Project and securing all required permits prior to project construction. I describe the area where the Transmission Project will be located and explain that the Project would be constructed within this area in compliance with all applicable environmental laws and regulations in New Mexico,

as well as the comprehensive environmental protections agreed upon by Pattern and its affiliated interests and Commission Staff and intervenors in several prior location approval proceedings presented to the Commission over the last several years. More specifically, these prior proceedings are: a) NMPRC Case No. 17-00221-UT; b) NMPRC Case No. 18-00065-UT; c) NMPRC Case No. 20-0008-UT; d) NMPRC Case No. 21-00281-UT; e) NMPRC Case No. 22-00101-UT; f) NMPRC Case No. 22-00202-UT; and NMPRC Docket No. 26-0000111, which is currently pending before the Commission. Collectively they are referred to herein as the "Prior Location Approval Proceedings."

Q. How is your testimony organized?

A. I begin with an overview of potential impacts of transmission lines to the environment and the development approach undertaken by the Project to avoid, minimize, and mitigate impacts to the extent practicable. I then provide information about the Transmission Project, its location, and an overview of the environmental analysis undertaken. I then review applicable regulations and rules that govern the application and the Commission's review, followed by statements of compliance with these regulations and rules.

II. POTENTIAL ENVIRONMENTAL IMPACTS AND DEVELOPMENT APPROACH

Q. How would you characterize the environmental impacts of transmission lines generally?

A. In the United States there are over 160,000 miles of high-voltage electric transmission lines such as the Mid-State Transmission Project, and millions of miles of lower-voltage electric distribution lines. Electric transmission lines have relatively few significant negative environmental impacts, largely because transmission projects have a small physical impact relative to other forms of development and do not require their ROWs to be converted entirely to industrial use. Transmission projects are typically able to microsite around sensitive, site-specific resources, such as archaeological and historical resources or wetlands and streams. The few environmental impacts associated with transmission lines consist primarily of habitat modification and direct impacts to birds.

Q. Please describe in brief terms how transmission lines can impact habitats.

A. Because transmission lines are long, linear projects, they inevitably bisect different habitats even though actual direct habitat modification is limited to disturbance along the transmission ROW. Habitat modification associated with transmission line development and operations is primarily the result of vegetative clearing of a transmission ROW to ensure that appropriate structure clearances are maintained

pursuant to the standardized requirements of the North American Electric Reliability Corporation ("NERC"). NERC establishes minimum clearance distances from vegetation to ensure the reliability of the North American bulk power system.

The effects of habitat modification associated with transmission lines are multiple, nuanced, and will vary widely across differing circumstances. Habitat modification can result in the permanent direct loss of preexisting habitat types within a ROW. This may occur, for example, where a transmission line crosses a heavily forested habitat in the Northeastern United States which requires clearing of vegetation for the operations and maintenance of the line in compliance with NERC. Conversely, a transmission line in the desert Southwest where vegetation growth is significantly lower is unlikely to require significant vegetative clearing within its ROW, and as such, habitat loss would largely consist of *de minimis* areas required for project structures, such as power poles. At the same time, vegetative restoration can be more challenging and take longer in arid environments. Transmission ROWs can also create valuable habitat for certain species utilizing edge habitat, such as pollinator insects and various passerine bird species. Large-body predators may utilize cleared transmission ROWs for travel. In contrast, species that utilize more heavily forested habitats may see habitat modification remove useful habitat.

Like most large linear projects, transmission line ROWs can be sited to minimize impacts to sensitive habitats, such as playa lakes. Also, because the permanent physical footprint of a transmission project consists primarily of power pole structures and aerial cables, power poles can further be micro-sited within the ROW to avoid impacts to specific sensitive resources. While avoidance of environmental impacts often comes at an economic cost, careful siting can significantly reduce the already modest environmental impacts caused by transmission projects.

Q. Please describe in brief terms how transmission lines can affect avian species?

A. I have discussed some of the potential effects on avian habitat. Birds can also be impacted by electrocution from or collision with powerlines.

Electrocution risk can be managed in a variety of ways, and it is an increasingly common practice to utilize electrocution prevention guidelines developed by the Avian Powerline Interaction Committee ("APLIC") to implement measures to reduce this risk. However, the Mid-State Transmission Project's 345 kV transmission line will be large enough to minimize the risk of electrocution due to the required spacing between individual electric circuits.

The majority of birds that collide with transmission lines are small passerine species with high fecundity rates and short lifespans, which conveys higher population

level resilience to individual mortality. APLIC has developed collision guidelines (Reducing Avian Collisions with Power Lines), which I have attached as PNM Exhibit IE-3, that detail risk factors for avian collision risk, including proximity to agricultural fields, water resources, and parks.

I believe that after a line has been sited, the most effective measure for minimizing avian mortality at transmission lines is the installation of bird diverters. Bird diverters are visual deterrents installed on transmission lines to make the lines stand out visually to flying birds. Bird diverters are specifically designed to be visually conspicuous to birds and are installed on portions of a transmission line identified based on various risk factors detailed in the APLIC guidelines on transmission line conductors. Pattern has implemented bird diverters on transmission lines for different projects across the country, including, in New Mexico: Western Spirit Wind, Western Spirit Transmission, SunZia Wind North, SunZia Wind South, SunZia Transmission, and Broadview and Grady Wind. When used appropriately, bird diverters can be very effective in further reducing collision impacts.

Q. Will the Project utilize bird diverters?

A. Yes. As design advances, we will conduct a Project-specific assessment of potential avian collision risk, based on the risk factors identified in the APLIC collision

guidelines (PNM Exhibit IE-3). The risk assessment will inform where bird diverters should be considered for installation on the Transmission Project.

Q. How can transmission lines impact cultural resources?

A. Transmission lines can impact cultural resources through construction and placement of structures in close proximity to sensitive cultural resources, such as archaeological or historical sites. Transmission lines can generally be constructed to avoid direct impacts to archaeological and historical sites altogether through careful siting of a transmission ROW and subsequently by micro-siting individual transmission pole structures to avoid altogether or to span a given resource within a ROW.

Q. Please describe how the Transmission Project has been developed and designed with respect to potential impacts to the environment.

A. Pattern has followed a tiered approach[1] to identifying, understanding, and addressing potential impacts of the Transmission Project to the surrounding environment as detailed in the Environmental Report (PNM Exhibit IE-4). For any given environmental resource considered, this approach typically begins with initial landscape-level site characterization relying on satellite imagery and publicly

[1] Pattern's tiered approach to transmission development is analogous to the approach established by the U.S. Fish & Wildlife Service's Voluntary Land Based Wind Energy Guidelines, available at https://www.fws.gov/media/land-based-wind-energy-guidelines.

available databases to identify initial constraints or potential resources of concern. Subsequently, specific resources of concern (including wildlife habitat, aquatic features, and known cultural resources) within a project area that could be impacted by project development are identified. Based on identification of these potential resources, and, typically, in coordination with regulatory agencies with potentially useful information, field studies are initiated to collect site-specific data. At each tier of analysis, potential or field-identified constraints are considered and used to inform iterations of project design and construction planning.

Pattern has implemented this tiered approach as well as the APLIC collision guidelines in developing the Mid-State Transmission Project. We have engaged various consultants to complete both desktop and initial field reviews of the Project, including site assessments for wetlands and streams, threatened and endangered species habitat, and cultural resources. The results of these studies allow us to understand not only the existing environment and possible resources of concern within the Transmission Study Corridor, but also the likelihood of their presence or absence, and provides opportunities to avoid impacts through changes in ROW alignment, micrositing of individual transmission structures within the ROW, or application of specific construction methodologies. Coordination with applicable natural resource agencies, such as U.S. Fish & Wildlife Service ("USFWS") and

the New Mexico Department of Wildlife,[2] has been initiated, and will be continued throughout Project development as design and survey plans advance.

Our approach to identifying potential aquatic resources has been refined over time. This approach includes a combination of desktop and field surveys to identify the potential occurrence of sensitive aquatic resources such as wetlands and streams. The Albuquerque District of the U.S. Army Corps of Engineers has approved such an approach for identifying potentially jurisdictional waters and upland areas that requires subsequent field verification. We have elected to conduct this analysis across all project areas ahead of actual proposed infrastructure. We have taken a similar approach to cultural resources and sensitive species habitats. This allows us to identify potential resource conflicts before, during, and after designing project infrastructure to minimize impacts to the maximum extent practicable.

In previous Pattern projects in New Mexico that include transmission line development, Pattern has successfully implemented a set of customized Best Management Practices developed in partnership with the New Mexico Public Regulation Commission Staff, the New Mexico State Land Office, and the Claunch-Pinto Soil and Water Conservation District. These BMP's (PNM Exhibit

[2] Pursuant to NMSA 1978, § 17-1-1.1, effective July 1, 2026, the former New Mexico Department of Game and Fish is renamed the Department of Wildlife. References to engagement with that agency prior to July 1, 2026, may use the former name.

IE-5) will be applied to the development, construction, and operations of the Mid-State Transmission Project as well on both state and private lands. In addition to these BMPs, numerous resource-specific protection measures have been identified in the Environmental Report that would further reduce impacts to important environmental resources.

Q. Please summarize the government consultation on environmental issues that you have completed in furtherance of the Project.

A. We have initiated consultation with relevant government entities to apprise them of the Transmission Project and to obtain their input on how best to minimize our modest, potential environmental impacts. Please refer to PNM Exhibit IE-6 for a table of federal, state, and local government agencies with whom Mid-State Transmission LLC has consulted to date. Consultation has been fruitful and positive and will be ongoing throughout the development of the Project.

Q. Did any of the local, state, or federal government agencies consulted raise significant concerns or provide recommendations with respect to the Transmission Project?

A. None of the agencies consulted raised significant concerns. The U.S. Forest Service provided initial guidance on permits and studies required to authorize portions of the Project within Cibola National Forest. USFWS provided suggestions for future

assessments that would improve understanding of potential impacts to species of concern, in particular avian species. The New Mexico Department of Wildlife suggested the Project's potential impacts to wildlife would likely be similar to those for previously developed transmission lines in the area, and that risks from the Project could be appropriately managed. Suggestions from these agencies have been integrated into future Project development plans, and consultation with these agencies, and others, will continue throughout development.

III. PROJECT DESCRIPTION AND ENVIRONMENTAL ANALYSIS

Q. Please describe the Transmission Project.

A. In this proceeding, the Applicant proposes to construct a Transmission Project which, depending upon final alignment within the Transmission Study Corridor, will have a linear length of approximately 102.8 miles (542,608.7 feet). The table below summarizes the approximate length of the Transmission Project over different landowners in both feet and miles.

Landowner	**Feet**	**Miles**
Private	440,095.7	83.4
New Mexico State Land Office ("NMSLO")	87,303.2	16.5
United States Forest Service ("USFS")	11,189.3	2.1
Middle Rio Grande Conservancy District ("MRGCD")	1,620.0	0.3
New Mexico Department of Wildlife ("NMDOW")	1,537.6	0.3
New Mexico Department of Transportation ("NMDOT")	742.6	0.1
Bureau of Land Management ("BLM")	120.3	0.02
Total	**542,608.7**	**102.8**

The Transmission Study Corridor encompasses approximately 66,000 acres, including approximately 53,815 acres of private land, approximately 10,340 acres of state lands, and approximately 1,625 acres of federal lands in the Counties of Torrance, Socorro, and Valencia in New Mexico. The Transmission Project is shown on PNM Exhibit IE-2. The Transmission Study Corridor is one mile wide.

Q. Is there a reason you do not describe the location of the Transmission Project with more specificity?

A. We have described and shown in maps our best approximation of the Transmission Project route at this time. PNM Exhibit IE-2 provides very detailed mapping of the Transmission Project with satellite imagery that provides the Commission extraordinary detail of the entire route and the Transmission Study Corridor. However, the siting of a transmission project's infrastructure is a data-driven process. While the Transmission Project will ultimately be restricted to a specified ROW at an approved width, the Project is still under active development. As part of the development process, we are constantly collecting data that is integrated into project siting and design. Generally, the more flexibility a project design has to integrate and adapt to site-specific data, the better a project will tend to be at the end of the day, both in terms of cost and minimization of environmental and other impacts.

The exact alignment of the ROW may change within the Transmission Study Corridor either due to micro-siting of the alignment of the Transmission Project and ROW or through adjustments of location of Project structures within the ROW. The Applicant will report any modification to the proposed route, and the reasons for the modification, in accordance with applicable Commission notice, reporting, review, and compliance requirements. Any modified alignment would remain within the Transmission Study Corridor and would remain subject to the environmental protection measures and other commitments, such as BMPs, described in my testimony and the Environmental Report.

We have performed a comprehensive environmental analysis of the Transmission Study Corridor, as documented in the Environmental Report (PNM Exhibit IE-4).

Q. What is the benefit of having performed the detailed environmental analysis over the entire project study area?

A. The Transmission Study Corridor has been studied holistically in the Environmental Report to analyze the potential impacts of the Transmission Project anywhere within this corridor. As a result, the extensive environmental analysis performed for the Project allows for micrositing to occur later in the project development as final development and design decisions are made considering ongoing data collection and in the event of unanticipated discoveries.

Q. What is the existing environment of the Project?

A. The Transmission Study Corridor where the Project will be located extends across approximately 66,000 acres of central New Mexico and traverses a diverse landscape that includes rangelands, grasslands, shrublands, pinyon-juniper woodlands, irrigated agricultural lands, the Rio Grande corridor, and developed areas near Los Lunas and Belen. The Transmission Study Corridor crosses portions of public lands administered by the Bureau of Land Management, United States Forest Service, New Mexico State Land Office, New Mexico Department of Wildlife, Middle Rio Grande Conservancy District, New Mexico Department of Transportation, and the National Park Service, in addition to privately-owned lands. Numerous natural and cultural resources occur within the corridor, including ephemeral stream systems, the Rio Grande, wildlife habitats, agricultural lands, archaeological sites, historic properties, scenic byways, in addition to utility and other infrastructure.

Q. What environmental authorizations are anticipated to begin construction and operation of the project?

A. The Project is still finalizing precise designs and schedules that will dictate the specific environmental authorizations necessary for construction and/or operation. At this time, it is expected that the Project will require environmental authorizations listed in Appendix C to the Environmental Report prior to start of construction.

Applications for appropriate permits will be submitted as design advances. To our current knowledge, no additional environmental authorizations other than those identified in the Environmental Report would be required. In the event of unanticipated discoveries of regulated environmental resources, additional authorizations may be required if impacts to those resources are unavoidable.

Q. When will these environmental authorizations be obtained?

A. Any environmental authorizations necessary to authorize construction activities will be acquired prior to the onset of construction or prior to the specific activity requiring authorization. Any environmental authorizations necessary to commence operation of the project would be acquired either prior to start of construction or during the course of construction.

Q. Will the Commission be informed of the specific environmental authorizations to be obtained for the project?

A. Yes. As design advances and necessary authorizations are confirmed, the Applicant will notify the Commission.

Q. What Commission approvals are the Applicant requesting with regards to the location of the Transmission Project?

A. As discussed in the direct testimony of PNM witness Adam Alvarez, the Applicant requests that the Commission approve the location of the Transmission Project, pursuant to NMSA 1978, § 62-9-3 ("Location Control Statute") and Commission Rule 17.9.592 NMAC ("Location Rule"). The Applicant is also requesting that the Commission approve at this time any future siting adjustments to the Transmission Project that may be located entirely within the Transmission Study Corridor, with the condition that any modifications from the proposed route for the Transmission Project will be reported to the Commission Staff and subject to the same review that the Commission has applied to previous location approval cases filed by Pattern and other applicants.

Q. Please explain why an extensive environmental analysis was performed of the entire Transmission Study Corridor.

A. As I mentioned earlier in my testimony, it is common practice in this type of project development to adjust proposed locations for transmission infrastructure as more information is obtained during the course of development and site preparation. If a necessary adjustment were to result in proposed infrastructure locations outside of the initial study corridor, it would be necessary to perform a subsequent environmental analysis and seek another formal location approval through a proceeding before the Commission.

To minimize the need for additional time-consuming and costly environmental studies and regulatory reviews, Pattern has significantly expanded the area evaluated by the comprehensive environmental analysis for Mid-State Transmission to a one-mile-wide corridor (the Transmission Study Corridor). This broader analysis approach has been utilized in the Prior Location Approval Proceedings presented to the Commission by Pattern and its affiliates. It is our hope and request that the Commission will continue to recognize the benefit of this detailed level of environmental review encompassing the entire Transmission Study Corridor and allow the Applicant to revise the siting of the Transmission Project as necessary during the construction phase anywhere within the area that has been evaluated in the Environmental Report. Furthermore, the Project BMPs (PNM Exhibit IE-5) and the resource protection measures identified in the Environmental Report would be implemented for any alignment of the Transmission Project within the Transmission Study Corridor. This helps to ensure an efficient development and construction process that balances avoidance of environmental impacts with the timely and affordable execution of the Project to satisfy the Project need.

Q. When is the project expected to be in-service?

A. The Project is expected to be in-service by the end of 2029.

Q. Please describe the Project interconnection facilities.

A. The Project will interconnect at its eastern end with the existing Western Spirit Switchyard located in Torrance County. The western terminus of the Project will interconnect at the Hidden Mountain Substation in Valencia County. Additional descriptions of the Project interconnection facilities, including a schematic diagram, are provided in the Direct Testimony of PNM witness Gregory Parent.

IV. LOCATION CONTROL STATUTE, NMSA 1978, § 62-9-3

Q. Why does the project require location approval?

A. My understanding is that New Mexico's Location Control Statute, specifically NMSA 1978, § 62-9-3(B), requires prior approval by the Commission for construction within New Mexico of transmission lines and associated facilities designed for or capable of operations at a nominal voltage of 230 kV or more to be constructed in connection with new generation.

The Commission's approval is required for the Transmission Project since it will be designed for or capable of being operated at a nominal voltage of 345 kV and will be constructed in connection with, and to transmit electricity from, new energy generation resources totaling greater than 300 MW.

Q. Please explain your understanding of the need to comply with state, county, or municipal land use.

A. I understand that NMSA 1978, § 62-9-3(G) prohibits the Commission from approving a location control application that violates an existing state, county, or municipal land use statutory or administrative regulation unless the Commission finds the regulation is unreasonably restrictive.

Q. Please explain your understanding of the statutory requirements for location approval for the Transmission Project.

A. My understanding is that Section 62-9-3(F) of the Location Control Statute requires the Commission to approve an application for location of transmission lines unless it finds that the location will unduly impair important environmental values. In making that determination, Section 62-9-3(M) of the Location Control Statute allows the Commission to consider the following factors:

(1) existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed location;

(2) fish, wildlife, and plant life;

(3) noise emission levels and interference with communication signals;

(4) the proposed availability of the location to the public for recreational purposes, consistent with safety considerations and regulations;

(5) existing scenic areas, historic, cultural or religious sites and structures or archaeological sites at or in the vicinity of the proposed location; and,

(6) additional factors that require consideration under applicable federal and state laws pertaining to the location.

Q. Does the Transmission Project comply with the requirements of the Location Control Statute?

A. Yes, the Application and supporting testimony and exhibits demonstrate that the Transmission Project complies with these requirements. The existing state, county, and municipal land use statutory and administrative regulations allow for the installation of the Transmission Project and this Transmission Project will not unduly impair important environmental values.

Q. Will operation of the Project unduly impair power-system reliability?

A. No. Based on the transmission-planning and engineering analyses described in the Direct Testimony of PNM witness Martinez, operation of the Project will not unduly impair power-system reliability.

V. LOCATION RULE, 17.9.592 NMAC

Q. What is your understanding of the requirements of the Commission's Location Rule, 17.9.592 NMAC, regarding applications for location of transmission lines?

A. Under the Location Rule, 17.9.592.10 NMAC, for transmission lines, an applicant must file an application supported by written testimony and exhibits that contain the following information for transmission lines for which location approval is required:

A. a description of the transmission line including, but not limited to:

(1) the location of the transmission line and a map depicting the location in electronic format and physical format with a scale not to exceed one inch equals five miles;

(2) identification of the ownership of the land (such as private, Bureau of Land Management, U.S. Forest Service, state trust, etc.) the transmission line will cross and the number of feet the transmission line will cross over each owner's land;

(3) the total length of each transmission line in feet;

(4) a description of interconnection facilities;

(5) a schematic diagram showing the transmission line and the interconnection of the transmission line to the transmission grid;

B. identification of all applicable land use statutes and administrative regulations and proof of compliance or statement of noncompliance with each;

C. if required under [the National Environmental Policy Act ("NEPA")], an environmental assessment prepared in connection with the transmission line;

D. if required under NEPA, an environmental impact statement and record of decision or a finding of no significant impact, prepared in connection with the transmission line;

E. if preparation of a federal environmental assessment or environmental impact statement is not required under NEPA in connection with the transmission line, then a report, comparable to an environmental impact statement, in the format prescribed in 40 C.F.R. Section 1502.10;

F. all written federal, state, and local environmental authorizations necessary to begin construction, and necessary to begin operation, of the transmission line; if any such authorization cannot be obtained until after construction of the transmission line, proof of application for such authorization;

G. testimony demonstrating that the transmission line will not unduly impair important environmental values; important environmental values include, but are not limited to,

(1) preservation of air and water quality;

(2) preservation of land uses, soils, flora and fauna; and

(3) preservation of water resources, mineral resources, socioeconomic resources, cultural resources, historic resources, religious resources, visual resources, geologic resources, and geographic resources.

H. the expected date that the transmission line will be in-service;

I. proof that the application has been served on all local authorities in each county and township where the transmission line will be located, the New Mexico Attorney General, the New Mexico Environment Department, and the New Mexico State Engineer;

J. any other information, including photographs, which the applicant wishes to submit in support of the application.

Q. Does the Transmission Project comply with the requirements of 17.9.592.10 NMAC?

A. Yes, the Application and supporting testimony and exhibits demonstrate that the Transmission Project complies with the requirements under 17.9.592.10 NMAC.

VI. THE APPLICANT WILL ASSURE THAT THE TRANSMISSION LINE DOES NOT UNDULY IMPAIR IMPORTANT ENVIRONMENTAL VALUES

Q. Has the Applicant evaluated the Transmission Project's potential impacts on the factors the Commission may consider in determining whether the location of a transmission line will unduly impair important environmental values?

A. Yes. As part of our responsibilities to the Applicant, we have reviewed the factors provided in NMSA 1978, § 62-9-3(M), 17.9.592.10 NMAC, and additional factors, including existing plans for development of the proposed location; fish, wildlife, and plant life; noise levels; interference with communication signals; availability for recreational purposes; scenic, historic, cultural or religious sites and structures or archaeological sites; cemeteries and burials; schools; aviation; soils; minerals and mining; geologic and paleontological resources; roads; and geographic resources. The Applicant considered each of these factors with respect to the Transmission Project. The Environmental Report provides further information on each of these resource areas. The protection measures included in the Environmental Report provide detailed measures for resource impact avoidance and minimization that provide further evidence of the minimal impacts expected from the Transmission Project. Many of these protection measures are reflected in the BMPs, which would be implemented in the construction and operation of the Project.

Q. Please summarize the impact of the Project on air resources.

A. Given the limited, localized, and temporary nature of emissions associated with Project construction, operation, and maintenance, including implementation of the protection measures described above, the Project is not expected to result in significant adverse impacts to air resources or unduly impair air resources. During the construction of the Project, the contractors and the equipment being used will be required to comply with all applicable emission standards. To the extent required, state and county air quality permits will be obtained by the Project prior to construction. The Project will implement numerous protection measures to reduce potential impacts to air resources during construction activities, as detailed in the Environmental Report.

Q. Please summarize the impact of the Project on water resources.

A. The Project is not expected to result in substantial adverse impacts to water resources. Temporary construction-related effects, such as localized erosion, sedimentation, or accidental spills, would be minimized through implementation of best management practices and protective measures, a Project-specific Stormwater Pollution Protection Plan, spill prevention measures, and site reclamation. With route refinement, appropriate permitting, and adherence to applicable water quality protection requirements, the Project is not expected to unduly impair surface waters, wetlands, floodplains, or groundwater resources.

Q. Please summarize your findings with respect to land uses.

A. The lands crossed by the ROW are primarily used for farmland, rangeland, and recreational resources. Long-term land use impacts on rangeland would primarily result from structure placement, ROW maintenance, and access roads. Current agricultural practices would be maintained for most of the ROW. Areas of pasture within the ROW could continue to be grazed. The only land that would be unavailable for agricultural use would be the relatively limited areas occupied by transmission structures, which would be approximately three feet to five feet in diameter at ground level, depending on the type of structure.

During construction and maintenance activities, agricultural lands would be subject to temporary impacts. Depending on the time of year, access for construction may result in damage to crops, compaction and rutting of soil, restrictions on access to the ROW, and restrictions on general agricultural practices in and around the ROW (such as prescribed burning of grassland pasture). Landowners would be compensated for crop and forage loss, and damaged soils would be restored to arable condition. Cattle may need to be relocated or confined away from the ROW areas of pasture during construction. Following completion of construction, disturbance and disruption to agricultural activities would generally cease. Periodic maintenance activities and emergency repairs would result in impacts similar to

those for construction. However, these activities would be infrequent over the life of the Project.

In addition to the ROW, multiple temporary laydown areas for construction material and equipment would be necessary for the duration of construction. These laydown areas would each be up to 20 acres in size. Where feasible, construction laydown areas are typically located at previously disturbed or developed locations such as vacant lots, existing utility yards, or parking lots to reduce impacts to sensitive resources. If existing yard locations are not available, preferred locations for yards would be undeveloped areas that are cleared of woody vegetation, flat, have all-weather access, and do not contain streams, wetlands, or other environmentally sensitive resources. No topsoil would be removed, and minimal, if any, regrading is expected to take place at these facilities. Laydown areas generally would be returned to pre-construction conditions upon completion of construction.

Based on the compatibility of the ROW with the current land uses, impacts to land uses would be largely temporary and limited in area during construction. The majority of the Project area would remain in its pre-construction use. With inclusion of the protection measures detailed in the Environmental Report, it is not expected that the proposed location of the ROW would unduly impair land use resources.

Q. Please summarize your efforts to avoid and minimize impacts of the Transmission Project with respect to flora and fauna.

A. Based on the limited amount and quality of habitat present for sensitive species, as well as the protection measures that the Applicant will implement, it is not expected that the Project would unduly impair biological resources. Direct effects during the construction phase include removal of vegetation and wildlife habitat, however these impacts would be short-term and low impact. There are fifteen related protection measures that Applicant has committed to implement identified in the Environmental Report at PNM Exhibit IE-4.

Q. Did the Project evaluate the impact on soil resources?

A. Yes. Based on the implementation of standard best management practices for erosion control, soil stabilization, and spill prevention, as well as the limited extent of permanent soil disturbance, the Project is not expected to result in substantial adverse impacts to soil resources.

Q. What impact will the Project have on paleontological resources?

A. Construction activities, including excavation, grading, and access road development, have the potential to affect previously undiscovered paleontological resources where fossil-bearing geologic units are present. Implementation of the protection measures identified in the Environmental Report, including

paleontological monitoring, worker training, and avoidance and discovery protocols where appropriate, would avoid, minimize, and mitigate potential impacts to paleontological resources. As a result, impacts to paleontological resources are expected to be minor and would not result in the undue impairment of important environmental values.

Q. Please summarize your findings with respect to noise impacts.

A. Based on compliance with applicable noise standards and implementation of the protection measures identified in the Environmental Report, combined with the localized, low-intensity, and temporary nature of construction- and maintenance-related noise, the Project is not expected to result in substantial adverse noise. Operational noise from the transmission line would be minimal and limited primarily to occasional corona noise under certain environmental conditions. Operational noise was also a factor considered in determining the appropriate ROW width for the Project, as described in the testimony and exhibits of PNM witness Greg Parent. Accordingly, the Project is not expected to create a significant noise burden or unduly impair important environmental values related to noise.

Q. Will the Transmission Project interfere with communication signals?

A. The Project is designed to avoid interference with communication pathways. Signaling structures that were identified within the Transmission Study Corridor

are listed in Section 3.14.2 of the Environmental Report in PNM Exhibit IE-4. The Project will avoid signaling structures to the extent practicable. Additionally, the Project will implement two protection measures. Transmission structures will be sited to maintain adequate separation from fixed broadcast, retransmission, or reception antennae used for radio, television, wireless telecommunications, and other communication systems, thereby avoiding potential safety hazards in the event of electrical equipment, structure, or conductor failure. Transmission structures will also be sited to minimize electromagnetic interference with signal transmission and reception.

Q. Will the Transmission Project impact recreational uses?

A. No direct or indirect impacts on state or county recreation lands, local parks, trails, or hunting access lands would occur as a result of the construction, operation, and maintenance of the ROW. Existing recreational opportunities would continue as they currently exist, with minor temporary disturbances possible during construction.

Q. What visual impact will the Project have?

A. New transmission structures, conductors, substation components, and cleared ROW areas would change the visual characteristics in the vicinity and the viewshed of the Transmission Project. However, the Transmission Project would not

significantly differ from other existing transmission lines and substations in the vicinity. Segments of the Project that would be co-located with the existing WL 115 kV line would also have the benefit of consolidating the visual impacts of what would otherwise be two distinct transmission lines and ROWs in the same visual landscape. As such, the Project would not unduly impair visual resources.

Q. What impact will the Project have on historic and archaeological resources?

A. As previously described, Pattern takes extensive precautions to minimize impacts to cultural resources such as historical and archaeological resources. Construction, operations, and maintenance impacts are generally low or avoidable for archaeological and historic-age cultural resources. Potential impacts to known cultural resources are anticipated to be minimal, as Project facilities would be sited and designed to avoid identified resources where practicable. Prior to the commencement of construction activities, intensive cultural resource surveys would be completed on federal lands, New Mexico State Land Office lands, and, to the extent practicable, high probability areas on privately-owned land. The results of these surveys would be used to identify cultural resources and support impact avoidance and minimization efforts. Any inadvertent or unanticipated discoveries made during construction would be managed through coordination with the appropriate federal and state agencies and in accordance with applicable

regulatory requirements, which would be outlined in a Project-specific Unanticipated Discoveries Plan ("UDP").

Q. Will the Transmission Project impact religious resources, cemeteries or burials?

A. No religious sites or cemeteries were identified within the proposed ROW, though unknown or abandoned religious sites may exist within the ROW. Prior to the commencement of construction activities, intensive cultural resource surveys would be completed on federal lands, New Mexico State Land Office lands, and, to the extent practicable, high probability areas on privately owned land in order to identify previously unrecorded religious and cemetery sites and reduce potential impacts from the Project. If sites are identified at the location of planned infrastructure, micrositing techniques will be used to avoid sites to the greatest extent practicable. The Project will follow a UDP, thereby providing protection upon discovery of unknown or unanticipated sites anywhere within the Project during construction.

Q. Will the Transmission Project adversely affect geologic resources?

A. The ROW traverses an area characterized by Permian-age sedimentary bedrock, shallow caliche-bearing soils, localized volcanic features, and generally limited geologic hazards. Existing geologic conditions that could influence Project design

and construction include localized steep slopes, landslide-prone terrain, flooding and erosion hazards, and potential karst-related subsurface features.

Portions of the ROW traverse areas of steep terrain and mapped landslide susceptibility, particularly between the Manzano and Los Pinos Mountains and near El Cerro de Los Lunas. Construction activities within these areas could require additional grading, slope stabilization measures, or specialized foundation design. During operation, transmission structures located on steeper slopes may be more susceptible to long-term stability concerns if site-specific geotechnical considerations are not incorporated into final design. These potential effects can be minimized through route refinement, engineering design, and implementation of appropriate construction practices.

Q. Will the Transmission Project adversely affect roads?

A. Potential impacts to roads would be the greatest during construction, with construction equipment and temporary increases in traffic having the potential to degrade existing road conditions. Existing roads used for Project construction would be maintained and, where affected by construction activities, restored to a condition generally equal to or better than their pre-construction condition, to the extent practicable and in accordance with landowner agreements. Fences, gates, cattleguards, and other improvements damaged during construction would be

repaired or replaced in coordination with the affected landowner. Temporary gates would be installed only with landowner approval and would be removed or restored to pre-construction conditions following completion of construction unless otherwise agreed upon.

Protection measures will be implemented to reduce impacts from the Project's construction activities. These will include documenting pre-construction conditions to facilitate restoration after construction has concluded, entering into agreements with the New Mexico Department of Transportation and local governments concerning use of the roadways, and establishment of speed limits for the roads.

Q. Will the Project adversely affect schools or educational resources?

A. No. There would be no direct or indirect impacts of the construction, operation, and maintenance of schools, as most schools and daycare facilities are all greater than a half mile from the Project. The nearest school, Gil Sanchez Elementary School, is approximately a half mile south of the ROW in Jarales. Therefore, it is not expected that the proposed location of the ROW would unduly impair school or educational resources.

Q. Did you evaluate potential impact to socioeconomic resources from the Project?

A. Yes. The Environmental Report, included as PNM Exhibit IE-4, discusses the impact on socioeconomic resources from the Project. Socioeconomic impacts associated with the construction, operation, and maintenance of the Project were evaluated based on population characteristics, employment and income, labor force participation, educational attainment, housing, public services, and local and regional economic conditions. The Project will result in minor short-term adverse effects during the construction process and long-term beneficial socioeconomic effects, including increased employment and income. Construction related disruptions would be temporary and localized. Overall, the Project will contribute to local and regional economic activity without displacing any existing activities.

Q. Please discuss whether the Project will pose any hazard from radioactive waste or other radiation hazards.

A. The transmission lines and associated Project facilities do not generate, create or hold radioactive waste or any radioactive hazards.

Q. Will the Project have any potential impacts due to the use of hazardous materials?

A. During construction, there is a risk of accidental releases of fuel, lubricants, or other automotive fluids. While such incidents are possible, they would be infrequent, limited in scope, and temporary in duration, and therefore anticipated to result in

minor to negligible impacts. The Project would prepare and implement a Spill Prevention, Control, and Countermeasure Plan, which would outline procedures for employee training, equipment inspection, maintenance and repair, availability of spill response materials, and refueling protocols, with an emphasis on spill prevention. All construction-related waste, including trash, solid waste, petroleum products, and other potentially hazardous materials, would be collected and transported on a weekly basis to a facility licensed and authorized to accept such materials.

Q. Has the Applicant identified protection measures to avoid and manage impacts of the resources you have discussed?

A. Yes. As discussed previously, there will be numerous protection measures implemented throughout the life of the Transmission Project. These protection measures are included in the Environmental Report and mirror those implemented by Pattern for numerous transmission and generation projects previously approved by the Commission.

Q. Please summarize your conclusions.

A. The Transmission Project has been developed and will be constructed and operated with the implementation of a robust set of scientific studies, BMPs, and protection measures. Further, in light of the robust practices set out above, the Transmission

Project will not unduly impair important environmental values. In the event of any unanticipated discoveries during the construction process, the information will be provided to Staff and mitigation measures will be agreed upon and implemented to mitigate any burden to an important environmental value.

VII. LAND USE, LAND OWNERSHIP, AND COMPLIANCE WITH LAND USE STATUTES AND ADMINISTRATIVE REGULATIONS

Q. Please describe the existing land ownership and land use on the Project.

A. The lands used in the Project are privately held, owned by the State of New Mexico, or by the United States. The lands crossed by the ROW are primarily used for farmland, rangeland, and recreational resources. The table below summarizes the length of the ROW over different landowners in both feet and miles best known at the time of this filing.

Landowner	Feet	Miles
Private	440,095.7	83.4
New Mexico State Land Office ("NMSLO")	87,303.2	16.5
United States Forest Service ("USFS")	11,189.3	2.1
Middle Rio Grande Conservancy District ("MRGCD")	1,620.0	0.3
New Mexico Department of Wildlife ("NMDOW")	1,537.6	0.3
New Mexico Department of Transportation ("NMDOT")	742.6	0.1
Bureau of Land Management ("BLM")	120.3	0.02
Total	**542,608.7**	**102.8**

The portions of the Project crossing the USFS, MRGCD, NMDOW, and BLM lands would be co-located with the existing WL 115 kV line.

Q. Will these uses continue following construction of the Transmission Project?

A. Yes. Ranching activities will continue since the land needed for the Project takes up very little footprint. Also, the easements with both the private landowners and the State of New Mexico do not restrict the owners from continuing ranching or farming activities. As previously mentioned, there will be no impact on state or county recreation lands, local parks, trails, or hunting access lands as a result of the construction, operation, and maintenance of the ROW.

Q. In summary, will the Transmission Project violate any existing state, county, or municipal land use statutory or administrative regulation?

A. No. Applicable land use statutes are identified in Appendix C of the Environmental Report.

VIII. COMPLIANCE WITH THE LOCATION RULE

Q. Does the application comply with 17.9.592.10 NMAC?

A. Yes, as follows:

A. We have provided a description of the Transmission Project, including;

(1) its location and a map to the required scale;

(2) identification of private, state, and federal land ownership crossed by the Transmission Project and the number of feet the Transmission Project will cross over each;

(3) the total length of the Transmission Project in feet;

(4) a description of the Transmission Project interconnection facilities;

(5) representational schematic diagram showing the transmission line and the interconnection of the transmission line to the existing grid.

B. We have identified all applicable land use statutes and administrative regulations in my testimony and in Appendix C of the Environmental Report. As explained in my testimony, there are no applicable zoning regulations in Torrance, Socorro, or Valencia Counties. Portions of the Project on state trust or federal lands are not subject to county zoning.

C. The Transmission Project does not require an environmental assessment under NEPA;

D. The Transmission Project does not require an environmental impact statement and record of decision or a finding of no significant impact under NEPA;

E. The Environmental Report was prepared for the Applicant in the format prescribed by 40 C.F.R. § 1502.10.

F. All written federal, state, and local environmental authorizations necessary to begin construction or operation of the Transmission Project are described in Appendix C of the Environmental Report.

G. As explained in the Environmental Report and as summarized in my testimony, the Transmission Project will not unduly impair important environmental values, including resources associated with air and water quality, flora and fauna, water, land uses, visual and scenic, cultural, historic, and archaeological, religious, geological and paleontological, soils, mineral, socioeconomic, roads, noise, and communication.

H. My testimony states that the Transmission Project is expected to be online by the end of 2029.

I. The Application will be served on all local authorities in Torrance, Socorro, and Valencia Counties in New Mexico, the New Mexico Attorney General, the New Mexico Environment Department, and the New Mexico Office of the State Engineer.

J. The Application provides additional information to facilitate the Commission's decision-making on the Applicant's request for location approval of the Transmission Project.

IX. CONCLUSION

Q. Please summarize your testimony.

A. The Applicant has provided a comprehensive environmental impact analysis for the Transmission Project. The comprehensive analysis presented demonstrates that the Project satisfies all statutory and regulatory requirements of the Commission.

Q. Does this conclude your direct testimony?

A. Yes.

GCG#535982

Ian Evans Educational Background and Relevant Employment Experience

PNM Exhibit IE-1

Is contained in the following 1 page.

Ian Evans

EDUCATIONAL AND PROFESSIONAL SUMMARY

Name: Ian Evans

Address: Pattern Energy Group
888 Westheimer Road, Suite 350
Houston, Texas, 77006

Position: Senior Manager, Environmental

Education: Bachelor of Arts in Conservation Biology, Middlebury College, 2010

Relevant Employment:

Employed by Pattern Energy since 2019

- Senior Manager, Environmental (2025 – Present)
- Environmental Manager (2021 – 2025)
- Natural Resources Environmental Associate (2019 – 2021)

Renewable Energy Wildlife Institute

- Research Program Manager (2017 – 2019)
- Research Associate (2013 – 2017)

Testimony:

Before the New Mexico Public Regulation Commission

Docket 26-0000111	JOINT APPLICATION FOR THE LOCATION APPROVAL OF THE CORONA WIND NORTH II PROJECT AND FOR THE RIGHT-OF-WAY WIDTH APPROVAL

Transmission Project and Transmission Study Corridor Mapbook

PNM Exhibit IE-2

Is contained in the following 29 pages.





Transmission Centerline
County Boundary
Map Index (1 inch = 1,500 ft)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor

0 10 20
Miles





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 1 of 28

0 2,000 4,000
US Feet

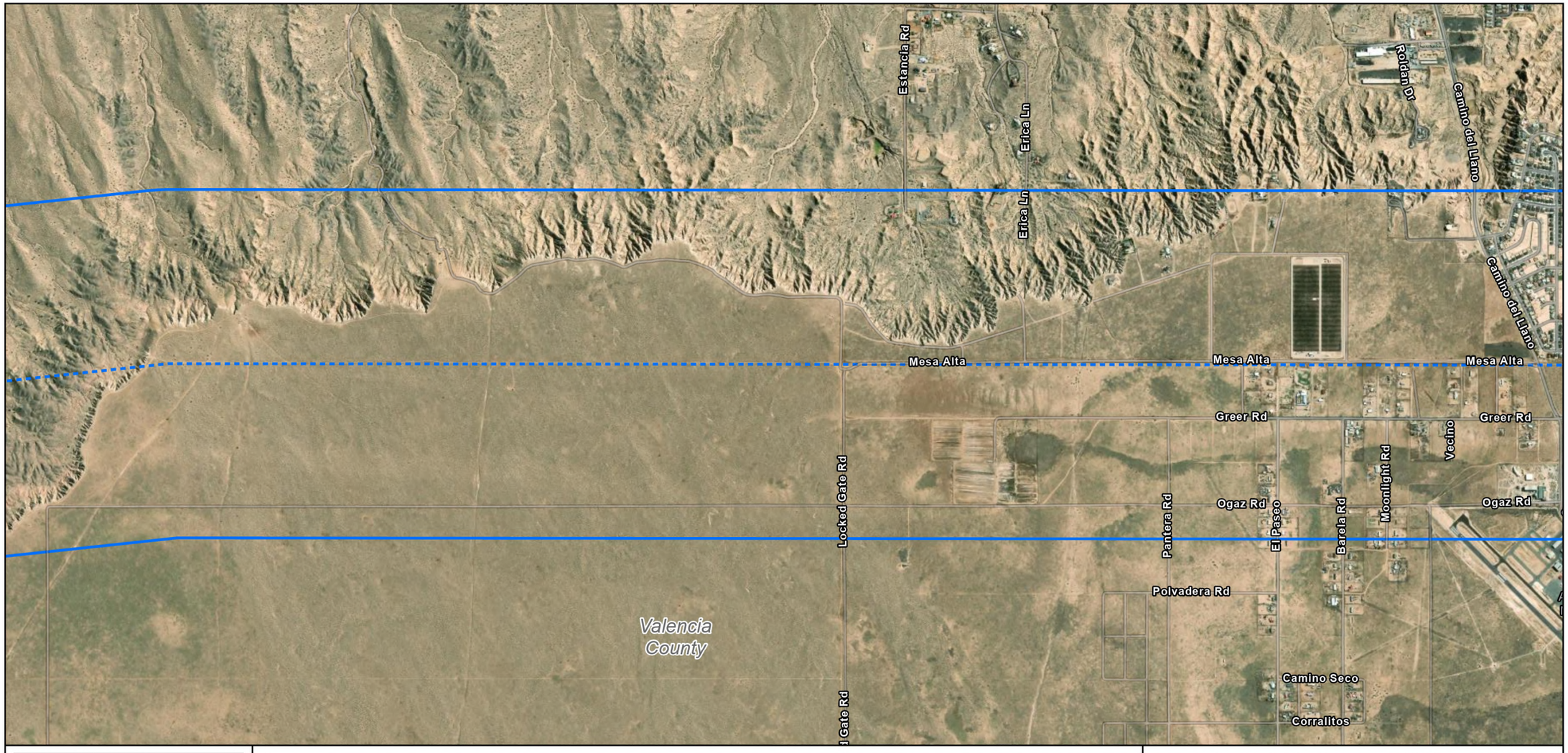


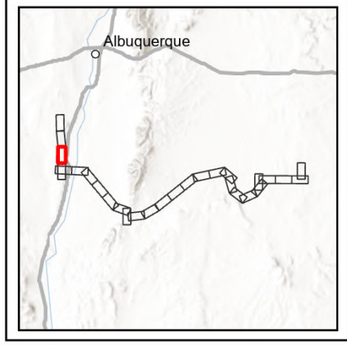
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 2 of 28

0 2,000 4,000
US Feet





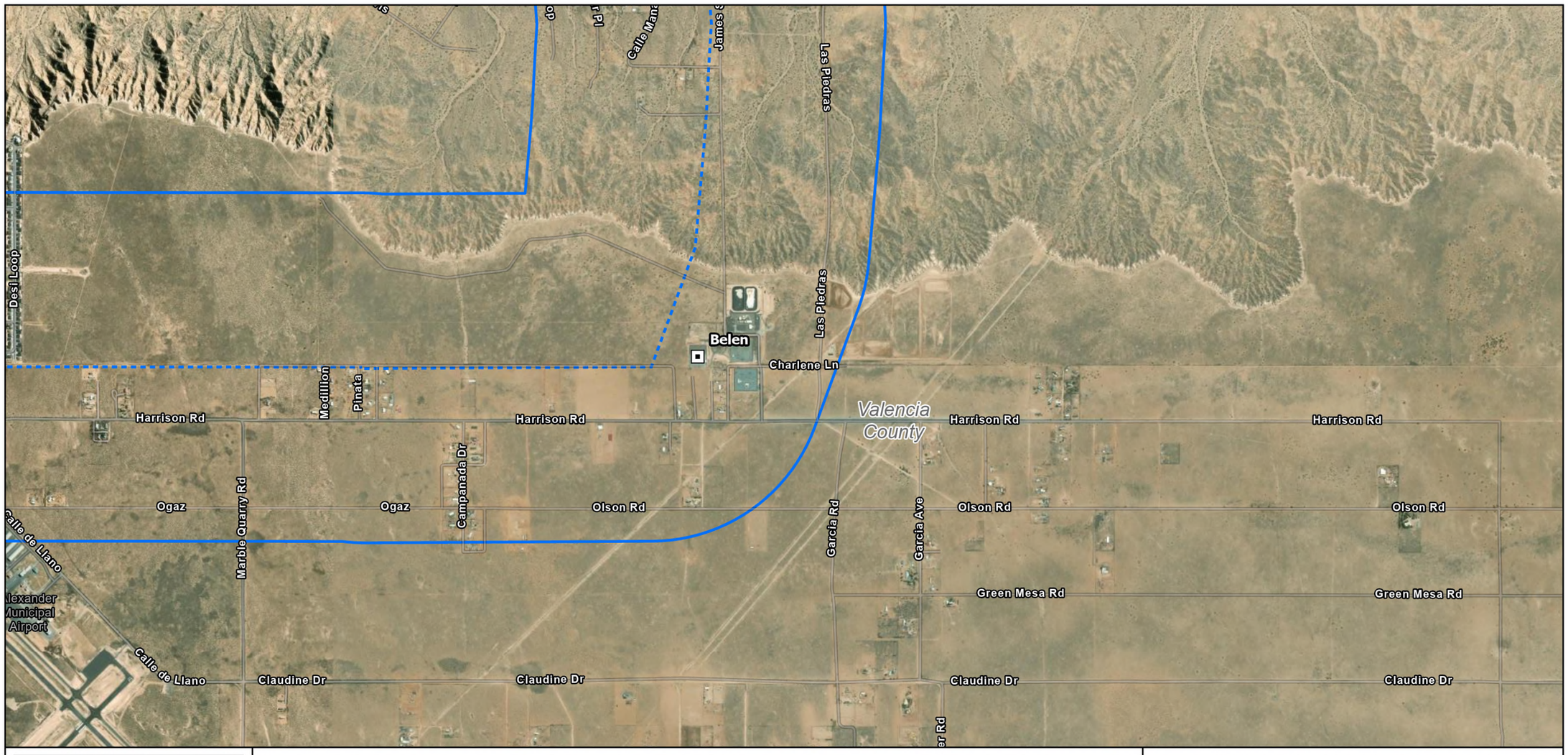
Project Components

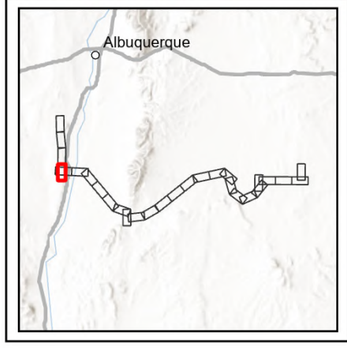
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 3 of 28

0 2,000 4,000
US Feet





Project Components

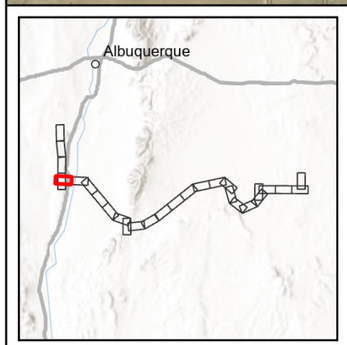
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 4 of 28

0 2,000 4,000
US Feet





Project Components

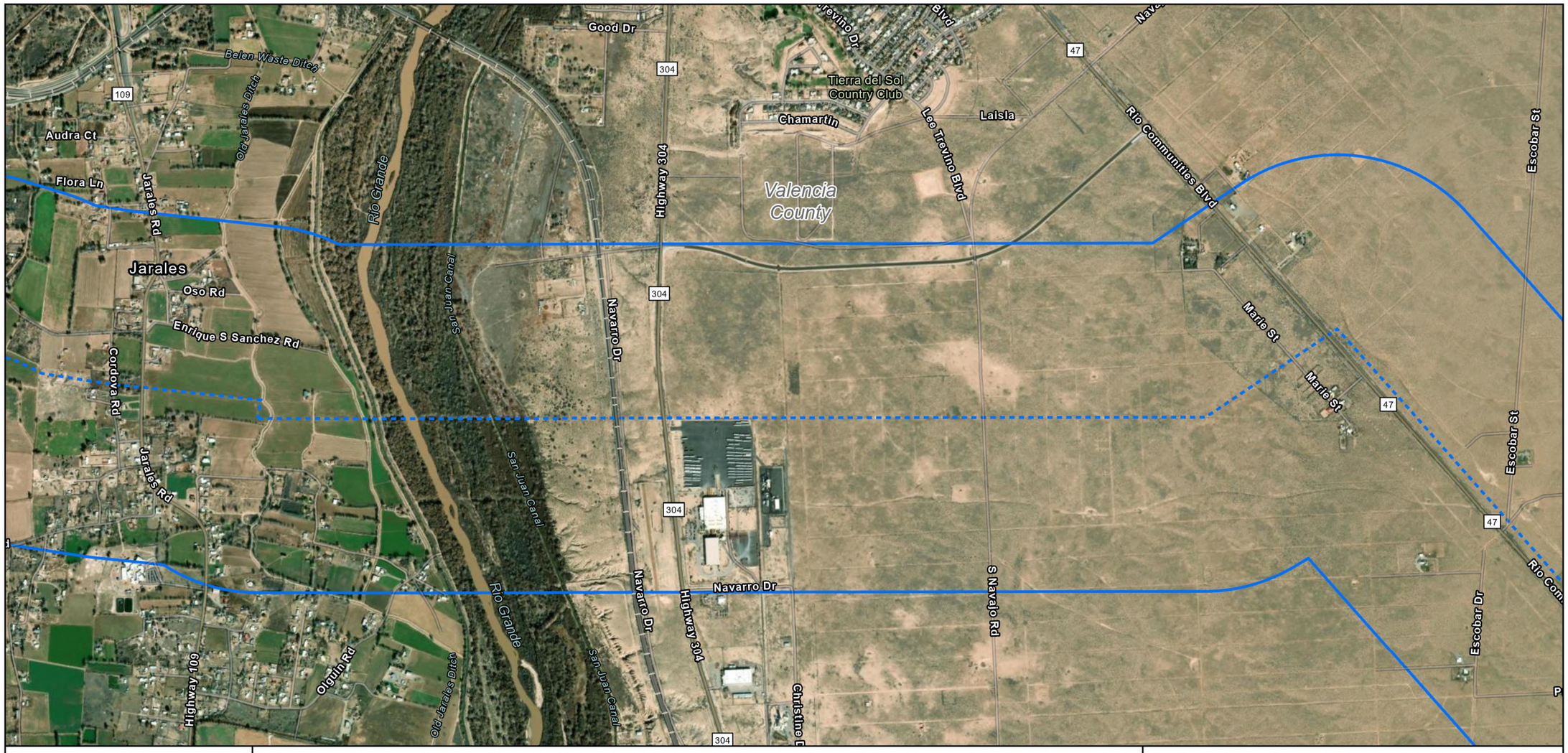
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

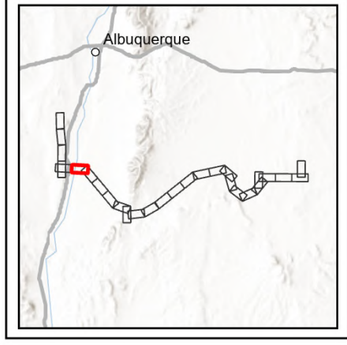
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 5 of 28

0 2,000 4,000

US Feet





Project Components

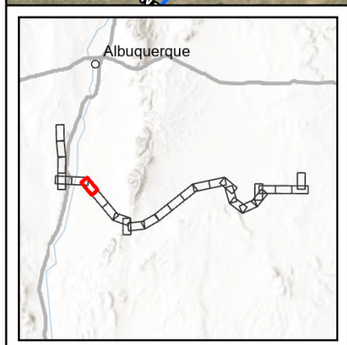
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 6 of 28

0 2,000 4,000
US Feet





Project Components

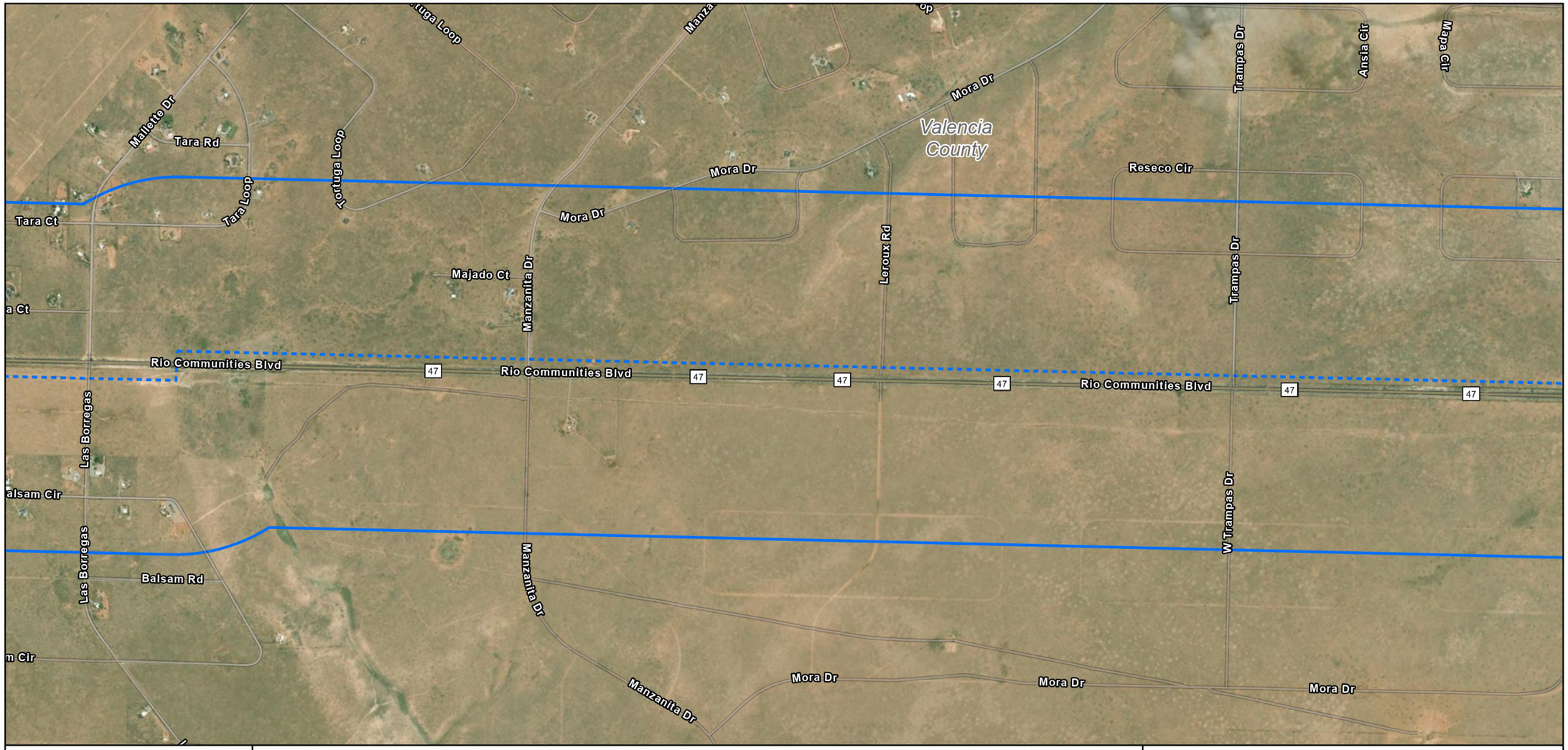
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

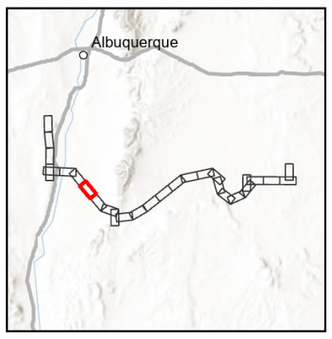
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 7 of 28

0 2,000 4,000

US Feet



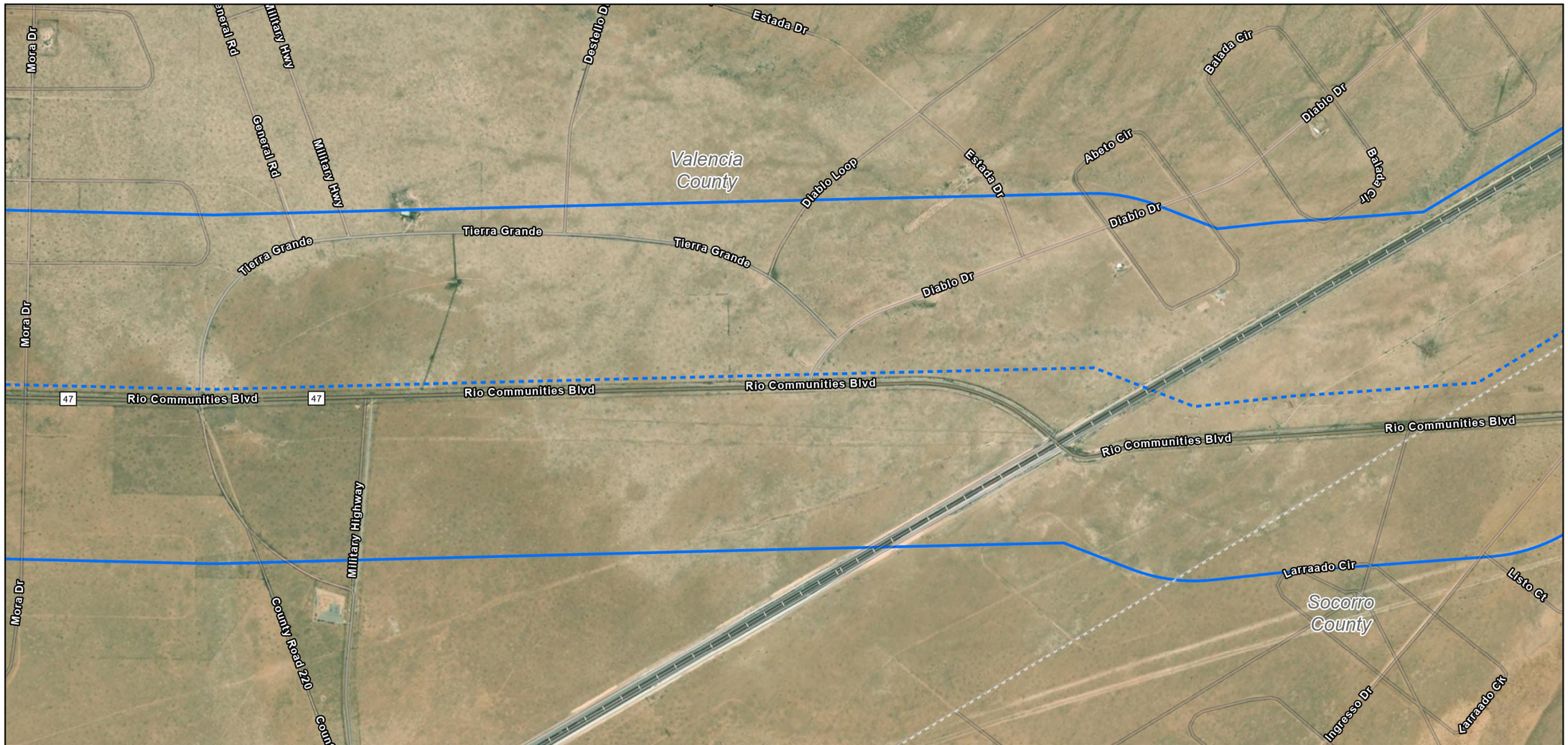


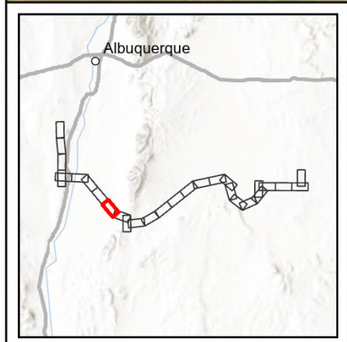
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 8 of 28

0 2,000 4,000
US Feet



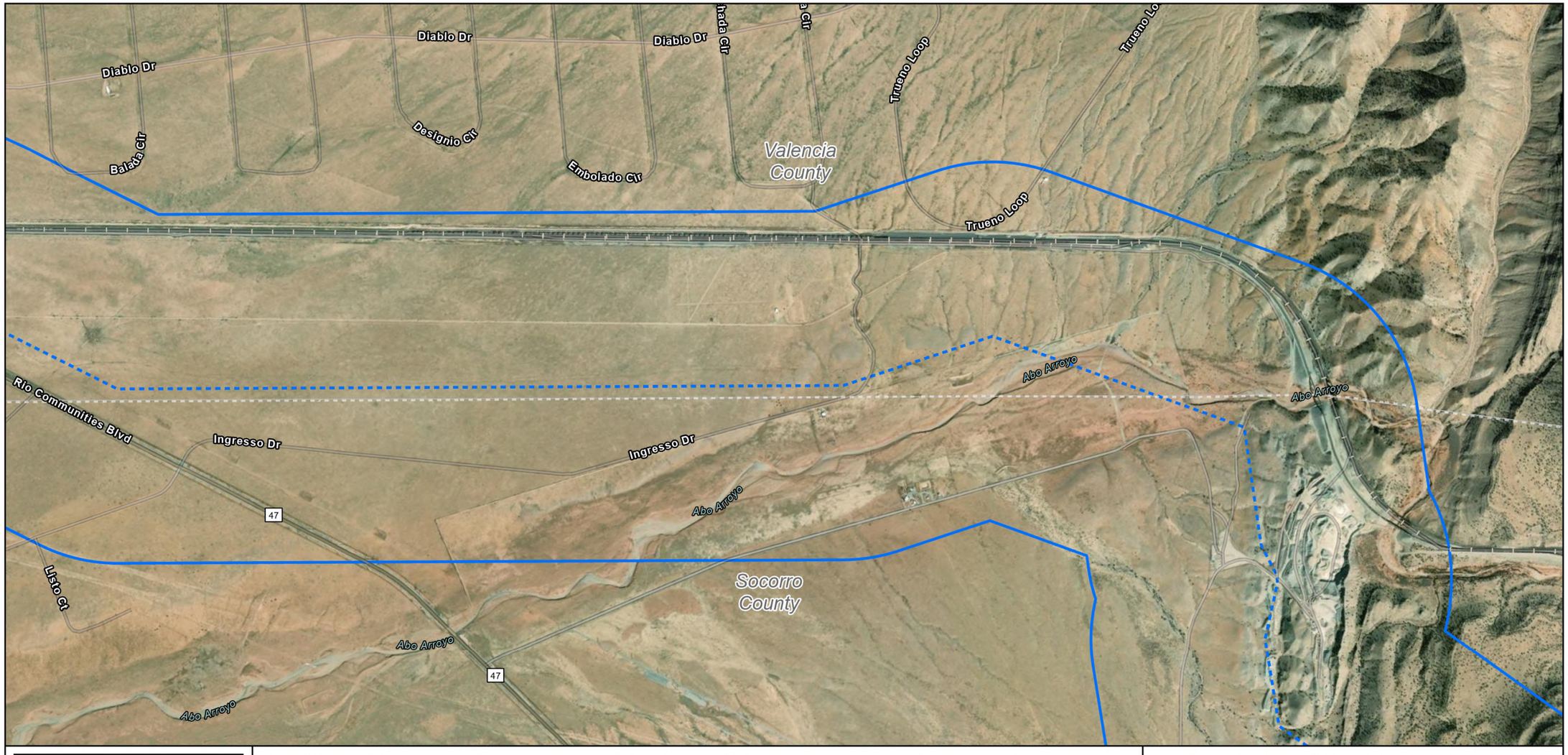


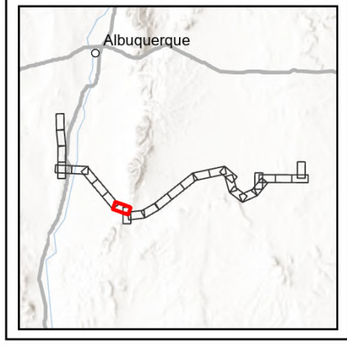
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 9 of 28

0 2,000 4,000
US Feet





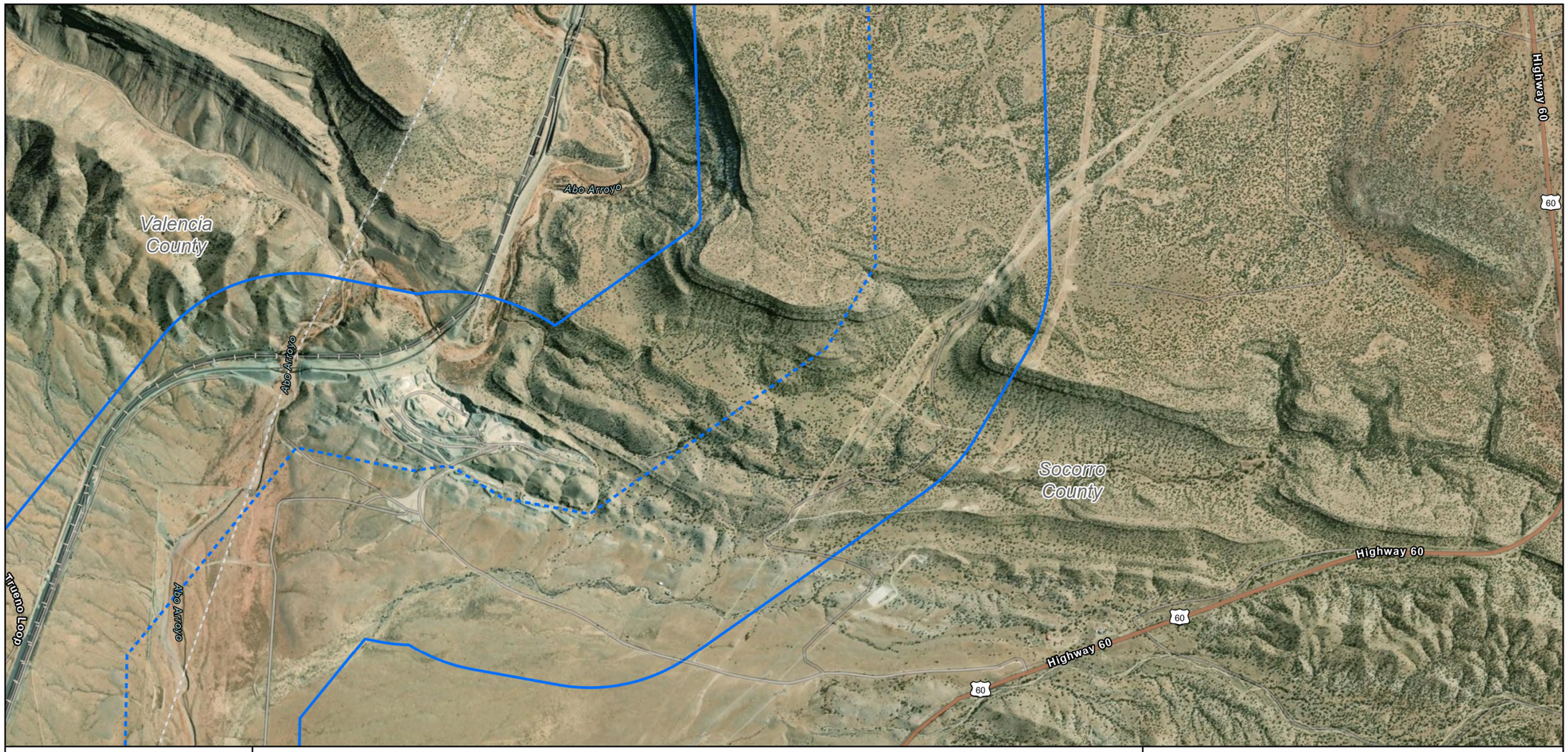
Project Components

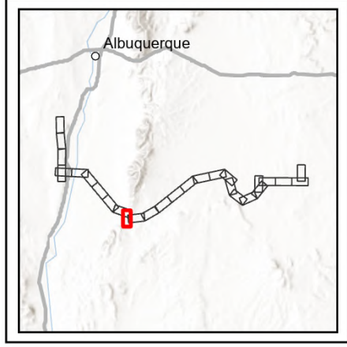
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 10 of 28

0 2,000 4,000
US Feet





Project Components

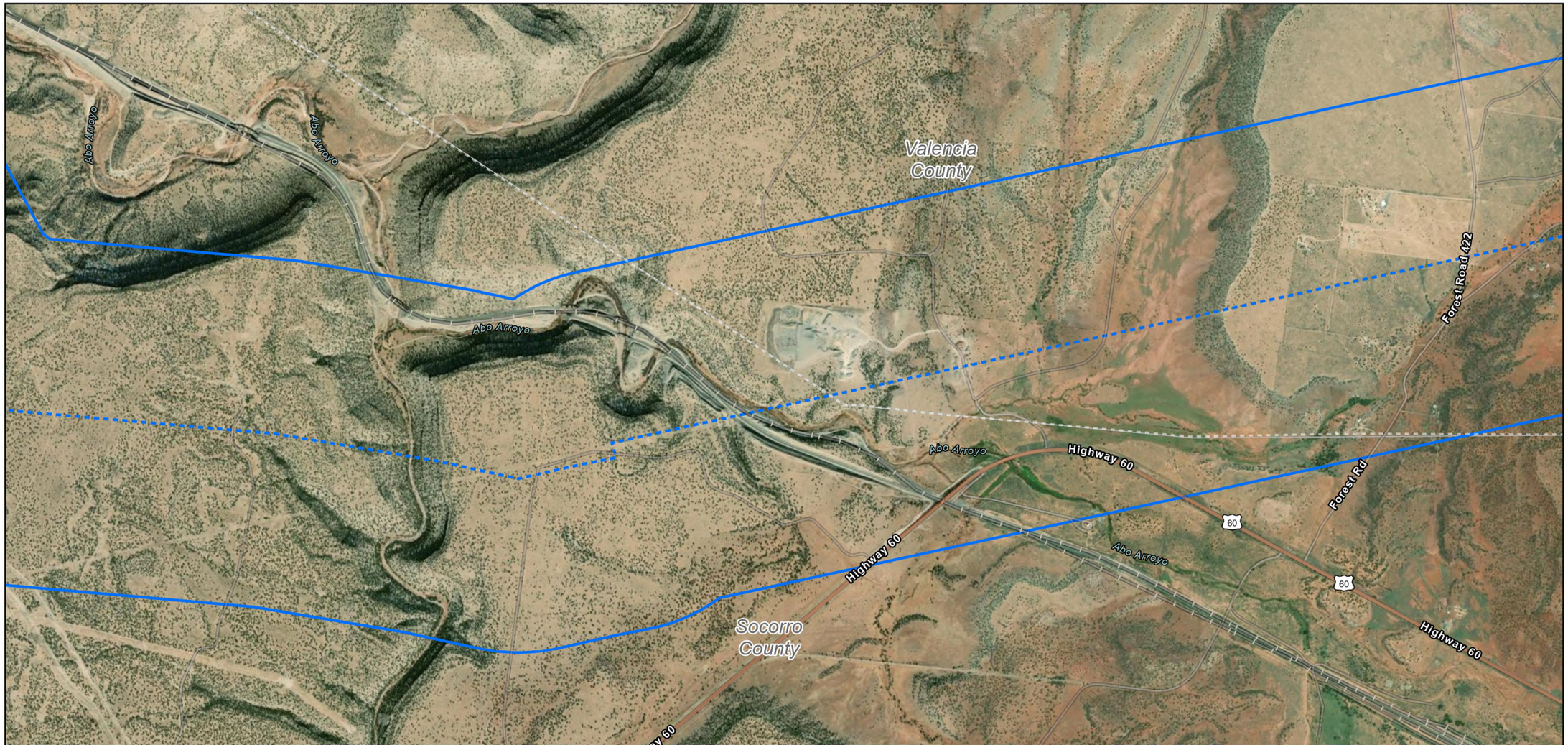
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

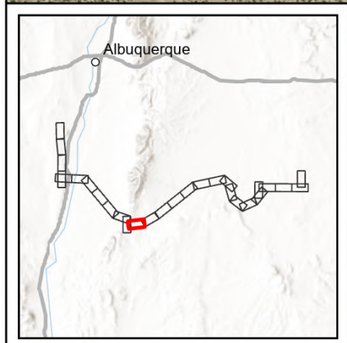
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 11 of 28

0 2,000 4,000

US Feet



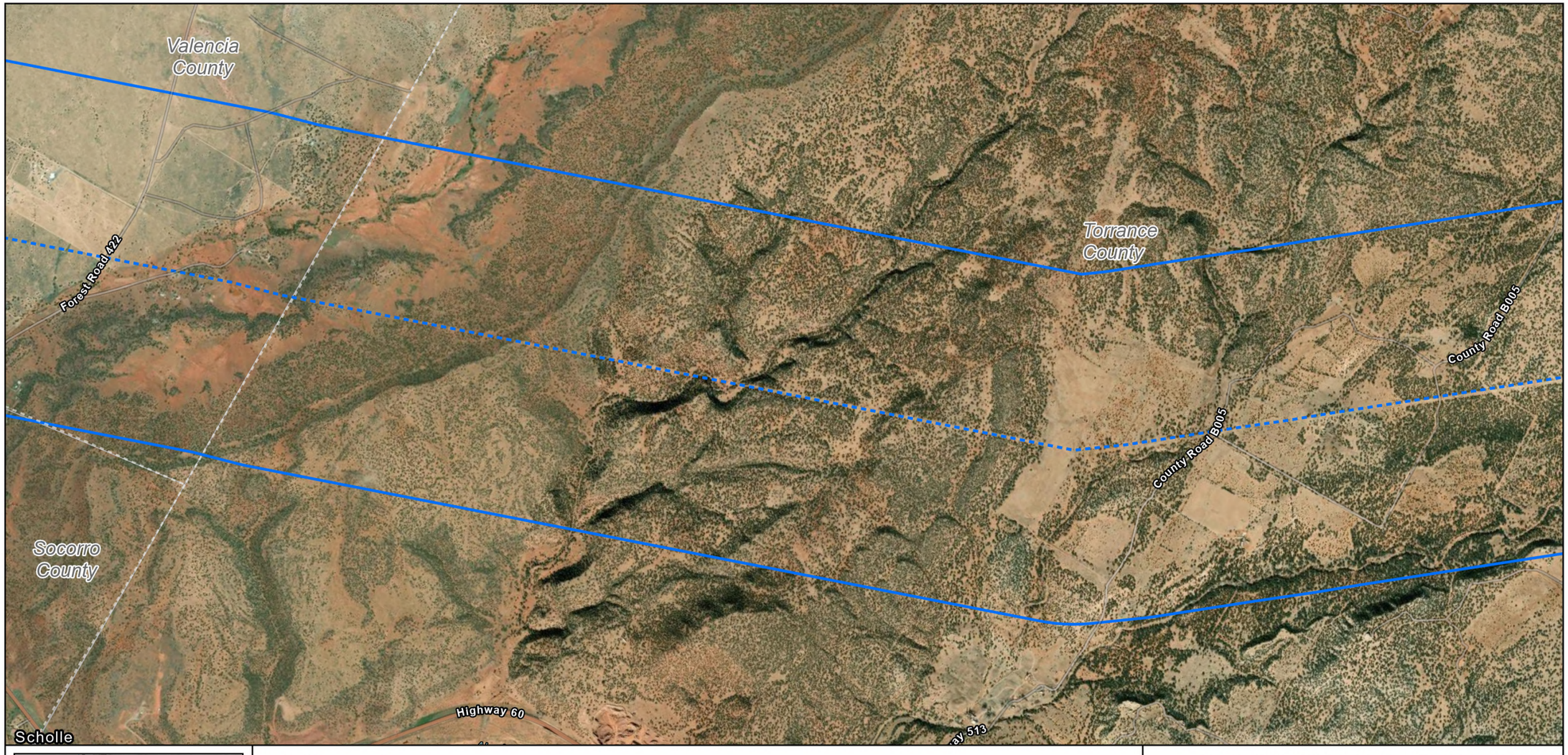


Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

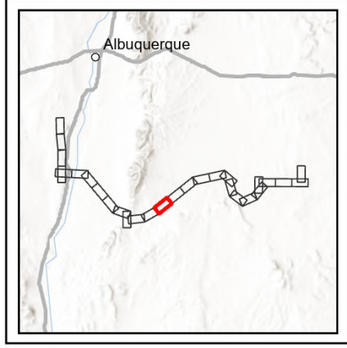
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 12 of 28

0 2,000 4,000
US Feet


Valencia County
Torrance County
Socorro County
Scholle
Forest Road 422
County Road B005
County Road B005
Highway 60
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
MID-STATE TRANSMISSION PROJECT
Transmission Project and Transmission Study Corridor
Page 13 of 28
0
2,000
4,000
US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

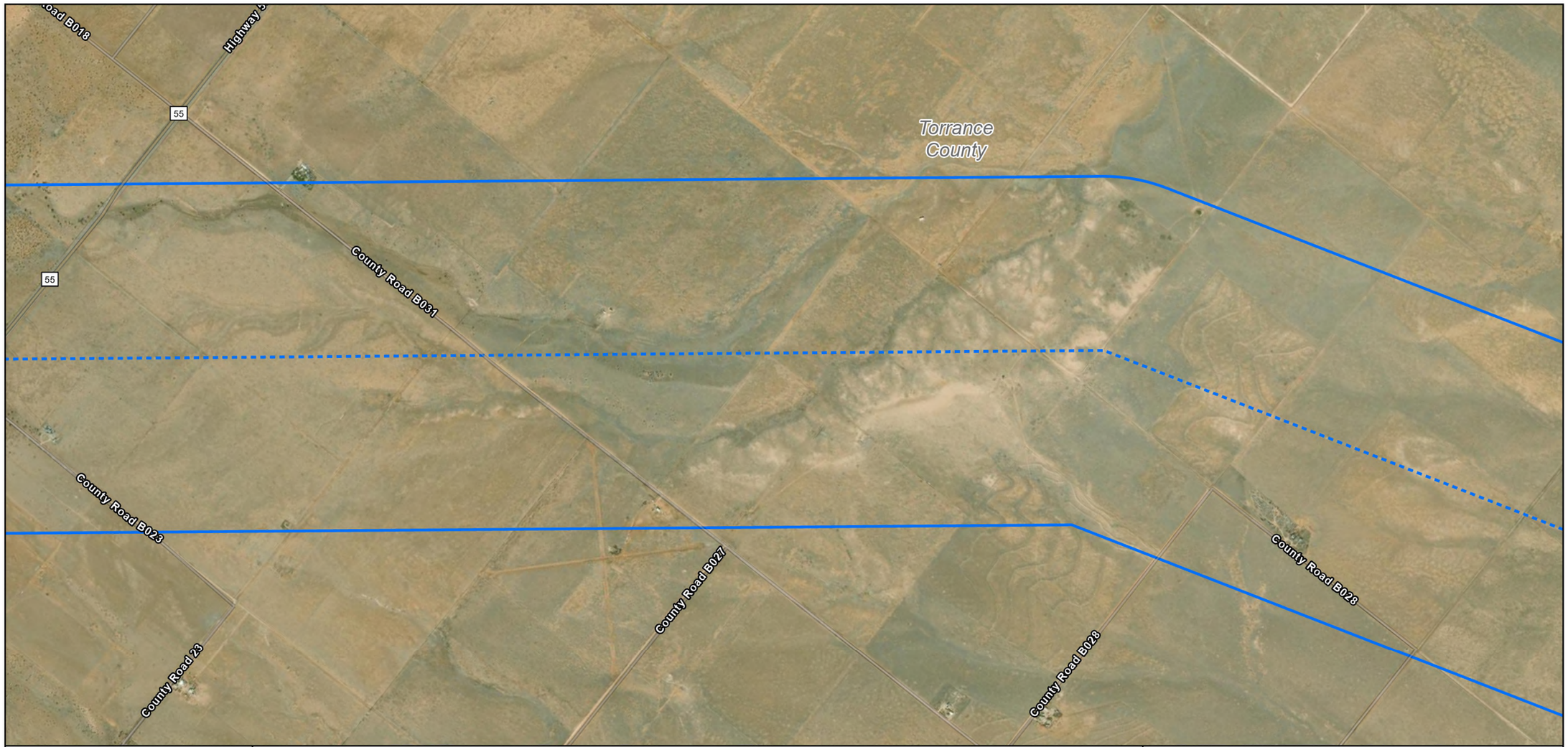
MID-STATE TRANSMISSION PROJECT

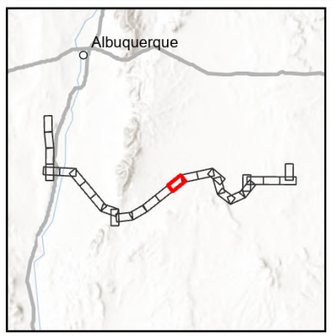
Transmission Project and Transmission Study Corridor
Page 14 of 28

0 2,000 4,000

US Feet


Torrance County
County Road B024
County Road B039
County Road B023
County Road B024
County Road B023
Highway 55
55
County Road B021
County Road B013
County Road B086
County Road B024
County Road B021
Highway 55
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
MID-STATE TRANSMISSION PROJECT
Transmission Project and Transmission Study Corridor
Page 15 of 28
0
2,000
4,000
US Feet





Project Components

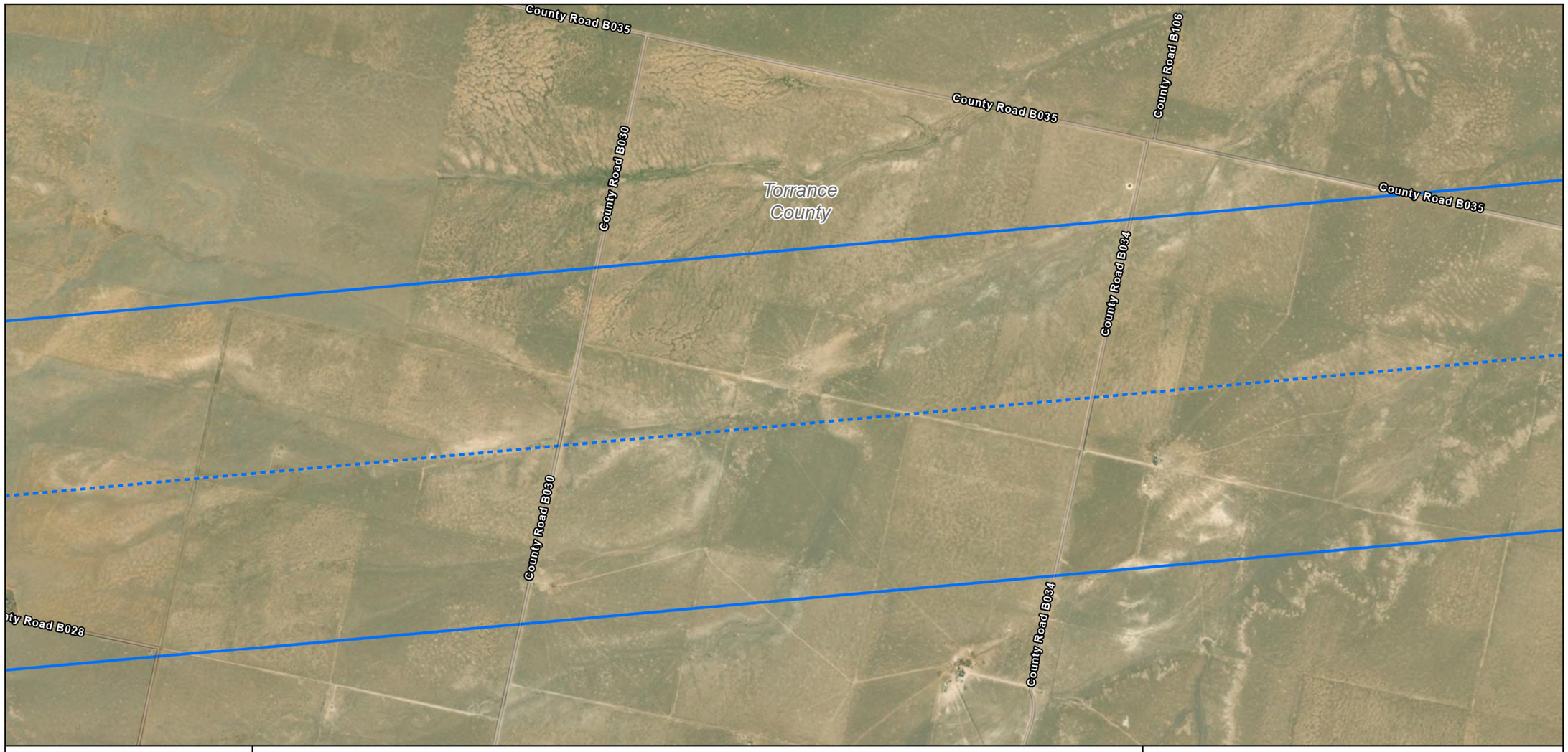
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

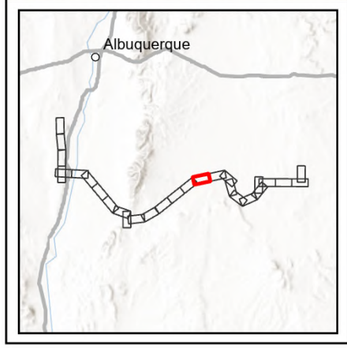
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 16 of 28

0 2,000 4,000

US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

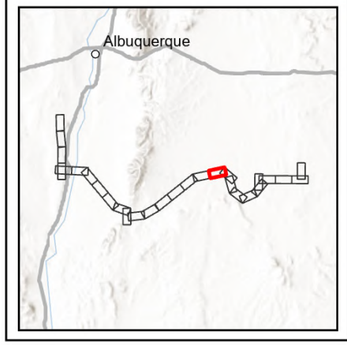
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 17 of 28

0 2,000 4,000

US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

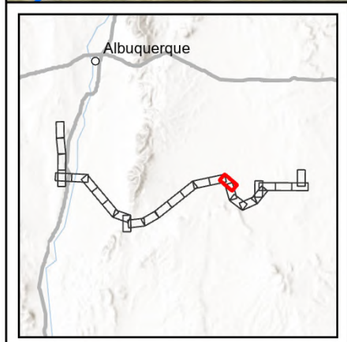
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 18 of 28

0 2,000 4,000

US Feet



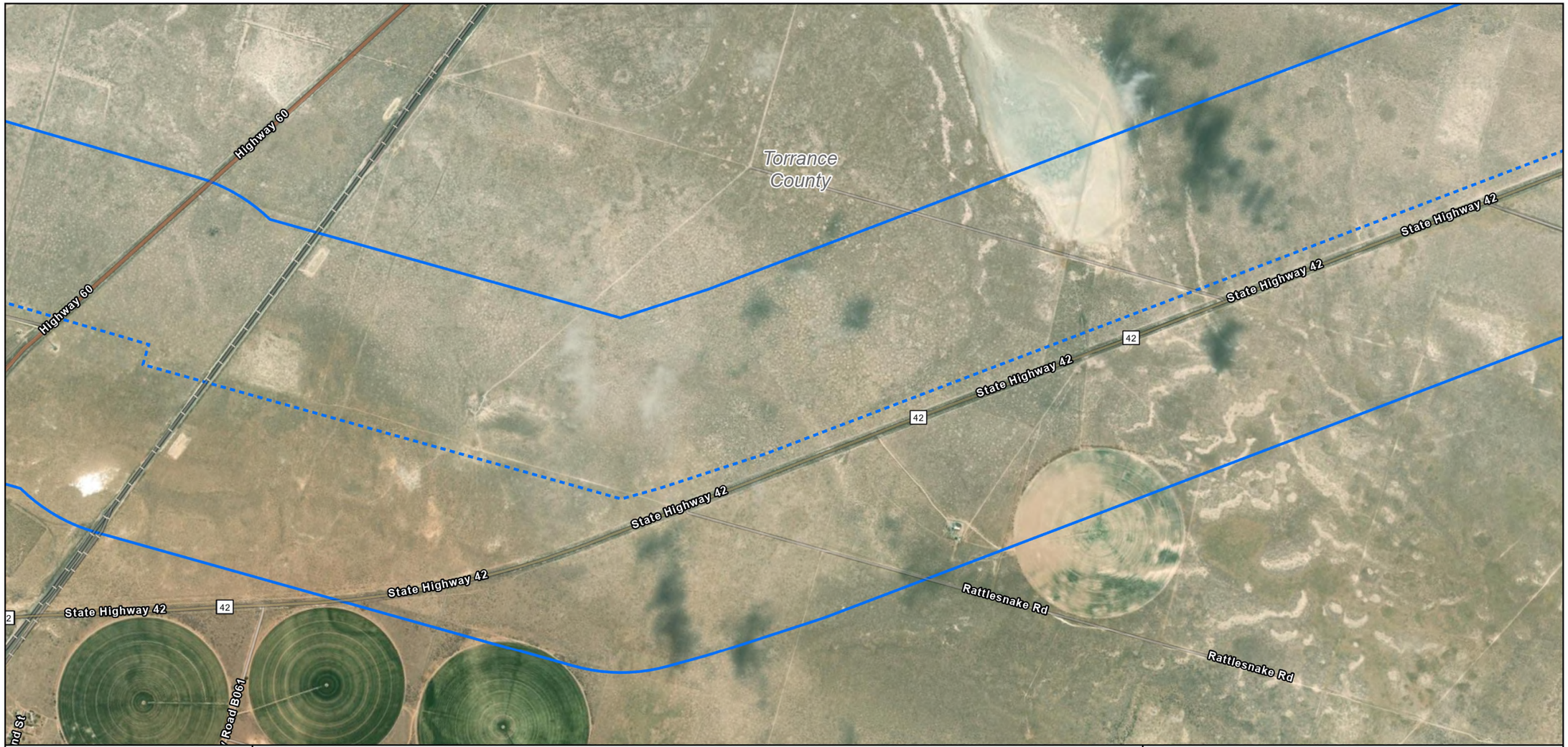


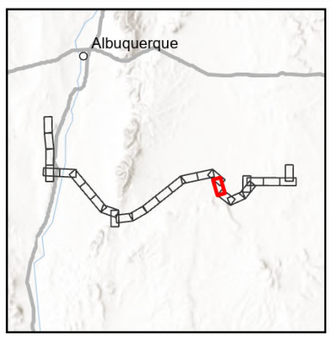
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 19 of 28

0 2,000 4,000
US Feet





Project Components

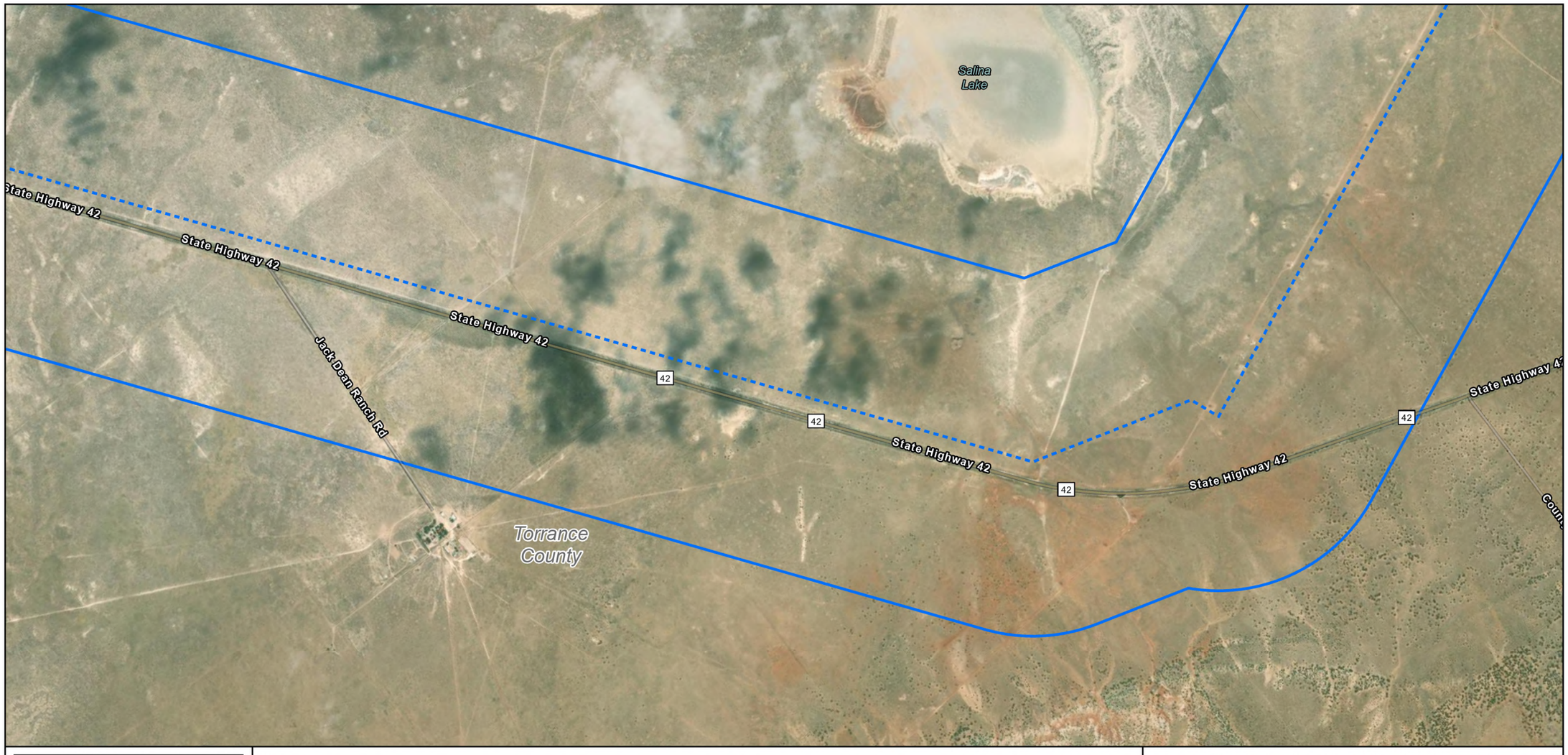
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

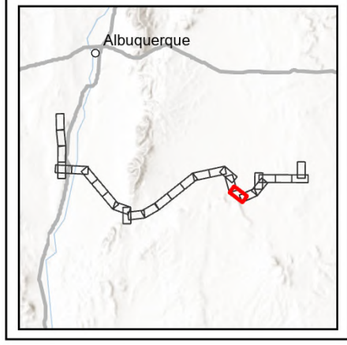
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 20 of 28

0 2,000 4,000

US Feet



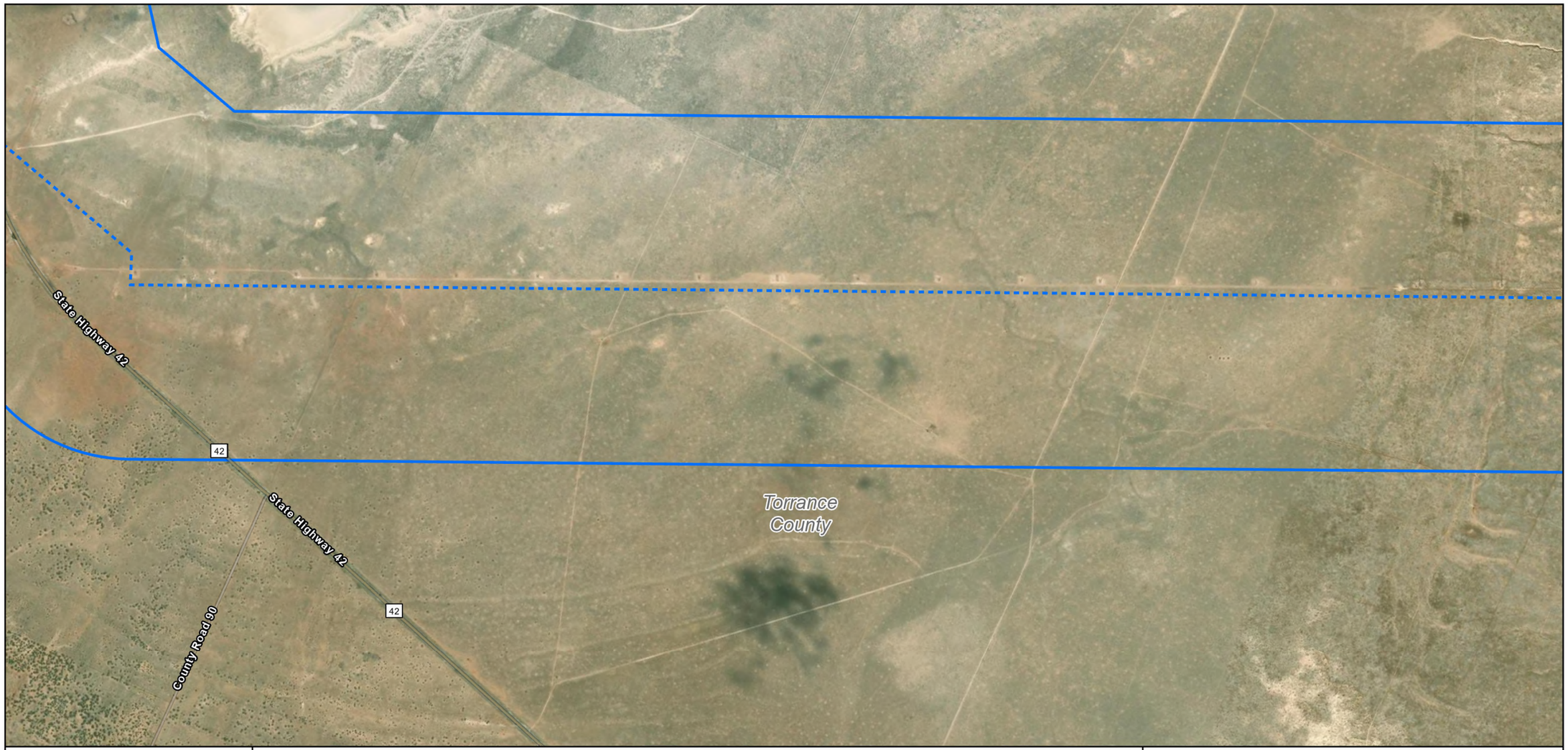


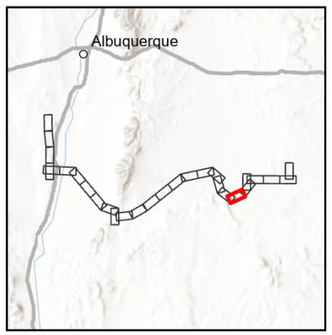
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 21 of 28

0 2,000 4,000
US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

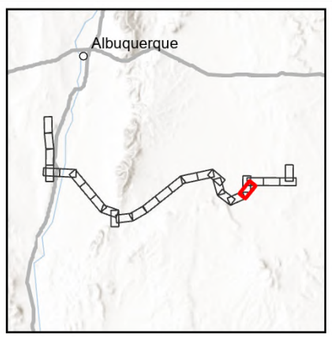
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 22 of 28

0 2,000 4,000

US Feet





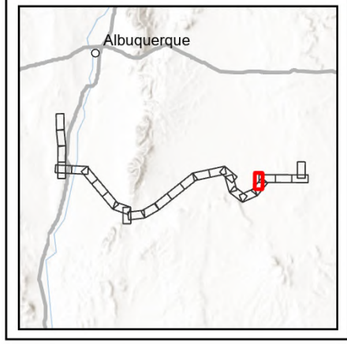
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 23 of 28

0 2,000 4,000
US Feet



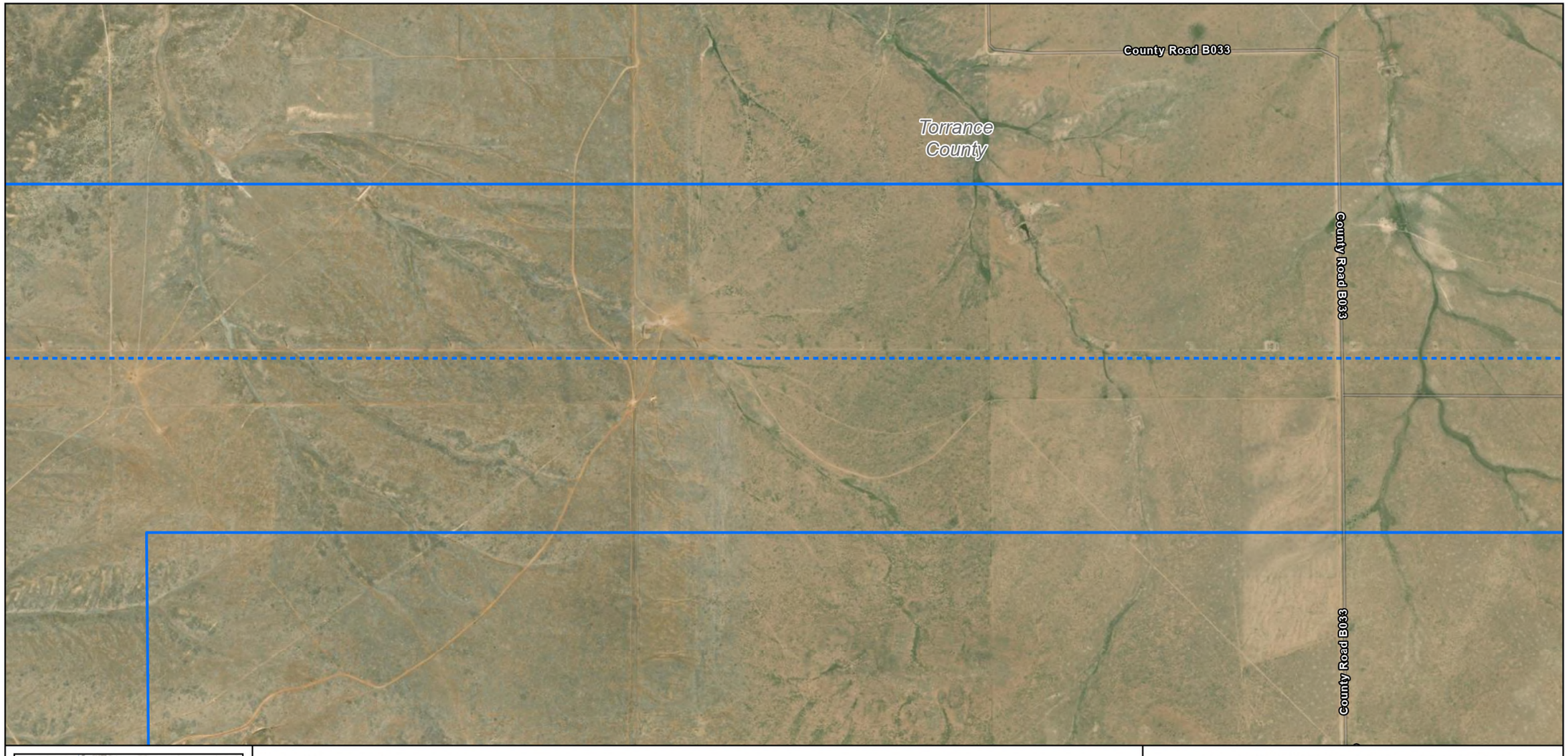


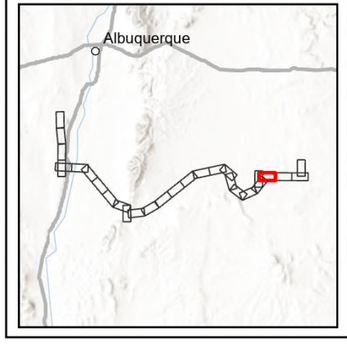
Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 24 of 28

0 2,000 4,000
US Feet





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 25 of 28

0 2,000 4,000
US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

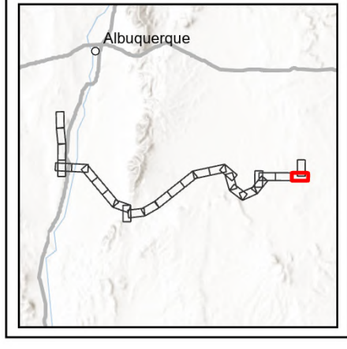
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 26 of 28

0 2,000 4,000

US Feet





Project Components

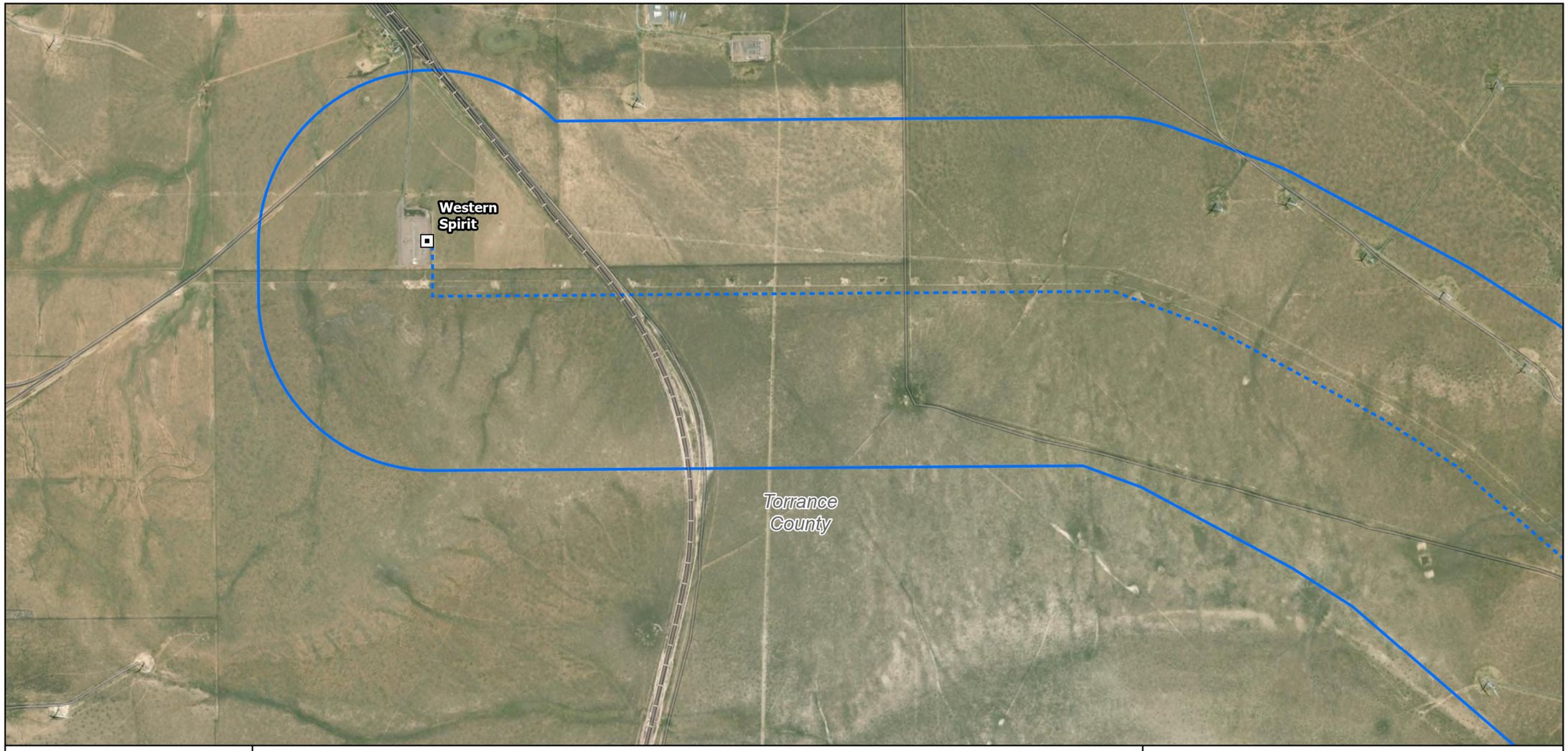
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

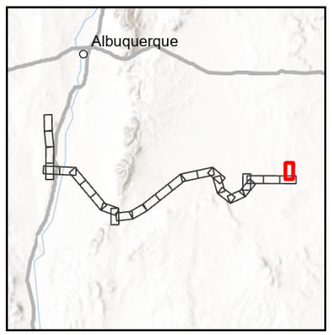
MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 27 of 28

0 2,000 4,000

US Feet





Project Components

- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

MID-STATE TRANSMISSION PROJECT

Transmission Project and Transmission Study Corridor
Page 28 of 28

0 2,000 4,000

US Feet

Reducing Avian Collisions with Power Lines

PNM Exhibit IE-3

Is contained in the following 184 pages.

Reducing Avian Collisions with Power Lines



The State of the Art in 2012

Edison Electric Institute
Power by Association
Avian Power Line Interaction Committee

THIS PAGE INTENTIONALLY LEFT BLANK

Reducing Avian Collisions with Power Lines

The State of the Art in 2012

Prepared by:

Avian Power Line Interaction Committee

October 2012





Additional copies of this book may be obtained through:

the Avian Power Line Interaction Committee (www.aplic.org) and the Edison Electric Institute (www.eei.org).

This book should be cited as follows:

Avian Power Line Interaction Committee (APLIC). 2012. *Reducing Avian Collisions with Power Lines: The State of the Art in 2012.* Edison Electric Institute and APLIC. Washington, D.C.

Cover photos copyright © (from left to right): Florida Fish and Wildlife Conservation Commission (transmission lines), Greg Forcey (great blue heron [Ardea herodias]*), Jerry Liguori (American white pelican* [Pelecanus erythrorhynchos]*), Jerry Liguori (Canada geese* [Branta canadensis] *flying over power lines), and Laura C. Williams (whooping crane* [Grus americana]*).*

Section header photos copyright © Jerry Liguori (Chapters 1 through 6), U.S. Fish and Wildlife Service (Chapter 7), Greg Forcey (Appendix A), Jerry Liguori (Appendices B, C, D, and E).

© 2012 by the Edison Electric Institute (EEI).
All rights reserved. Published 2012.
Printed in the United States of America.

No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system or method, now known or hereinafter invented or adopted, without the express prior written permission of the Edison Electric Institute.

Published by:
Edison Electric Institute
701 Pennsylvania Avenue, N.W.
Washington, D.C. 20004-2696
Phone: 202-508-5000
Website: www.eei.org

Attribution Notice and Disclaimer

This work was prepared by the Avian Power Line Interaction Committee (APLIC) for the Edison Electric Institute (EEI). When used as a reference, attribution to APLIC is requested. APLIC, any member of APLIC, and any person acting on its behalf (a) does not make any warranty, express or implied, with respect to the accuracy, completeness, or usefulness of the information, advice, or recommendations contained in this work and (b) does not assume and expressly disclaims any liability with respect to the use of or for damages resulting from the use of any information, advice, or recommendations contained in this work.

The views and opinions expressed in this work do not necessarily reflect those of APLIC, EEI, or any member of APLIC or EEI. This material and its production, reproduction, and distribution by EEI does not imply endorsement of the material.

CONTENTS

Abstract		xi
Foreword		xv
Acknowledgements		xvii
Dedication: Richard "Dick" S. Thorsell (1927–2012)		xix
Chapter 1	**Introduction**	1
	Purpose and Scope of the Manual	1
	Reader Guide to the Manual	3
	Overview of Power Lines	4
	Perspectives for Dealing with Bird Collisions	10
Chapter 2	**Progress in Dealing with Collision Issues**	13
	North America	13
	International	17
	Future Research Priorities	19
Chapter 3	**Avian Regulations and Compliance**	21
	Overview of Existing Laws and Policies	21
	Permit Requirements	26
Chapter 4	**Understanding Bird Collisions**	29
	Susceptibility of Birds to Power Line Collisions	30
	Identifying Collision Mortality	30
	Variability in Reported Mortality Rates	31
	Biological Significance of Collision Mortality	32
	Biological Characteristics Influencing Avian Collision Risks	36
	Environmental Conditions Influencing Avian Collision Risks	46
	Engineering Aspects Influencing Avian Collision Risks	50
Chapter 5	**Minimizing Collision Risks**	53
	Opportunities for Minimizing Collision Risks	53
	Modifying Existing Power Lines	54
	Planning New Power Lines	64
	Public Participation to Address Social and Cultural Issues	72

CONTENTS

Chapter 6	**Line Marking to Reduce Collisions**	75
	Overview of Line Marking Devices	75
	Effectiveness of Designs	77
	Marking Constraints and Considerations	80
	Line Marking Devices	85
	Large Diameter Wire	100
Chapter 7	**Avian Protection Plans**	103
	Overview of Avian Protection Plans	103
	Components of an Avian Protection Plan	104
	Creating and Implementing an Avian Protection Plan	109
Appendix A:	**Literature Cited and Bibliography**	111
Appendix B:	**Designing Site-Specific Studies for Collision Monitoring**	137
	Considerations for Site-Specific Collision Monitoring	138
	Issues Related to Estimating Mortality Rates	143
Appendix C:	**Glossary**	147
Appendix D:	**Acronyms**	153
Appendix E:	**Resources**	155

ILLUSTRATIONS

FIGURE		PAGE
1.1	The highest wire on a transmission line is the shield wire, which can be difficult for birds, especially flocking birds such as waterfowl, to see.	2
1.2	Schematic of the electric power system from the generation facility to the customer (modified from Rural Utilities Service).	4
1.3	Transmission lines (left) and distribution lines (right).	4
1.4	Height comparison of transmission (typically 18.3 to 58 m [60 to 190 ft] tall) (A) and distribution structures (typically 6.4 to 14.6 m [21 to 48 ft] tall) (B).	5
1.5	Horizontal (A) and vertical (B) transmission line configurations.	5
1.6	Bundled phase conductors on a three-phase, single-circuit, 138-kV transmission line.	6
1.7	Distribution underbuild on a double-circuit transmission line.	6
1.8	Shield wires are the highest wires on a transmission line.	7
1.9	The neutral wire is usually positioned below the phase conductors on a distribution line.	7
1.10	Typical high voltage direct current transmission line structures.	8
1.11	Biologists gather data to assess the risk of bird collisions.	10
1.12	Engineers work with biologists to reduce risk through appropriate design and routing of power facilities.	11
1.13	Engaging the public may help a utility meet requirements for electrical reliability and reduce collision risk to birds.	12
2.1	APLIC has helped fund studies on the effectiveness of different types of line marking devices in reducing bird collisions with power lines.	14
2.2	In Canada, the first reported collision victims were snow geese.	16
2.3	Researchers have studied the effects of power line collisions on vulnerable species, such as the Ludwig's bustard of Europe, Asia, and Africa.	18
2.4	Because of the susceptibility of some endangered species, such as the whooping crane, power lines in these species' ranges require careful evaluation and routing.	19
2.5	APLIC, EPRI, and CEC are three organizations that provide some funding for research on avian/power line interactions.	20
3.1	The Migratory Bird Treaty Act of 1918 is the legal cornerstone of bird protection in the United States, protecting more than 1,000 North American bird species such as this cedar waxwing (*Bombycilla cedrorum*).	22

ILLUSTRATIONS

FIGURE		PAGE
3.2	Habitat Conservation Plans help landowners incorporate conservation measures for species, such as the wood stork (*Mycteria americana*), into their development plans.	23
3.3	Canada geese (*Branta canadensis*) are protected by both the Migratory Bird Treaty Act and Canada's equivalent, the Migratory Birds Convention Act.	24
3.4	Most songbirds, such as these horned larks (*Eremophilia alpestris*), are protected by the Migratory Bird Treaty Act.	26
3.5	Bald eagles are protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.	27
4.1	Collision risk is highly variable among species, with heavy-bodied birds, such as this common loon (*Gavia immer*), being more vulnerable because they cannot readily maneuver.	31
4.2	Because of their higher reproductive rates, common bird species are generally at less risk of population effects from power line collisions.	32
4.3	The United States' population of endangered whooping cranes has had such significant mortality from natural causes that additional power line collision mortality is now viewed as a threat to the species.	34
4.4	Whooping crane migration corridor in North America (2005 data from Stehn and Wassenich 2007).	35
4.5	Collision mortality has occurred with the expansion of the reintroduced population of the endangered California condor.	35
4.6	Wing loading and aspect ratio, among other factors, influence susceptibility to collisions (after Bevanger 1998).	36
4.7	Birds with high wing loading, such as swans, are more susceptible to collisions.	37
4.8	Flocking species, such as these snow geese, can be more vulnerable to collisions.	38
4.9	Aerial hunters that forage in flight within a couple hundred meters (several hundred feet) of the ground, such as swallows, can become collision victims.	39
4.10	Swans' poor frontal vision, along with their large size, increases their susceptibility to collisions.	40
4.11	Because they are nearsighted and fly at high speeds, mergansers may be unable to readily detect small diameter wires as they approach them.	41
4.12	Some juvenile birds, such as sandhill cranes, collide with power lines more frequently than their adult counterparts.	42
4.13	Endangered Newell's shearwater mortalities at a Kauai power line were mostly non-breeding adult and subadult birds.	42
4.14	Gulls (pictured) and waterfowl tend to make feeding flights at dusk and dawn, when reduced light increases collision risk.	43

ILLUSTRATIONS

FIGURE		PAGE
4.15	Power lines located between the foraging and roosting sites of wading birds, such as this white ibis *(Eudocimus albus)*, may result in higher collision risk.	45
4.16	Research conflicts on whether or not overhead wires within a single habitat, such as this wetland, are more likely to cause collisions than those between two habitats.	45
4.17	Power lines crossing agricultural fields with seasonally attractive crops or residue can contribute to collision risk for some flocking species, such as cranes, waterfowl, songbirds, and these trumpeter swans (*Cygnus buccinator*).	47
4.18	Birds usually initiate migration in favorable weather conditions, but when they encounter inclement weather they may decrease their flight altitude, which increases collision risk when power lines are present.	49
4.19	Orientation of power lines parallel to ridges or narrow, low altitude flyways presents a lower risk of collision than perpendicular orientation.	51
5.1	Opportunities and strategies for minimizing collision risks.	54
5.2	The Bird Strike Indicator, a tool used to detect bird strikes with power lines, can be installed from a bucket truck or helicopter.	57
5.3	Reducing collisions in wooded areas. A tree line or other obvious obstacle at the appropriate height warns birds to gain altitude, which results in birds flying over the power line screened by the trees (after Thompson 1978).	59
5.4	Habitat modifications, such as cooperative programs to encourage earlier plowing of grain stubble, which is attractive to migrating sandhill cranes, may help to reduce collision risk.	60
5.5	Removing shield wires can reduce bird collisions but leaves the lines unprotected from lightning strikes and jeopardizes service reliability.	61
5.6	Buried power lines may be a solution to bird collisions in some instances, but can cost from 3 to 20 times more than overhead lines and have other environmental impacts.	63
5.7	Conceptual model of avian collision risk assessment.	65
5.8	Schematic of the terminology used when planning new transmission lines.	67
5.9	Potential collision risk (A) has been reduced (B) when bird-use areas are on the same side of the line (modified from Thompson 1978).	68
5.10	Routing with respect to local topographic features (after Thompson 1978).	69
5.11	Reducing collisions by clustering lines in one right-of-way (after Thompson 1978).	70

ILLUSTRATIONS

FIGURE		PAGE
5.12	Collision risks for separate (A) and clustered (B) lines (after Thompson 1978).	71
5.13	Public participation programs may provide information through a public relations campaign, but they also go further to engage the public in discussions and decision making (after EEI 2001).	72
6.1	Studies at the San Luis National Wildlife Refuge show that the line marking devices tested work well for most species, the exception being the American coot, which is more vulnerable to collisions because it primarily flies at night.	79
6.2	A helicopter crew installing line marking devices on a power line.	81
6.3	Positioning of line marking devices on the central portion of two shield wires on transmission lines (after Eskom Transmission [South Africa] 2009).	83
6.4	Positioning of line marking devices on one shield wire or staggered on two parallel shield wires.	83
6.5	Line marking devices staggered on a distribution line.	83
6.6	When a device is added to a power line, it may add to the loading of the line, which further increases under icy or windy conditions and may also cause problems for deicing operations.	84
6.7	Power structures and line markers can become targets for vandalism and a detriment to service reliability. Public participation and outreach programs, like this hotline, may reduce vandalism.	85
6.8	Aerial marker spheres, also known as aviation balls, were designed to make power lines more visible to aircraft operators.	86
6.9	Aerial marker spheres in use on a power line above a wetland habitat.	86
6.10	Spiral vibration dampers act to reduce line vibration, and they also make power lines more visible to birds.	88
6.11	The Bird-Flight™ Diverter is a spiral device made of PVC.	89
6.12	Bird-Flight™ Diverters installed on a distribution line.	89
6.13	The Swan-Flight™ Diverter is a double-ended spiral device.	91
6.14	Swan-Flight™ Diverters installed on the phase conductors of a distribution line.	92
6.15	Examples of suspended devices (swinging and fixed).	94
6.16	The FireFly™ FF (left) has a swinging tag for use in light winds and the FireFly™ HW (right) has a fixed tag to withstand higher, sustained winds.	95
6.17	BirdMark BM-AG (After Glow) in daylight (left) and darkness (right).	96
6.18	Hanging strips of neoprene, such as this Spanish-made Baliza Avifauna, are being used as line marking devices in Europe and South Africa.	97

ILLUSTRATIONS

FIGURE		PAGE
6.19	Baliza Avifauna installed on a power line in Europe.	97
6.20	The Avifaune Spiral is commonly used in France and other parts of Europe.	98
6.21	Avifaune Spirals installed.	98
6.22	The Mace Bird Lite is a spiral device with a central fluorescent tube that is illuminated by the ambient electrical field.	98
6.23	The RIBE line marking device is available as a swinging triangular tag or as a series of black-and-white, rigid plastic pieces that swing (pictured).	99
6.24	The Inotec BFD 88, a South African device, is a reflective stainless steel sphere reported to be visible from all angles and in low-light conditions.	99
6.25	Tree wire on all three phases of a distribution line marked with suspended devices.	100
6.26	Tree wire (right of pole) and standard wire (left of pole) on a distribution line.	101
6.27	Collision-electrocutions cause an electrical short, like this one caused by tree branches, and can kill two or three birds in a flock even if only one bird makes phase-to-phase contact.	101
6.28	Tree wire on the top phase conductor of a two-phase distribution line (vertical configuration) with line marking devices.	102
7.1	Utility employee training should include the reasons and methods for reporting bird mortalities, nest management protocols, proper disposal of carcasses, applicable regulations, and the consequences of non-compliance.	104
7.2	An Avian Protection Plan may include opportunities to enhance avian populations or habitat with nesting structures, habitat restoration, or other projects.	107
7.3	Raising public awareness about avian collisions and the utility's commitment to avian protection can increase support for an Avian Protection Plan.	108
7.4	Integrating an Avian Protection Plan into an electric utility's operations will help the utility meet demands for reliable, cost-efficient, and environmentally compatible power delivery while protecting and enhancing bird populations.	110
B.1	Classes used to describe birds' approach, crossing, and departure altitudes in collision studies on transmission lines (after James and Haak 1979).	139

TABLES

TABLE		PAGE
1.1	Quick guide to the Collision Manual.	3
1.2	Voltage classifications in North America.	4
4.1	Typical evidence of bird injuries or mortalities from power line collisions.	30
4.2	Average distance of collision mortalities from nearest water body.	46
6.1	Summary of data on line marking devices available in the United States.	76
6.2	Distance of collision mortalities from the nearest pole (parallel to distribution lines in the right-of-way).	82
6.3	Spacing and positioning for aerial marker spheres (aviation balls).	86
6.4	Representative studies for aerial marker spheres (aviation balls).	87
6.5	Spacing and positioning for spiral vibration dampers (SVDs).	88
6.6	Representative studies for spiral vibration dampers (SVDs).	88
6.7	Spacing and positioning for Bird-Flight Diverters (BFDs).	90
6.8	Representative studies for Bird-Flight Diverters (BFDs).	91
6.9	Spacing and positioning for Swan-Flight Diverters (SFDs).	92
6.10	Representative studies for Swan-Flight Diverters (SFDs).	93
6.11	Spacing and positioning for general designs of suspended devices.	94
6.12	Representative studies for general designs of suspended devices.	95
6.13	Spacing and positioning for FireFlys.	96
6.14	Representative studies for FireFlys.	96
6.15	Spacing and positioning for BirdMark BM-AG.	97
B.1	Summary of considerations and issues for designing site-specific collision monitoring.	137

ABSTRACT

PURPOSE AND SCOPE OF THIS MANUAL

Reducing Avian Collisions with Power Lines (Collision Manual) was first published by the Avian Power Line Interaction Committee (APLIC) and Edison Electric Institute (EEI) in 1994 under the title *Mitigating Bird Collisions with Power Lines*. The 2012 edition of this manual provides electric utilities, wildlife agencies, and other stakeholders with guidance for reducing bird collisions with power lines based on the most current information. This is especially important given the need to reduce bird injury and mortality from collisions, comply with bird protection laws, and enhance the reliability of electrical energy delivery.

PROGRESS IN DEALING WITH COLLISION ISSUES

In the United States, most studies of bird collisions have occurred since the late 1970s. These studies described the problem and led to a growing awareness among stakeholders. In 1989, APLIC was founded to address whooping crane (*Grus americana*) collisions with power lines. APLIC published its first *Collision Manual* in 1994 to summarize the knowledge of bird collisions with power lines at that time. National and international collaboration on bird/power line interactions has since grown. Research today includes studies on collision reduction, monitoring systems, and standardization of collision mortality data collection. Future priorities include improving the comparability of studies, testing and documenting line marker efficacy, and refining remote collision detection devices.

As power line infrastructure expands to meet the growing demand for electricity, the collision risk to avian species also seems likely to increase. Yet, this risk may be reduced by assessing potential avian impacts during line siting and routing, improving line marking devices, standardizing study methods, and increasing awareness.

AVIAN REGULATIONS AND COMPLIANCE

In the United States, three federal laws protect almost all native avian species and prohibit *taking* (killing or injuring) them even if the act was unintended and occurred as a result of otherwise legal activities. The Migratory Bird Treaty Act (16 U.S.C. 703-712) protects 1,007 (2012) North American migratory bird species (50 CFR 10.13). The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) provides additional protection for these two species. The Endangered Species Act (16 U.S.C. 1531-1555) provides protection to federally listed species (designated as threatened or endangered) and to their critical habitat. Utilities in the United States should work with both the U.S. Fish and Wildlife Service (USFWS) and state wildlife agencies to identify permits and procedures that may be required.

In Canada, two laws protect avian species by prohibiting *take*. The Migratory Birds Convention Act protects most species of migratory birds in Canada. The Canadian Species at Risk Act provides for the protection and recovery of threatened and endangered species. Additional protection for species at risk has been developed by the provincial governments, such as the Alberta Wildlife Act. Utilities in Canada should work with the Canadian Wildlife Service and provincial wildlife agencies to identify permits and procedures that may be required.

UNDERSTANDING BIRD COLLISIONS

Understanding the nature of bird collisions is essential for minimizing them. Bird collisions with power lines result from a complex mixture of biological, environmental, and engineering factors. Biological characteristics include body size, weight, maneuverability, flight behavior, vision, age, sex, health, time of day, season, habitat, and habitat use. Environmental conditions include land uses, weather, visibility, lighting, and sudden disturbances.

ABSTRACT

Engineering aspects include size of lines, line placement, line orientation, line configuration, structure type, and sometimes obstruction lighting under Federal Aviation Administration rules.

It is difficult to extrapolate collision risk from one power line study and apply or compare it with other studies because of site-specific conditions and the lack of standard study methods, which result in variability of reported mortality rates. Species of birds reported to be susceptible to collisions generally have a large body size, long wing span, heavy body, and poor maneuverability. Examples include species of loons, storks, grebes, waterfowl, and some species of hawks and eagles. Flight behavior and other biological attributes contribute to species risk. Individual losses from collision mortality are unlikely to affect large and robust populations. However, for species that are rare or endangered, the loss of a few or even one individual may impact a local population or the overall population's viability.

MINIMIZING COLLISION RISKS

Engineers and biologists can work together to identify and address collision issues when modifying existing lines or planning new lines. Early consideration of risk factors may reduce the need for costly modifications later. In addition, while a utility is taking steps to minimize collision risk, a proactive public participation program can address social issues by building positive relationships, increasing public knowledge, identifying and responding to public concerns early, and promoting responsible behavior (e.g., discouraging vandalism of line marking devices).

When modifying existing lines, study options include collision monitoring, line modification studies, and avian risk assessment. Line modifications must be carefully evaluated to identify, quantify, and balance the existing risks with the potential effectiveness and risks posed by the alternatives. Risk reduction options include line marking, managing surrounding lands, removing the shield wire, changing the size or configuration of wires, rerouting the line, and burying lines. Typically, the first options are line marking and managing surrounding lands because the remaining options are seldom feasible.

When planning new lines, three study options can be used to identify the optimal route: spatial analysis using GIS, field assessment, and avian risk assessment. Risk reduction options could include line placement, orientation, and configuration relative to biological and environmental factors.

LINE MARKING DEVICES

Studies suggest that most bird collisions occur with the shield wire, which is the smallest diameter and highest wire on a transmission line. Many studies of lines with high collision rates indicate that collision risk can be lowered by 50% to 80% when these lines are marked, though the most recent study published at this writing demonstrated only a 9.6% reduction (Barrientos 2012). However, recommendations for which device is the most effective and standard spacing are not possible due to differences in study designs and site-specific conditions. As a result of these differences, reduction rates may not be replicable from one line or study to another.

Since 1994, line marking devices have been further developed in North America, Europe, and South Africa. Advances in aerial marker spheres, spirals, and suspended devices include changes to design, colors, attachments, and materials in an effort to improve effectiveness and durability and to reduce possible damage to lines.

AVIAN PROTECTION PLANS

In 2005, APLIC and the USFWS announced their jointly developed *Avian Protection Plan Guidelines (Guidelines)*. An Avian Protection

ABSTRACT

Plan (APP) is a voluntary, utility-specific plan for reducing the risks to birds and system reliability that result from avian interactions with electric utility facilities. An APP provides the framework necessary for implementing a program to reduce bird mortalities, document utility actions, improve service reliability, and comply with bird protection laws. The *Guidelines* are intended to help utilities craft their own APPs for managing avian/power line issues that are particular to their location and operations.

THIS PAGE INTENTIONALLY LEFT BLANK

FOREWORD

Avian interactions with power lines, including collisions, electrocutions, and nesting have been documented since the early 1900s. Collisions with telegraph lines were first reported in 1876. However, it was not until the 1970s that biologists, engineers, resource agencies, and conservationists began to realize the extent of these interactions. It was then that they began investigating and addressing collision issues. We commend this early professional leadership in tackling a complex issue and building a foundation of credibility and cooperation that characterizes the relationship between the U.S. Fish and Wildlife Service (USFWS) and the Avian Power Line Interaction Committee (APLIC) today.

In December 1983, an ad hoc group began to address whooping crane *(Grus americana)* collisions with power lines in the San Luis Valley, Colorado. This work led to the 1989 founding of APLIC and the publication of *Mitigating Bird Collisions with Power Lines: State of the Art in 1994 (Collision Manual)*, which became the companion of *Suggested Practices for Raptor Protection on Power Lines: State of the Art in 1981 (Electrocution Manual)*. The 1994 *Collision Manual* brought together what was known about collision mitigation and presented research protocols for studying problem lines. It focused on standardizing these protocols so that data from various studies might be comparable and applicable to the issues experienced by electric utilities nationwide. This theme is carried forth and expanded upon in this 2012 revision.

Today electric utilities across North America recognize that bird/power line interactions may create operational risks, health and safety concerns, and avian injuries or mortalities, all of which reduce electrical reliability and increase a utility's liability. The USFWS is responsible for conserving and protecting United States trust resources covered by the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act. It is within this potentially adversarial framework that the longstanding collaborative partnership between industry and agency has emerged.

With this edition of the *Collision Manual* (now titled *Reducing Avian Collisions with Power Lines*) along with the 2006 *Electrocution Manual*, the 2005 *Avian Protection Plan Guidelines*, and Edison Electric Institute's 2001 *Introduction to Public Participation*, utilities have a toolbox of the latest technology, science, expertise, and field experience. APLIC and the USFWS hope you will use this edition of the *Collision Manual*, along with its companion documents, to help implement avian protection plans, conserve protected birds, and improve electrical system reliability.

Jerome Ford
USFWS, Assistant Director Migratory Bird Program

Dave Bouchard
APLIC, Immediate Past Chair

Peggy Jelen
APLIC, Chair

ACKNOWLEDGEMENTS

APLIC wishes to express appreciation to the following individuals and organizations for contributing their time, resources, and expertise to making the 2012 edition of this manual possible.

PROJECT LEADERS

Dave Bouchard
Project Manager, Lead Editor
American Electric Power

Misti Schriner
Project Manager, Science Editor
Western Area Power Administration

Karen C. Hill
Project Manager, Technical Editor-Writer
Normandeau Associates, Inc.

James R. Newman
Lead Author, Technical Reviewer
Normandeau Associates, Inc.

CONTRIBUTORS AND REVIEWERS

Mike Best
Technical Reviewer
Pacific Gas and Electric

Jenny Carter
Editor
Normandeau Associates, Inc.

Peter Colverson
Contributing Author
Normandeau Associates, Inc.

Kara Donohue
Contributing Author, Technical Reviewer
Southern California Edison

Haley Edwards
Contributing Author, Technical Reviewer
Puget Sound Energy

Greg Forcey
Contributing Author
Normandeau Associates, Inc.

Caleb Gordon
Technical Contributor
Normandeau Associates, Inc.

Nikki Heck
Contributing Author, Technical Reviewer
AltaLink

Sherry Liguori
Technical Reviewer
PacifiCorp

Albert M. Manville, II
Contributing Author, Technical Reviewer
U.S. Fish and Wildlife Service

Susan Marynowski
Contributing Editor

Rocky Plettner
Technical Reviewer
Nebraska Public Power District

Von Pope
Technical Reviewer
Chelan County Public Utility

Dennis Rankin
Contributing Author
USDA Rural Utilities Service

Tom Stehn
Technical Reviewer
U.S. Fish and Wildlife Service (ret.)

Natalie Turley
Contributing Author, Technical Reviewer
Idaho Power Company

Mel Walters
Contributing Author, Technical Reviewer
Puget Sound Energy

Ondine Wells
Contributing Author
Normandeau Associates, Inc.

ACKNOWLEDGEMENTS

SPECIAL THANKS

APLIC recognizes those who pioneered research in avian collisions with power lines and those whose contributions made the 1994 edition of this manual possible: Carroll Belser, Bill Bolin, Wendy M. Brown, Jim Burruss, Edward Colson, Alan Ansel, Bob Turner, Jim Lewis, Rod Drewien, Sidney A. Gauthreaux, Jr., Franz Koops, John Ledger, A. Dean Miller, Judith H. Montgomery, Maurice Murphy, Dan Pearson, Leroy Sanchez, Frank Schlicht, Dick Thorsell, Pete Quincy, Phil Havens, Frank Moseley, Mark Czaplewski, Sheila Byrne, Jerry Roppe, Jerry Martinez, Joel Mazelis, and Echo Films' Morley Nelson, Norman Nelson, and Tyler Nelson. The vision, effort, and energy of each of these individuals continue to contribute to the growing understanding of this complicated issue.

APLIC also wishes to thank the following individuals for their service during the production of this edition of the manual: Brad Loveless, Dave Bouchard, and Peggy Jelen for serving as Chair of APLIC and Rick Loughery for serving as the Edison Electric Institute Liaison to APLIC.

ADDITIONAL THANKS

Additional content was provided by Michelle Turner with the Canadian Electricity Association. Additional technical review was provided by the following engineers: Artis Karnei (American Electric Power), Chuck Wright (PacifiCorp), Bard Jackson (USDA Rural Utilities Service), and Wayne Galli (Clean Line Energy Partners).

CONTRIBUTING LITERATURE

A diverse collection of literature was used in the research to prepare this manual. APLIC acknowledges the great contribution that this body of literature made. This literature is included in Appendix A. Literature Cited and Bibliography.

This manual was funded by the Edison Electric Institute and the Avian Power Line Interaction Committee.

ACKNOWLEDGEMENTS

APLIC COLLISION SUBCOMMITTEE

The APLIC Collision Subcommittee deserves special recognition for their dedication to avian collision research and protection efforts and for their review and guidance in creating the 2012 edition of this manual.

Sarah Ball
Edison Electric Institute

Mike Best
Pacific Gas and Electric

Dave Bouchard
American Electric Power

Jim Candler
Georgia Power Company

Amy Dierolf
Progress Energy

Kara Donohue
Southern California Edison

Haley Edwards
Puget Sound Energy

Jodie Gless
Florida Power & Light

Donald Harron
AltaLink

Nikki Heck
AltaLink

Peggy Jelen
Arizona Public Service

Brendon Jones
AltaLink

Carl Keller
Bonneville Power Administration

Sherry Liguori
PacifiCorp

Jim Lindsay
Florida Power & Light

Rick Loughery
Edison Electric Institute

Brad Loveless
Westar Energy

Al Manville
U.S. Fish and Wildlife Service

Sam Milodragovich
Northwestern Energy

Chuck Partridge
Pacific Gas and Electric

Mike Pehosh
National Rural Electric Cooperative Association

Rocky Plettner
Nebraska Public Power District

Von Pope
Chelan County Public Utility District

Dennis Rankin
USDA Rural Utilities Service

John Rasmussen
AltaLink

Misti Schriner
Western Area Power Administration

Tom Stehn
U.S. Fish and Wildlife Service (ret.)

Natalie Turley
Idaho Power Company

Mel Walters
Puget Sound Energy

THIS PUBLICATION IS DEDICATED TO THE MEMORY OF

Richard "Dick" S. Thorsell

(April 11, 1927 – April 15, 2012)



Dick Thorsell had a lifetime devotion to birds and was one of the founders of APLIC. He brought electric utilities, government agencies, and environmental groups together to work in cooperation to study and mitigate bird deaths from power line collisions and electrocutions. Dick came to the Edison Electric Institute (EEI) in 1970 after serving as the Executive Director of the Stony Brook–Millstone Watershed Association in New Jersey. Dick was the producer of films on utility/natural resource issues, including *Silver Wires, Golden Wings.* The film featured Morley Nelson's work on understanding and reducing raptor electrocutions. It brought awareness of electrocution issues to electric utilities and credibility to the industry for its efforts to address the problem.

Dick was a WWII Navy veteran, and in 1953 he graduated from Lehigh University with a B.A. in Conservation. During the summer of 1950, he took a job as a Ranger Naturalist for the U.S. National Park Service. In 1954, as a graduate student, he travelled to Bermuda to help determine what was destroying nests of the Bermuda petrel, or cahow *(Petrodroma cahow),* a bird that until 1951 was thought to have been extinct for more than 300 years. During 47 days of field observations he conceived a way to reduce nest predation of the cahow by the more aggressive white-tailed tropic bird *(Phaethon lepturus),* known in the islands as the longtail. His solution was credited as one of the most critical developments in the cahow's recovery and conservation.

In 1988, Dick was honored by the Raptor Research Foundation for his pioneering efforts in raptor protection: *"All who appreciate the flight, spirit, and symbolism of the golden eagle are in your debt; and those who know you well enough understand that having hundreds, if not thousands of living eagles to your credit, is sufficient personal award for your accomplishments."*

Dick received APLIC's Morley Nelson Award in 2009 to acknowledge his efforts in pioneering avian/power line conservation and his dedication to developing and maintaining positive partnerships among the key interests in avian/power line issues.

Dick retired from EEI in1991 and pursued his personal interests while remaining ever ready to advise the industry on developing issues and to keep us on track.

THIS PAGE INTENTIONALLY LEFT BLANK



CHAPTER 1

Introduction

IN THIS CHAPTER

- Purpose and Scope of the Manual
- Reader Guide to the Manual
- Overview of Power Lines
- Perspectives for Dealing with Bird Collisions

Some birds flying in the vicinity of power lines may be susceptible to collision. While power lines are only one of numerous causes of bird injury and mortality, collisions with power lines can be reduced. This chapter introduces the problem of bird collisions, defines the categories and configurations of power lines, and presents the biological, engineering, economic, and social and cultural perspectives on bird/power line collisions.

PURPOSE AND SCOPE OF THE MANUAL

Reducing Avian Collisions with Power Lines (Collision Manual) was first published by the Avian Power Line Interaction Committee (APLIC) and the Edison Electric Institute (EEI) in 1994, under the title *Mitigating Bird Collisions with Power Lines*, as a comprehensive review of avian collisions with power lines (collisions) and recommendations for minimizing them. Since 1994, the understanding of bird collisions and the methods for reducing them has grown (e.g., Bevanger 1994, 1998; Janss 2000; Rubolini et al. 2005; and Jenkins et al. 2010). Collisions with power lines cannot be eliminated, but they can be reduced. This edition of the manual builds upon the foundation of the 1994 *Collision Manual* using the research and experience gained through the years since its original publication.

Power lines are an integral part of the modern landscape. Estimates of the number of miles of transmission lines in the United States range from 862,000 kilometers (km) (535,622 miles [mi]) (J. Goodrich-Mahoney, EPRI, pers. comm.) to 1,024,534 km (636,616 mi) (EEI 2010) based on 2009 and 2010 data from the Federal Energy Regulatory Commission, North American Electric Reliability Corporation, and other sources. For distribution lines, the number of miles is less certain, but it is about five to six times that of transmission lines based on two large company systems (D. Bouchard, pers. comm.).

Some bird species that are active in the vicinity of power lines are more susceptible to collision and electrocution risk than others. The risks and reduction measures for bird electrocutions are addressed in the publication *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* (APLIC 2006).

Power lines are only one of numerous anthropogenic causes of bird collision mor-

tality. Others include tall buildings, windows, vehicles, communication towers, airplanes, and wind turbines (Avery et al. 1980; Erickson et al. 2005). Estimates of bird collision mortality vary widely because of differences in mortality monitoring and extrapolations of those data. Based on reviews, Erickson et al. (2005) estimated that buildings and windows account for most bird collision mortality in the United States, followed by power lines, automobiles, communication towers, and wind turbines. This manual only addresses bird collisions with power lines.

Interactions between birds and power lines are a complex mixture of biological, environmental, and engineering factors. Electric utility stakeholders need to understand the nature of bird interactions with power lines when siting, routing, and designing power lines and determining mortality reduction measures. This is especially true given the need to reduce bird collisions, comply with bird protection laws, and enhance reliable electrical energy delivery.

This manual was developed for electric utilities, wildlife agencies, and other stakeholders and is based on what is known to date about collisions. It is intended to provide this audience with:

- An overview of power lines and perspectives on dealing with avian/power line collisions (Chapter 1)
- A summary of current knowledge, literature, and field experience related to avian collisions with power lines and the factors that influence them (Chapters 2 and 4)
- A discussion of the laws, regulations, and the operational implications of avian collisions (Chapter 3)
- A review and discussion of current practices for planning, management options, study design, and devices used to minimize avian collisions with power lines (Chapter 5, Chapter 6 and Appendix B)
- An overview for developing an Avian Protection Plan (Chapter 7)
- A compilation of collision literature spanning several decades (Appendix A)
- A glossary of collision terms and resources for further information (Appendices C and E)



FIGURE 1.1: The highest wire on a transmission line is the shield wire, which can be difficult for birds, especially flocking birds such as waterfowl, to see.

© JERRY LIGUORI

READER GUIDE TO THE MANUAL

Table 1.1 provides a quick guide to common collision topics in this manual. Readers can also search the electronic version (a CD is included) for specific keywords. This manual consists of the following chapters and appendices.

TABLE 1.1: Quick guide to the Collision Manual.

Subject	Chapter(s)
Power lines, voltage, and the electric power system	1
Perspective of power line engineers	1, 4, 5, 6
Perspective of biologists	1, 4, 5, Appendix B
Perspective of the public and other stakeholders	1, 5, 6, 7
Advantages and disadvantages of underground power lines	1, 5
History of bird collisions and mitigation	2, 6, Appendix A
Current state of knowledge related to bird collisions	2, 4, 5, Appendix A
Funding organizations for collision research	2, Appendix E
Study methods and options	2, 4, 5, Appendix B
Strategies and approaches to address bird collisions	2, 4, 5, 6, 7
Laws and policies governing birds and bird mortality	3
Permits related to bird laws and policies	3
Factors that contribute to collisions	4
Variability in reported collision mortality rates	4
Significance of mortality for bird populations	4
Scientific methods to assess risk and impacts	4, 5, Appendix B
Methods for reducing bird collisions on an existing power line	5, 6
Methods for routing and designing a new power line while minimizing bird collisions	5, 6
Benefits of public participation	5, 7
Legal issues and other considerations for line marking	6
Effectiveness of line marking devices	6
How to develop a voluntary, utility-specific Avian Protection Plan	7

- Chapter 1. Introduction
- Chapter 2. Progress in Dealing with Collision Issues
- Chapter 3. Avian Regulations and Compliance
- Chapter 4. Understanding Bird Collisions
- Chapter 5. Minimizing Collision Risks
- Chapter 6. Line Marking to Reduce Collisions
- Chapter 7. Avian Protection Plans
- Appendix A. Literature Cited and Bibliography
- Appendix B. Designing Site-Specific Studies for Collision Monitoring
- Appendix C. Glossary
- Appendix D. Acronyms
- Appendix E. Resources

1

OVERVIEW OF POWER LINES

TRANSMISSION VERSUS DISTRIBUTION LINES

Power lines are rated and categorized, in part, by the level of electrical voltage they carry. Because the amount of electricity is large, voltage is usually specified as kilovolts (kV) where 1 kV is equal to 1,000 volts (V). In a power system, from the power generation facility to the customer (Figure 1.2), four voltage classifications are used: power source, transmission, distribution, and utilization (Table 1.2). Although there are exceptions to these voltage classifications, they hold in general and will be used this way in this manual.

Voltage classification also depends on the purpose a power line serves. Transmission lines (≥60 to 765 kV) are used to transmit large blocks of electricity from the power generation facility to the load centers (communities). Within load centers, the high voltage of transmission lines is reduced at substations and then delivered via distribution lines (2.4 to 60 kV) for residential, commercial, and industrial uses. The distribution voltages are again stepped down to the lower voltages for the end user (120 to 600 V) usually by pole- and pad-mounted transformers. Both transmission and distribution lines are power lines, a term used throughout this manual (Figure 1.3).

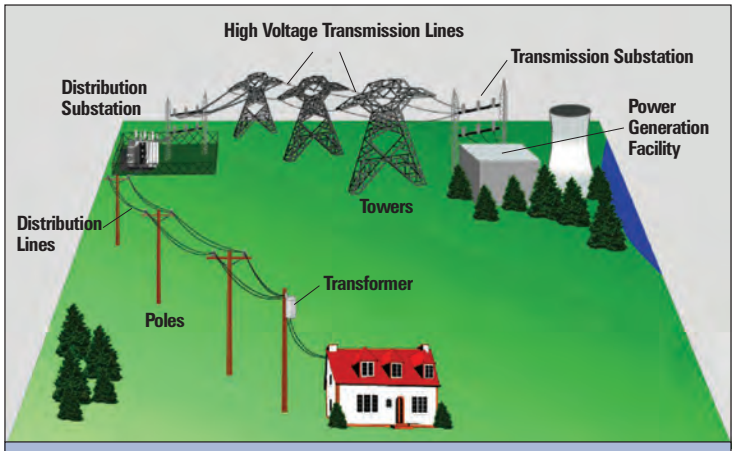


FIGURE 1.2: Schematic of the electric power system from the generation facility to the customer (modified from Rural Utilities Service).

TABLE 1.2: Voltage classifications in North America.

Classification	Voltage
Power Generation Facility	12 V to 22 kV
Transmission	60 to 765 kV*
Distribution	2.4 to 60 kV
Utilization	120 to 600 V

* This is the typical range for transmission; however, there are exceptions.



FIGURE 1.3: Transmission lines (left) and distribution lines (right).

© JERRY LIGUORI (LEFT) AND DAVE BOUCHARD, AEP (RIGHT)

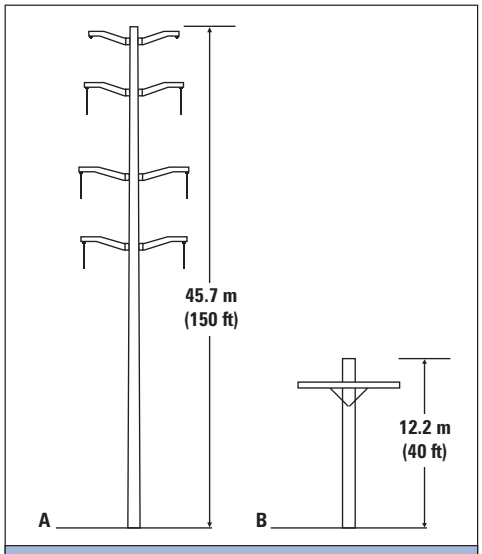


FIGURE 1.4: Height comparison of transmission (typically 18.3 to 58 m [60 to 190 ft] tall) (A) and distribution structures (typically 6.4 to 14.6 m [21 to 48 ft] tall) (B).

POWER LINE CONFIGURATION

Power lines may be energized (carrying electricity) or non-energized (grounded). Energized lines are called phase conductors. Distribution lines may have one, two, or three phase conductors per circuit. Alternating current (AC) transmission lines always have three phases per circuit, and structures may carry multiple circuits. For example, a three-phase, double-circuit line would have six phase conductors. Phase conductors may be configured horizontally or vertically on the tower or pole (Figure 1.5). High voltage transmission lines may be bundled, which means two to six lines per phase are placed in close proximity to each other instead of using only one line per phase (Figure 1.6). Distribution lines may also be installed on transmission structures below the transmission lines; this is referred to as a distribution underbuild (Figure 1.7).

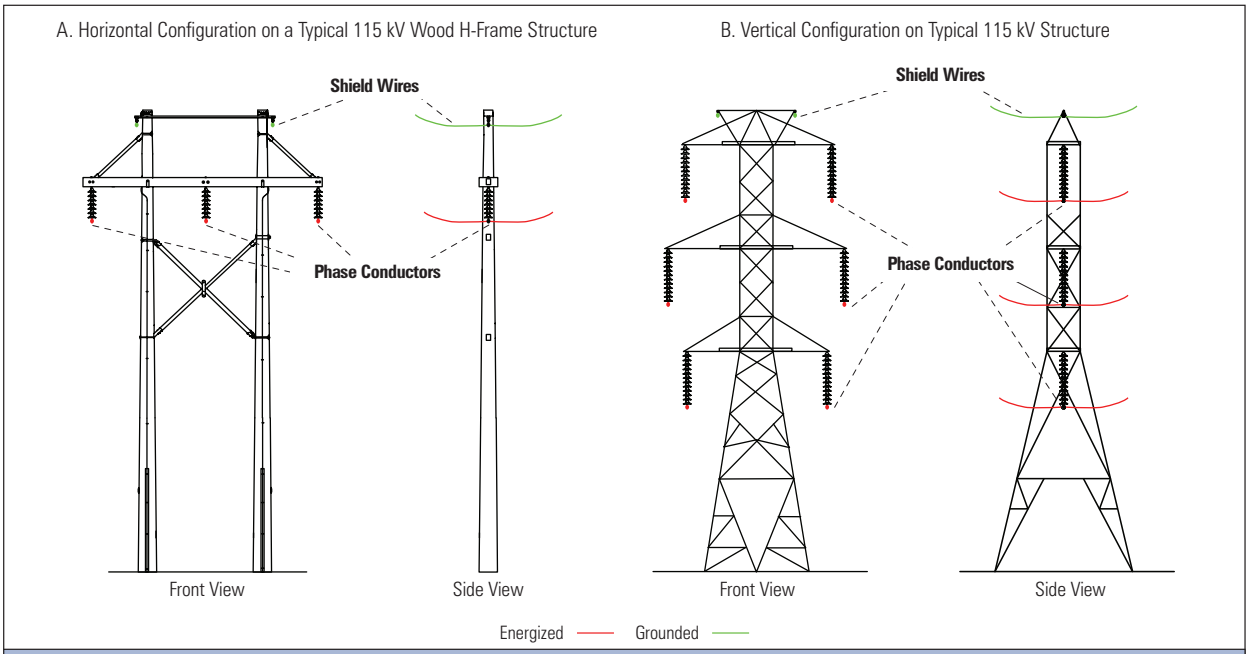
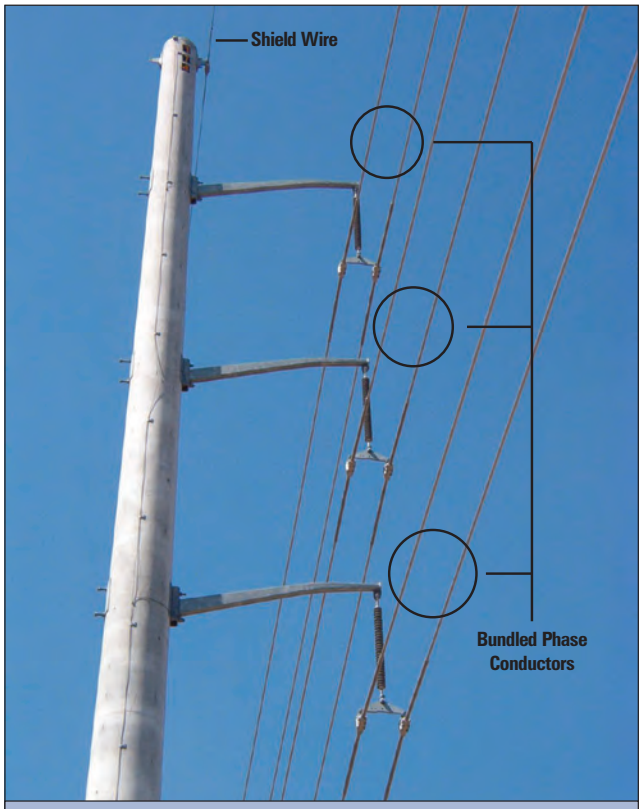


FIGURE 1.5: Horizontal (A) and vertical (B) transmission line configurations.



© DAVE BOUCHARD, AEP

FIGURE 1.6: Bundled phase conductors on a three-phase, single-circuit, 138-kV transmission line.



© JERRY LIGUORI

FIGURE 1.7: Distribution underbuild on a double-circuit transmission line.

Non-energized conductors are at ground potential or zero voltage potential. There are two kinds of non-energized conductors: shield wire (also called static wire or overhead ground wire) and neutral wire.

Shield wires are installed above the phase conductors on transmission lines to protect them from lightning (Figure 1.8). Static electricity from the shield wire is taken to earth (ground) by grounding conductors. In a low lightning area, some transmission lines with lower voltages (e.g., 69 kV) may not have a shield wire. Shield wires are the lines most associated with bird collisions on transmission lines because they are the highest wire and are smaller in diameter (1 to 1.3 centimeters [cm]; 0.4 to 0.5 inches [in])[1] than phase conductors (2.5 to 5 cm [1 to 2 in]; bundled lines are multiples of these), making them more difficult to see (e.g., Savereno et al. 1996). When birds are flying at the elevation of shield wires or gaining altitude to avoid the more visible phase conductors, the potential for collision with the shield wire increases. For more information on how power line configuration affects collision risk, see Chapters 4 and 5.

[1] Measurements are provided first in metric, then in English form.

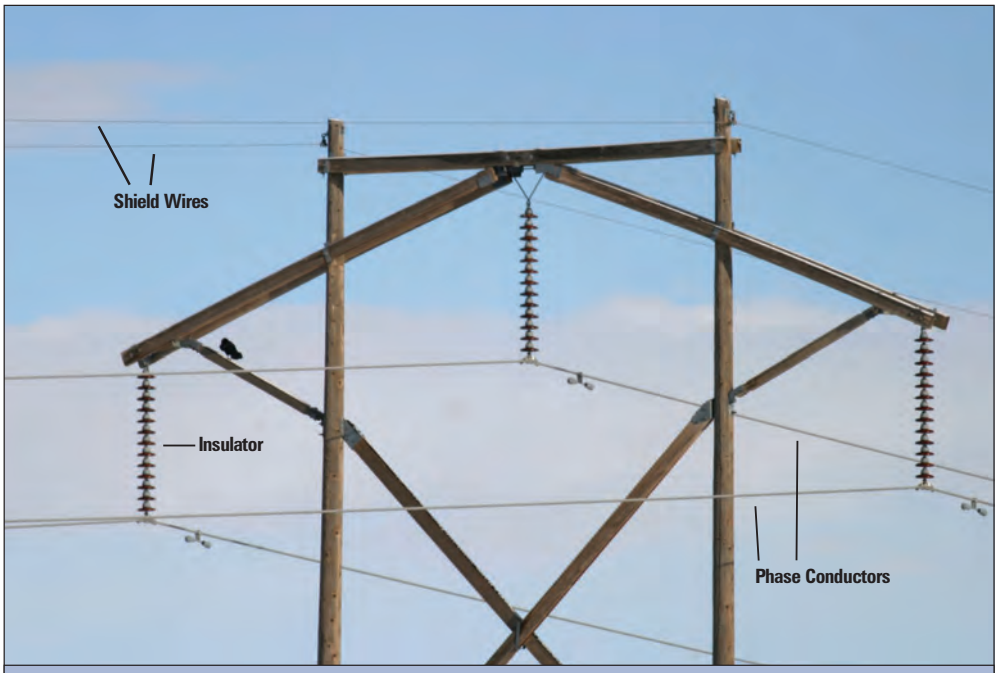


FIGURE 1.8: Shield wires are the highest wires on a transmission line.

© JERRY LIGUORI

The neutral wire, with regional exceptions, is installed below or parallel to the phase conductors on a distribution line (Figure 1.9) and carries return current, which is taken safely to ground via grounding conductors. In high lightning areas there are exceptions where the neutral is also used as a shield wire on a distribution line.

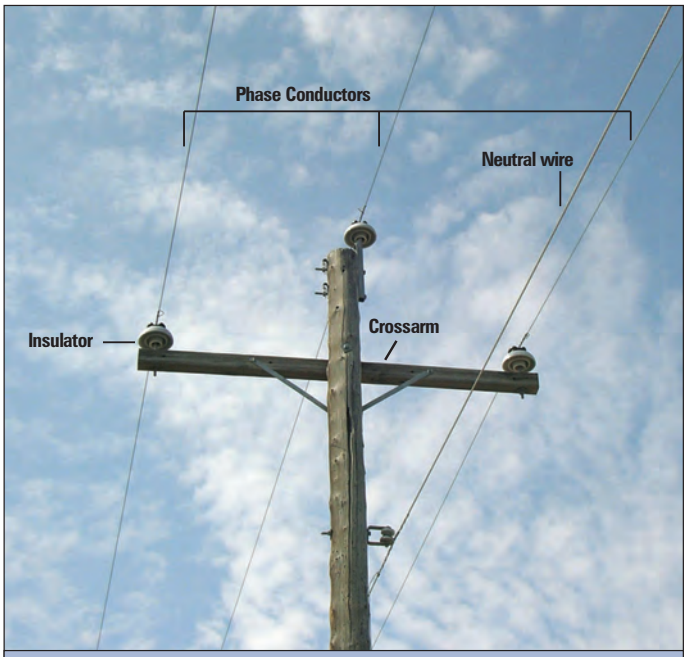


FIGURE 1.9: The neutral wire is usually positioned below the phase conductors on a distribution line.

© JERRY LIGUORI

High Voltage: Alternating Current versus Direct Current

Alternating current (AC) transmission and distribution systems are the world's most prevalent type of line. AC transmission systems consist of three phases, each phase consists of 1 to 6 wires (two or more is a bundle). Three phases make a circuit, and a line may have more than one circuit. AC phases may be arranged either horizontally or vertically. As voltage increases, loss over distance decreases, but at some distance high voltage direct current (HVDC) becomes more efficient than high voltage alternating current (HVAC). HVDC transmission systems have a growing presence in the United States and the world. They are most effective in transmitting electricity long distances at high voltages (400 to 600 kV in North America and up to 800 kV in other countries). HVDC structure design is similar to HVAC designs, but with two poles instead of three phases (Figure 1.10). HVDC is transmitted on two bundled conductors known as positive and negative poles. The poles are spaced at least 9.1 meters (m) (30 feet [ft]) apart and are always arranged horizontally. Both systems require shield wires for lightning protection. Most importantly, both systems have the same cautions for attaching collision-preventive devices, i.e., these devices may be applied to shield wires, but are not always compatible with energized lines ≥150 kV or as manufacturers have otherwise demonstrated.

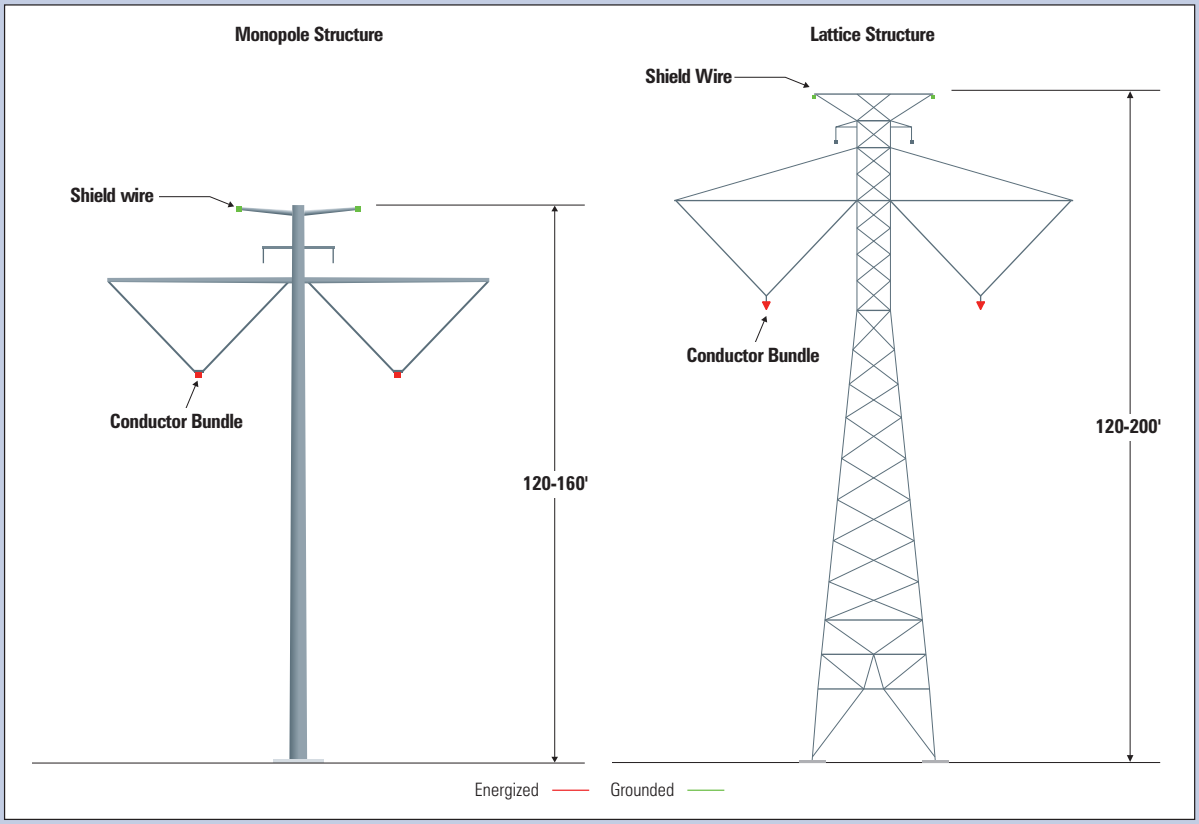


FIGURE 1.10: Typical high voltage direct current transmission line structures.

MEETING ELECTRICAL POWER DEMANDS (LOAD REQUIREMENTS)

A power line's voltage, configuration, conductor spacing, location, and structure type are determined by the present and anticipated power demands or load requirements the line will serve. Because electric utilities are required by law to provide reliable electrical service, they plan, fund, and build new power lines. If enough power is available in an area, then building new distribution lines can sometimes meet the increasing demand. Alternatively or additionally, transmission lines can be built to bring power to the load center from distant power generation facilities.

Transmission line corridors are determined by the location of power generation facilities and substations in relation to load centers. Within the corridor, the preferred and alternative routes are determined, among other things, by rights-of-way (ROWs) availability, land use patterns, potential environmental impacts, terrain, archeological sites, proximity to habitable dwellings, and crossings over water, highways, and other power lines (see *Planning New Power Lines* in Chapter 5 for a discussion and illustration of the planning process).

Different ROW widths are required for different transmission line voltage ratings; these are generally determined by state statutes and the National Electrical Safety Code. ROW widths are also a function of structure height, span length, the conductor height above ground, and the low point of the conductor. ROW widths for transmission lines will vary from 15.2 m (50 ft) to more than 60.9 m (200 ft). Because ROWs are becoming increasingly difficult to obtain,

Transmission Lines and Renewable Energy

Current renewable energy mandates are leading to the development of wind, solar, and other renewable sources. Because these renewable energy sources are typically remote, new transmission lines are often needed to connect them to the grid and carry electricity to load centers.

Overhead versus Underground Power Lines

Electric utilities install power lines either overhead or underground depending upon numerous considerations. Some key factors include customer needs, costs, code requirements, terrain, voltage, and technological and environmental restrictions. Cost is a major concern as electric utilities have mandates to serve customers with high quality, reliable electric service at the lowest cost possible.

Power lines, particularly residential distribution lines, are installed underground in many areas throughout the country where it has been found technically and financially feasible to do so. However, at transmission voltages, there are many more areas where installing lines underground is not feasible (see *Burying Power Lines* on page 62). It becomes more practical to build them overhead as the voltage of the line increases. Therefore, the focus of this manual is to provide guidance for addressing issues associated with reducing collision risks on overhead power lines.

it is a common practice to increase the voltage levels of lines in existing ROWs when statutes and safety allow. As voltages increase, the amount of power that can be transmitted increases by a greater multiple.[2] Transmission voltages for carrying electricity long distances are generally in the range of 115 to 765 kV in the United States.

PERSPECTIVES FOR DEALING WITH BIRD COLLISIONS

A single approach is rarely successful in solving a complicated, multi-faceted issue such as bird collisions with power lines. An integrated approach that considers the biological, environmental, engineering, economic, and social and cultural perspectives of collisions is needed.

BIOLOGICAL AND ENVIRONMENTAL PERSPECTIVES

Biologists generally focus on gathering data to better understand the problem and creating solutions to minimize collision risk. Utility biologists and/or their consultants may be responsible for site evaluation studies and collision studies (see Chapters 5 and 6 and Appendix B). Site evaluation studies determine baseline avian and habitat conditions and assess the possible collision risks to birds following power line construction. Collision studies can help determine reliable mortality rates and quantify the effectiveness of measures taken to minimize collisions.

Collecting high quality data is critical for collision studies. Utilities should plan their studies carefully, using methods and metrics that can be replicated to gather and analyze data. The data should be sufficient for use in estimating the likelihood of collisions and for measuring the effectiveness of collision reduction efforts. In addition, methods must be sufficiently flexible to accommodate the species and site-specific conditions being studied and applied consistently throughout a study and between studies (Bevanger 1999; Barrientos et al. 2011).

In most cases, the approach to these studies is based on type of information needed to make management decisions, determine if line modifications are effective, and/or identify areas of bird activity and high collision risk. In some cases, wildlife agencies may recommend specific studies or protocols, and it is advisable to obtain their comments on a study design. Utilities and their consultants should also consider peer review by independent scientists for the study findings, since the results may undergo rigorous legal cross-examination if the issue is litigated. Publication in a refereed scientific journal is encouraged because it makes the data more widely available and contributes to a greater resource pool for the development of study design methods.



© JERRY LIGUORI

FIGURE 1.11: Biologists gather data to assess the risk of bird collisions.

[2] The carrying capacity of a line increases at a greater rate than the increase in voltage, i.e., one 765-kV circuit = three 500-kV circuits = six 345-kV circuits. Another advantage of higher voltage is that the voltage drop or loss over distance decreases as the voltage increases.



FIGURE 1.12: Engineers work with biologists to reduce risk through appropriate design and routing of power facilities.

© USDA/ARS

ENGINEERING PERSPECTIVE

Engineering research, development, and design are essential in the integrated approach to preventing or minimizing bird/power line collisions. Utility engineers should work with biologists early in the design and routing process to identify the key collision issues (see Chapter 4) and to develop feasible collision reduction strategies when modifying existing lines and planning new lines (see Chapters 5 and 6). Early science-based site evaluations and avian risk assessments can be part of improving route selection and line configurations to minimize collision problems. This can reduce or eliminate the need for costly modifications after construction. Design decisions also include other factors such as cost, routing through public or private land, crew availability, and material availability; as a result, a less favorable design for avian interactions may need to be used.

ECONOMIC PERSPECTIVE

No integrated approach would be complete without considering the economics of construction, operation, and maintenance of a power line. The cost for bird friendly power lines and configurations needs to be included during the design phase and route selection. A cost benefit analysis of appropriate collision minimization designs and mitigation can be performed. The later in the process that a biological or engineering solution is initiated, the more difficult, time-consuming, and costly it can become. Since electrical reliability is mandated by utility commissions, avoiding power outages, including those caused by birds, is a priority for electric utilities. Early planning can help meet requirements for reliability, regulatory compliance, efficiency, public acceptance, and cost-effectiveness.



© USFWS

FIGURE 1.13: Engaging the public may help a utility meet requirements for electrical reliability and reduce collision risk to birds.

SOCIAL AND CULTURAL PERSPECTIVES

In addition to cost and power reliability, the public may have concerns about power line design and placement, including esthetics, environmental effects, wildlife, and safety. Vandalism is also a persistent problem. Electrical components and line marking devices on power lines can become targets. Engaging the public may make it easier for a utility to meet the requirements of providing reliable electricity while reducing risks to birds. It can also reduce delays and costs associated with controversy and litigation (EEI 2001).

Utilities and their consultants can use a variety of public participation tools to engage the public (see Chapter 5 and Appendix E). Used effectively, these tools can build positive relationships, increase public knowledge, identify and respond to public concerns early, and promote responsible behavior (e.g., discouraging vandalism of line marking devices).



CHAPTER 2

Progress in Dealing with Collision Issues

IN THIS CHAPTER

- North America
- International
- Future Research Priorities

Much progress has been made since the 1970s in understanding and addressing bird collisions with power lines. This chapter recalls the conferences and studies that have occurred in North America and internationally. The major avian power line research organizations are introduced, along with future research priorities.

NORTH AMERICA

UNITED STATES

The first reported bird collision with overhead lines in the United States was documented in 1876 (Coues 1876); numerous bird carcasses, mostly horned larks (*Eremophilia alpestris*), were reported during one week in a 5.8-kilometer (km) (3-mile [mi]) section of an overhead telegraph line between Cheyenne, Wyoming, and Denver, Colorado. Coues indicated that such collisions had already been reported in Europe, although no references were given. Another early report of collisions with electric wires in the United States was documented in 1904 (Emerson 1904). Emerson reported that shorebirds, as well as a black rail (*Laterallus jamaicensis*), collided with electrical wires over a salt marsh and evaporation ponds in the San Francisco Bay area. Avery et al. (1980) provides an annotated bibliography of other early power line collision literature.

Most collision studies have been published since the late 1970s and have led to a growing awareness among stakeholders. During the 1970s, Bonneville Power Administration conducted studies on reducing collisions with power lines (Lee and Meyer 1977; James and Haak 1980; and Beaulaurier 1981). Lee and Meyer (1977) proposed using devices such as image intensifiers for nocturnal observation and collision detectors that would measure the number of bird strikes on wires. They also suggested using thermal imaging, a relatively new technique at the time, to view birds and bats flying near power lines and wind turbines. Lee and his colleagues set a new scientific standard for studies of the interaction between birds in flight and power lines.

In 1978 bird/power line issues were addressed at a national conference sponsored by the U.S. Fish and Wildlife Service (USFWS),



FIGURE 2.1: APLIC has helped fund studies on the effectiveness of different types of line marking devices in reducing bird collisions with power lines.

© JERRY LIGUORI

the Environmental Protection Agency, and the Oak Ridge Associated Universities (Avery 1978).[3] This conference was followed by a 1978 meeting at the Edison Electric Institute (EEI) in Washington, D.C. There, EEI and the Electric Power Research Institute (EPRI) discussed a research program on bird/power line interactions. EPRI funded an assessment of completed, ongoing, and planned research; an analysis of future research needs regarding the impact of power lines on birds in flight; and a series of studies aimed at developing different methods for measuring the impact of power lines on birds in flight.

In 1989, a group of biologists representing a wide range of utility interests, together with representatives from the USFWS and the National Audubon Society, formed the Avian Power Line Interaction Committee (APLIC).[4] APLIC, in cooperation with the USFWS, funded a study on the effectiveness of different types of line markers in the San Luis Valley of Colorado. Such a study was needed because aerial marker spheres were commonly recommended for power lines where bird collision potential existed, although there were no data that established their effectiveness. Further details can be found in Brown and Drewien (1995).

APLIC and EPRI were also instrumental in developing and providing funding for an international conference on bird interactions with utility structures (Miami, September 1992). The proceedings of that workshop included papers and case studies by researchers from various utilities and universities in the United States, Canada, South Africa, and India, and other organizations and agencies including the USFWS, Bureau of Land Management, and U.S. Navy.

---

[3] Avery 1978 is the citation for the USFWS version of the proceedings; the original proceedings were documented by Oak Ridge Associated Universities. This reference will be noted as Avery 1978 in this document.

[4] Founding APLIC utility members included Bonneville Power Administration, Edison Electric Institute, Central and South West Services (currently American Electric Power), Florida Power & Light Company, Houston Lighting and Power Company (currently CenterPoint), Nebraska Public Power District, Pacific Gas and Electric Company, Pacific Power & Light Company (currently PacifiCorp), Public Service Company of Colorado (currently Xcel Energy), San Luis Rural Electric Cooperatives, Southern California Edison Company, and Virginia Power (currently Dominion). A list of current APLIC members can be found at www.aplic.org.

In 1994, APLIC published *Mitigating Bird Collisions with Power Lines* (APLIC 1994) to compile the research on bird collision issues to date. Since then, research and reviews of this issue have continued. In 1999, EPRI held a workshop sponsored by APLIC and EEI entitled Avian Interactions with Utility and Communication Structures, which included papers and discussions on the bird collision issues these two industries face (see EPRI 2001). Every three to four years since 1976, electric utilities and utility organizations including EEI, EPRI, and APLIC help sponsor the International Symposium on Environmental Concerns in Rights-of-Way Management. This symposium often includes papers on bird collisions. APLIC also conducts avian protection workshops at its semi-annual business meetings and at other times through the year upon request (see www.aplic.org for information on upcoming workshops).

Since the early 2000s, the California Energy Commission (CEC) has sponsored a large number of research projects including identification of research needs on avian collisions with power lines in California: *A Roadmap for PIER Research on Avian Collisions with Power Lines in California* (Hunting 2002). CEC also has a searchable database on avian collision literature, *An Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).

Other CEC, APLIC, and EPRI sponsored studies include:

- *Human-related Causes of Raptor Mortality in Western Montana: Things are not Always as They Seem* (Olson 2001)
- *Bird Strike Indicator/Bird Activity Monitor and Field Assessment of Avian Fatalities* (EPRI 2003)
- *Raptor and Raven Electrocutions in Northwestern Mexico* (Cartron et al. 2004)
- *Corona Testing Devices Used to Mitigate Bird Collisions* (EDM 2004).
- *Assessment of Avian Mortality from Collisions and Electrocutions* (Dorin and Spiegel 2005)
- *Preventing Raptor Electrocutions in an Urban Environment* (Dwyer and Mannan 2007)
- *Evaluating and Reducing Avian Collisions with Distribution Power Lines at Cosumnes River Preserve* (Yee 2007)
- *Bird Strike Indicator Field Deployment at the Audubon National Wildlife Refuge in North Dakota* (Pandey et al. 2008)
- *Raptor and Corvid Response to Power Distribution Line Perch Deterrents in Utah* (Prather and Messmer 2010)
- *Evaluating Diverter Effectiveness in Reducing Avian Collisions with Distribution Lines at San Luis National Wildlife Refuge Complex, Merced County, California* (Ventana Wildlife Society 2009)
- *Contemporary Knowledge and Research Needs Regarding the Potential Effects of Tall Structures on Sage-grouse* (UWIN Cooperative 2010)
- *Protocol for Investigating the Effects of Tall Structures on Sage-grouse (Centrocercus spp.) Within Designated or Proposed Energy Corridors* (UWIN 2011)
- *Line Marking Study near Coleharbor, ND, 2006-2008* (WAPA 2011)

Bibliographies of Collision Literature

Appendix A of this manual includes the literature cited and a bibliography of collision literature. An annotated bibliography of early collision literature was provided by Avery et al. (1980). In addition, the California Energy Commission hosts a searchable database on collisions: *On-Line Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).



© DAVE MANKE, USFWS

FIGURE 2.2: In Canada, the first reported collision victims were snow geese.

CANADA

The first reported bird collision in Canada was published by Blokpoel and Hatch (1976) after several thousand snow geese (*Chen caerulescens*) were flushed by an aircraft into a transmission line. The geese had been feeding on a stubble field near Winnipeg, Manitoba. Between 25 and 75 geese were reportedly injured or killed after striking the wires.

Since then, there have been few published accounts of bird collisions in Canada. In 1997, the *Blue Jay* published a discussion on birds and power line risk (Curtis 1997). Other accounts can be found in proceedings from the Canadian hosted 5th and 7th International Symposium on Environmental Concerns in Rights-of-Way Management in Quebec (1993) and Alberta (2000). In 2007, a study on using a landscape-scale model to predict the risk of collisions in Alberta was completed (Heck 2007; Quinn et al. 2011). It examined the practicality of using GIS spatial modeling to predict areas with elevated collision frequency across large, existing electric service territories.

Bird/power line interaction knowledge is growing in Canada and more emphasis is being placed on identifying the root cause in relation to a utility's reliability issues. The cause of many outages has been identified as a direct result of wildlife interactions, including birds. Many utilities are also installing line marking devices in areas where collisions have been reported or suspected.

Depending on the species, collisions with power lines may be violations of federal and provincial wildlife laws (see Chapter 3) and can result in penalties. Most bird species present in Canada are migratory and are very often the same species present in the United States and subject to many of the same collision risks, which stem from the same biological, environmental, and engineering factors outlined in Chapter 4.

Although Canada has wildlife laws in place, as of 2011 there is not a Canadian organization addressing the management of bird interactions with power lines; so Canadian companies have turned to American utilities for support by joining APLIC. In 2012, the first APLIC workshop in Canada was held in Banff. Electric utility representatives, consultants, contractors, and government regulators from across the country attended.

In addition to legal requirements and due diligence, Canadian companies have recognized that bird collisions need to be minimized for environmental, public relations, and public health reasons. Through increased management of avian collision issues, companies have been better able to demonstrate to utility staff, regulators, and the public, their commitment to reducing utility impacts on birds.

MEXICO

In Mexico, the USFWS has been working with officials of the Mexican government through the Trilateral Committee of the North American Free Trade Agreement, the

Migratory Bird Treaty with Mexico, Partners in Flight, and the National Wind Coordinating Collaborative to help Mexico better address avian collision and electrocution issues. These efforts are also tied to Mexico's land-based wind energy development, which includes power line issues (R. Villegas-Patraca, pers. comm.; A. Manville, pers. comm.; Mexico Institute of Ecology and USFWS, unpubl. reports, respectively).

INTERNATIONAL

Important collision research has been conducted in Europe, Asia, and Africa. In 2003, BirdLife International prepared the guide *Protecting Birds from Power Lines: A practical guide on the risks to birds from electricity transmission facilities and how to minimize any such adverse effect* (BirdLife International 2003). It reviewed the risks from power lines, including collisions, and recommended standards to protect birds, siting considerations, use of underground power lines, hiding or obscuring power lines against more prominent landscape features, and the use of line marking devices. In 2007, BirdLife International developed a policy position statement on the risks to birds from transmission lines (BirdLife International 2007). In 2009, the Council of Europe issued *Follow-up Recommendation No 110, 2004* (Schuerenberg et al. 2009) on minimizing adverse effects of power lines on birds. It reviews standards and retrofitting methods and provides an exhaustive list of actions taken by 26 European countries.

In 2011, the United Nations Environment Programme (UNEP) for the African-Eurasian Waterbird Agreement (AEWA) and the Convention on Migratory Species (CMS) released a *Review of the Conflict between Migratory Birds and Electricity Power Grids in the African-Eurasian Region* (CMS 2011a) and the *Guidelines for Mitigating Conflict between Migratory Birds and Electricity Power Grids* (CMS 2011b). CMS (2011a) provides a summary of collision issues and hot spots in Europe, Asia, and Africa. Also in 2011, the *Budapest Declaration on Bird Protection and Power Lines* (MME 2011) was adopted by the participants of the Budapest Conference, Power Lines and Bird Mortality in Europe. The declaration aims for all new construction of power poles to be bird-safe by 2016 and all dangerous poles to be retrofitted by 2020. The conference was attended by 123 participants from 29 European and Central Asian countries, the European Commission, UNEP AWEA, six energy and utility companies, experts, businesses, and non-government organizations.

In Asia, the risk of bird collisions with power lines is being recognized as more studies are conducted on bird electrocutions associated with new power line structures. For example, in Mongolia, while performing a review of raptor electrocutions on new concrete poles with metal crossarms, researchers found that Pallas' sandgrouse (*Syrrhaptes paradoxus*) were killed after colliding with power lines during an unusual seasonal relocation (Gombobaatar et al. 2010).

In Uzbekistan, systematic collision monitoring using standard protocols has not been conducted and therefore reported mortalities can only be considered anecdotal. However, these observations have shown that certain species are more susceptible to collisions and/or electrocutions. It is known that during spring and autumn migration, medium and large size birds collide with or are electrocuted on the power lines, which include rare and declining species like the steppe eagle (*Aquila nipalensis*), golden eagle (*Aquila chrysaetos*), imperial eagle (*Aquila heliaca*), osprey (*Pandion haliaetus*), short-toed eagle (*Circaetus gallicus*), and Saker falcon (*Falco cherrug*) (Abdunazarov 1987; Shernazarov and Lanovenko 1994).



© HANS HILLEWAERT/CC-BY-SA-3.0

FIGURE 2.3: Researchers have studied the effects of power line collisions on vulnerable species, such as the Ludwig's bustard of Europe, Asia, and Africa.

In Kazakhstan, researchers found 409 bird carcasses of 34 different species during a 2006 survey of power line mortality. Many deaths were due to electrocutions and 44% were raptors. Deaths due to collisions were also noted (Lasch et al. 2010).

The great bustard (*Otis tarda*), which once ranged from Manchuria to Portugal, is now extirpated or endangered across much of the continent because of habitat loss, disease, and mortality from power line collisions (Janss and Ferrer 2000; Garcia-Montijanoi et al. 2002; Alonso and Martin 2005). It is one of the world's heaviest flying birds with a maximum weight of 21 kilograms (46 pounds). As a result, great bustards maneuver slowly in flight and are not able to avoid wires spotted at the last moment. Collisions have been observed by researchers in Mongolia (Kessler 2007). The research group notes that great bustard collisions with power lines are a common occurrence in developed Western Europe and are becoming more frequent in China.

In South Africa, The Endangered Wildlife Trust has a Wildlife & Energy Program that coordinates and sponsors research on bird/power line interactions (EWT 2011) (see Appendix E). This includes a study on the vision characteristics of the Ludwig's bustard (*Neotis ludwigii*) and blue crane (*Anthropoides paradiseus*) with respect to their ability to see power lines while in flight and how to reduce the collision risk for these species. It also includes a range-wide study of the collision rates of the Ludwig's bustard.[5]

In Kenya, a 2009 risk assessment of bird interactions with electrical infrastructure identified several sites of high collision risk to birds of conservation concern. These species included the grey-crowned crane (*Balearica regulorum*), lesser flamingo (*Phoeniconaias minor*), white stork (*Ciconia ciconia*), secretary-bird (*Sagittarius serpentarius*), and a number of vultures and raptors (Smallie and Virani 2010).

[5] The range of the Ludwig's bustard includes Angola, Botswana, Lesotho, Namibia, and South Africa.

FUTURE RESEARCH PRIORITIES

As more power lines are built across the landscape, collision risk is anticipated to increase. Yet, this risk may be offset through assessment of potential avian impacts during siting and route selection, improved line marking devices and study methods, and increased awareness among stakeholders. With the continued growth in power line mileage, more collision research is needed. Because of the susceptibility of some endangered species, such as the whooping crane (*Grus americana*) and California condor (*Gymnogyps californianus*), power lines in these species' ranges will require careful evaluation and routing in addition to line marking devices and/or other collision reduction measures.

National and international collaboration on bird/utility interactions has increased markedly since the late 1990s. Guidelines for the development of Avian Protection Plans are a product of this collaboration (see Chapter 7). Electric utilities are increasingly adopting avian protection policies, plans, and conservation measures, and APLIC will continue to provide guidance on bird collision issues. Cooperation in addressing collision issues will continue between electric utilities and wildlife agencies. This relationship will advance the collision risk reduction measures discussed in this manual (see Chapters 5 and 6).



© LAURA C. WILLIAMS

FIGURE 2.4: Because of the susceptibility of some endangered species, such as the whooping crane, power lines in these species' ranges require careful evaluation and routing.

Regional and species-specific studies of collision mortality and methods for minimizing collisions would be especially helpful. At this time there is no organized attempt to understand the extent and magnitude of collision mortality from power lines. Current knowledge of collisions is geographically, regionally, and site biased because most studies have been conducted on lines with known collision problems. In addition, avian/power line collision risk is not uniformly distributed because it is highly dependent on species and habitat variables. Bevanger (1999) recommended several areas of investigation that combine well-planned observational studies with experimental studies rather than non-standardized collision records that cannot be scientifically or statistically compared. Recent studies on the effectiveness of line markers (e.g., Yee 2008 and Murphy et al. 2009) follow these recommendations. Standardized protocols for monitoring mortality at communication towers (e.g., Manville 2002, 2009b; Gehring et al. 2009) and wind turbines (e.g., CalWEA 2011) could also provide models that could be adapted for power line mortality assessments.

The effectiveness of line marking devices needs further study. In particular, more research is required to determine the device and spacing best suited to different environmental conditions and species. Except for studies sponsored by the CEC and APLIC (e.g., Ventana Wildlife Society 2009; Yee 2008; WAPA 2011) relatively few systematic studies have looked at the comparative effectiveness

of different line marking devices. Barrientos et al. (2011) conducted a meta-analysis of line marking studies, discussed the limitations, and provided recommendations for more scientifically rigorous evaluations. In addition, no systematic comparison of the effectiveness of these devices with different species, in different habitats, or in different weather conditions has been conducted. As new styles of line markers continue to be developed and existing markers are modified, associated effectiveness testing will be needed.

Funding Organizations for Collision Research

APLIC, EPRI, and CEC are three organizations that provide some funding for research on avian/power line interactions (see Appendix E). The USFWS conducts limited primary research and funds state research through Section 6 Endangered Species Act grants.

APLIC funds research projects that further the knowledge of avian/power line interactions including:

- Assessments of collision and/or electrocution rates associated with power lines
- Risk assessments to identify factors contributing to collisions and electrocution mortality risks for different species
- Evaluations of impacts of power line construction on bird species



© JERRY LIGUORI

FIGURE 2.5: APLIC, EPRI, and CEC are three organizations that provide some funding for research on avian/power line interactions.

EPRI's research priorities emphasize information and monitoring systems that will improve understanding of and mitigating for avian interactions with utility facilities. These include the Bird Activity Monitoring System and avian vision studies that may help develop more effective collision prevention devices.

The CEC (Hunting 2002) identified a number of research priorities that still apply today and need to be considered to better understand avian collisions with power lines. These include:

- Standardizing mortality estimation
- Testing and documenting the efficacy of line marking devices
- Testing and documenting the efficacy and limitations of remote collision detection devices
- Determining collision risk levels associated with potential high avian-use habitats
- Monitoring and reporting over the long term



CHAPTER 3

Avian Regulations and Compliance

IN THIS CHAPTER

Overview of Existing Laws and Policies
Permit Requirements

Most native North American birds are protected by the Migratory Bird Treaty Act. Additional statutes provide further protection for bald and golden eagles *(Haliaeetus leucocephalus* and *Aquila chrysaetos)* and birds that are threatened or endangered. This chapter describes United States' and Canada's federal regulations that protect these birds, their habitat, and the corresponding conservation and permitting measures.

OVERVIEW OF EXISTING LAWS AND POLICIES

UNITED STATES

Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (MBTA) (16 U.S.C. 703–712) is the legal cornerstone of migratory bird conservation and protection in the United States. It is a strict liability statute, meaning that proof of intent is not required in the prosecution of a taking (injuring or killing) violation. Most actions that result in *taking* or possessing a protected species, its nest, parts, and/or eggs are 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…."

Generally speaking, the MBTA protects the majority of birds that nest in North America (50 CFR 10.13). As of 2012 there were 1,007 bird species on the list of migratory bird species protected under the MBTA. The list includes waterfowl, shorebirds, seabirds, wading birds, raptors, and songbirds. The 1972 MBTA amendment extended protection to birds of prey—eagles, hawks, falcons, and owls—and to corvids, such as crows and ravens. However, the MBTA does not protect non-migratory upland game birds (such as grouse and quail) or introduced species such as house (English) sparrows (*Passer domesticus*), European starlings (*Sturnus vulgaris*), rock pigeons (common/feral pigeons, *Columba livia*), monk parakeets (*Myiopsitta monachus*), and 121 other less commonly encountered species that have been excluded from protection by the MBTA (USFWS 2005a [70 Fed. Reg. 49, 15 March 2005]).



© BILL THOMPSON, USFWS

FIGURE 3.1: The Migratory Bird Treaty Act of 1918 is the legal cornerstone of bird protection in the United States, protecting more than 1,000 North American bird species such as this cedar waxwing (*Bombycilla cedrorum*).

An individual, which can mean a corporation or other organization, who violates the MBTA may be fined up to $15,000 and/or imprisoned for up to six months for a misdemeanor conviction. 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. The MBTA has no provision for permitting incidental or accidental take.

Federal agencies taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations are directed by Executive Order 13186 (3 CFR 2001; Office of the President 2001. [66 Fed. Reg. 11, 17 January 2001]) to develop and implement a memorandum of understanding (MOU) with the U.S. Fish and Wildlife Service (USFWS) that shall promote the conservation of migratory bird populations. This includes federal agencies' power line infrastructure-related collisions and electrocutions of protected birds. To date (2012), MOUs have been signed by the Department of Defense, Department of Energy, U.S. Forest Service, National Park Service, Bureau of Land Management, Minerals Management Service/Bureau of Ocean Energy Management, and the Federal Energy Regulatory Commission, with others under development.

Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act of 1940 (BGEPA) (16 U.S.C. 668–668d) provides additional protection to these eagle species. If a proposed project or action would occur in areas where nesting, feeding, or roosting eagles occur, then utilities may need to take additional conservation measures to achieve compliance with the BGEPA.

The BGEPA prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit ([16 USC 668(a)]. *Take* under this statute is defined as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" (50 CFR 22.3). *Programmatic take* is defined as *"take* that (1) is recurring, but not caused solely by indirect effects, and (2) occurs over the long-term and/or in a location or locations that cannot be specifically identified" (50 CFR 22.26). *Disturb* is defined as "to agitate, or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (50 CFR 22.3). Violators may be fined up

to $100,000 and/or imprisoned for up to one year. Individuals with subsequent convictions or who commit intentional *takes* face penalties of up to $250,000 and/or two years imprisonment.

The BGEPA has been amended to provide a permit for non-purposeful *take*, including *take resulting in disturbance* and limited *take resulting in mortality* that may occur as a result of otherwise lawful activities, provided the breeding populations are stable or increasing. Because there are no breeding populations in the eastern United States that can sustain *take*, the USFWS will not authorize *take* for golden eagles east of approximately 100° west longitude, except for *take* of nests for safety emergency situations (USFWS 2009a).



© NORMANDEAU ASSOCIATES, INC.

FIGURE 3.2: Habitat Conservation Plans help landowners incorporate conservation measures for species, such as the wood stork (*Mycteria americana*), into their development plans.

Endangered Species Act

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531–1544) protects the United States' native plants and animals that are in danger of becoming extinct and may also protect their habitats. Federal agencies are directed to use their authority to conserve listed and candidate[6] species and to ensure that their actions do not further jeopardize these species or adversely modify designated critical habitat for them. The law is administered by the USFWS and the National Marine Fisheries Service (NMFS). The USFWS has responsibility for terrestrial and freshwater organisms, while the NMFS oversees endangered marine life. These two agencies work with other agencies to plan or modify federal projects to minimize project impacts on listed species and their habitats. Protection is also gained through USFWS' financial and technical assistance partnerships with states, tribes, and private landowners.

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,[7] harm,[8] pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The ESA authorizes the USFWS to issue Incidental Take Permits (ITP) for *take* resulting from otherwise legal activity.

Section 10 of the ESA allows Habitat Conservation Plans (HCP) for the con-

---

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

7 Harass is defined as an intentional or negligent act or omission, which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly impair normal behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).

8 Harm is defined as an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation when it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).

struction and management of facilities, e.g., transmission lines, on private lands that are used by endangered species. These plans help landowners incorporate conservation measures into their land and/or water development plans. Landowners who develop and implement HCPs can also receive ITPs that allow their activities to proceed with authorization for limited *take*.

State Policies and Regulations

States have additional bird protection regulations. A utility should consult with its respective state wildlife agency to determine whether more regulations apply and if permits are required.



© JERRY LIGUORI

FIGURE 3.3: Canada geese (*Branta canadensis*) are protected by both the Migratory Bird Treaty Act and Canada's equivalent, the Migratory Birds Convention Act.

CANADA

Migratory Birds Convention Act

The Migratory Birds Convention Act (MBCA) of 1917 and amended 1994 (1994, c.22) is Canada's equivalent of the United States' MBTA (1918), which provides legal protection for migratory birds. One notable exception is raptors, which are protected by provincial and territorial wildlife acts instead of MBCA. The MBCA satisfies the terms of the Migratory Birds Convention of 1916, when both countries recognized concerns about overhunting waterfowl and shorebirds. The MBCA recognizes three classifications of protected birds: migratory game birds, migratory insectivorous birds, and migratory non-game birds. It further lists them by family and gives examples.

In Canada, the MBCA is administered by the Wildlife Enforcement Division of Environment Canada in cooperation with provincial and territorial governments. Enforcement of the Act is made in concert with the Canadian Wildlife Service (CWS), Royal Canadian Mounted Police, and provincial and territorial enforcement authorities.

The MBCA and its associated regulations state that "No person shall hunt a migratory bird except under authority of a permit," and "Subject to subsection 5(9), no person shall (a) disturb, destroy, or *take* a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird, or (b) have in his possession a live migratory bird, or a carcass, skin, nest or egg of a migratory bird."

Individuals, which includes corporations, who violate the MBCA and associated regulations may be subject to a fine of up to $300,000 and/or six months imprisonment. Upon summary conviction or upon indictment, fines of up to $1,000,000 and/or two years imprisonment may be applied.

Species at Risk Act

The Canadian Species at Risk Act (SARA) was enacted in 2003. The objective of SARA is to protect native species from extinction, ensure measures are taken for the recovery of threatened or endangered species, and encourage best management practices for maintaining healthy populations.

SARA adopted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as an advisory body to assess potentially at-risk wildlife species, identify existing and potential threats to the species, and classify the status of the species (i.e., extinct, extirpated, endangered, threatened, of special concern, or not currently at risk). Established in 1977, COSEWIC is an independent committee of wildlife experts and scientists from federal, provincial and territorial governments, universities, and non-government organizations that uses the best available science to support its recommendations. Under SARA, the government of Canada will take COSEWIC's designations into consideration when establishing the legal list of wildlife species at risk (COSEWIC 2009).

SARA states that "No person shall kill, harm, harass, capture or *take* an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." However, SARA does make allowance for the incidental *take* of animals through the issuance of permits (similar to the ESA in the United States).

Provincial Policy and Regulations

Federal and provincial governments have worked together to develop complementary policy and programs to protect species at risk. For example, the Alberta Wildlife Act and Regulations seek to protect wildlife whereby "a person shall not hunt wildlife unless the person holds a licence authorizing the person, or is authorized by or under a licence, to hunt wildlife of that kind." The legislation also states that "a person shall not wilfully molest, disturb or destroy a house,[9] nest or den of prescribed wildlife" where wildlife is defined as "big game, birds of prey, fur bearing animals, migratory game birds, non game animals, non-licence animals and upland game birds." Similarly, other provinces have enacted legislation for the protection of wildlife, including birds.

INTERNATIONAL POLICIES AND AGREEMENTS

Since 2000, there has been an increasing international awareness of the issue of bird collisions for certain species. International conventions and policies (see CMS 2011a) that are relevant to bird collisions include:

- Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands, List of Wetlands of International Importance
- Convention on the Conservation of Migratory Species of Wild Animals (CMS)
- MOU on the Convention of Migratory Birds of Prey in Africa and Eurasia
- MOU on the Conservation and Management of the Middle-European Population of the Great Bustard
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)
- Various European Union Directives

These agreements have resulted in research, reviews, and guidance on bird collisions that may provide some further insight into bird collisions.

[9] The term "house" includes artificial structures such as bird boxes and nesting platforms.

PERMIT REQUIREMENTS

UNITED STATES

Federal and state permits may be required for activities that may affect species protected by the MBTA, BGEPA, ESA, or state laws. For species protected by the MBTA, utilities are encouraged to contact their regional USFWS Migratory Bird Permit Office and their state wildlife agency to identify permit requirements and, if necessary, obtain permit applications. For species protected by the ESA and BGEPA, utilities must contact their USFWS Ecological Services field office.

Migratory Bird Permits

Migratory bird permits are issued by the regional USFWS Migratory Bird Permit Offices. Permits are issued for falconry, raptor propagation, scientific collection, rehabilitation, conservation education, migratory game bird propagation, salvage, *take* of depredating birds, taxidermy, waterfowl sale and disposal, and special purpose. Annual reporting to the USFWS is required as a condition of each permit. Policy for migratory bird permits is developed by the Division of Migratory Bird Management. The regulations governing migratory bird permits can be found in 50 CFR part 13, General Permit Procedures, and 50 CFR part 21, Migratory Bird Permits.

In 2003, the USFWS issued a memorandum clarifying the definition of *take* under the MBTA as it applies to active nests (nests containing eggs or young). Under the MBTA, the collection, possession, and transfer of inactive bird nests requires a permit, but the destruction of nests that do not contain eggs or birds is permissible. This does not apply to eagles or species listed by the ESA, whose active and inactive nests are protected. The memo also stated that the USFWS may issue permits for the removal of occupied nests when public safety is at risk (see 50 CFR 21.27).

Bald and Golden Eagle Permits

BGEPA permits are administered by the regional USFWS Migratory Bird Permit Offices in coordination with the Division of Migratory Bird Management's Washington, D.C. office and the local Ecological Services field office where an eagle *take* might occur.

Under BGEPA (50 CFR parts 22.26 and 22.27), the USFWS can issue permits to *take* bald eagles and golden eagles or their nests, where the *taking* is associated with, but not the purpose of, the activity and cannot practicably be avoided. Permits may be authorized for non-purposeful *take*, which includes *take resulting in disturbance* or limited *take resulting in mortality* provided the breeding populations are stable or increasing. USFWS will not issue golden eagle *take* permits east of the 100° meridian (see BGEPA discussion on page 22).

USFWS may also issue permits for programmatic *take* (e.g., recurring *take* for an entire power line over a specified amount of time) or for individual *take* (e.g., for disturbance due to one-time construction of a power line where the location of the *take* and when it will occur are known). *Programmatic take* permits may be issued to entities, such as electric utilities or transportation providers, that may currently *take* eagles in the course of



© JERRY LIGUORI

FIGURE 3.4: Most songbirds, such as these horned larks *(Eremophilia alpestris),* are protected by the Migratory Bird Treaty Act.



© JERRY LIGUORI

FIGURE 3.5: Bald eagles are protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.

otherwise lawful activities but who can work with the USFWS to develop and implement advanced conservation practices (ACPs). ACPs are defined as "scientifically supportable measures that are approved by the Service and represent the best available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining *take* is unavoidable" (50 CFR 22.3).

The regulations are intended to provide a mechanism—under carefully considered circumstances—where non-purposeful *take* of bald and golden eagles can be legally authorized. How-ever, BGEPA provides the Secretary of Interior with the authority to issue eagle *take* permits only if it is able to determine that the *take* is compatible with eagle conservation. This must be "…consistent with the goal of increasing or stable breeding populations."

Regulation establishes the issuance of permits for removing eagle nests where (1) necessary to alleviate a safety emergency to people or eagles, (2) necessary to ensure public health and safety, (3) the nest prevents the use of a human-engineered structure, or (4) the activity or mitigation for the activity will provide a net benefit to eagles (50 CFR 22.27). Only inactive nests may be *taken* except in the case of safety emergencies. Inactive eagle nests are defined by the continuous absence of any adult, egg, or dependent young at the nest for at least 10 consecutive days leading up to the time of *taking* the nest.

Special Purpose or Salvage or Miscellaneous Permit

In compliance with federal regulations, utilities may need certain permits to handle or "possess" injured or dead birds found along power lines. Salvaging and possessing carcasses of birds protected under the MBTA requires a Federal Special Purpose or Salvage or Miscellaneous Permit (50 CFR 21.27). This permit allows the burial or incineration of migratory birds found dead on a utility property or temporary possession for transporting to a suitable disposal location, rehabilitation facility, repository, or wildlife pathology laboratory. Permit conditions may vary but if the bird is a federally endangered or threatened species or eagle, most permits require the USFWS to be notified within 48 hours of discovery of the carcass. Depending on permit requirements, a quarterly and/or an annual report must be submitted to the USFWS regional permit office.

Endangered Species Act Consultation, Incidental Take Permit (ITP), and Habitat Conservation Plan (HCP)

When utilities propose the construction of, for example, power generation or transmission facilities where a federal nexus exists (i.e., on federal lands, with federal funding, or requiring federal authorization or permits), they

must first consult with the USFWS through Section 7 of the ESA if any threatened or endangered species may be at risk. Before initiating an action, the federal agency owning the land or providing the funding or the non-federal permit applicant (e.g., an electric utility) should 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 that describes the consultation process in detail (USFWS and NMFS 1998). Based on a Biological Assessment, an ITP may be issued under Section 7 of the ESA.

When non-federal activities (i.e., lacking a federal nexus) will or may *take* threatened or endangered species, an ITP is required under Section 10 of the ESA. Approval of an ITP issued in conjunction with an HCP requires the Secretary of the Interior to find, after an opportunity for public comment, that among other things, the *taking* 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 or adversely modifying critical habitat. Information about consultations and HCPs can be obtained by contacting the local USFWS Ecological Services field office.

CANADA

Both MBCA and SARA provide for permitting and authorization of incidental *take* of migratory birds and species at risk. However, for MBCA, the Canadian government, through the CWS, has declared that they will not develop the permitting system; instead they recommend that companies use due diligence to prevent incidental impacts to migratory birds through best management practices.

SARA does provide for incidental harm to a species or destruction of its critical habitat under carefully controlled circumstances provided the activity does not jeopardize the survival or recovery of the species. These provisions include permits (three-year duration) or agreements (five-year duration). These authorizations are tied to strictly prescribed conditions. The government continues to work with stakeholders to develop operational policies to better implement SARA.

The requirement to protect critical habitat for migratory birds only applies in federal lands such as national parks, national wildlife areas, and bird sanctuaries. For critical habitat located in federally protected lands, the prohibition on destruction of this habitat applies automatically once the Environment Minister posts a description of the critical habitat in the Canada Gazette (typically within 90 days after the recovery strategy/action plan is posted to the SARA Public Registry).

The Environment Minister can recommend that the Cabinet protect a migratory bird species and/or the critical habitat of a species not on federal land if there is reason to believe the province or territory is not sufficiently protecting the species. However, the decision by the Cabinet to order protection is discretionary. There is also a species and habitat harm exemption clause in SARA for activities that have been authorized by other permits or agreements. This clause has not been implemented to date (2012).



CHAPTER 4

Understanding Bird Collisions

IN THIS CHAPTER

- Susceptibility of Birds to Power Line Collisions
- Identifying Collision Mortality
- Variability in Reported Mortality Rates
- Biological Significance of Collision Mortality
- Biological Characteristics Influencing Avian Collision Risks
- Environmental Conditions Influencing Avian Collision Risks
- Engineering Aspects Influencing Avian Collision Risks

Understanding the nature of bird collisions is essential for minimizing and mitigating them. This chapter presents what is known about bird collisions including the susceptibility of certain species, variability in reported mortality rates, biological significance of collision mortality, and the biological, environmental, and engineering factors that influence collision risk.

Some bird species have a greater collision risk than others. Because of the need for power lines to deliver electricity, engineering design requirements, and potential interaction of birds with power lines, collisions cannot be eliminated, but they can be reduced. The understanding of bird collisions has grown since 1994 and revolves around the following principles:

- Exposure to collisions is largely a function of behavior. Specific behaviors (such as flushing, courtship displays, and aerial hunting) may distract birds from the presence of power lines.
- Exposure is increased for birds that make regular and repeated flights between nesting, feeding, and roosting areas in proximity to power lines.
- Susceptibility to collisions is partially a function of wing and body size and vision. Larger, heavy-bodied birds with short wing spans and poorer vision are more susceptible to collisions than smaller, lighter-weight birds with relatively large wing spans, agility, and good vision.
- Environmental conditions (such as inclement weather and darkness) may distract birds from the presence of power lines or obscure their visibility.
- Engineering aspects, including design and placement, can increase or decrease the exposure for collisions.

SUSCEPTIBILITY OF BIRDS TO POWER LINE COLLISIONS

Summaries of studies on birds' susceptibility to collisions have primarily come from Europe (see Bevanger 1998; Janss 2000; Rubolini et al. 2005). Based on the Bevanger (1998) summary of risk, the orders of birds reported to be most susceptible to collisions included:

- Gaviforms (e.g., loons)
- Podicipediformes (e.g., grebes)
- Procellariiformes (e.g., shearwaters, albatross, petrels)
- Pelecaniformes (e.g., pelicans, cormorants)
- Cicioniformes (e.g., storks, ibis, herons)
- Anseriformes (e.g., ducks, geese)
- Falconiformes (e.g., hawks, eagles)
- Galliformes (e.g., grouse)
- Gruiformes (e.g., rails, cranes)
- Charadriformes (e.g., gulls, terns)
- Apodiformes (e.g., swifts)
- Columbiformes (e.g., pigeons, doves)
- Strigiformes (e.g., owls)
- Passeriformes (e.g., song birds)

The reasons for this susceptibility are functions of species characteristics, in particular the birds' body size, weight, wing shape, flight behavior, and nesting habits (see *Biological Characteristics Influencing Avian Collision Risks* on page 36). For example, literature shows that, in general, birds of prey are good fliers, have the ability to avoid obstacles, and are not prone to collisions. It is when they are engaged in certain activities (e.g., territorial defense, pursuing prey) that their collision risk increases (see Harness et al. 2003; Olendorff and Lehman 1986).

IDENTIFYING COLLISION MORTALITY

Reporting bird injuries and mortalities is part of the U.S. Fish and Wildlife Service (USFWS) permit requirements (see Chapter 3) and permits are an element of utility Avian Protection Plans (APPs; see Chapter 7). In order to report mortalities correctly, the affected species and the cause (collision or electrocution) needs to be properly identified. Field guides can be used to identify the bird species, and a guide for identifying raptor remains is also available (CEC 2005). The U.S. Geological Survey's National Wildlife Health Center also provides information and technical assistance for identifying bird carcasses (USGS 2011). See Appendix E for resources.

Table 4.1 lists the typical damage evident in bird carcasses from collision injuries. Electrocution injuries often occur as burn marks on the feathers and feet (see APLIC 2006). Collisions can also lead to electrocutions

TABLE 4.1: Typical evidence of bird injuries or mortalities from power line collisions.*

Evidence	Description
Predominant bone fractures	Fractured wings, legs, shoulder bones, vertebra, or skull; torn off limbs
Damage to plumage	Mechanical damage, such as torn off or broken feathers
Skin injuries	Skin torn open or off, and open muscle, sinew, and bone tissue visible; power line may leave imprint in skin where the bird struck the line; necropsy may reveal internal bleeding and bruising
Secondary damage to extremities	Limited areas of infection at open wounds, bones, sinews, and muscles
General condition of injured birds	State of shock; handicapped by injuries and secondary damage

* Source: Adapted from BirdLife International (2003)

(called collision-electrocutions) if the bird's size is sufficient to make simultaneous contact with two phase conductors or with a phase conductor and grounded equipment, or if the collision causes two lines to slap together or get close enough to cause an electric arc.

VARIABILITY IN REPORTED MORTALITY RATES

It is difficult to extrapolate collision risk from one study and apply it to other power lines or compare it with other studies because of site-specific conditions and varying study methods and metrics. Likewise, many collision studies have been conducted in high risk areas and would not be applicable to lower risk areas. Numerous authors have summarized collision mortality with power lines (e.g., Faanes 1987; Bevanger 1998; Alonso and Alonso 1999; Rubolini et al. 2005; and Jenkins et al. 2010) and report mortality rates ranging from no birds killed to several hundred birds killed along a given segment of line per year. The California Energy Commission (CEC) study (Hunting 2002) provides a summary of collision mortality rates per unit area per distance. Reported mortality rates are highly variable and do not lend themselves to extrapolation to other lines because of site- and study-specific differences in:

- Species involved, such as ducks and sandhill cranes (*Grus canadensis*)
- Habitats, such as wetlands and agriculture
- Time periods and sampling regimes, such as single seasons versus multiple seasons
- Weather conditions, such as fog, wind, etc.
- Sampling biases, such as scavenger removal rates and searcher efficiency
- Types of power lines

Another limit to extrapolating bird/power line collision mortality estimates is the tendency to select worst-case scenarios as case studies (e.g., Koops 1987; Erickson et al. 2001; Manville 2005a). The CEC study (Hunting 2002) points out the difficulty in generalizing collision rates, and Bevanger (1999) provides an excellent summary of the



© JERRY LIGUORI

FIGURE 4.1: Collision risk is highly variable among species, with heavy-bodied birds, such as this common loon (*Gavia immer*), being more vulnerable because they cannot readily maneuver.

Bibliographies of Collision Literature

Appendix A of this manual includes the literature cited and a bibliography of collision literature. An annotated bibliography of early collision literature was provided by Avery et al. (1980). In addition, the California Energy Commission hosts a searchable database on collisions: *On-Line Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).

methodological issues in calculating these rates. For example, Faanes' (1987) calculation of 125 collisions/kilometer(km)/year (0.62 miles[mi]/year) for a line near a North Dakota wetland with abundant waterfowl during migration periods has been referenced by others including Bevanger (1999) and Erickson et al. (2005). Janss and Ferrer (2000) calculated collision rates of "one of the densest breeding populations of the great bustard (*Otis tarda*) in Spain," and for a large wintering population of common cranes (*Grus grus*) feeding in grain fields. Extrapolations from these studies could lead to exaggerated overestimates.

Adding to the difficulty in providing an overall assessment of collision mortality is that bird collisions do not usually cause power outages and consequently are not usually discovered. On the other hand, electrocutions are more likely to cause power outages and be reported (see APLIC 2006). To generate collision estimates for a particular power line, power line segments have to be selected randomly for mortality monitoring and should represent a diversity of habitats. Collision mortality can be relatively high or low depending upon the species, habitat, and the local circumstances. Appendix B provides recommendations for collision monitoring studies.

BIOLOGICAL SIGNIFICANCE OF COLLISION MORTALITY

Understanding the biological significance of collision mortality is necessary for developing proper reduction strategies. Collision mortality may have significance from social, wildlife policy, and biological points of view. Social and wildlife policy aspects relate to how the public and wildlife agencies consider collision mortality. The biological aspects relate to how the mortality affects bird populations. The social or wildlife policy assumption of significance is not necessarily biologically significant.



© JERRY LIGUORI

FIGURE 4.2: Because of their higher reproductive rates, common bird species are generally at less risk of population effects from power line collisions.

From a biological perspective, significance evaluates whether collision mortality will affect the viability of a species' population. Biological significance results from an influence that significantly affects the ability of a species' population to sustain itself or increase its size.

This definition is used by population biologists to understand the influence of an adverse effect on a particular population or species. During site evaluation studies, utility biologists need to be aware of the possible impacts to rare species and to determine if the line would create a biologically significant risk as well as significant risk from a wildlife policy perspective (see Chapter 3).

Drewitt and Langston (2008) conclude that few studies of bird collisions with power lines show that collisions are biologically significant, which means individual losses from collision mortality are unlikely to affect large and robust populations. As an independent mortality factor, the effect of power line collisions on bird populations is generally thought to be compensated for in populations that have high reproductive rates (Bevanger 1998).

Biologically significant risk from collisions may occur in a population that is so small

that the loss of a few individuals may impact local, rare, or endangered populations (Crowder 2000). Power line collisions may be significant to very small and/or declining populations, as they may not be capable of compensating for this loss (Bevanger 1998). Drewitt and Langston (2008) note that low reproductive rates and small populations of some species may further contribute to the likelihood of population effects. In addition, there are examples where collision mortality has occurred locally and concern has been expressed. Although not a federally endangered species, recent studies of sandhill cranes in Nebraska have shown that local populations can be affected by collision mortality (Murphy et al. 2009). Collisions during spring migration stopovers at major night roosts along the Platte River in Buffalo County, Nebraska, have been historically high near two 69-kilovolt (kV) transmission lines. The Newell's shearwater (*Puffinus auricularis newelli*), an endangered species in Hawaii, is an example of a species with a relatively small and restricted population that is threatened by multiple factors including power line collisions (Podolosky et al. 1998). Other threats include ground nest predation by dogs, cats, rats, pigs, and mongooses; collisions with buildings, cars, and other objects; and attraction to lights that may disorient them and cause them to fly around the light until they fall from exhaustion. Power line collisions appear to be a major contributor to the threats to Newell's shearwater's survival (Podolosky et al. 1998; Day et al. 2003; R. Podolosky, pers. comm.).

Outside North America, collision mortality is considered biologically significant for these species with low population numbers:

- Red-crowned cranes (*Grus japonensis*) in Japan (Archibald 1987, cited in Crowder 2000)
- Wattled cranes (*Bugeranus carunculatus*) in South Africa (Van Rooyen and Ledger 1999, cited in Crowder 2000)
- Capercaillie (*Tetrao urogallus*) in Norway (Bevanger 1995; Bevanger and Broseth 2004)
- Dalmatian pelicans (*Pelecanus crispus*) in northern Greece (Crivelli et al. 1988, cited in Drewitt and Langston 2008)
- Bonelli's eagle (*Aquila fasciata*) in Spain (Mañosa and Real 2001)
- Sarus crane (*Grus antigone*) in India (Sundar and Choudury 2005)
- Eagle owl (*Bubo bubo*) in Sweden (Herren 1969)
- Mute swans (*Cygnus olor*) in the United Kingdom (Kelly and Kelly 2005)

In the United States, collision mortality from power lines is considered biologically significant for two species with small populations: the whooping crane (*Grus americana*) and the California condor (*Gymnogyps californianus*).

WHOOPING CRANE

Losses of wild and reintroduced (or experimental) whooping cranes to power line collisions have been reported (Crowder 2000; Brown et al. 1987; Morkill and Anderson 1991; Stehn and Wassenich 2007). The one natural wild population, the Aransas-Wood Buffalo Population (AWBP), has been subjected to significant natural causes of mortality such that additional collision mortality is viewed as a threat to the species. The loss of 57 cranes (21.4% of the flock of 266) that died of starvation and infectious disease in the 12 months following spring 2008 (34 between spring and fall, 23 during the winter) was a serious setback (T. Stehn, pers. comm.). The additional loss of more than 10 birds per year for any reason could destabilize this species' recovery. However, the population has shown resilience with 279 whooping cranes at the Aransas National Wildlife Refuge in the spring of 2011 (T. Stehn, pers. comm.) compared to 247 in the spring of 2009.



© USFWS

FIGURE 4.3: The United States' population of endangered whooping cranes has had such significant mortality from natural causes that additional power line collision mortality is now viewed as a threat to the species.

The actual percentage of whooping crane mortality caused by collisions with power lines is hard to extrapolate for the AWBP because monitoring the small population during migration over such a large area (Figure 4.4)[10] is so difficult. In the 1980s, two of nine radio-marked juvenile whooping cranes in the AWBP died within the first 18 months of life as a result of power line collisions; that is 33% of total post-fledging losses (n = 6) of the radio-marked birds during the study (Kuyt 1992). Five of 13 known causes of mortality (38%) for the AWBP between April and November from 1950 to 1987 resulted from collisions with power lines (total mortality from all causes equaled 133 cranes) (Lewis 1992).

Collisions have been reported in other whooping crane populations as well. In the non-migratory Florida population, 20 out of 166 cases with known causes of mortality (12%) were from collisions with power lines, and in the migratory Wisconsin population, 3 out of 18 mortalities (17%) were from collisions with power lines (Stehn and Wassenich 2007). From 1950 to 2008, out of 508 fledged whooping cranes that have died, only 44 (8.7%) of the carcasses were recovered (C. Strobel, USFWS, unpubl. data). Of the 44 carcasses recovered, no cause of death could be determined for 17. Of the remaining 27 carcasses where a cause of death was established, 9 (33%) were from power line strikes and 18 (67%) were from other causes (e.g., disease, predators, and shooting).

[10] The whooping crane migration corridor is 322 km (200 mi) wide and extends 4,023 km (2,500 mi) from Wood Buffalo National Park in the Alberta and Northwest territories in Canada to the Aransas National Wildlife Refuge on the Gulf Coast of Texas (see Stehn and Wassenich 2007).

CALIFORNIA CONDOR

The federally endangered California condor was rescued from extinction when the last remaining wild individuals were captured from the mountains of southern California in 1987 to establish a captive breeding and reintroduction program. In 1991, reintroduction of captive-bred individuals began in select areas of the southwestern United States. As of December 2011, the total wild population of California condors was 210 individuals (NPS 2011). Reintroduced individuals from the captive breeding program have come into contact with power lines and collision mortality has occurred. For example, in a six-month period, three of eight condors that died in the wild died after colliding with power lines (D. Pearson, pers. comm.).

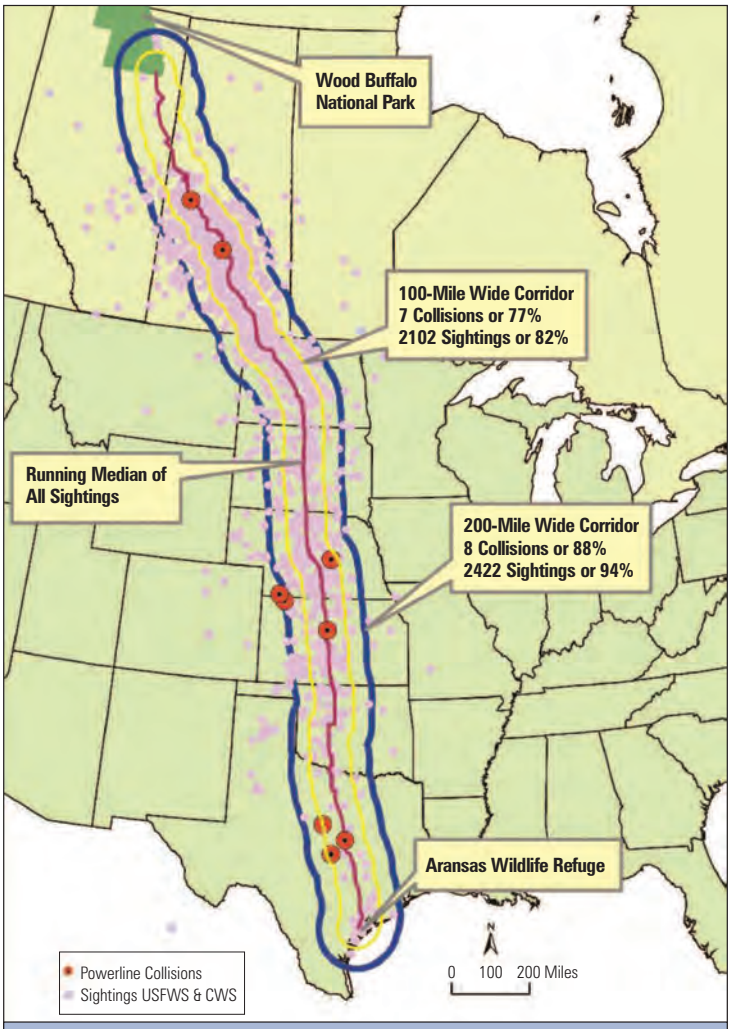


FIGURE 4.4: Whooping crane migration corridor in North America (2005 data from Stehn and Wassenich 2007).



FIGURE 4.5: Collision mortality has occurred with the expansion of the reintroduced population of the endangered California condor.

© USFWS

BIOLOGICAL CHARACTERISTICS INFLUENCING AVIAN COLLISION RISKS

Different bird species have different collision risks based on their biology, behavior, habitat use, and inherent abilities to avoid risk (e.g., Savereno et al. 1996) (see *Susceptibility of Birds to Power Line Collisions*, page 30). A number of biological characteristics influence the susceptibility of species to collisions with power lines:

- Body size, weight, and maneuverability
- Flight behavior
- Vision
- Age and sex
- Health
- Time of day and season
- Habitat and habitat use

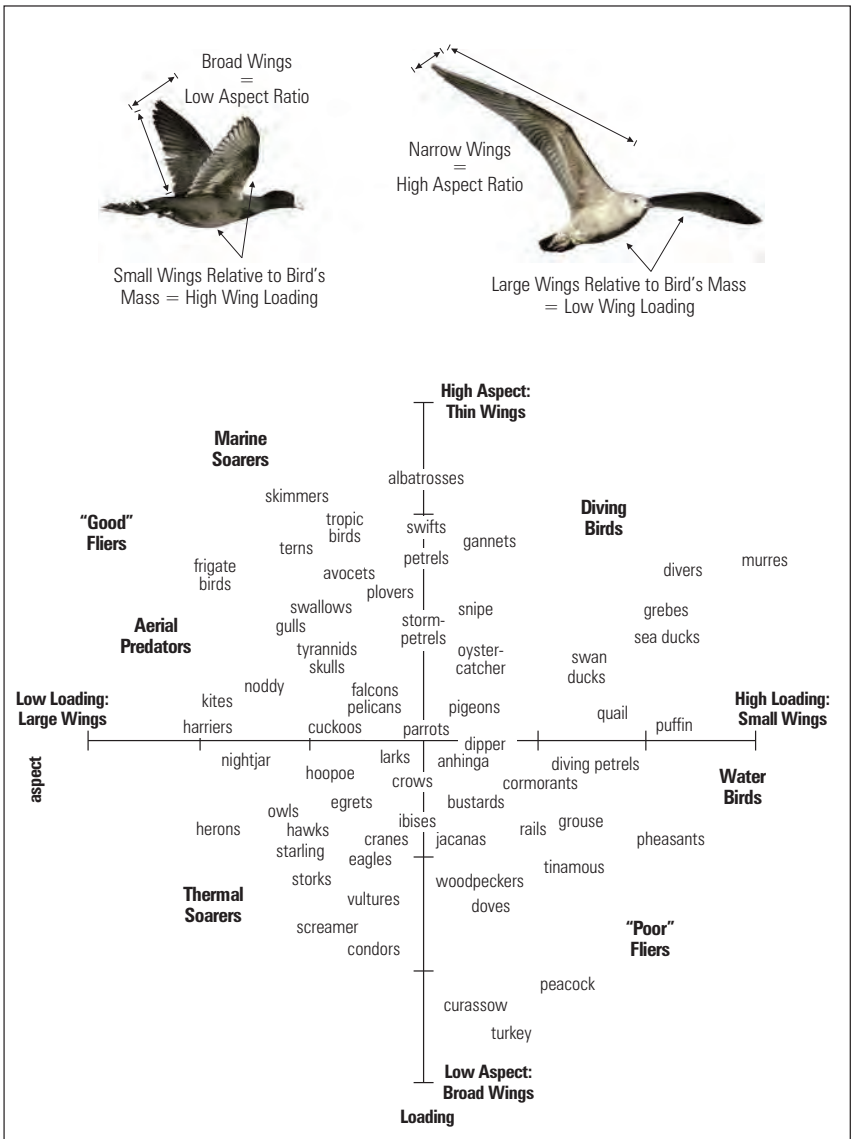


FIGURE 4.6: Wing loading and aspect ratio, among other factors, influence susceptibility to collisions (after Bevanger 1998).

IMAGES © JERRY LIGUORI

Knowing what avian species are involved, when they are present, and how they use the habitat along a power line route will help to estimate risk.

BODY SIZE, WEIGHT, AND MANEUVERABILITY

Several studies of collision vulnerability have addressed the relationship between bird size and maneuverability (e.g., Bevanger 1994, 1998; Janss 2000; Crowder and Rhodes 2002; and Rubolini et al. 2005). They classified birds based on weight and with these characteristics quantified wing loading (the ratio of body weight to wing area) and wing aspect ratio (ratio of the square of the wing span to the wing area) (Figure 4.6). Using Rayner's characterization (Rayner 1988), bird species were grouped according to the relationship of wing loading and wing aspect ratio and analyzed for collision susceptibility (Bevanger 1998). He developed six categories: poor flyers, waterbirds, diving birds, marine soarers, aerial predators, and thermal soarers. Bevanger (1994, 1998), Janss (2000), Crowder and Rhodes (2002), and Rubolini et al. (2005) have also evaluated different species and their collision susceptibility using wing loading and wing aspect ratio. They found in general that birds

with high wing loading are more susceptible to collisions than birds with low wing loading; and that birds with low aspect ratios are more susceptible than birds with high aspect ratios. Birds with high wing loading and low aspect ratios represent poor fliers. Bevanger (1998), supported by Janss (2000) and Rubolini et al. (2005), also found this to be true.

High wing loading birds are frequently reported as collision casualties, including large, heavy-bodied birds with large wing spans such as herons (Mead et al. 1979), cranes (Walkinshaw 1956; Tacha et al. 1979; Brown et al. 1987), swans (Banko 1956; Beer and Ogilvie 1972), pelicans (Willard et al. 1977), and condors (D. Pearson, pers. comm.). These and similar species generally lack the maneuverability to quickly avoid obstacles.

Heavy-bodied, fast fliers are also vulnerable to collision. This characteristic is typical of most waterfowl, coots, rails, grebes, pigeons and doves, and many shorebirds (e.g., sandpipers and plovers). For example, waterfowl accounted for the majority of collision mortality at a site in the San Luis Valley, Colorado (Brown and Drewein 1995). Researchers have also noted that species with long legs and necks collide more often than those with more compact profiles (NUS Corporation 1979, unpubl., cited in Hunting 2002).

In comparison, terns with low wing loading and smaller body size are considered agile fliers and have a keen ability to avoid lines despite their high potential exposure. Henderson et al. (1996) found only two casualties beneath wires in a study of a common tern (*Sterna hirundo*) colony located within an industrial complex, where birds of all age classes and both sexes were making hundreds of flybys per hour (>10,000 flybys observed).

Body size and maneuverability do not explain all collision risk. Other factors can also contribute. For example, gulls and terns have low wing loading, yet they can be subject to collisions because of behavioral



FIGURE 4.7: Birds with high wing loading, such as swans, are more susceptible to collisions.

© JERRY LIGUORI

characteristics, such as flocking, spending large amounts of time in the air, and flying at night. Although the low wing loading (light body) gives gulls and terns a more buoyant, graceful, and potentially slow flight speed, they are over-represented in Janss' mortality data set because of their large abundance at his study sites. This point is also made by Bevanger (1998) who cites observational studies by Meyer (1978), James and Haak (1980), and Beaulaurier (1981) to assert that gulls were 50 to 100 times less likely to collide with power lines when compared with ducks.

Passerines (songbirds) were reported in Bevanger (1998) to have a great deal of variation in flight morphology, yet most are not particularly heavy bodied or thin winged. Certain songbirds such as European starlings (*Sternus vulgaris*) may be so abundant that their representation among power line collision casualties may actually be attributed to abundance rather than susceptibility (Janss 2000). On the other hand, passerine carcasses are so small that they are much more difficult to discover and may be under-reported (Scott et al. 1972, cited in Drewitt and Langston 2008).

FLIGHT BEHAVIOR

Understanding the flight behavior of birds active near a power line can be useful in identifying the potential risk for collisions and how those risks might be reduced. The following flight behaviors have been reported in the literature (e.g., Drewitt and Langston 2008) as influencing collision risk:

- Flocking
- Flight altitude patterns of migrating and non-migrating birds
- Courtship, nest building, and feeding flights to and from and around the nest, especially for colonial species
- Flight ability of fledglings and juveniles
- Flights between nesting/roosting and foraging areas

Flocking species, such as waterfowl and wading birds, are more vulnerable to collisions than solitary species (Bevanger 1998; Crowder 2000; Crowder and Rhodes 2002; Drewitt and Langston 2008). The density of large flocks leaves little room to maneuver around obstacles; in fact, birds sometimes collide with each other when panicked (Brown 1993). Bevanger (1998) and Drewitt and Langston (2008), citing several studies, conclude that flocking behavior may lead to greater susceptibility, as trailing birds have obstructed views of an upcoming obstacle. Crowder (2000) and Crowder and Rhodes (2002) observed that flocks react to power lines at a greater distance from the line than do solitary birds. Scott et al. (1972) and James and Haak (1980) stated that flocking behavior was an important factor in starling collisions, as did Blokpoel and Hatch (1976) for snow geese (*Chen caerulescens*). A number of birds within large flocks of sandhill cranes were involved in power line collisions in the Platte River area, Nebraska; in several instances collisions of some birds within flocks were observed (Murphy et al. 2009).



© JERRY LIGUORI

FIGURE 4.8: Flocking species, such as these snow geese, can be more vulnerable to collisions.

Flight altitude is a function of species and environmental conditions such as winds, thermal conditions, visibility, precipitation, and time of day, as well as the type of flight (Newton 2008). Two types of bird flight altitude are observed: migrating or non-migrating.

Migrating birds take advantage of thermals and stronger tail winds when conditions permit, allowing them to conserve energy (Newton 2008) while staying well above power lines. In general, flight altitudes of migrating birds range from a couple hundred meters (m) (several hundred feet [ft]) to more than 6,000 m (20,000 ft). Weather conditions (e.g., wind speed and direction) influence flight altitude of migrants (see *Weather Conditions and Visibility*, page 48). Most transmission towers in the United States range from 15.2 m (50 ft) to less than 60.9 m (200 ft)[11] high depending upon design and voltage. If a

[11] Some structures exceed 61 m (200 ft) in height especially at river crossings and to clear other lines that might otherwise intersect (M. Schriner, pers. comm.; D. Bouchard, pers. comm.).

bird's flight altitude is at or below the height of power lines, collision risk can increase.

There are two basic types of migrating birds: long distance and daily migrants. Long distance migrants can fly thousands of kilometers (miles) without stopping and will have the least exposure to power lines during migration (e.g., some shorebirds, swallows, swifts, and terns). Most long distance migrants migrate at night, resting and feeding during the day (Manville 2007a). Daily migrants take shorter flights and make numerous stops to rest and feed (Newton 2008). Daily migrants include cranes, ducks, geese, and raptors. If power lines are in their landing or take-off paths, collision risk increases.

For non-migrating birds, flight altitude is likely to be within the range of power line height. Their flight is a function of their feeding, reproductive, and foraging behaviors. These behaviors usually occur within approximately 200 m (660 ft) of the ground, which can expose birds to collision risk when in the proximity of power lines. For predatory birds, the exposure to collision risk can be related, in part, to the pursuit of prey. Bevanger (1994) suggests that aerial hunters such as swifts, swallows, and certain raptors, such as the peregrine falcon (*Falco peregrines*), golden eagle (*Aquila chrysaetos*), and goshawk (*Accipiter gentilis*), typically have excellent maneuverability and very good vision. Yet because they chase prey at high speeds, the presence of a power line may not be perceived soon enough to avoid a collision with it.

Flight related to nesting behavior can increase collision risk if nests occur in close proximity to power lines. Such behavior includes courtship (e.g., aerial displays and pursuit), nest building, fledgling flights, feeding flights to and from the nest, territorial defense, and general flying around the nest or colony. These behaviors are most important for birds that nest in colonies, such as herons and egrets. Risks can also be associated with the age of a bird (i.e., adults and juveniles). Older birds are often acclimated to the presence of a line and will exhibit lower collision risk through well-developed flight patterns. Fledgling birds have less control of the flights and are more vulnerable to collisions than adults (see *Age and Sex*, page 41). There may also be risks for birds crossing a power line from the nesting site to a foraging area. Again, this is most important for colonial birds that will travel together to feed (see also *Habitat and Habitat Use*, page 44). Collision risks to foraging birds will occur when birds departing from and returning to a colony have to cross power lines. Their risk will be a function of the direction of foraging flights and the frequency of crossings. Mojica et al. (2009) reported 21 bald eagle (*Haliaeetus leucocephalus*) mortalities attributed to power line collisions in a study in Maryland conducted from 1985 to 2007.



FIGURE 4.9: Aerial hunters that forage in flight within a couple hundred meters (several hundred feet) of the ground, such as swallows, can become collision victims.

© JERRY LIGUORI

VISION

Information on the visual acuity of birds relative to power lines is generally lacking (Bevanger 1998). However, when they are able to see power lines, birds do exhibit avoidance behavior. The use of line marking devices that increase the visibility of lines has confirmed this (see Chapter 6).

For birds, detecting power lines depends on the visibility of the wires and on the characteristics of their vision. Compared to humans, the frontal vision of many bird species is not high-resolution, and many species mainly use their lateral vision to detect details (Martin 2011). Birds often tend to look downwards when in flight (e.g., to look for conspecifics [their own kind] or food), which for some species puts the direction of flight completely inside their blind zone (Martin and Shaw 2010; Martin 2011; CMS 2011a).

Some birds have highly developed vision that they use to capture prey and avoid predators (Gill 1995). The eyes of most birds are on the sides of their heads, which allows them to see things on each side at the same time as well as in front of them. This wide field of vision enables birds to spot predators and obstacles. However, widely spaced eyes can make judging distances and depth perception more difficult, except in the area where the eyes' fields-of-view overlap.

In addition, birds have blind spots caused by the length, width, and position of their bills. For some species, depending upon the size and movement of their bill, these blind spots can reduce the visual field. Researchers have noted that swans' poor frontal vision makes them more susceptible to collision (Martin and Shaw 2010). Martin and Shaw (2010) provided evidence that some species, such as bustards and cranes, have extensive blind spots in the frontal hemisphere and that downward head movement (forward pitch) greater than 25 degrees and 35 degrees, respectively, can render them blind in the direction of travel. If this occurs, objects directly ahead of the bird may not be detected during flight regardless of the visual capacities of the bird's eyes or the size and contrast of the object.

Raptors' eyes are closer to the front of their heads, giving them binocular vision, which is important for making distance judgments while pursuing prey. Having depth perception also makes them less vulnerable to collisions than birds with eyes on the sides of their head.

Birds with eyes adapted to underwater vision, such as ducks, tend to be emmetropic (objects are in sharp focus) in water and slightly myopic (nearsighted) in air (Jones et al. 2007). This may affect their ability to detect small diameter wires as they approach them at high speeds. A red-breasted merganser (*Mergus serrator*) was observed colliding with a shield wire with no reaction prior to the collision, and other mergansers were observed flying within 30.5 cm (12 in) of the shield wire with no reaction (N. Turley, pers. comm.). These observations suggest that the



© JERRY LIGUORI

FIGURE 4.10: Swans' poor frontal vision, along with their large size, increases their susceptibility to collisions.

mergansers were not aware of the wire, which indicates that vision characteristics may play a role in collision risk. Examples of other birds in this group with eyes adapted to underwater vision include loons, grebes, other diving ducks (buffleheads, scoters, and eiders), gannets, and kingfishers.

Some species have the ability to keep objects at different distances in focus simultaneously. For example, they are able to scan the horizon while keeping the ground in focus during flight, regardless of changes in elevation. This is believed to be achieved by asymmetry of the lens and cornea about an optical axis (Jones et al. 2007). This results in the eye being emmetropic in some parts of the visual field (the lateral and upper lateral visual fields) and myopic in others (lower lateral visual fields). For prey species such as pigeons, these characteristics allow the bird to scan the horizon for predators and conspecifics while foraging for objects on the ground. This same ability is also found in quail and sandhill cranes (Jones et al. 2007), but is generally not possessed by raptors or other species that must capture mobile prey.

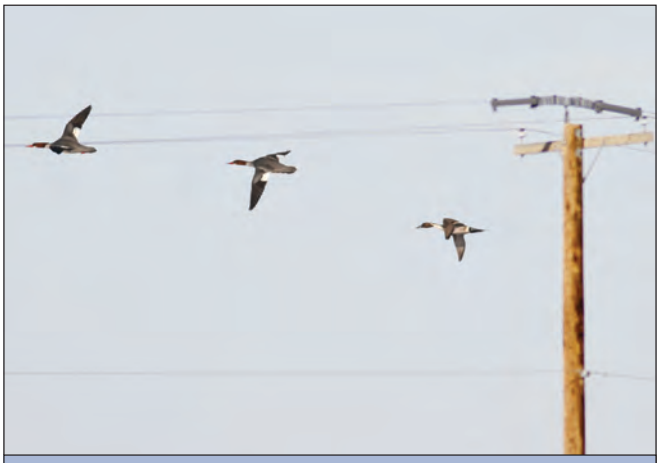


FIGURE 4.11: Because they are nearsighted and fly at high speeds, mergansers may be unable to readily detect small diameter wires as they approach them.

© JERRY LIGUORI

In the last two decades, research on avian vision has indicated that ultraviolet sensitivity is an important component of avian vision. Birds detect a wider bandwidth of light in the violet and ultraviolet (UV) spectrum (440 nanometers [nm] to 10 nm) than humans do. This difference in sensitivity may relate to many different aspects of bird behavior including prey detection, foraging, display and mating, navigation, and circadian rhythm (Hart et al 1998; Bennett and Thery 2007). Based on this research, UV materials have been applied to line marking devices to help birds detect hazards that otherwise would not be seen. However, these UV materials have not been systematically tested in collision studies.

Regardless of a bird's vision, environmental conditions such as inclement weather and the time of day (e.g., low light or dark) can reduce a bird's ability to see even marked power lines. A number of line modification and marking strategies can be used to reduce the effect of these factors (see Chapter 5 and Chapter 6).

AGE AND SEX

Age and sex have a species-specific influence on collision risk. Crowder (2000) cites numerous studies showing that juveniles are more susceptible than adults (Thompson 1978; McNeil et al. 1985; Brown et al. 1987; Crivelli 1988; Savereno et al. 1996; Mathiasson 1999) but also notes two examples where adults are more susceptible (Ogilvie 1966; Anderson 1978). Brown et al. (1987) and Morkill and Anderson (1991) demonstrated statistically that juvenile sandhill cranes col-

lided with power lines more frequently than their proportion of the population would indicate. Conversely, Anderson (1978) found that adult mallards (*Anas platyrhynchos*) were more vulnerable to collisions than juveniles. Ogilvie (1966) suggested that age was not a factor in collision susceptibility for mute swans.

Many authors suggest that young birds or those unfamiliar with the area are more vulnerable than experienced birds (Anderson 1978; Thompson 1978; McNeil et al. 1985). The less-controlled flight of young birds also increases their collision risk. These birds are generally believed to be more susceptible to both electrocution and collision, though this may be confounded by the greater proportion of young birds in the population (Bevanger 1998). Most (11 of 14 = 78.6%) of Newell's shearwater collisions at a Kauai, Hawaii, power line were non-breeding birds, though many of those were likely subadults. The proportions of non-breeding adults and subadults in the population were not reported (Cooper and Day 1998). Juveniles of many migratory species are especially at risk because they have not yet encountered nor learned to avoid the assortment of risks they face.



© KEITH SWINDLE, USFWS

FIGURE 4.13: Endangered Newell's shearwater mortalities at a Kauai power line were mostly non-breeding adult and subadult birds.



© USFWS

FIGURE 4.12: Some juvenile birds, such as sandhill cranes, collide with power lines more frequently than their adult counterparts.

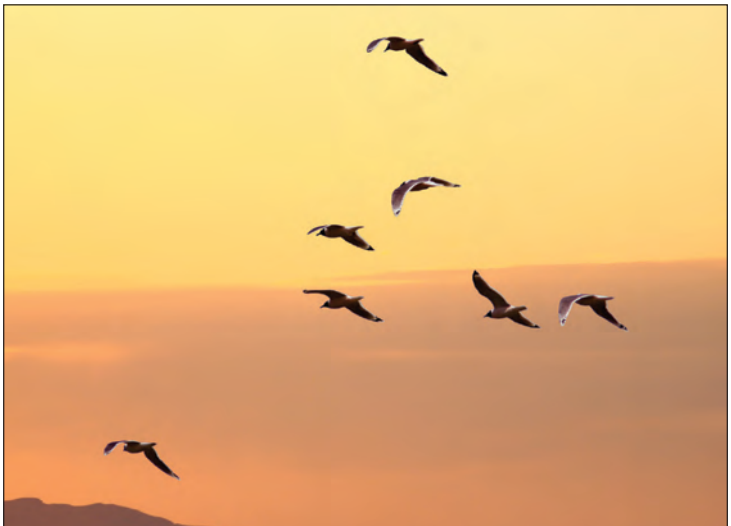
Less information about the differing vulnerability of sexes exists because comparative data are rarely available. However, several studies have presented evidence that male ducks are more prone to collisions than females (Boyd 1961; Avery et al. 1977; Willard et al. 1977; Brown and Drewien 1995). The courtship and pursuit behaviors of male ducks greatly increase their frequency of local flights and can distract them from seeing and avoiding power lines. Distractions for other species also include pursuit of mates, competitors, or prey, which can increase collision risk (Willard et al. 1977; Anderson 1978).

HEALTH AND CONDITION OF THE BIRD

Studies of birds killed by power line collisions indicate that poor health may increase collision risk. Mute swans with elevated blood lead levels had higher collision risk than did healthier birds (Kelly and Kelly 2005). Low weight swans and swans with heavy burdens of toxins were over-represented among swans killed by collisions in Sweden (Mathiasson 1999).

The ability of the bird to maneuver can also be impaired by entanglement with fishing lines and other anthropogenic materials. Manville (2005b) reported on entanglement issues involving Canada geese (*Branta canadensis*) and other waterbird species with six-pack beverage rings and monofilament fishing line, along with plastic debris ingestion, all of which may increase their susceptibility to power line collisions due to weakened conditions, altered aero-dynamics, and impaired health.

Collision mortality can also lead to health effects in populations of birds. In rare instances, collisions that occur in high enough numbers can indirectly contribute to some diseases, such as botulism. Malcom (1982) reported the deaths of several thousand grebes and ducks from botulism that were initiated by the victims of collisions with a transmission line in south central Montana. The collision victims fell into a wetland where their carcasses provided the energy substrate in which dormant *Clostridium botulinum* spores became active. These bacteria produce a toxin that invertebrates consume and concentrate without ill effects. Those toxin-laden invertebrates (e.g., fly-egg-maggot) become food for other ducks and a vicious cycle can develop and become protracted (Rocke and Friend 1999), much as Malcom observed.



© JERRY LIGUORI

FIGURE 4.14: Gulls (pictured) and waterfowl tend to make feeding flights at dusk and dawn, when reduced light increases collision risk.

TIME OF DAY AND SEASON

Time of Day

Studies have shown that time of day is important to collision frequency in daily flights and during migration. Different species generally feed at different times of day. Non-breeding birds, including migrating species, generally feed continuously during the day and are considered to have continuous exposure to power lines in the vicinity of their feeding areas. When birds are nesting, they often show a periodicity in feeding.

Collisions are much more likely during the night than the day (Scott et al. 1972; Krapu 1974; Anderson 1978; and James and Haak 1980; all cited in Crowder 2000; Pandey et al. 2008). Gulls and waterfowl tend to make feeding flights after sunset and before sunrise. Many waterbird species regularly fly at night in response to tidal cycles or prey activity (Black and Collopy 1982; Erwin 1977; Robert et al. 1989; Dodd and Colwell 1998) or predator avoidance. Inability to see the wires due to low light conditions probably raises the collision risk for these species (Scott et al. 1972; Krapu 1974; James and Haak 1980; Brown and Drewien 1995). At the San Luis National Wildlife Refuge Complex in California, bird flight diverters were effective on waterfowl but not on coots, which authors attribute to the fact that coots

fly at night and cannot see the diverters (Ventana Wildlife Society 2009).

Species that migrate at night, such as songbirds and herons, may be vulnerable to collisions if weather forces them to fly at low altitudes. However, generalizing from one species to another or one habitat to another that nocturnal flight behavior may be more risky than diurnal flight behavior needs to be cautioned. Deng and Frederick (2001) investigated nocturnal bird flights of wading birds in the vicinity of a 550-kV transmission line adjacent to the Everglades in south Florida. They observed nine species of wading birds including herons, egrets, and wood storks (*Mycteria americana*). The investigation showed that nocturnal-flying wading birds were less responsive to the power lines than diurnal-flying birds; however, the birds generally flew higher over the power lines at night than during the day. No collisions were observed but the authors stated that the sampling period was short (118 hours). One of the suggested reasons for the lack of collisions was that the birds were acclimated to the presence of the line.

Similarly, radar data collected by Harmata et al. (1997) along the Missouri River indicated that birds flying at night flew at heights well above power lines. By flying higher at night, waterbirds and other species may lower collision risk with natural and anthropogenic obstacles. However, there may be risks from lines that occur in the departing and arriving zones for roosting or foraging habitats. For example, dark-rumped petrels (*Pterodroma phaeopygia*) and Newell's shearwaters in Kauai, Hawaii, crossed much closer to power lines in morning seaward flights than in evening landward flights, and all recorded Newell's shearwater collisions occurred during morning flights (Cooper and Day 1998).

Season

Seasonal bird abundance is also correlated with collision mortality. For example, seasonal flight behavior differences resulted in more wintertime collisions for ptarmigan in Norway (Bevanger and Broseth 2004). Migration seasons generally pose a greater risk to migrating birds because of both higher flyover frequency and unfamiliarity with local landscapes. The nighttime proportion of crane and waterfowl collision mortality versus total collision mortality was 31.8% in the fall (1990) during migration and 7.7% in the spring (1991) in San Luis Valley, Colorado (Brown and Drewein 1995).

Willard (1978) described a situation in the Klamath Basin, Oregon, that illustrates how both collision mortality and its population effects can increase during the breeding season. At Lower Klamath Lake National Wildlife Refuge, adult American white pelicans (*Pelecanus erythrorhynchos*) flew low over canals and collided with power lines while searching for food. For this species, this meant a double loss: first, the loss of the adult that collided with the line, and second, the loss of the young, which rarely fledge after one parent is lost because both parents must forage extensively to feed them.

HABITAT AND HABITAT USE

Power lines located near habitats with high avian use (such as nesting, foraging, roosting, and resting sites) may pose greater exposure to collisions for some species. For example, power lines between foraging and roosting sites of wading birds will be frequently crossed, which increases the collision risk potential. This is especially true when only a short distance separates the two habitats. Birds in these situations typically fly at low altitudes, potentially putting them at the height of power lines. Willard et al. (1977) suggested that overhead wires within a single habitat (e.g., within a wetland) are more likely to cause collisions than those between two habitats (e.g., wetlands and uplands); other studies have found the opposite to be true (e.g., Faanes 1987; Brown et al. 1987; Morkill and Anderson 1991).

The critical questions are how often, and in what numbers, do birds fly across a power line during their daily routines? For example, in a study in the San Luis Valley of Colorado, Brown et al. (1987) found that power lines dividing wetlands (used for roosting) from grain fields (used for feeding) caused the most collisions for sandhill cranes and field-feeding waterfowl. This occurred because these habitats encouraged the birds to cross the lines at low altitudes several times each day. However, the same power lines had little effect on diving ducks, which had restricted their activities to wetlands. Thus, the risk of a particular power line depends in part upon the way each species uses the adjacent habitat.



FIGURE 4.15: Power lines located between the foraging and roosting sites of wading birds, such as this white ibis *(Eudocimus albus)*, may result in higher collision risk.

© JERRY LIGUORI

Power lines, including those that border habitat such as a wetland used by many birds, may present little risk if the adjacent habitat separated by the power lines is not attractive to birds (e.g., a city rail yard). Conversely, if the adjacent habitat is a grain field, collisions may result in fall and winter for field-feeding birds that make daily flights between wetland roosts and foraging sites, including sandhill cranes, Canada geese, mallards, and pintails (*Anas acuta*) (Thompson 1978; Brown et al. 1987; Morkill and Anderson 1991). The same line may represent lower risk during the breeding season when these birds remain in wetlands throughout the day. Although forested habitats located near power lines can



FIGURE 4.16: Research conflicts on whether or not overhead wires within a single habitat, such as this wetland, are more likely to cause collisions than those between two habitats.

© NIKKI HECK

sometimes reduce collision risk (see *Managing Surrounding Lands* on page 58), in some forested habitats where there are open clearings for the power lines, collision risk may be higher for birds that fly across the open corridor while going between forested areas.

During migration, birds make stopovers in their preferred habitats. When migratory birds' staging, roosting, resting, and foraging areas are located near power lines, especially when ingress or egress coincides with inclement weather, collision risk increases (Manville 2005a, 2009a). This can be especially true when there are large concentrations of birds; for example, sandhill cranes that number in the tens of thousands along the Platte River in Nebraska (Murphy et al. 2009).

Some habitats, such as lakes and ponds, have seasonal use patterns. Proximity to shoreline habitat was linked to bald eagle collisions (21) and electrocutions (24) at Aberdeen Proving Grounds, Maryland (Mojica et al. 2009). Higher collision mortality was found at power lines near shorelines used as feeding areas. The 16,000 hectare (39,537 acre) area on Chesapeake Bay had 42 resident pairs and seven known communal roosts used by migrants from the north and south during the winter and summer months, respectively. In a high bird concentration area along Lake Ontario, double-crested cormorants (*Phalacrocorax auritus*) were the most commonly reported collision victim, although they were over-represented relative to their abundance in the area, and gulls and waterfowl were the next most commonly reported species to collide with lines (Barrett and Weseloh 2008). A PacifiCorp study calculated the distance of collision mortalities to the nearest water body using survey data collected in Oregon, California, Idaho, Utah, and Wyoming from 2004 to 2009 (S. Liguori, PacifiCorp, unpubl. data) (Table 4.2).

TABLE 4.2: Average distance of collision mortalities from nearest water body.*

Species	Sample Size	Average Distance
Snow goose *(Chen caerulescens)*	37	82.3 m (270 ft)
American white pelican *(Pelecanus erythrorhynchos)*	17	82.6 m (271 ft)
Tundra swan *(Cygnus columbianus)*	3	89.3 m (293 ft)
Sandhill crane *(Grus canadensis)*	7	119.8 (393 ft)
Great blue heron *(Ardea herodias)*	7	154 m (505 ft)
Mallard *(Anas platyrhynchos)*	5	213.4 m (700 ft)

* Source: PacifiCorp, unpubl. data

ENVIRONMENTAL CONDITIONS INFLUENCING AVIAN COLLISION RISKS

Environmental conditions that can increase the risk for collisions with power lines include:

- Land uses
- Weather conditions and visibility
- Sudden disturbances

The relative importance of these conditions varies with location, season, species, and different populations of the same species.

LAND USES

Land uses, such as conservation, recreational, residential, agricultural, and industrial, have

habitats and management practices that can attract or discourage bird use. Collision risk depends on the location of power lines within these areas and the bird species that are drawn to them.

Conservation and Nature-Based Recreation Lands

Conservation areas and wildlife refuges vary greatly in size and habitat type and are often managed for specific types of wildlife and/or nature-based recreation uses. Many conservation lands have distribution lines that supply their power needs and may also be crossed by transmission lines. These lines may present collision risk depending on the habitats, species, and human activities present. The potential for disturbing and flushing birds into nearby power lines can be higher in recreation areas due to increased human activity or lower if resident birds are acclimated to human activity. Power lines that cross high avian-use habitats such as wetlands or are placed between foraging and roosting areas may also result in a higher risk of bird collisions (see *Habitat and Habitat Use* on page 44). Although a proposed power line route may not be able to avoid such conservation areas, managers need to be aware of the potential risks so they may be minimized (see Chapter 5).



© HALEY EDWARDS, PUGET SOUND ENERGY

FIGURE 4.17: Power lines crossing agricultural fields with seasonally attractive crops or residue can contribute to collision risk for some flocking species, such as cranes, waterfowl, songbirds, and these trumpeter swans (*Cygnus buccinator*).

Residential and Urban Recreation Lands

Residential and urban recreation lands vary widely in their attractiveness to birds (e.g., Chace and Walsh 2006). Generally, urban recreation lands such as parks and golf courses are interspersed within or between densely populated residential areas. These lands often become habitat islands. For example, they may have small wetlands that are used by various protected birds. Distribution lines may be especially plentiful in residential and recreational areas and can pose a collision risk, depending on the susceptibility of the species, when situated in the flight patterns of birds.

Agricultural Lands

Agricultural fields and ponds can attract birds; for example, grain crops are seasonally attractive to many flocking species such as cranes, waterfowl, and blackbirds, along with rodents that attract raptors. Because grain fields are used only as feeding areas by these species, they may be attractive when they are in close proximity to nesting, roosting, or wintering habitat. Agricultural fields, especially those that are managed with burning or flooding or have nearby wetlands, can also attract a variety of bird species during staging and migration and may even result in shortstopping, i.e., drawing birds to these attractive sites for the winter rather than their historical wintering sites (Viverette et al. 1996). Collision problems may develop when birds must cross power lines to make daily, low-altitude flights between feeding areas and nesting or roosting sites. See also *Habitat and Habitat Use* (page 44).

Industrial Lands

Industrial lands sometimes provide attractive bird habitat. Gulls, vultures, crows, ravens, and



other scavengers often gather at landfills in large numbers. Cooling ponds at electricity generation facilities, municipal sewage ponds, settling ponds at mines, and other industrial water bodies can attract waterbirds, shorebirds, and raptors. As with other types of land use, the degree of hazard posed by power lines will vary depending upon the proximity of the lines to these avian-use areas (see *Habitat and Habitat Use* on page 44). If bird collisions become a problem, property managers may be able to choose from a variety of options to modify or discourage bird use of the area (see *Managing Surrounding Lands* on page 58).

WEATHER CONDITIONS AND VISIBILITY

Weather conditions play a very important role in both the visibility of power lines and in the behavior of birds in flight during migration and local movements, such as daily foraging activity. When weather conditions interact with biological characteristics (e.g., flight behavior, wing loading and aspect ratio, and season), collision risk may be dramatically affected.

Adverse weather conditions, such as fog, dense cloud cover, high and variable wind speeds, precipitation, and reduced or zero visibility are associated with greater collision risk. Reduced visibility and high wind speeds can also cause birds to fly at lower altitudes, potentially putting them at the same height as power lines. The influence of weather on flight altitude was reviewed in depth by Shamoun-Baranes et al. (2006), and the effect of weather on flight height and behavior has been observed in many bird species (Drewitt and Langston 2008; Newton 2008).

Weather and biological factors are often interrelated and may affect flights within high bird-use areas. The timing of daily flights may subject certain species to adverse weather conditions associated with collisions, such as fog (Scott et al. 1972; Tacha et al. 1979) or wind (Brown 1993). This is especially true in coastal and low-lying areas that are frequently foggy or windy. When possible, birds will avoid flying in heavy precipitation or fog. Problems most often occur when birds unexpectedly encounter these conditions. Storms or fog can arise quickly and birds may collide with power lines when attempting to leave feeding areas for protected roosts (Wheeler 1966; Tacha et al. 1979). In foul weather, birds may be attracted to lighted areas on the ground (Manville 2007a). If power lines are also in or near those areas they could be in the landing approach of the attracted birds and become a collision risk (see *Lighting*, page 52).

Wind, wind shear, and turbulence most often appear to influence collisions when birds fly at power line heights. Some birds decrease flight altitude in high winds (Scott et al. 1972; Raevel and Tombal 1991). Poor conditions—wet feathers, precipitation, high winds, wind gusts, and turbulence—also hamper birds' ability to control flight and further increase collision risk (Walkinshaw 1956; Avery et al. 1977; Willard et al. 1977; Anderson 1978). In high-velocity winds, birds may collide with other birds, buffeting them into fully visible and familiar power lines (Brown et al. 1987; Morkill and Anderson 1991; Raevel and Tombal 1991; Brown and Drewien 1995).

In the San Luis Valley, Colorado, collisions occurred more frequently on days with winds >24 km per hour (15 mi per hour) (Brown and Drewein 1995). Collisions were also more likely with tailwinds, which increase a bird's ground speed, than with headwinds, which have the opposite effect (Savereno et al. 1996). Crowder (2000) reviewed older evidence of power line collisions resulting from stormy (Wheeler 1966), foggy (Tacha et al. 1979), or windy (Brown et al. 1987; Morkill and Anderson 1991) conditions. These studies showed that wind, especially associated with stormy weather, is an important contributor to collisions. It has been suggested that birds, such as gulls, with a high aspect ratio and low wing loading are more susceptible to being blown into lines than other bird



© JERRY LIGUORI

FIGURE 4.18: Birds usually initiate migration in favorable weather conditions, but when they encounter inclement weather they may decrease their flight altitude, which increases collision risk when power lines are present.

species without these physical characteristics (Bevanger 1998).

The impact of weather is also related to season, as adverse weather may pose a greater risk during migration (APLIC 2007) and can influence the initiation of migration (Shamoun-Baranes et al. 2010). Songbirds usually begin migration in favorable conditions, but may encounter inclement weather en route. The weather hazard may be worsened when migratory birds respond to fog and precipitation by decreasing their flight altitude (Gauthreaux 1978a) or by attempting to land (Manville 2007a). In known or historic staging, roosting, resting, feeding, or stopover areas for migratory birds located in immediate proximity to power lines, there can be a substantial increase in collision risk, especially when bird ingress or egress coincides with inclement weather (Manville 2005a, 2009a). This effect is magnified when flocks are very large, as with migrating sandhill cranes in the Platte River area of Nebraska (Murphy et al. 2009).

The flight altitudes of migratory birds can vary greatly and are strongly correlated with winds aloft, air clarity, turbulence, thermals, and weather, both day and night. In particular, thunderstorms and low cloud ceiling conditions are known to cause nocturnally migrating songbirds to land or to fly at lower altitudes that increase collision risk, particularly with illuminated structures (Winkelman 1995; Gill et al. 1996; Erickson et al. 2001; Johnson et al. 2002; Kerlinger 2003). Various radar studies have estimated that under normal weather conditions, 84% to 97% of nocturnally migrating songbirds fly at altitudes of 125 m (410 ft) or more above ground level where they are not exposed to risk of collision with power lines (Mabee and Cooper 2002; Cooper 2004; Mabee 2004).

SUDDEN DISTURBANCES

Sudden disturbance can panic and flush birds, especially flocks of birds, into nearby power lines and has been well documented as a contributing factor to collisions (Krapu 1974; Blokpoel and Hatch 1976; Anderson 1978; Brown et al. 1984; Archibald 1987). Birds may be flushed by vehicles, trains, pedestrians, aircraft, farm equipment, hazing, hunters, predators, etc., along ROWs and may collide with power lines in their effort to escape (APLIC 2007). Crowder (2000) reviewed older evidence of power line collisions resulting from sudden disturbance of geese by vehicles (Schroeder 1977) or airplanes (Blokpoel and Hatch 1976). One such disturbance resulted in a collision event with mallards during Crowder's (2000) field study. Murphy et al. (2009) support the idea that most sandhill crane collisions at Platte River, Nebraska, occur when closely congregated birds are flushed after dark. In Washington, roosting American white pelicans collided with an adjacent distribution line when flushed during the night by a passing train, even though line marking devices were installed (S. Liguori, PacifiCorp, pers. comm.).

ENGINEERING ASPECTS INFLUENCING AVIAN COLLISION RISKS

The following engineering aspects can influence the risk of collisions with power lines:

- Diameter of lines (shield wires versus phase conductors)
- Line placement (proximity to avian habitat)
- Line orientation (relative to biological and environmental factors)
- Line configuration (aligned vertically or horizontally and the number of lines)
- Structure type (guyed versus self-supporting)
- Lighting (steady burning versus blinking)

DIAMETER OF LINES

The smaller diameter of transmission line shield wires compared to phase conductors influences the risk of collisions, with shield wires being the lines most often involved (Scott et al. 1972; Willard et al. 1977; Brown et al. 1987; Faanes 1987; APLIC 1994; Savereno et al. 1996; Jenkins et al. 2010). Because of their smaller diameter (1 to 1.3 centimeters [0.4 to 0.5 inches]) compared to phase conductors (2.5 to 5 cm [1 to 2 in]) and their position above the phase conductors, shield wires are the least visible type of power lines and they are in the flight path of birds that gain altitude to avoid the more obvious phase conductors. The shield wire protects, or shields, the phase conductors from lightning strikes.

Distribution lines consist of phase conductors and a neutral wire, which is at the same level or below the phase conductors. Though it is not absolute, most birds gain altitude to avoid an obvious line, which implies that neutral lines are less likely to be involved in collisions.

LINE PLACEMENT

The proximity of power lines to bird take-off and landing areas can affect collision risk (Lee 1978; Thompson 1978; Faanes 1987), but no specific setback distance has been found in the literature. Brown et al. (1984, 1987) found that no sandhill crane or waterfowl collisions occurred where distances from power lines to bird-use areas were ≥1.6 km (1 mi). Faanes (1987) found that collision rates dropped off dramatically after 400 m (1,312 ft). Faanes (1987) stated that "among the sites I examined, power lines situated 400 m (1,312 ft) or more from the edge of the water generally had lower observed mortality than sites where the power line was within this distance." Quinn et al. (2011) found no bird carcasses under power lines that were situated more than 500 m (1,640 ft) from the edge of the water; at distances of 60 m (197 ft), collision mortality dropped off dramatically ($p = 0.0012$, $df = 3$). See also *Habitat and Habitat Use* on page 44. See Chapter 5 for examples of risk and reduced risk situations.

LINE ORIENTATION

Orientation of power lines relative to biological characteristics (e.g., flight behavior, season, habitat, and habitat use) and environmental conditions (e.g., topographical features and weather patterns) can influence collision risk. When planning power line routes, features that are traditional flight corridors, such as mountain ridges, river valleys, and shorelines, should be considered (Colson and Yeoman 1978; Faanes 1987). Power lines that parallel primary bird flight paths pose less risk than a perpendicular orientation (Crowder 2000; Scott et al. 1972; McNeil et al. 1985). For example, the perpendicular orientation of a line relative to a topographical feature poses a greater collision risk to local and migrating birds than a parallel orientation (see Figure 4.19).

Lines that are at or below the height of nearby trees rarely present a problem to small tree-dwelling birds because of their maneuverability; furthermore, large birds will gain altitude to fly over the tree line and consequently avoid the power line (Thompson 1978; Raevel and Tombal 1991). For example,



© JERRY LIGUORI

FIGURE 4.19: Orientation of power lines parallel to ridges or narrow, low altitude flyways presents a lower risk of collision than perpendicular orientation.

a power line that crosses a narrow river bordered by trees that are taller than the line is likely to have a lower collision risk than lines crossing broad rivers because most birds will fly over the tree tops to cross the narrow river valley (CMS 2011a).

Strong tail winds can be detrimental to birds' ability to execute avoidance maneuvers. Brown (1993) suggested that north-south orientation of lines increased collision frequency for cranes and waterfowl in the San Luis Valley, Colorado, because birds crossing them on an easterly heading were often subjected to prevailing westerly winds. See also *Biological Characteristics*, on page 36, and *Weather Conditions and Visibility* on page 48.

LINE CONFIGURATION

Line configuration—phase conductors aligned vertically or horizontally, and the number of conductors—is a collision factor that intuitively makes sense, but there are too few studies to draw conclusions. Most researchers agree that keeping the vertical arrangement of multi-conductor transmission lines to a minimum is beneficial because it reduces the height of the collision zone. However, a single-pole vertical structure is often esthetically more acceptable and requires less ROW width.

Thompson (1978) and others (Bevanger 1998; Crowder 2000; Drewitt and Langston 2008) have suggested that clustering lines (i.e., several power lines sharing the same ROW) may reduce the risk of collisions because the resulting network of wires is confined to a smaller area and is more visible. Birds only have to make a single ascent to cross lines before resuming their preferred altitude. However, when there is decreased visibility, collision risk for birds may increase where several lines are clustered together. In addition, when there are two shield wires at different heights, and only the higher one is marked, there may be collisions at the lower unmarked shield wire, thus both shield wires may need to be marked (S. Liguori, pers. comm.). See Chapter 5 for examples of risk and reduced risk situations.

STRUCTURE TYPE

Because of the collision risk posed by guyed communication towers (e.g., Shire et al. 2000; Manville 2007a; Gehring et al. 2009; Gehring et al. 2011; Longcore et al. 2012), the question of collision risk associated with guyed power line structures has occasionally been asked. Guy wires on power line structures are used for support and stability especially where a line ends (deadend structure) or changes direction (e.g., makes a 90-degree turn). There is no published information to suggest that guyed power line structures pose a significant collision risk for birds. PacifiCorp has surveyed over 120,000 poles in six states and has not found collision victims at any of the guyed structures (S. Liguori, pers. comm.). Based on exposure alone, the relative short lengths of the guy wires and the low heights on power lines pose much less risk to birds than do the longer, multiple guy wires on communication towers whose height can

exceed 300 m (>1,000 ft; Gehring et al. 2011). In addition, some types of lighting on communication towers can attract birds into the collision zone in low visibility weather. Because transmission towers are, with very few exceptions, unlit, they are not expected to have the same risk.

LIGHTING

Studies of bird collisions with communication towers and other tall structures have shown that steady-burning white or red lights can disorient migrating birds at night especially when migration coincides with inclement weather (Manville 2007a, 2009; Gehring et al. 2009, 2011). This disorientation can cause birds to collide with the lighted structure, guy wires on a communication tower, or each other. It can also cause the birds to circle the light source, which may also result in exhaustion and injury or death. Collision incidence on lighted communication towers, for example, depends on the type and intensity of the lights (i.e., steady burning, blinking, or strobe) as well as whether the birds are navigating visually or magnetically. In a Michigan communication tower study, extinguishing steady-burning, L-810, red side lights, while leaving on the red, blinking incandescent pilot warning lights, reduced bird collision mortality by up to 72% (Manville 2007a; Gehring et al. 2009). However, any light, including blinking incandescent and strobe lights, can cause some bird attraction, even during clear weather (Manville 2009a).

In the United States, any structure that is ≥60.9 m (200 ft) above ground level is subject to Federal Aviation Administration (FAA) lighting requirements for aviation safety. Transmission towers in the United States are typically <60.9 m (200 ft) tall[12] and do not have lights. However, shorter structures may also require lighting depending on their location (e.g., in proximity to airports). If lighting is used on transmission lines, it should be compatible with FAA regulations, the Canadian Aviation Regulation, and USFWS bird protection guidelines, and these agencies should be consulted on lighting. The FAA no longer recommends using L-810 steady-burning red lights.[13] In general, the USFWS recommends avoiding lights, particularly steady-burning lights, and using motion- and heat-sensitive lighting where feasible (e.g., for infrastructure security lighting).

[12] Some structures exceed 60.1 m (200 ft) in height, especially at river crossings and to clear other lines that might otherwise intersect (M. Schriner, pers. comm.; D. Bouchard, pers. comm.).

[13] This change is expected to be included in the revision to the FAA's 2007 lighting circular, which is underway at this time (2012). As a preliminary step, in June 2012 the FAA published the results of its pilot conspicuity studies on the elimination of steady-burning red (L-810) side lights at communication towers.



CHAPTER 5

Minimizing Collision Risks

IN THIS CHAPTER

- Opportunities for Minimizing Collision Risks
- Modifying Existing Power Lines
- Planning New Power Lines
- Public Participation to Address Social and Cultural Issues

There are a number of design and engineering strategies for minimizing collision risk with power lines. This chapter introduces evaluation studies and risk reduction strategies for modifying existing lines and planning new lines. This chapter also discusses how to address social and cultural issues through public participation programs.

OPPORTUNITIES FOR MINIMIZING COLLISION RISKS

By working together, engineers and biologists can identify and address collision issues when modifying existing lines and planning new lines (Figure 5.1). Collision issues typically develop or are discovered long after a power line is built, which makes minimizing collision risk more difficult. However, early evaluation of factors that influence collisions (see Chapter 4) can reduce collision potential and may reduce the need for costly modifications later.

Engineers and biologists can reduce collisions when…

Modifying Existing Power Lines	Planning New Power Lines
Evaluation studies include: • Collision monitoring to examine the causes and conditions associated with the risk and to help determine the type and effectiveness of modifications. • Avian risk assessment and spatial analysis to prioritize line segments for modification.	*Evaluation studies include:* • Spatial analysis that considers habitat variables, species, behavior, and other factors to help choose the optimal route. • Field assessment to identify species, abundance, and high bird-use areas. • Avian risk assessment to evaluate collision risk along potential routes.
Risk reduction options include: • Line marking to increase the visibility of the line. • Managing surrounding land to influence bird use. • Removing the shield wire if lightning is not an issue or if lightning arresters can be used instead. • Increasing the diameter or changing the configuration of wires when a line is being rebuilt. • Rerouting the line if all other attempts have been exhausted and populations are significantly impacted. • Burying the lines if feasible and warranted.	*Risk reduction options include:* • Line placement that takes migratory patterns and high bird-use areas into account. • Line orientation that considers biological and environmental factors such as bird flight paths, prevailing winds, and topographical features. • Line configuration that reduces vertical spread of lines, clusters multiple lines in the same right-of-way (ROW), increases the visibility of lines, and/or decreases the span length if such options are feasible. • Line marking to increase the visibility of the line. • Burying lines if feasible and warranted.

FIGURE 5.1: Opportunities and strategies for minimizing collision risks.

MODIFYING EXISTING POWER LINES

EVALUATION STUDIES FOR LINE MODIFICATIONS

If a significant collision risk has been observed along a segment of line, it may be possible to eliminate or minimize the risk by modifying the line in various ways. Line modifications should be supported by collision monitoring studies that examine the causes and conditions associated with a high collision rate (e.g., bird species involved, avian use patterns, mortality rates, weather, and biological significance of mortality levels). Although collision monitoring study methods must be tailored to site-specific biological, environmental, and engineering factors (see Chapter 4), basic, standardized ornithological field survey procedures should be used to produce results that would be comparable to other studies. Appendix B presents considerations and issues for designing site-specific

Comparing the Effectiveness of Line Modifications

Assessments of line modification effectiveness are often based on pre- and post-modification mortality (Rigby 1978; Beaulaurier 1981; Archibald 1987; Brown et al. 1987). Although evaluations based on casual observations or limited sampling of collisions contribute to the knowledge of line modification effectiveness, more rigorous studies are necessary to adequately compare the effectiveness of various measures (e.g., Crowder 2000; Yee 2007, 2008; Ventana Wildlife Society 2009; and Pandey et al. 2008).

study methods for collision monitoring. Once monitoring data are collected, line modification options can be evaluated to identify, quantify, and balance existing risks with the effectiveness and risks posed by the modifications.

Collision Monitoring Studies

To design a collision monitoring study, a number of key questions need to be answered:

- What species is/are at risk?
- What is the magnitude of risk?
- Does this risk contribute to population level impacts?
- What biological, environmental, and engineering factors contribute to collision risk?
- Is the study protocol scientifically sound?
- What are the regulatory and policy considerations of collisions?
- What methods effectively minimize collisions for new and existing power lines?

Collision monitoring results should include the following information:

- Collision rates among species and between sexes and ages (if known) within a single species
- Collision rates expressed as the number of bird collisions relative to the number of birds that are exposed to the line in the strike zone, i.e., collisions/flybys
- Biological, environmental, and engineering factors affecting collision risks (see Chapter 4)
- Mortality corrected for site-specific sampling bias (see Appendix B)
- Behavioral responses of different species to the lines and to line marking devices or other modifications
- Effectiveness of line marking devices based on changes in mortality after marking devices were installed or other line modifications were made

These and other monitoring considerations are discussed in greater detail in Appendix B.

To understand the mortality risk for an entire line, it is essential to study representative segments of the line rather than focusing only on high collision segments, since doing so will overestimate the overall mortality risk. The study method should ensure that test and control segments are of comparable length and that they have as much environmental homogeneity as possible (see Appendix B). On lines with high environmental variability across their length, stratified random sampling may allow the investigator to treat the segments similarly enough to collect meaningful data.

The greatest problem faced by researchers in most field studies is controlling for external variables (e.g., Alonso and Alonso 1999; Jenkins et al. 2010; Barrientos et al. 2011). The results of Brown and Drewien (1995) support the hypothesis of Thompson (1978) that collision rates are not predictable from one study to another and one season to another. They found that rates varied among species, seasons, and years and attributed much of the variability to changes in the local environment, which, in turn, influenced bird densities (see also Blair 1996). This suggests that, ideally, studies should compare test

and control line segments within the same time period.

Regardless of whether assessments are made before or after line modification or by using test and control segments, collision risk comparisons are most meaningful if collisions are expressed in relation to bird numbers or, preferably, flybys. This allows a collision rate to be calculated. Where feasible, observations of birds' avoidance behavior when crossing the lines are valuable in understanding how a line affects flight behavior. Actual mortality may be low, which presents a statistical challenge in comparing retrofitting options. This condition should be anticipated and integrated into the study design (see Appendix B).

Collision monitoring studies should incorporate the basic methods used in other mortality evaluations (see Appendix B) including:

- Defining the collision zone for birds crossing lines
- Establishing an adequate search area for mortalities (increasing with the height of the line)
- Obtaining sampling bias estimates for injuries, searcher efficiency, scavenger removal, and habitat differences

Evaluation of bird behavior at marked and unmarked lines provides insight to collision rates. Morkill and Anderson (1991) and Brown and Drewien (1995) demonstrated that bird responses varied with marked and unmarked lines. Observations should be made on marked and unmarked portions simultaneously to minimize environmental variability. For example, Deng and Frederick (2001) showed that the number of birds flying above or below marked and unmarked lines was not statistically significant; however, they observed that the birds approaching a marked line reacted earlier than birds approaching an unmarked line.

Behavioral criteria evaluated may include:

- Type of reaction to lines
- Distance from the line that the reaction occurred
- Height above the line when crossing

Because these estimates require evaluations by observers, it is important to standardize survey procedures (see Appendix B). All observers should be given training and practice time before the study begins and, when possible, the same observers should be used throughout the study. Brown and Drewien (1995) found that most observers required about 12 hours of practice before they became consistent. As an alternative to field observers, the Bird Strike Indicator (BSI), a vibration sensing and recording tool, can be installed on lines to detect bird strikes (see box, page 57). However, the BSI does not identify what species struck the line; hence, mortality monitoring or field observations, which would also reveal pre-strike behavior, would be required.

Avian Risk Assessment and Spatial Analysis

Avian risk assessment and spatial analysis can be used to prioritize segments of line for modification. See *Evaluation Studies for Siting New Power Lines* on page 64.

OPTIONS FOR MODIFYING EXISTING LINES

Potential options for line modification include line marking, managing surrounding land, removing the shield wire, changing the diameter or configuration of wires, and rerouting or burying existing lines where feasible. Utilities are encouraged to work with wildlife agencies (see Chapter 3) to evaluate collision risks to species of concern and options for reducing those risks. Typically, the first option is marking high risk segments of the line and/or managing the surrounding lands. Redesigning, reframing, relocating, or

Remote Sensing with the Bird Strike Indicator

The Bird Strike Indicator (BSI) is an automated vibration sensing and recording tool designed by Electric Power Research Institute (EPRI) to detect bird strikes on overhead lines. Previously, the only means for identifying whether collisions were occurring was for observers to monitor lines and to conduct ground surveys for bird carcasses. Manually monitoring bird collisions is labor-intensive, expensive, and its effectiveness is limited to daylight hours. Carcass surveys may correct for lack of monitoring during low-light periods, but these are often associated with vegetation, water, and scavenger detection biases (see Appendix B). Some birds also may fly beyond the search zone after the collision. If the collision itself was not observed then this type of contact would be missed by standard monitoring methods.



© EPRI, CEC, AND EDM INTERNATIONAL, INC.

FIGURE 5.2: The Bird Strike Indicator, a tool used to detect bird strikes with power lines, can be installed from a bucket truck or helicopter.

BSI sensors can be installed on phase conductors or shield wires. Each installation will be unique to the surrounding environment. For example, the lightweight accelerometers in BSIs are meant to detect stress waves caused by avian collisions, but in one study, BSIs also picked up the vibrations from daily trains (M. Schriner, pers. comm.). For a horizontal line configuration, the BSI is only needed on the outside wires (M. Schriner, pers. comm.). The BSI generates a collision log including the wire struck along with the date, time, and temperature. The BSI wirelessly transmits these data to a base station in real time. Base stations serve multiple sensors simultaneously and are accessible through an interface. Each sensor is designed for up to six months of autonomous operation between battery replacements. The units check and report their health each morning and can be reprogrammed remotely.

Research during the development of the BSI (Pandey et al. 2008) and independent trials conducted afterwards (Murphy et al. 2009) demonstrated that the BSI is as reliable as human observers for detecting collisions during daylight. The technology is especially useful for monitoring collisions in low-light or no-light conditions and over-water crossings where carcass recovery is compromised. However, unlike human observations, BSI does not identify the species that struck the line; mortality monitoring or field observations would be required to determine this. The BSI has also been successfully used to monitor communication tower guy wire collisions in Cold Bay, Alaska, which demonstrated that the BSI allows continuous line monitoring under all lighting and weather conditions (R. Harness, pers. comm.).

As of 2012, a new companion technology to the BSI, called the Bird Activity Monitoring System (BAMS), is in its technical development phase with EPRI funding and is envisioned as an intelligent, image-based, sensing and recording tool that will assist with detailed study of wildlife interactions with various types of structures including power lines.

burying power lines may not be economically or technically feasible. Such options are usually a last resort and only contemplated when an avian resource has been documented to be seriously affected.

Line Marking

Most studies have shown a reduction in collisions and/or an increase in behavioral avoidance at marked lines when compared to unmarked lines, but this can vary with location, type of line marking device, and bird species (Jenkins et al. 2010; Barrientos et al. 2011; see Chapter 6 for detailed information on devices and effectiveness). There are three general categories of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). Large diameter wire may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see Chapter 6). Line marking devices are selected based on product availability and durability, cost, ease of installation, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and potential for vandalism.

Lighting has also been successfully used to reduce collisions. In Washington, a spot light (using the line as a power source) was installed in an uninhabited area to illuminate a section of marked distribution line at night. This effectively reduced collisions of American white pelicans (*Pelecanus erythrorhynchos*) that roost adjacent to the distribution line. The pelicans had collided with the line when flushed during the night by passing trains, even though line marking devices were installed (S. Liguori, PacifiCorp, pers. comm.). In Botswana and South Africa, the Mace Bird Lite, a spiral device with a fluorescent light, has been used to reduce flamingo collisions (Eskom 2003; Eskom Transmission 2009; see *Devices Available in Other Countries* on page 97).

When using lighting, the effects of lighting on birds as well as applicable regulations for lighting should be considered (see *Lighting* on page 52).

Managing Surrounding Lands

The location and condition of habitat and the surrounding or nearby land uses, such as wetlands and agriculture, and their proximity to power lines influences collision risk (see Chapter 4). Modifying habitat, land uses, or management practices to influence bird use in strategic areas can reduce collision risk where there is a willing agency or landowner. Sometimes, land management can be less costly and more effective than other line modifications. Options are discussed for conservation, recreation, residential, agricultural, and industrial land uses.

Planting Trees

Where climate and location will allow, planting native trees that will grow to or above the height of nearby power lines, without interfering with line operations, may prevent collisions by forcing birds to gain enough altitude to clear the more visible tree line (Thompson 1978; Raevel and Tombal 1991). For instance, greater white-fronted geese (*Anser albifrons*) flew over power lines more in woodlands than over lines in rice fields in Japan (Shimada 2001), and areas with shorter trees had higher collision rates than areas with taller trees for ptarmigan in Norway (Bevanger and Broseth 2004). For mitigation purposes, tree planting is a long-term strategy because of the time it takes for trees to grow to the desired height; thus, short-term mitigation would likely be necessary in the interim. Because trees can potentially cause operational and reliability problems with lines, a design engineer and a forester should be consulted concerning minimum clearances and line maintenance requirements so appropriate tree species and planting locations can be determined.

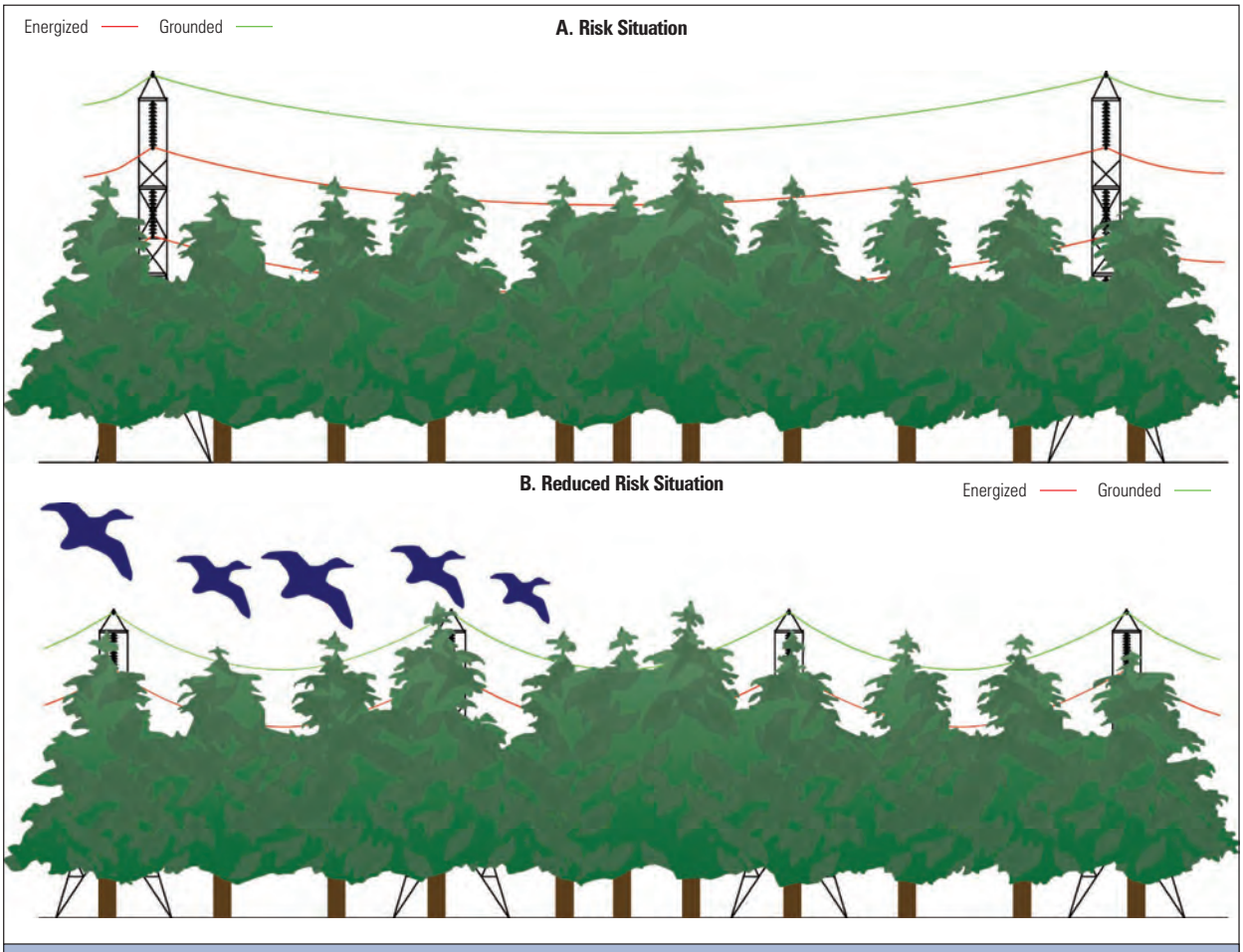


FIGURE 5.3: Reducing collisions in wooded areas. A tree line or other obvious obstacle at the appropriate height warns birds to gain altitude, which results in birds flying over the power line screened by the trees (after Thompson 1978).

Removing Disturbances

Reducing and modifying human access points to decrease the likelihood that human activities will disturb birds where they congregate near power lines can reduce collisions caused by frightening and flushing birds into the power lines (see *Sudden Disturbances* on page 49). Restricting access roads on power line ROWs to utility-related activities is an option that may be open to landowners or land managers. Conservation area managers and private landowners can limit or prohibit hunting or other high-disturbance activities near power lines. On public access roads, speed limit restrictions and signage indicating bird-use areas may reduce flushing of birds. Crane and waterfowl collisions at Bosque del Apache National Wildlife Refuge in New Mexico were reduced simply by having personnel drive slowly and stop when birds

were on refuge roads, which allowed the birds to leave the area without panic. However, this was not successful enough and the lines were eventually buried. (J. Bradenburg, pers. comm.)

Habitat Modification on Conservation, Recreation, and Residential Lands

Land managers and landowners may be able to manipulate bird habitat to minimize collision risk. For example, when waterfowl need to use two distinct habitat types (e.g., one for feeding and one for roosting), they will generally select those that are closest to each other. If a power line divides those habitats, the collision risk is greater. It may be possible to create both habitat types on one side of the line to reduce the crossing frequency (see *Line Placement* on page 66).

Management Practices on Agricultural Lands

Sometimes it is possible to enlist the help of landowners to modify management practices, including the timing of practices that may be attractive to birds, such as burning or flooding fields, where a line is experiencing a high collision rate. For example, in the San Luis Valley, Colorado, farmers plow barley stubble into the ground in preparation for planting in late fall and early spring—times when sandhill and, in the past, whooping cranes (*Grus canadensis* and *Grus americana*) forage in the stubble. The cranes may collide with power lines that border these fields, especially when feeding very close to the line. Through a program sponsored by utility companies, farmers were encouraged to begin plowing the stubble closest to the lines before the birds arrived. This reduced the risk of collisions by causing



© JERRY LIGUORI

FIGURE 5.4: Habitat modifications, such as cooperative programs to encourage earlier plowing of grain stubble, which is attractive to migrating sandhill cranes, may help to reduce collision risk.

the birds to forage farther from the lines where the stubble remained standing (C. Bryant, pers. comm.).

Discourage Bird Use of Industrial Lands

For industrial features such as landfills, cooling ponds, municipal sewage ponds, settling ponds at mines, and other industrial water bodies, property managers can choose from a variety of options that will discourage bird use, such as covering garbage, placing nets over a pond, and using visual or sonic deterrents. Cost, effectiveness, and maintenance should be considered when evaluating bird dissuasion options.

Removing the Shield Wire

Removal of the shield wire from transmission structures (AC or DC) can reduce bird collisions (Beaulaurier 1981; Brown et al. 1987), but is rarely a viable option because it exposes the lines to lightning strikes, which jeopardize service reliability (Figure 5.5). Shield wires are typically installed on the top of transmission structures to protect the phase conductors from lightning strikes and the electric grid from lightning related power outages. This overhead shielding has proven to be the most effective and economical lightning protection for transmission lines.

The lightning arrester system, one alternative to the shield wire, is effective when used on lines with distribution voltages from 4.2 to 35 kilovolts (kV) and provides sufficient protection to the line and associated equipment. However, lightning arresters may not be a viable option due to cost, design characteristics, and effectiveness for transmission voltages. Their presence would also increase the electrocution risk to birds that perch on power line structures. Because the shield wire often incorporates a fiberoptic communication line, the cost of modifications to the communications system would also need to be included in the analysis.



FIGURE 5.5: Removing shield wires can reduce bird collisions but leaves the lines unprotected from lightning strikes and jeopardizes service reliability.

© NOAA

Changing the Line Configuration

When collisions cannot be reduced by another method such as line marking or managing surrounding lands, the configuration of an existing line can sometimes be changed to minimize collisions. This is usually only possible for new construction or when a line is being rebuilt. Effective design changes would need to be based on studies of the flight behaviors of the bird species at risk (see *Evaluation Studies for Line Modifications*, page 54). In addition, the redesigned section(s) of line would need to be compatible with the rest of the line. Options for changes might include:

- Lowering the height of the lines (e.g., below the tree line)
- Changing the wire diameter
- Bundling wires
- Using spacers to improve visibility

- Rearranging wire configuration (e.g., converting from vertical to horizontal)
- Changing the structure type to increase its visibility
- Decreasing span length (e.g., by adding a pole mid-span)

Rerouting Existing Lines

If all other attempts to reduce significant collision risks to an acceptable level have been exhausted, rerouting may need to be considered. This option would require routing analysis, acquisition of a new or additional ROW, removal and relocation of existing structures, and a scheduled outage for the work. The rerouting analysis should include a comparative risk assessment to evaluate the collision risk for the new line (i.e., whether its risk is measurably lower than that of the existing line) to determine if the rerouting is justified (see *Avian Risk Assessment* on page 65). Environmental benefits and economic cost should be part of the risk analysis. Given the potential land costs and limited options for ROW , together with the cost of structure changes, the economics and logistics of rerouting make this option rarely possible.

Burying Power Lines

Burying power lines with voltages less than 345 kV have been proposed to reduce collisions. However, there are innate characteristics of buried lines that make them only rarely feasible. These include voltage and type of cable, land use patterns, soil conditions, regulatory acceptance, outage risk and reliability requirements, termination facility requirements, length and operating limits, and other environmental concerns. Depending on these characteristics, the cost of buried power lines can vary from 3 to 20 times that of an overhead line (Bumby et al. 2009).

Voltage and Type of Cable

As the voltage increases, costs increase. The type of cable (power line) used also affects the cost. Current options include paper-insulated cable installed in oil-filled pipes, and solid dielectric cables installed in conduits or buried directly in the earth with selected backfill (see *Soil Conditions*, page 63).

Lines ≥69 kV are normally installed in pressurized, oil-filled pipes in order to eliminate voids and moisture pockets in the cable insulation. They have an excellent reliability record when properly designed, installed, and maintained. The oil also tends to dissipate the heat generated by the current flow in the cables. If the oil can be circulated under pressure, the capacity and reliability of the cable will be enhanced.

Solid dielectric cables are currently being used for 115-kV and 230-kV applications. They are less reliable than oil-filled pipes. The preferred design is to place them in a conduit so that construction in highly developed areas may move rapidly and the necessary excavation can be covered quickly to reduce the impact and inconvenience to the public. The conduit also provides some physical protection to the cable from accidental excavations.

Land Use Patterns (Urban, Rural, etc.)

In highly developed areas where other utilities are buried (e.g., water, sewer, gas, communication), costs and space are at a premium. In rural areas, some conflict may exist with pipelines, rivers, and lakes (see Figure 5.6 and *Environmental Concerns* on page 63). In undeveloped areas, geologic formations may prevent economical trenching. In addition, underground lines require termination areas at both ends, similar to small substations, to accommodate the overhead-to-underground transitions.



FIGURE 5.6: Buried power lines may be a solution to bird collisions in some instances, but can cost from 3 to 20 times more than overhead lines and have other environmental impacts.

Soil Conditions

The soils must be able to dissipate heat during periods of high electricity demand. Soil condition also directly affects construction cost (i.e., sandy soils are more easily trenched than rocky soils). In many cases, the spoils from the cable trench have to be hauled away and replaced with heat-dissipating sands to meet the cable design standards.

Regulatory Acceptance

Utility regulatory commissions set rates and control costs. This can have a direct bearing on the feasibility of an underground project. There are documented projects where regulatory commissions have instructed the parties requesting underground construction to pay the difference in installation cost (e.g., Colorado Public Utility Commission Decision No. R82-93).

Outage Risk and Reliability Requirements

Cable failures are difficult to locate and the line must be dug up for repairs and maintenance. Extended outages normally result because of the length of time it takes to locate and repair a fault in the cable. Certain customers, such as hospitals and large industrial or mining operations, have higher reliability requirements than others.

Requirements for Termination Facilities

These include access for large equipment, a fenced area, transition structures, switches and other protective equipment, a transmission line tower or distribution structure, and in some cases a pumping station. Such overhead electrical facilities should be designed to minimize avian electrocution risk (see *Suggested Practices for Avian Protection on Power Lines*, APLIC 2006).

Length and Operating Limitations

As the length of the line increases, the operating limitations are approached and the options to address this will further increase costs.

Environmental Concerns

Environmental damage can result if a buried power line is near or crosses a waterway or is in wetlands or other sensitive habitats (Figure 5.6). If an oil-filled pipe leaks, the oil would contaminate the water and surrounding soils. Ground disturbance during construction, repairs, and maintenance can result in large, permanent displacement of excavated soil and subsequent issues with re-establishing native vegetation and preventing the overgrowth of invasive species. A University of California study (Bumby et al. 2009) found that underground power lines have more environmental impacts than overhead power lines for all categories and most scenarios in southern California.

PLANNING NEW POWER LINES

EVALUATION STUDIES FOR SITING NEW POWER LINES

The potential for avian/power line interactions can be identified and addressed during corridor and routing evaluations such as spatial analysis, field assessment, and avian risk assessment. Methods for these evaluations differ because every route is unique with regard to the species, habitat, and line design. Ornithologists or wildlife biologists knowledgeable in local bird issues should be consulted for pertinent information on bird movement patterns and the presence of species of concern that could be affected by collisions with power lines. Habitats that influence bird presence and movement may present a collision risk and should be identified. Other biological, environmental, and engineering factors that contribute to collision risk should be understood (see Chapter 4) and considered as well.

Spatial Analysis

The siting process for new lines is in large part a geospatial analysis that facilitates the selection of a route that is compatible with regulatory, land use and availability, environmental, economic, and engineering considerations. Spatial analysis of habitats has been aided by the development of GIS software, which can help identify and characterize risk. GIS is often preferred because it can predict the optimal route by incorporating all the variables under consideration. Features in some GIS software systems can apply segment weighting to help determine the optimal route. GIS software specifically for siting and routing power lines has been developed by the Transmission Line Siting Methodology research project (see EPRI 2006). It uses a multi-step approach that starts with a large study area (corridor) and through various levels of evaluation selects potential routes and a preferred route. GIS software can also be used to create maps, which may be used to rank habitats for their prospective bird use within potential line routes. This approach is especially useful when species of concern occur along a proposed route.

About GIS

GIS (geographic information systems) software incorporates, stores, analyzes, manages, and presents data linked to a specific geographical location. It merges cartography, statistical analysis, and database technology. As a tool, GIS software helps decision-makers understand and predict the relationships between human uses and natural resources such as wildlife and habitat.

Field Assessment

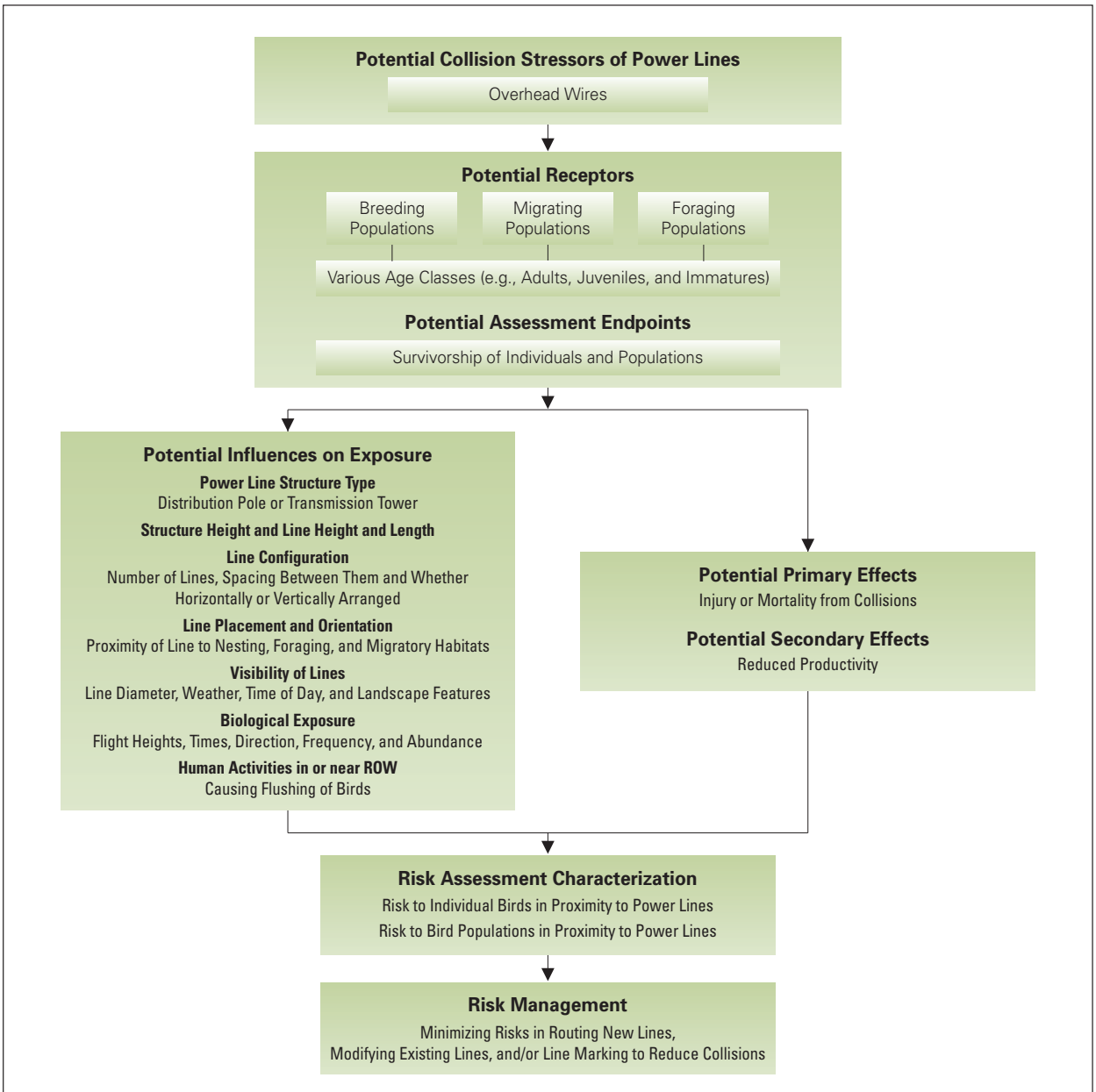
Field assessment can often minimize collision risks (see Chapter 4) by identifying high-use bird habitats to avoid during route evaluation. Study designs should be scientifically defensible and developed to meet the needs of the project. Ideally, the following information should be obtained during the field assessment:

- Presence and abundance of bird species in the vicinity of the alternative routes
- Occurrence of species of concern, such as endangered species
- Location of habitat used by birds of concern
- Daily and seasonal use patterns for each species, including a differentiation between migration and daily use

This information can be obtained by using standard bird survey techniques, such as point counts, and from existing avian databases, such as the Christmas Bird Count and eBird (see Appendix E).

Avian Risk Assessment

Avian risk assessment can be used to characterize the collision risk of a planned or existing line and to prioritize the segments that need to be modified. Risk assessment is a systematic process for characterizing the probability of an adverse effect occurring (USEPA 1998). It has been adapted for a



J. NEWMAN, NORMANDEAU ASSOCIATES, INC.

FIGURE 5.7: Conceptual model of avian collision risk assessment.

wide range of applications, including avian/power line interactions. Avian risk assessment in this context evaluates the collision risk that a power line may pose to birds. It includes several steps: problem formulation (e.g., identifying species affected and specific collision issues), characterization of exposure and effects, risk assessment, and risk management. Figure 5.7 presents a conceptual model of avian collision risk assessment.

Both qualitative and quantitative estimates of risk can be used. One or both of these approaches may be appropriate depending upon the type of risk characterization required and the data available.

Qualitative risk assessment provides a non-numeric narrative description of risks. The resulting risk statement is descriptive (not mathematically quantifiable) and provides an estimate of risk, such as low, moderate, high, etc. This approach uses existing information about the proposed site, its ecological resources, literature on the physiology and behavior of species of concern, and reported effects (e.g., accounts of known collision mortality at existing power line projects). Implementing a qualitative methodology does not generally require field studies before construction, but uses site visits to confirm conditions and supplement available information.

Quantitative risk assessments provide estimates of the number of birds anticipated to be at risk to collisions. A quantitative approach accounts for, among other things, the spatial configuration of the stressor (power lines) and the spatial and temporal exposure of the receptor (birds) (i.e., the number of receptors that interact with the stressors in question).[14] Quantitative risk assessments can be developed using literature and other data but, because this method is typically used when greater precision is needed, it is frequently supplemented by site-specific data on power line engineering and/or design and site-specific observations and studies to further assess collision potential.

Sometimes a tiered risk assessment can be used starting with a qualitative assessment and proceeding to a quantitative assessment. For example, if more than one route is being compared for risks, a higher or lower risk ranking may be appropriate using a qualitative approach. If a specific prediction of the amount of mortality is required, a quantitative or modeled approach may be appropriate. Spatial analyses have been used with quantitative modeling to identify and prioritize high risk bird collision areas with varying degrees of success depending upon the quality and quantity of the data (see Heck 2007; Shaw et al. 2010; and Quinn et al. 2011).

OPTIONS FOR MINIMIZING COLLISION RISK DURING ROUTE EVALUATION

Engineering aspects such as line placement, line orientation, and line configuration all contribute to either increasing or decreasing the level of collision risk relative to biological and environmental factors (see Chapter 4). However, line routing is primarily a function of the origin and destination of the power being carried by these lines (see Figure 5.8), so other options such as line marking in areas where there is unavoidable collision risk and burying power lines where feasible and warranted may need to be considered.

Line Placement

Broadly, line routing should consider migratory patterns, areas of high bird use, and, if available, historical bird abundance information. On a finer scale, proximity to bird habitats (e.g., wetlands, trees, and other roosting, nesting, and foraging sites) is an important

[14] A stressor is a hazard in the environment that is capable of causing an adverse effect on a receptor. A wildlife receptor can be wildlife individuals, populations, or habitats that are subject to the potential impacts of a stressor.

Terminology Used When Planning New Transmission Lines

For transmission line planning, the following terms may have different meanings to various stakeholders. Figure 5.8 illustrates these terms, which will be used in this manual in the following way.

Planning is the process that identifies the need for a transmission line to deliver electricity from the generation facility to a load or demand center.

Siting determines where the ends of the line need to be—Point A and Point B.

Corridor or study area is usually a rectangular boundary between Points A and B within which the alternative and preferred transmission line routes are plotted.

Alternative routes through the corridor are identified based on a long list of considerations that include endangered species and wildlife habitat. Examples of additional considerations are:

- Cities and towns
- Landowner agreement
- Crossings, such as highway, water, other power lines
- Airports
- Heliports
- Cemeteries
- Communication towers
- Historic places and archaeological sites
- Wetlands
- Land availability
- Land use
- Homes/businesses/schools
- Hospitals
- Parks/recreation
- Pipelines
- Churches
- Wells
- Bridges
- Topography
- Line voltage, design, engineering, and construction

Determining a route through public land is distinctly different than through private land. On public land, an agreement with only a few landowners is necessary; whereas on private land, hundreds of landowners may be involved along with a diversity of land uses and concerns to consider.

The **preferred route** is suggested by the utility. After stakeholder participation, the public utility commission determines the final route, which may be the preferred route, an alternative route, or a combination of the preferred and alternative routes.

The **right-of-way (ROW)** is the land that will be used for the power line. Easements along the ROW give utility crews access to the line for maintenance and are legal agreements, including compensation, between the utility and the landowner.

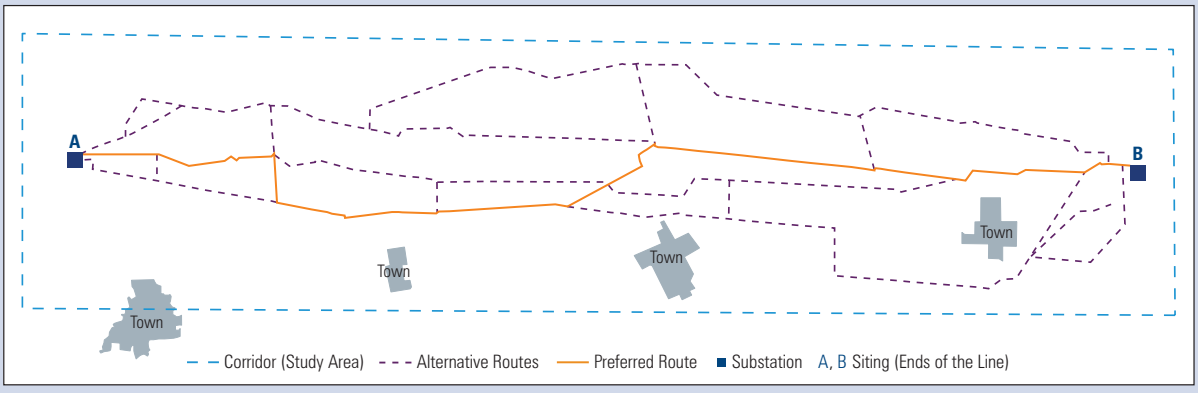


FIGURE 5.8: Schematic of the terminology used when planning new transmission lines.

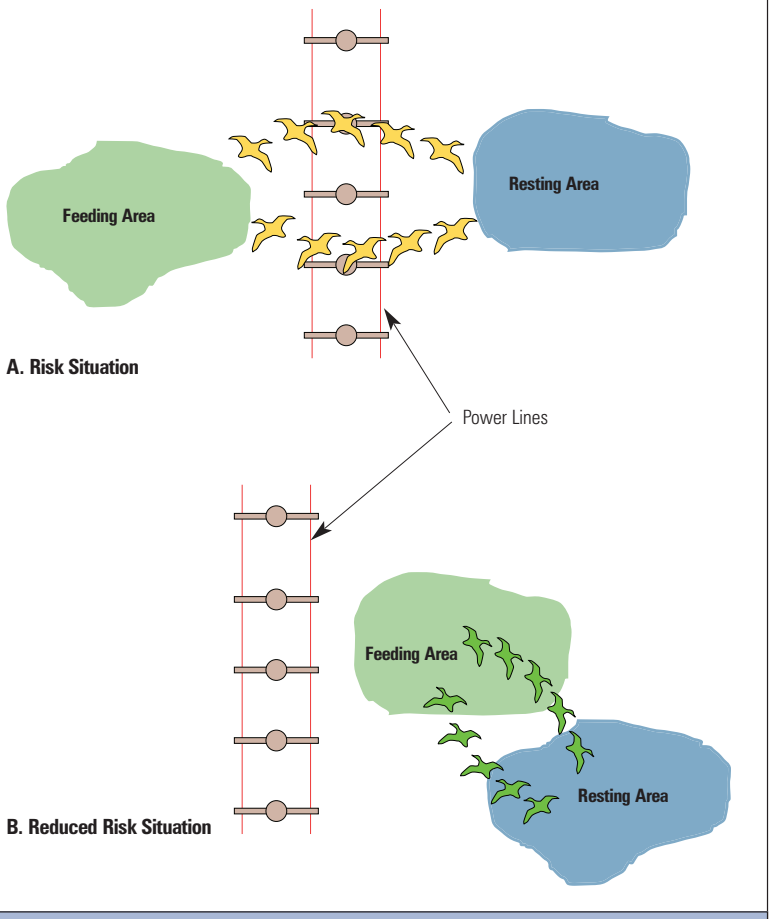


FIGURE 5.9: Potential collision risk (A) has been reduced (B) when bird-use areas are on the same side of the line (modified from Thompson 1978).

consideration when selecting a line route (see Chapter 4). The proximity of power lines to bird take-off and landing areas can affect the risk of collision (Lee 1978; Thompson 1978; Faanes 1987; Brown et al. 1984, 1987; Heck 2007; Quinn et al. 2011). For results of studies on distance of collision mortalities from specific areas, see *Habitat and Habitat Use* (page 44) and *Line Placement* (page 50). Spatial analysis with GIS is useful for evaluating different power line placement options relative to bird migration and habitat use patterns (see *Spatial Analysis* on page 64).

Line Orientation

Orientation of power lines relative to biological characteristics (e.g., flight behavior, season, and habitat use) and environmental conditions (e.g., weather patterns and topographical features) can influence collision risk. When planning power line routes, features such as mountain ridges, river valleys, and shorelines that are in traditional flight corridors should be considered (Colson and Yeoman 1978; Faanes 1987; Figure 5.10). Power lines that parallel primary bird flight paths pose less risk than a perpendicular orientation (Crowder 2000; Scott et al. 1972; McNeil et al. 1985). For example, the perpendicular orientation of a line relative to a topographical feature poses a greater collision risk to local and migrating birds, whereas a parallel orientation reduces risk.

Where perpendicular orientation cannot be avoided, forest habitats located near power lines can sometimes reduce collision risk (see Figure 5.3) Lines that are at or below the height of nearby trees rarely present a problem to small tree-dwelling birds because of their maneuverability; furthermore, large birds will gain altitude to fly over the tree line and will consequently avoid the power line (Thompson 1978; Raevel and Tombal 1991). For example, a power line crossing a narrow river bordered by trees that are taller than the line is likely to pose a lower collision risk than a broad river crossing because most birds will fly over the tree tops to cross the narrow river valley (CMS 2011a).

Strong tail winds can be detrimental to birds' ability to maneuver. Brown (1993) suggested that north-south orientation of lines increased collision frequency for cranes and waterfowl in the San Luis Valley, Colorado, because birds crossing them on an easterly heading were often subjected to prevailing westerly winds.

Line Configuration

Line configuration—phase conductors aligned vertically or horizontally and the number of conductors—is a collision factor that intuitively makes sense, but there are too few studies to draw conclusions. Most researchers agree that keeping the vertical arrangement of multi-conductor transmission lines to a minimum is beneficial because it reduces the height of the collision zone. However, a single-pole, vertical structure is often esthetically more acceptable and requires less ROW width.

Thompson (1978) and others (Bevanger 1998; Crowder 2000; Drewitt and Langston

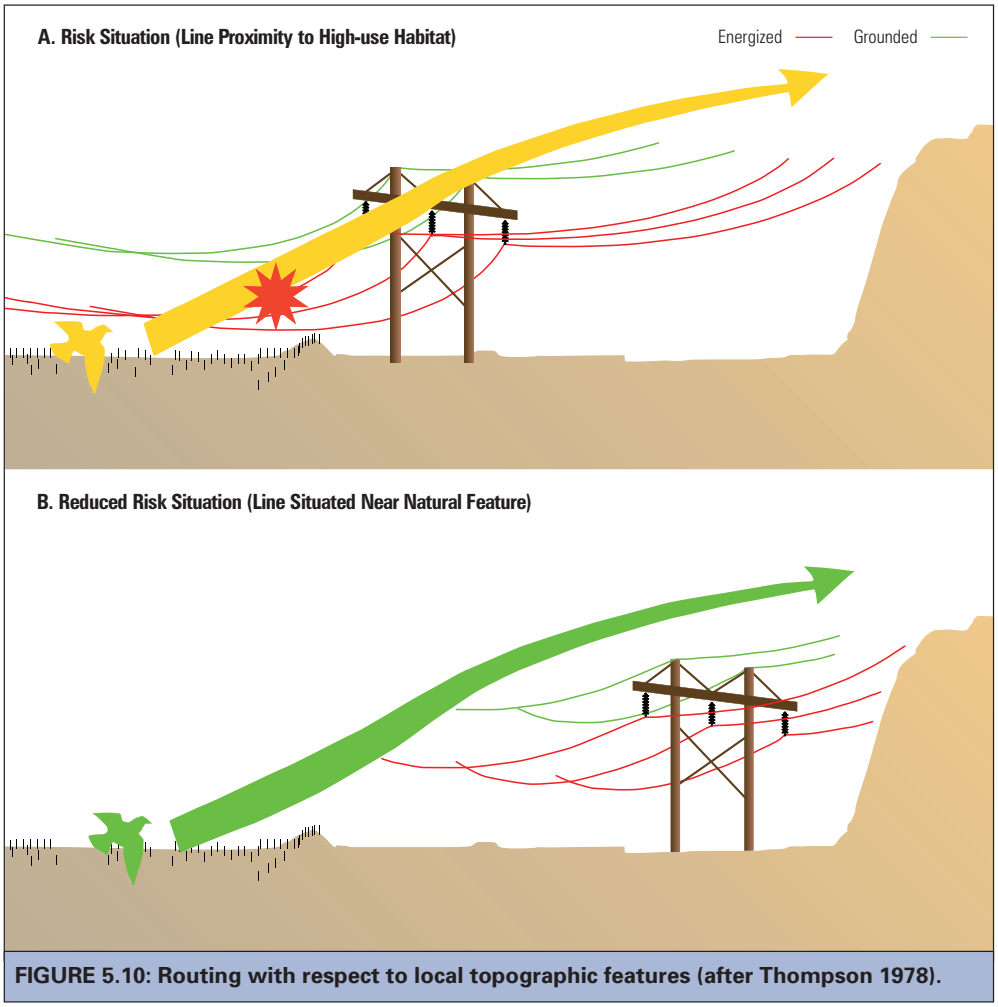


FIGURE 5.10: Routing with respect to local topographic features (after Thompson 1978).

2008) have suggested that clustering lines (i.e., several power lines sharing the same ROW) may reduce collision risk because the resulting network of wires is confined to a smaller area and is more visible. Birds only have to make a single ascent and descent to cross lines in this arrangement (Figure 5.11 and Figure 5.12). However, when there is decreased visibility, collision risk for birds may increase where several lines are clustered. When there are two shield wires at different heights, and only the higher one is marked, there may be collisions at the lower unmarked shield wire; both shield wires may need to be marked (S. Liguori, pers. comm.).

Other configuration options include:

- Lowering the height of the lines (e.g., below the tree line)
- Changing the wire diameter
- Bundling wires
- Using spacers to improve visibility

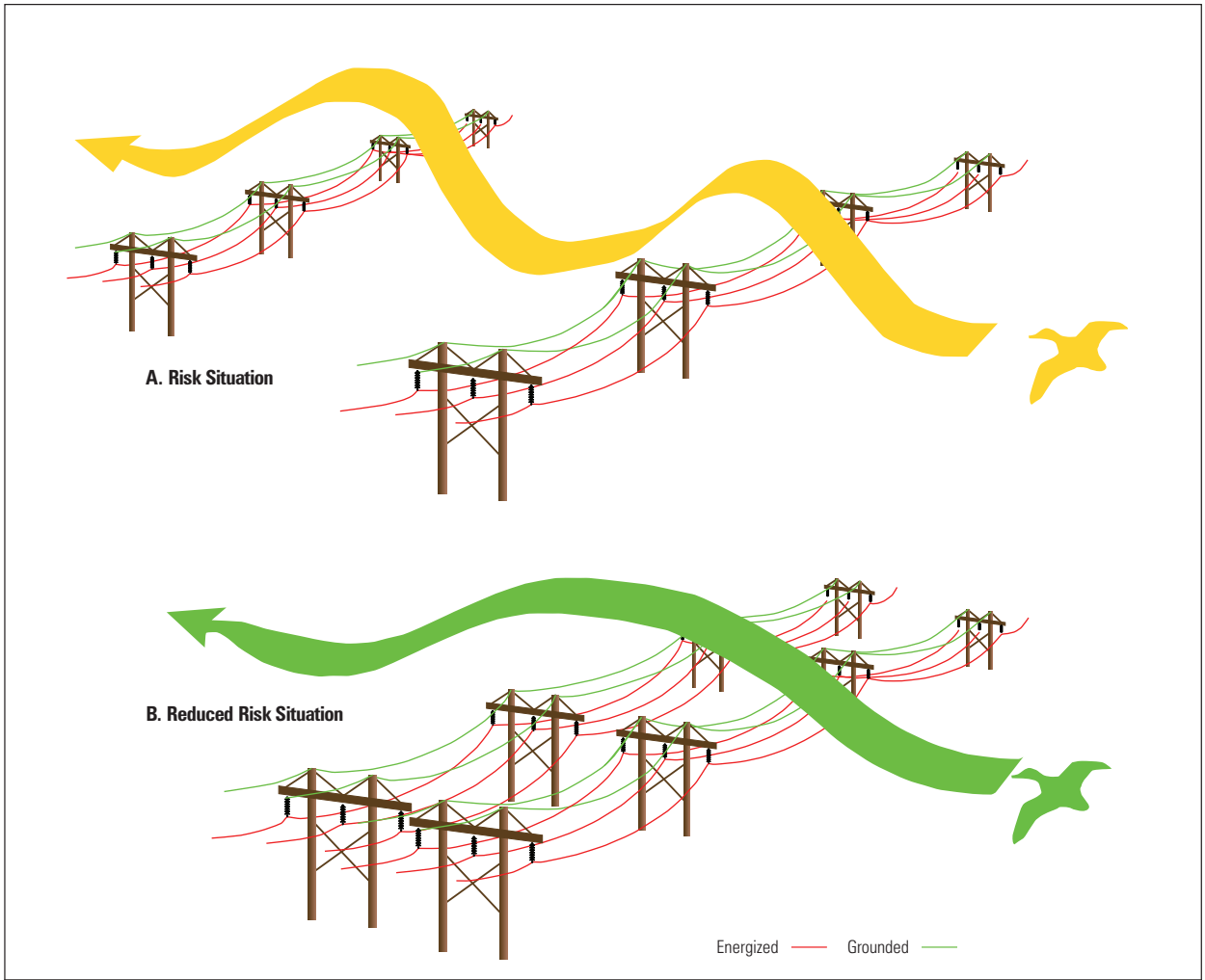


FIGURE 5.11: Reducing collisions by clustering lines in one right-of-way (after Thompson 1978).

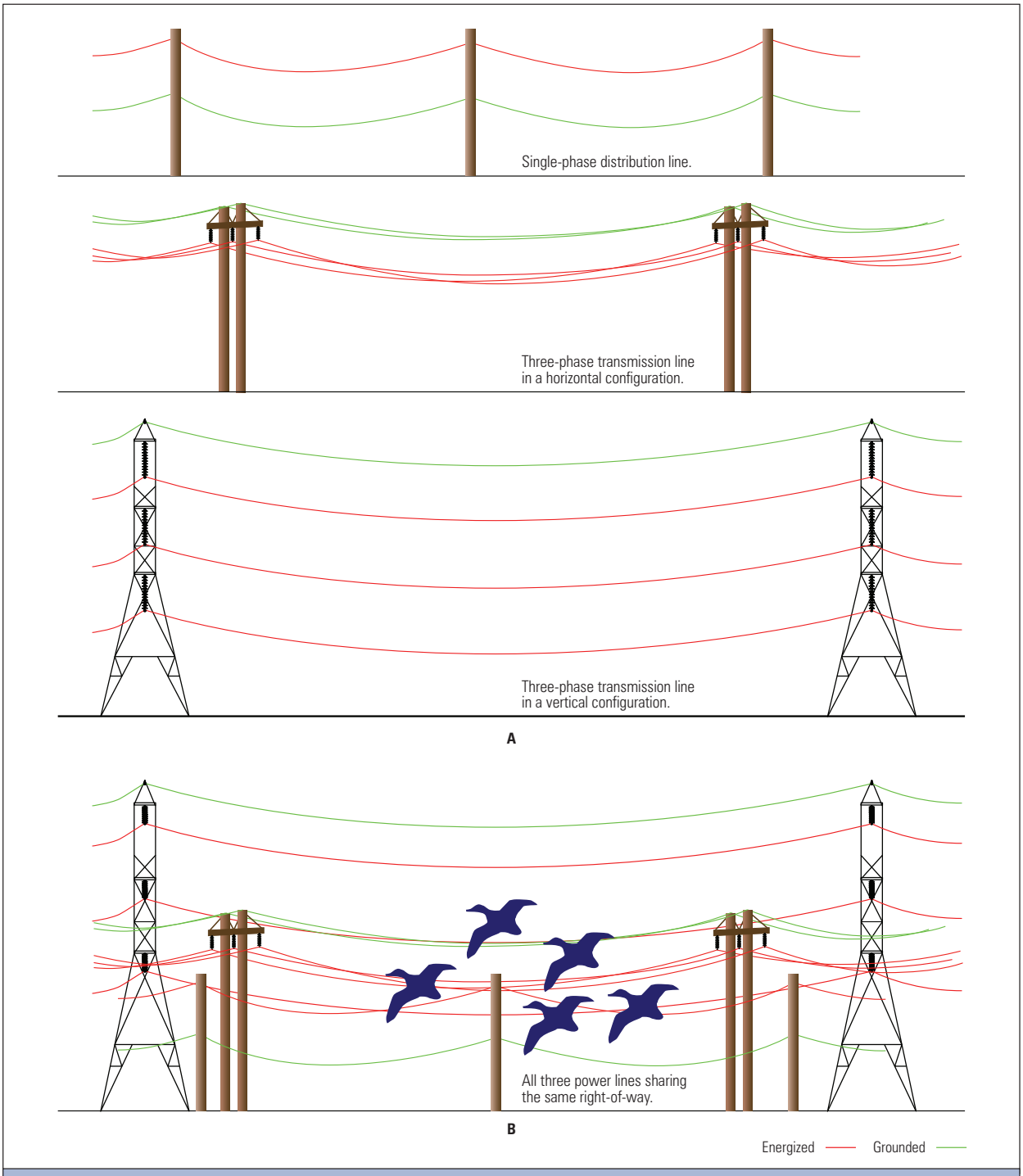


FIGURE 5.12: Collision risks for separate (A) and clustered (B) lines (after Thompson 1978).

- Rearranging wire configuration (e.g., converting from vertical to horizontal)
- Changing the structure type to increase its visibility
- Decreasing span length (e.g., by adding a pole mid-span)

Line Marking

In areas where there is collision risk, line marking devices should be considered. Most studies have shown a reduction in collisions and/or an increase in behavioral avoidance at marked lines when compared to unmarked lines, but this can vary with location, type of line marking device, and bird species (Jenkins et al. 2010; Barrientos et al. 2011; see Chapter 6 for detailed information on devices and effectiveness). There are three general categories of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). Large diameter wire may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see Chapter 6). Line marking options are based on accessibility of the line, product availability and durability, ease of installation, cost, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and potential for vandalism.

Burying Power Lines

See the discussion on *Burying Power Lines* under *Options for Modifying Existing Lines* (page 62).

PUBLIC PARTICIPATION TO ADDRESS SOCIAL AND CULTURAL ISSUES

The public may have concerns about power line design and placement, including esthetics, environmental effects, wildlife, and safety. Vandalism is also a persistent problem—electrical equipment and line marking devices can become targets. When a utility is taking steps to minimize collision risk, a public participation program can help build positive relationships, increase public knowledge, identify and respond to public concerns, and promote responsible behavior (e.g., discouraging vandalism of line marking devices).

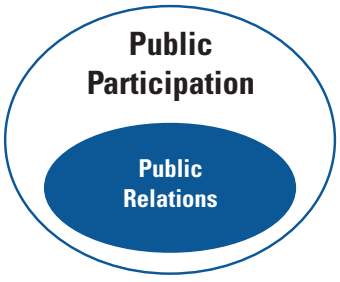


FIGURE 5.13: Public participation programs may provide information through a public relations campaign, but they also go further to engage the public in discussions and decision making (after EEI 2001).

WHAT IS PUBLIC PARTICIPATION?

Public participation is different from public relations or public information programs. While a public relations campaign provides information to the public, public participation programs actively engage the public in discussions and decision making. A well-designed public participation program requires the expertise of someone who can communicate technical information in an easily accessible way, facilitate groups, and cultivate trust with stakeholders. For a public participation program to succeed, the commitment and involvement of top management including the key decision makers is essential.

Utilities can use a variety of public participation tools to address social and cultural aspects of collision risk (see EEI 2001 and Appendix E for resources). Exhibits, signs, publications, web pages, and public announcements can be used to inform the public. Other techniques, such as webcasts, public

forums, interviews, polls, retreats, citizen advisory panels, social media communications, and workshops promote engagement in the process. All efforts should be based on knowledge of the target audiences, consistent messages, audience participation in building a shared understanding, complete and objective information, and partnerships with supportive organizations and businesses. Edison Electric Institute's (EEI) *Introduction to Public Participation* (EEI 2001) is an excellent source of practical information for electric utilities.

Case Study: How Public Participation Benefitted Transmission Line Routing

The Project: Florida Power & Light (FPL) Crane-Bridge-Plumosis Transmission Line in southeast Florida (Martin and Palm Beach counties).

The Issue: FPL sought licensing for a 64.4-kilometer (40-mile) transmission line that traversed two densely populated counties. The route chosen for the power line generated some controversy because it included residential areas and a sensitive environmental tract. Alternative routes were proposed and submitted by various non-governmental and neighborhood groups as well as individuals. Continued opposition was expected.

Public Participation: A Citizens Advisory Panel (CAP) was appointed that included members from many different interest groups. The CAP recommended a route that was similar to the one originally recommended by FPL staff and consultants. FPL chose the panel's route.

The Result: The chosen route was initially rejected by the permitting agency but formed the basis of the final approved route.

Benefits of Public Participation: By establishing and working with the CAP, FPL precluded numerous separate meetings with different interest groups. The CAP increased understanding and support for the project despite initial opposition by individual parties. The discussions led to acceptable compromises, and costly appeals and reviews were avoided. In the end, FPL had an approved route that was similar to their preferred route and many members of the CAP felt positive that their input resulted in an improved project. The goodwill developed in the community benefited FPL's public image and set the stage for better relations on future projects.

(Modified from a case study that originally appeared in EEI 2001)

BENEFITS OF EFFECTIVE PUBLIC PARTICIPATION

Past experience shows that public participation has a record of creating cooperative working relationships (EEI 2001). According to EEI (2001), public participation:

- Reduces delays and costs associated with controversy and litigation. It often reduces implementation time because the public already supports or accepts the decision.
- Builds a positive relationship with the public, which is important even when it is necessary to make an unpopular decision.
- Develops and maintains credibility even with those who disagree with a given decision. A negative public image in one arena can affect a company's bottom line and trigger opposition in other arenas.
- Creates collaborative problem solving for achieving better and more acceptable decisions. When people believe that utility decisions are being imposed on them, they are more likely to increase their opposition.
- Gathers information from the public that the utility needs to make informed decisions.
- Can improve programs and policies, which will enjoy greater support.
- Can help management understand that technical issues have important social components. Some decisions appear to be technical, but are actually decisions about values.

CREATING A STRUCTURED PROGRAM

There are three phases to establishing a successful public participation program: decision analysis, program planning, and implementation. For case studies and a thorough description of how to plan and implement a public participation program use *Introduction to Public Participation* (EEI 2001) as your guide.

Phase 1: Decision Analysis

Clearly identify the decision-making process for the project and establish what role the public will play. Consider who will be affected by the project and if public support for the project is needed. Determine whether regulatory requirements or constraints may limit the opportunities for public participation. A thorough decision analysis will ensure that you engage the public for the right reasons and are not promising something that is not in your power to provide.

Phase 2: Program Planning

Successful participation plans address the needs and goals of both the utility and the public. The steps in creating a participation plan are:

- Identify the issues that will be important and assess the level of controversy of each. Issues and concerns typically focus on one or more of the following: mandate, economics, health, proximity, values, and existing uses of the property or area.
- Identify the parties (stakeholders) that need to be represented in the process. Invite a cross-section of the public including those who will be affected, those with a vested interest, and those who have decision-making power.
- Determine the goals for your public participation program. Goals provide focus and a course of action for the process. Clearly defined goals also make it easier to evaluate the success of the process.
- Define the level of public participation needed and state this clearly when inviting participants. In some cases, the public may be making decisions, while in other cases they may be providing support or recommendations.
- Select appropriate techniques of public participation based on the issues, level of controversy, and audience. Techniques, such as newsletters, web pages, exhibits or news releases provide information, whereas focus groups, meetings, workshops, polls, and interviews foster active public participation and collaboration.
- Outline the decision-making process including all steps from identifying the problem to formulating, evaluating, and selecting alternative approaches.

Phase 3: Implementation

Implement the program according to the collaboratively developed plan. During implementation, participants may see the need to make adjustments or changes, so be flexible and prepared.

Characteristics of Successful Public Participation

Successful public participation programs often do the following:

- Make public participation an integral part of the project, rather than an afterthought.
- Commit to a decision-making process at the outset and maintain that commitment.
- Ensure that the interested public is involved in all phases of decision making: definition of the problem, range of possible alternatives, criteria used to evaluate alternatives, and selection of the final course of action.
- Carefully assess the needs of different audiences and choose techniques appropriate for all groups and for the information that will be collected.
- Ensure that management is engaged and has endorsed the program. This will create a climate of acceptance, which is essential to meaningful public participation.



CHAPTER 6

Line Marking to Reduce Collisions

IN THIS CHAPTER

- Overview of Line Marking Devices
- Effectiveness of Designs
- Marking Constraints and Considerations
- Line Marking Devices
- Large Diameter Wire

A common observation in collision studies is that birds show the ability to avoid a power line if they see the lines early enough. Many of these studies indicate that collision risk can be lowered by more than half and, in some cases, by as much as 80% after lines have been marked. This chapter discusses what is known about line marking, including the different devices, their reported effectiveness, and considerations in their use.

OVERVIEW OF LINE MARKING DEVICES

Studies suggest that the majority of bird collisions occur with the smallest diameter wire, which is typically the shield wire located above the phase conductors on transmission lines (e.g., Savereno et al. 1996) or the phase conductor and neutral wire on distribution lines. Most collisions occur mid-span (e.g., Eskom Transmission 2009). As a result, most of the efforts to reduce bird collisions have focused on marking the shield wires on transmission lines and the phase conductors on distribution lines. As discussed in Chapter 4, different biological, environmental, and engineering factors contribute to birds' ability to see and avoid a power line; each should be considered when choosing among line marking options.

There are three general types of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). In addition, large diameter wire, though not a marking device, may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see *Large Diameter Wire* on page 100). Since 1994, aerial marker spheres, spirals, and suspended devices have been further developed. Advances include changes to shape, colors and color patterns, and attachments, along with UV resistance, which improves durability and colorfastness. Other designs have been developed, but are not currently available in the United States (see *Devices Available in Other Countries* on page 97).

Because there are few comparative studies, no single device is considered to be the best performing. However, Jenkins et al. (2010) concluded that any sufficiently large line marking device that thickens the appearance of the line for at least 20 centimeters (cm) (7.8 inches [in]) in length and is placed with at least 5 to 10 meters (m) (16.4 to 32.8 feet [ft]) spacing is likely to lower collision rates by 50% to 80%. In addition, the South African Electric Supply Commission (Eskom Transmission 2009) describes its use of spirals and suspended devices on transmission lines and recommends suspended devices over small-diameter spirals because their swinging or flapping motion makes them more visible and more effective.

Devices can be purchased in a variety of colors, which may be important but there are insufficient comparative studies to provide firm conclusions. In general, what seems to be effective is to alternate the colors to make the lines more obvious (Eskom Transmission 2009). For aerial marker spheres, yellow seems to be the preferred choice over international orange because they provide better contrast in poor light conditions.

Table 6.1 provides a general description of the most commonly used devices that are available in the United States.

TABLE 6.1: Summary of data on line marking devices available in the United States.*

Name†	Description	Dimensions	Spacing§	General Comments on Effectiveness§
Aerial Marker Spheres				
Aerial Marker Spheres or Aviation Balls	Large, colored spheres that attach to wires.	Diameter ranges from 23 cm (9 in) to 137 cm (54 in). The 23 cm (9 in) and 30.5 cm (12 in) are most often used for line marking.	Up to 100 m (328 ft) apart. See Table 6.3 for details.	Reduction in collisions noted in certain situations. Sometimes this marker is used in conjunction with other line marking devices. See Table 6.4 for details.
Spirals				
Spiral Vibration Damper (SVD)	Extruded plastic (PVC) spiral device that fits over the shield wire and distribution conductors.	Various lengths, ranging from 112 to 165 cm (46 to 65 in), to fit different conductor sizes.	Often placed about 3 m (9.8 ft) apart on the shield wire. Stagger on distribution lines to prevent interphase contact.	Reduction in collisions noted. Not as commonly studied as other line marking devices. See Table 6.6 for details.
Bird-Flight™ Diverter (BFD)	Spiral device made from high impact PVC that attaches at one end to the shield wire or distribution conductor and increases in diameter at the other end.	Lengths range from 17.8 to 59.7 cm (7 to 23.5 in). Diameter at the large end ranges from 3.8 to 12.7 cm (1.5 to 5 in).	Ranges from 4.6 to 21 m (15 to 68.9 ft) apart. See Table 6.7 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.8 for details.
Swan-Flight™ Diverter (SFD)	Similar to the BFD, but this device attaches at both ends with the larger diameter spirals in the center.	Lengths range from 50.8 to 116.8 cm (20 to 46 in). Diameter of central spiral ranges from 17.8 to 20.3 cm (7 to 8 in).	Ranges from 15 to 30 m (49.2 to 98.4 ft) apart. See Table 6.9 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.10 for details.

Continued

TABLE 6.1: Summary of data on line marking devices available in the United States.* (cont.)

Name†	Description	Dimensions	Spacing§	General Comments on Effectiveness§
Suspended Devices				
General Designs	Swinging and fixed devices; plastic flapper of various shapes and colors with reflective and glowing surfaces; connected to a clamp that attaches to the power line.	Size and shape varies with device and design.	5 to 30 m (16.4 to 98.4 ft) apart. Staggering devices on parallel lines is recommended. See Table 6.11 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.12 for details.
FireFly™	Swinging and fixed models; rectangular devices with reflective and glowing surfaces; connected to a clamp that attaches to the power line.	Acrylic plastic tag measures 9 cm x 15 cm (3.5 in x 6 in).	4.6 to 15.2 m (15 to 50 ft) apart. See Table 6.13 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. See Table 6.14 for details.
BirdMark BM-AG	Swinging perforated disk has a reflective center and spins and flutters, it also glows; connected to a clamp that attaches to the power line; perforations allow device more wear resistance in high wind locations.	29.21 cm (11.5 in) long with a 13.33-cm (5.25-in) diameter disk.	4.6 m (15 ft) apart	Mentioned in reviews, but no scientific studies were found.

* Source: Summarized from available literature and Hunting (2002); see *Line Marking Devices* on page 85 for detailed information and sources.
† This table only includes devices that are available in the United States; see *Devices Available in Other Countries* on page 97.
§ Summarized from different sources and studies with varying methodologies, environments, and species; see tables in *Line Marking Devices* for detailed information and sources.

EFFECTIVENESS OF DESIGNS

EARLY STUDIES (1960 TO 1994)

In Europe during the 1960s and 1970s, numerous studies addressed the effectiveness of different devices to make power lines more visible so collision rates could be reduced. Most of these studies tested aerial marker spheres (aviation balls) and various types of plastic or rubber strips attached to the lines. These studies found that increasing the visibility of lines resulted in a statistically significant reduction of collision risk.

In 1964, a 275-kilovolt (kV) line near Teeside, England, was marked with 15-cm (6-in) black vanes (flags). Koops and de Jong (1982) reported that this effort was successful in reducing bird collisions, although no quantitative data were given. Renssen et al. (1975, cited in Beaulaurier 1981) investigated several marking schemes: black, white, and orange aerial marker spheres on the shield wire.

Overall, the dozen or more studies during this period (see lists in Beaulaurier 1981 and Hunting 2002) found that marking devices ranged from no effect to a 60% reduction in collisions. The limitation of these early studies was that most were conducted over a short period of time or they were not held to rigorous experimental protocols. Often, quantifying and comparing flight intensities over marked and unmarked lines were not done.

In addition, the durability of these devices was often very limited because of the plastic and cloth materials used.

LATER STUDIES (1995 TO 2012)

Testing and reporting on the effectiveness of line marking devices have broadened to include the behavioral responses of birds approaching power lines. Hunting (2002), Lislevand (2004), Jenkins et al. (2010), and Barrientos et al. (2011) identified approximately two dozen studies that have focused on the effectiveness of certain devices for selected species. However, most of these studies involved transmission lines, and relatively few have looked at the comparative effectiveness of different devices. Hunting (2002) also concluded that making recommendations on the comparative device effectiveness is not possible due to the variation in study designs.

Barrientos et al. (2011) conducted a meta-analysis of published and unpublished collision studies to evaluate whether line marking reduced the number of collisions and which devices might be more effective. Although they showed that line marking reduced collision rates by 78%, the variability in study designs made it impossible to compare the effectiveness of these devices with different species, in different habitats, in different weather conditions, or on different line configurations. Barrientos et al. (2012), a before-after-control-impact (BACI) study of the effectiveness of two spiral devices (the smaller bird flight diverter and the larger swan flight diverter), concluded that line marking is an effective way of reducing mortality on distribution and transmission lines. Their estimate of overall effectiveness was significant, but not as high as others have reported; more definitive predictions were not possible because of study design and data limitations.

Comparison studies that use the same monitoring time intervals, control for habitat differences, and standardization of the periodicity of carcass searches are necessary to determine the device best suited to a given set of environmental conditions and species intended for protection. The following examples reflect various approaches to studying the effectiveness of line marking devices. (For studies on the effectiveness of each device, see *Line Marking Devices* on page 85.)

In San Luis Valley, Colorado, Brown and Drewien (1995) evaluated the effectiveness of two devices: yellow spiral vibration dampers (SVDs) and yellow swinging fiberglass plates with a diagonal black stripe (30.5 cm × 30.5 cm [12 in × 12 in]). Marked segments 0.8 kilometers (km) (0.5 mile [mi]) long were compared with unmarked segments of equal length during spring and fall seasons over a three-year period. They found that SVDs reduced sandhill crane (*Grus canadensis*) and waterfowl mortality by 60% and the swinging plates reduced mortality by 63%. Flight intensities were quantified. Evaluation of the flight behavior of sandhill cranes, Canada geese (*Branta canadensis*), and ducks at marked and unmarked lines indicated that birds reacted to marked lines by increasing their altitude and reaction distance. Although both devices significantly reduced mortality, the swinging plates damaged power lines.[15] The authors suggested that the silhouette of the swinging plate also provided an important benefit in low-light conditions.

In west-central Spain, Janss and Ferrer (1998) studied the effectiveness of three devices (white spiral, series of crossed bands, and thin black strips) on marked and unmarked transmission (380 kV and 132 kV) and distribution (13 kV) lines over a four-year period. The three devices were examined by comparing marked to unmarked spans

[15] The concept of swinging plates has developed into a variety of suspended devices. This new generation of suspended devices has reduced the line-wear problem while maintaining effectiveness.

along the same power line. Monthly carcass searches were conducted without correcting for monitoring biases (see Appendix B). The species exhibiting the highest mortality included bustards, cranes, and shorebirds. The white spiral devices (30 cm × 100 cm [11.8 in × 39.4 in]), similar to a Swan-Flight™ Diverter (SFD), reduced expected mortality by 81% for all birds. The series of two black, crossed bands (35 cm × 5 cm [13.8 in × 1.9 in]) reduced expected mortality by 76% for all birds but not for great bustard (*Otis tarda*). The thin black strips (70 cm × 0.8 cm [28.6 in × 0.3 in]) placed at 12-m (39.4 ft) intervals from the central conductor did not reduce mortality. The authors state that the data could not be used for statistical comparison of effectiveness of the different diverters for specific species.



FIGURE 6.1: Studies at the San Luis National Wildlife Refuge show that the line marking devices tested work well for most species, the exception being the American coot, which is more vulnerable to collisions because it primarily flies at night.

© JERRY LIGUORI

The Ventana Wildlife Society (2009) conducted a comparative effectiveness study of Bird Flight™ Diverters (BFD) and SFDs at six sites at San Luis National Wildlife Refuge Complex in California. Although approximately 800 hours of observation were made during three winter seasons from 2005 to 2008, few collisions were observed. However, many reactions to power lines were documented, such as altitude changes or sudden changes in flight direction called flutter or flare. The birds exhibited reactions at greater distances from power lines after flight diverters were installed, especially on lines with SFDs. Estimated total collisions were significantly higher for the unmarked control lines than for the lines marked with BFDs or SFDs. The difference in estimated total collisions between control lines and marked lines was even greater when the analysis excluded the American coot (*Fulica americana*), which primarily flies at night and accounted for approximately half of all carcasses found. The study concluded that both diverters were ineffective for the American coot. The study also suggested that site-specific differences can influence the effectiveness of diverters.

Western Area Power Administration conducted a line marking study along 3.2 km (2 mi) of line in 2006, 2007, and 2008 (WAPA 2011). Three line marking devices were used: SFD, BirdMark (solid orange), and FireFly™. The study occurred near Coleharbor, North Dakota, along the Audubon causeway, which separates Lake Audubon on the east from Lake Sakakawea on the west. More than 1,000 bird carcasses (from road mortality and collisions with power lines) and 300 hours of observational data were collected. The results indicated that marking the line decreased the number of observed flyovers for the majority of species; rather than flying over the lines, birds turned and flew parallel to the line. The study also indicated that the differences in device efficacy were minimal.

Regardless of the variability in studies on the effectiveness of devices, most studies have shown a reduction in collisions and/or an increase in behavioral avoidance when compared to unmarked sections of a line.

MARKING CONSTRAINTS AND CONSIDERATIONS

The choice of marking device is often based on consideration of product availability and durability, cost, ease of product installation, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and vandalism. Utilities are encouraged to investigate and test products before installing them on a large scale. A general discussion of these considerations is presented here. For specific considerations on each device, see *Line Marking Devices* on page 85. For additional information on what devices may be appropriate, utility companies can consult with the manufacturer and with other utilities.

PRODUCT AVAILABILITY AND DURABILITY

Three general types of devices are available in North America: aerial marker spheres, spirals, and suspended devices. In addition, larger diameter wire can be considered for increasing line visibility. Several distributors supply these devices, so utility managers should consult with their suppliers for available options. Other devices have been developed, but are not currently available in the United States (see *Devices Available in other Countries*, page 97).

The durability of line marking devices and diverters was a commonly reported concern in the 1990s and 2000s. Since then most manufacturers have redesigned these devices to withstand ultraviolet (UV) light degradation, and they have improved the attachment clamps on suspended devices so that damage to the power line is reduced or eliminated—device specifications can be obtained from the manufacturer.

Static devices (such as spirals) and dynamic devices (such as some suspended devices) have different durability. Static devices have been more durable since they do not have moving parts. However, they have had limited success in South Africa since they can be less visible than dynamic devices. It is assumed that the motion is what makes the dynamic devices more visible. The disadvantage of dynamic devices is that they are subject to wear and have a more limited useful life than static devices. Some dynamic devices can also cause wear damage on the power line (Eskom Transmission 2009). In high wind areas, some devices with moving parts broke within several months (PacifiCorp, unpubl. data).

COST CONSIDERATIONS

Costs will vary with power line access, installation method, type of device, spacing, number of devices needed, and durability of the device. These depend in part on the line design, voltage, and length of line to be marked. Cost will also vary if the marking is done during construction of new lines or retrofitting existing lines. Power lines that are higher or over a water body (e.g., rivers, lakes, etc.) can be difficult to access and require more costly installation methods, such as a boat or helicopter. The durability of each device also varies, which makes long-term maintenance and impacts on line reliability additional considerations in cost estimates. Product cost contributes the least to the overall cost of line marking.

EASE OF INSTALLATION

The various types of line marking devices require different installation techniques: from the ground, bucket truck, boat, helicopter, line trolley, or other means. Some devices can be attached by hand and others need to be attached by a hot stick. Devices that coil onto



© DAVE BOUCHARD, AEP

FIGURE 6.2: A helicopter crew installing line marking devices on a power line.

lines may be easier to install by hand, if possible, than by hot stick. Some, such as suspended devices, may be installed by either one or two people, and a tool may be required for one-person installation.[16] In areas where access to the power line is difficult, product durability may be a more important consideration than ease of installation. For products with a shorter lifespan, the ease of product removal for repairs or replacement should also be considered.

COMPLIANCE AND LEGAL ISSUES

Associated issues must be considered to ensure that the line marking system complies with all applicable company, industry, and legal requirements. Installation must not reduce National Electrical Safety Code (NESC) clearance requirements, cause damage to standard power line hardware, conductors, and/or supporting structures, or affect the line or system reliability. Attachment procedures must adhere to worker and industry safety standards and be compatible with standard industry tools and equipment. Where facilities are shared, the easement documents may have restrictions concerning additions or modifications. In addition, legal counsel of some utility companies may object to the use of aerial marker spheres for preventing bird collisions because they prefer that the spheres only be used in compliance with Federal Aviation Administration (FAA) regulations to mark hazards to aircraft.

SPACING AND POSITIONING

Spacing and positioning determine the ability of marking devices to increase line visibility, the number of devices needed to mark each span, and how much the marking will add to the ice and wind loading. Over the years, studies have discussed spacing and positioning of devices on power lines. However, there have been no systematic comparisons of devices and their spacing and positioning. The following are general recommendations for spacing and positioning. For specific recommendations on each device, see *Line Marking Devices* on page 85.

Spacing recommendations vary depending on species considerations, environmental conditions, line location, and engineering specifications (e.g., wind and ice loading, conductor size, and the presence or absence of the shield wire). In general, intervals of 5 to 30 m (16 to 98 ft) have been most commonly used and recommended for all but the aerial marker spheres (aviation balls), where a greater spacing is used, and SVDs, where less spacing is used (see Table 6.1). Jenkins et al. (2010) concluded that any sufficiently large line marking device that increases the diameter of the line by at least 20 cm (8 in) for a length of at least 10 to 20 cm (4 to 8 in) and is placed at intervals of 5 to 10 m (16 to 32 ft) is likely to lower general collision rates by 50% to 80%.

For positioning, Eskom Transmission (2009) recommends marking only 60% of a span, the central portion of the shield wires on transmission lines, since this is where

[16] A utility should consult with its safety department to determine appropriate practices for individual or crew work.

TABLE 6.2: Distance of collision mortalities from the nearest pole (parallel to distribution lines in the right-of-way).*

Taxa or Species	Sample Size	Distance	
		Mean Std Dev	Range
Geese	43	11.9 ± 10.7 m (39 ± 35 ft)	0.6 to 45.7 m (2 to 150 ft)
Ducks	25	16.2 ± 13.1 m (53 ± 43 ft)	0.6 to 48.8 m (2 to 160 ft)
Swans	5	18.6 ± 9.4 m (61 ± 31 ft)	6.1 to 60.9 m (20 to 200 ft)
Raptors	12	37.5 ± 11.9 m (123 ± 39 ft)	18.3 to 54.9 m (60 to 180 ft)
Great blue heron (*Ardea herodias*)	7	17.4 ± 12.8 m (57 ± 42 ft)	1.5 to 33.5 m (5 to 110 ft)
American white pelican (*Pelecanus erythrorhynchos*)	16	19.8 ± 15.2 m (65 ± 50 ft)	1.8 to 45.7 m (6 to 150 ft)
Sandhill crane (*Grus canadensis*)	6	21.9 ± 16.5 m (72 ± 54 ft)	6.1 to 45.7 m (20 to 150 ft)

* Source: PacifiCorp, unpubl. data

most collisions occur. In surveys conducted from 2004 to 2009 in Oregon, California, Idaho, Utah, and Wyoming, PacifiCorp (unpubl. data) found that most waterfowl collision mortalities were found mid-span in the right-of-way (ROW), parallel to distribution lines, at distances of 12 to 18 m (39 to 61 ft) from the nearest pole (Table 6.2); typical span lengths were 91.5 to 121.9 m (300 to 400 ft). Sandhill cranes (*Grus canadensis*), American white pelicans (*Pelecanus erythrorhynchos*), and raptors were found farther from the nearest pole than were other species (PacifiCorp, unpubl. data.). These distances can help direct the placement of line marking devices (Figure 6.3).

Another commonly recommended strategy is to stagger the devices on parallel lines in the same plane to increase the visual density of the marked power line (Figure 6.4 and Figure 6.5). This would also reduce the number of markers on each individual line and each line's ice and wind loading.

SAFETY CODES: ICE AND WIND LOADING

The NESC identifies minimum safety and engineering standards for power lines within the United States. The NESC ice and wind loading and safety criteria for conductors and supporting structures must be reviewed prior to marking. These guidelines are used when designing a line so the constructed power lines meet or exceed NESC criteria. In addition, some states have adopted additional codes and regulations that further specify design criteria.

When any device is added to an overhead power line, it adds to the weight or loading of the line. Ice or wind adds still more loading to the line and supporting structures. The added weight of the devices and the extra wind and ice loading must not exceed line

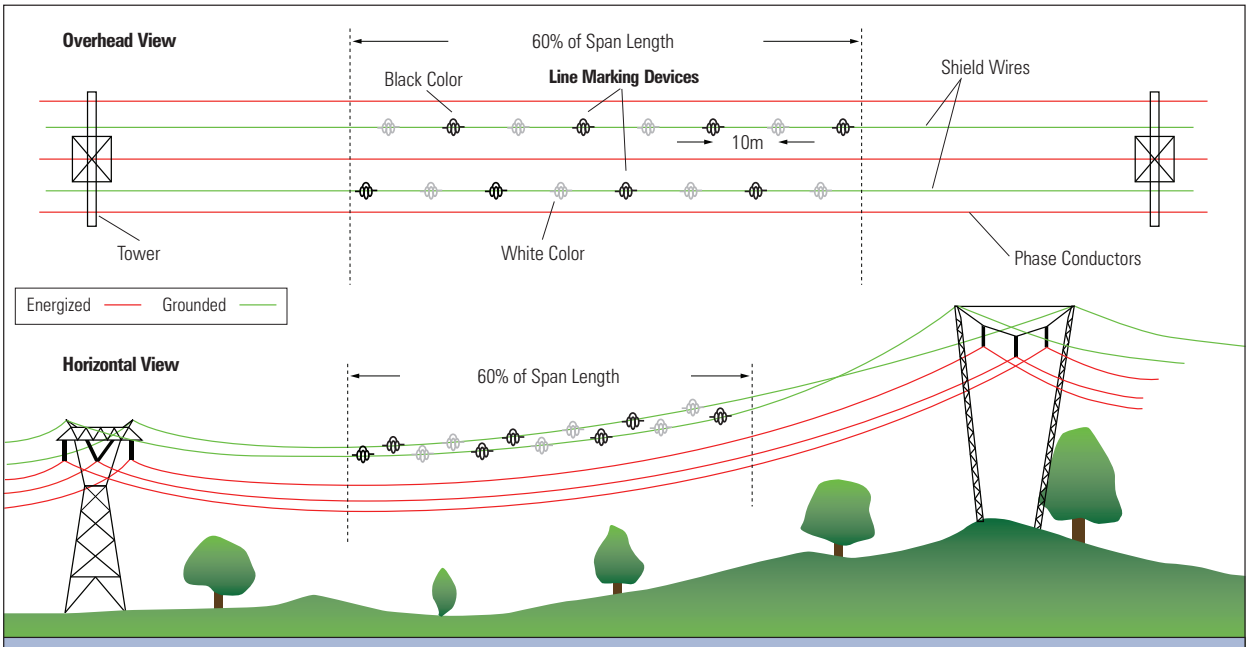


FIGURE 6.3: Positioning of line marking devices on the central portion of two shield wires on transmission lines (after Eskom Transmission [South Africa] 2009).

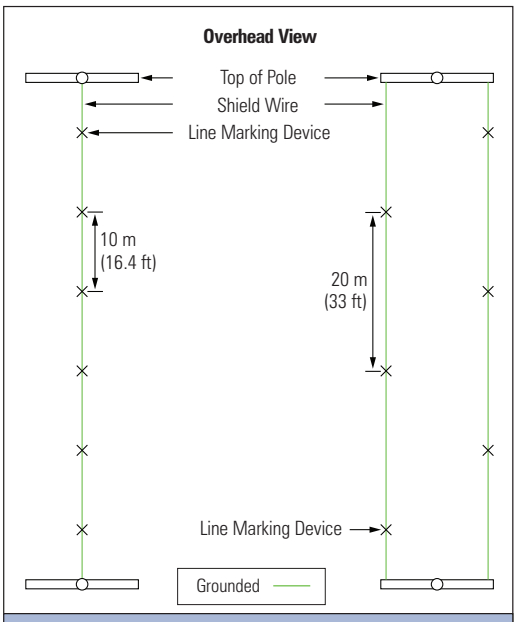


FIGURE 6.4: Positioning of line marking devices on one shield wire or staggered on two parallel shield wires.

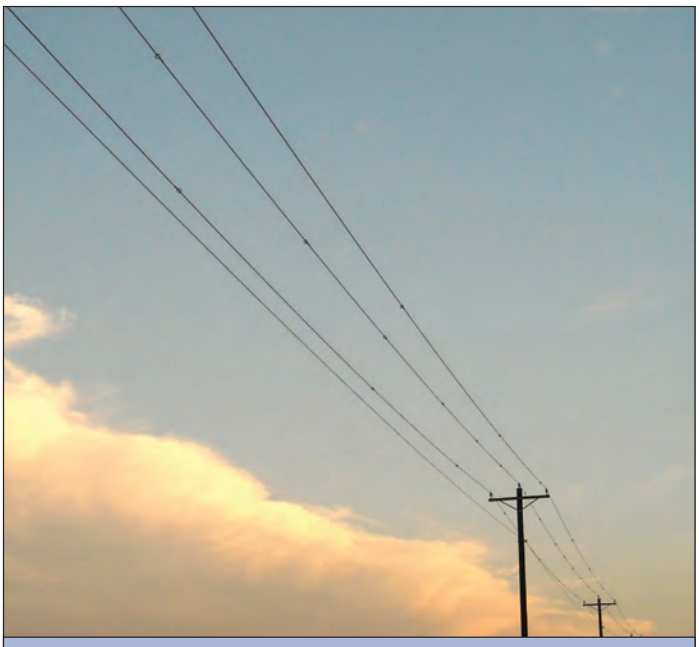


FIGURE 6.5: Line marking devices staggered on a distribution line.

© DAVE BOUCHARD, AEP



© MANITOBA HYDRO

FIGURE 6.6: When a device is added to a power line, it may add to the loading of the line, which further increases under icy or windy conditions and may also cause problems for deicing operations.

design limits and code requirements or cause additional sag that could lead to interphase contact (one conductor contacting another) and an outage. Consultation with the design engineers is imperative to ensure that adding any type of line marking device will not exceed design criteria. For existing lines, additional loading must be considered when retrofitting with line marking devices. When designing new power lines that may require marking, include allowances for the additional loading of those marking systems to prevent safety criteria from being exceeded.

CORONA EFFECTS

Electric corona occurs when the voltage of a phase conductor, typically 115 kV or greater, ionizes the surrounding air, which also becomes a conductor (Hurst 2004). Corona can degrade certain materials over time (Hurst 2004). Corona discharges appear as bluish tufts or streamers around the phase conductor, generally concentrated at irregularities on the conductor surface. A hissing sound, an odor of ozone, and local radio interference often occurs. Sharp corners of energized parts and voids, bubbles, and other heterogeneous components within solid materials (e.g., diverters) can cause corona effects.

Hurst (2004) tested several devices (Bird Flapper, FireFly™, BirdMark BM-AG, BFD, and SFD) at three simulated voltages. The study found that most of the devices had very little or no corona at 115 kV (except for some of the suspended devices) but did have corona effects at 230 kV and 345 kV. The best-performing devices at 115 kV were the BFD and the SFD, neither of which had any detectable corona discharge. At 230 kV, the BFD and the SFD had a medium level of corona, whereas suspended devices were characterized with a high level. At 345 kV, all of the devices had a very high level of corona. The corona generally occurred at the point of attachment to the phase conductor and at the top of the Bird Flapper and FireFly.

ESTHETICS

Visual management and esthetics have become concerns related to the construction or modification of power lines. With appearance as a consideration, dull rather than shiny materials are now widely used for overhead lines. Consequently, power lines were designed to blend with the background and be as invisible as possible, particularly in heavily forested areas. However, with growing concern about bird collisions, design goals are changing toward making the line acceptable to people but not invisible to birds.

If the power line is located where the viewshed is an environmental value, such as on or near public land or in residential areas, the addition of line marking devices may become an esthetic issue. For public lands and resi-

Using Public Participation to Address Social Constraints of Line Marking



© BONNEVILLE POWER ADMINISTRATION

FIGURE 6.7: Power structures and line markers can become targets for vandalism and a detriment to service reliability. Public participation and outreach programs, like this hotline, may reduce vandalism.

Participation and outreach programs can increase public support for strategies such as line marking and can change or reduce behaviors such as vandalism. This can make it easier for a utility to meet requirements for electrical reliability and customer satisfaction while reducing risks to birds. See Chapter 5 for a discussion on using public participation to address social issues that influence collision risk. Appendix E includes resources.

dential areas, the marking system should be effective and acceptable in appearance. Public participation and outreach programs can increase support for line marking in areas where viewshed or esthetics are concerns, which could avoid the need for making a trade-off between esthetics and collisions (see *Public Participation* in Chapter 5).

VANDALISM

Vandalism is a persistent problem with overhead power lines, particularly from irresponsible shooters. In general, the poles, insulators, towers, signs, and line marking devices can become targets when lines traverse sparsely populated areas. As a result, electrical conductors have been damaged or severed, and extensive outages have resulted. Repair and replacement costs are ultimately borne by the utility companies and ratepayers. In addition, some customers with critical electricity needs, such as hospitals and mining operations, have had to rely on emergency back-up measures in order to maintain safety levels (A. D. Miller, pers. comm.). When evaluating any line marking system, the potential for vandalism should be addressed. Public participation and outreach programs may help reduce or prevent vandalism (see *Public Participation* in Chapter 5).

LINE MARKING DEVICES

AERIAL MARKER SPHERES (AVIATION BALLS)

Aerial marker spheres (or aviation balls) were one of the earliest devices used in an attempt to reduce bird collisions (Figure 6.8 and Figure 6.9). Originally they were used to warn aircraft pilots of power lines. These large, colored balls are usually attached to distribution phase conductors or transmission shield wires. They are available in a variety of diameters: 23 cm (9 in) to 137 cm (54 in). The most often used sizes for line marking are 23 cm (9 in) and 30.5 cm (12 in).

Aerial marker spheres are available in a variety of colors, including international orange, gloss white, or gloss yellow. Studies



© P&R TECHNOLOGIES, INC.

FIGURE 6.8: Aerial marker spheres, also known as aviation balls, were designed to make power lines more visible to aircraft operators.



© JERRY LIGUORI

FIGURE 6.9: Aerial marker spheres in use on a power line above a wetland habitat.

regarding the effectiveness of color for warning pilots have shown that international orange is not the most effective color for all lighting conditions (Electrical World 1986). The FAA suggests a combination of international orange, gloss white, or gloss yellow for marking lines for aircraft. In bird collision studies, yellow has been shown useful because it reflects light better at dawn and dusk, and it does not blend in with the background colors as readily as international orange.

Recommended spacing between spheres generally ranges from 30 to 100 m (100 to 328 ft) (Table 6.3 and Table 6.4). For an existing line that crosses water, where the addition of aerial marker spheres may not be suitable, a separate (non-energized) cable for the purpose of holding the aerial markers could be installed. In this application, a larger size cable (visible to birds) should be used so that it does not contribute to bird collisions. This may provide adequate marking to reduce collisions.

TABLE 6.3: Spacing and positioning for aerial marker spheres (aviation balls).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Aerial Marker Spheres (Aviation Balls)	30 to 100 m (98.4 to 328 ft) apart (APLIC)	Spacing is not critical and will depend upon local conditions. The general rule is 20 m (65.6 ft) apart (Preformed Line Products)	Up to 100 m (328 ft) apart. Some studies staggered devices on parallel lines to increase visual density.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.4 for study details and sources.

TABLE 6.4: Representative studies for aerial marker spheres (aviation balls).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Yellow spheres with black vertical stripe, 30 cm (11.8 in)/spacing: irregular intervals	Nebraska/ sandhill cranes	Transmission, 69 kV to 345 kV	Behavioral avoidance was greater (birds flew higher and reacted sooner) for marked versus unmarked line	Significantly reduced collisions	Morkill and Anderson 1991
Yellow aviation balls with black stripes, 30 cm (11.8 in)/spacing: 100 m (328 ft); staggered on opposing shield wires for a visual effect of 50 m (164 ft)	South Carolina/ various waterfowl species	Transmission, 115 kV	Behavioral avoidance was greater (birds reacted sooner) for marked versus unmarked line	Collision rate was 53% lower at marked line	Savereno et al. 1996
Yellow aviation marker ball with 20.3 cm (8 in) black dots/spacing: not provided	Hawaii/ shearwaters	–	–	Reduced collisions	Telfer 1999 cited in Bridges et al. 2008

Considerations for Aerial Marker Spheres (Aviation Balls)

- Improper design or installation of aerial marker spheres on phase conductors or shield wires can cause spheres to work loose and slide to the center of the span or be pushed by wind to the end of a span. Line damage from this may cause an outage.
- Aerial marker sphere size should be compatible with the design constraints of the line. For example, very large spheres can be heavy and should only be used on lines that can handle this weight.
- Adding aerial marker spheres can affect line tension and structure design more than other devices, particularly in areas where heavy ice and wind loading occurs. Accommodating the additional loading could affect construction costs.
- When installed on higher voltage conductors, there can be corona damage (depending on the type of marker balls). To avoid corona damage, marker balls designed for installation on higher voltage lines, though more costly, should be used.
- Spheres are moderately labor-intensive to install on an existing line, but less costly when added to a new line during construction.
- Although aerial marker spheres are more costly per unit than spirals, the overall cost of marking new or existing lines would be about the same because fewer spheres would be required.
- The legal counsel of some utility companies objects to the use of aerial marker spheres to prevent bird collisions. They prefer that spheres be used only in compliance with FAA regulations to mark hazards to aircraft.
- Depending upon the location, aerial marker spheres can be targets for irresponsible shooters.
- The size and number of aerial marker spheres used may result in visual degradation of environments where esthetics are important (tourist areas, scenic mountain views, historic areas, etc.)

SPIRALS

Spirals available in the United States include spiral vibration dampers (SVDs), Bird-Flight™ Diverters (BFDs), and Swan-Flight™ Diverters (SFDs).

Spiral Vibration Damper (SVD)

Spiral vibration dampers (SVDs) are pre-formed PVC spirals that were designed to reduce line vibration (aeolian vibration), but were also found to increase line visibility and

to reduce collision risk. Aeolian vibration is induced by low-velocity winds of 4.8 to 12.9 km per hour (3 to 8 mi per hour)



© JERRY UGLORI

FIGURE 6.10: Spiral vibration dampers act to reduce line vibration, and they also make power lines more visible to birds.

(Figure 6.10). SVDs change the airfoil of a power line under normal and icing conditions to reduce conductor gallop.

SVDs are available in various lengths, ranging from 112 to 165 cm (46 to 65 in), to fit different wire sizes. Standard SVDs are made of solid thermal plastic. They are available in gray or yellow with UV stabilizers that help the devices retain color, flexibility, and durability when exposed to extreme sunlight and weather conditions. They are also available in a yellow, high-impact PVC.

SVDs are often placed about 3 m (9.8 ft) apart on transmission line shield wires (Table 6.5 and Table 6.6). For distribution lines, to prevent interphase contact and increase line visibility, SVDs should be staggered so that every third one is on an alternate phase conductor.

TABLE 6.5: Spacing and positioning for spiral vibration dampers (SVDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Spiral Vibration Damper (SVD)	2.7 m (9 ft) on the shield wire. On distribution phase conductors, stagger SVDs to prevent interphase contact. (APLIC)	–	3.3 m (10.8 ft) apart (Brown and Drewien 1995)

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.6 for study details and sources.

TABLE 6.6: Representative studies for spiral vibration dampers (SVDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Yellow spiral vibration dampers, 1.27 cm × 112 to 125 cm (0.5 in × 44 to 49.2 in) / spacing: 3.3 m (10.8 ft)	Colorado/ waterfowl and sandhill cranes	Distribution, 7.2 kV Transmission, 69 to 115 kV	Reacted sooner and changed flight patterns in marked versus unmarked lines	Reduced mortality by 60%	Brown and Drewien 1995

Considerations for Spiral Vibration Dampers

- When installed on triangularly spaced distribution lines, SVDs should be staggered on all three phase conductors. Despite their light weight, if they are only applied on the top or ridge phase conductor, wind or ice may make the top phase sag, which may cause interphase contact.
- When installed on a single shield wire, given the relatively light weight of SVDs, the rate of coverage, and the distance between the shield wire and the phase conductors, line sag on the shield wire would rarely present an issue.
- SVDs are not recommended for use on transmission phase conductors (AC or DC) with voltage ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Installation of SVDs is moderately labor intensive on lower-height distribution lines and more so on transmission lines that range from 15.2 to 59 m (50 to 195 ft) above the ground.



FIGURE 6.11: The Bird-Flight™ Diverter is a spiral device made of PVC.

© PREFORMED LINE PRODUCTS, INC.

Bird-Flight™ Diverter (BFD)

BFDs are preformed, increasing-radius spirals made of extruded, high-impact PVC (Figure 6.11 and Figure 6.12). One end of the spiral grips the power line while the radius quickly increases toward the other end of the spiral. BFDs were developed in Great Britain and have been used in Europe since the early 1970s and more recently in the United States and South Africa. They are also called "small pigtails" in South Africa (Eskom Transmission 2009). Since 1994, more designs have become available.



FIGURE 6.12: Bird-Flight™ Diverters installed on a distribution line.

© DAVE BOUCHARD, AEP

TABLE 6.7: Spacing and positioning for Bird-Flight Diverters (BFDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Bird-Flight Diverter (BFD)	4.9 to 15.2 m (16 to 50 ft) (APLIC) 10 m (32.8 ft), staggered (Eskom) 21 m (68.9 ft) (Iberdrola)	4.6 m (15 ft) apart depending upon local conditions (Preformed Line Products)	5 m (16.4 ft), 10 m (32.8 ft), 15 m (49.2 ft), and 20 m (65.6 ft). Some studies staggered devices on parallel lines to increase or maintain visual density and to reduce and distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions. Manufacturer recommendations are the closest spacing that would be required.
† See Table 6.8 for study details and sources.

Various sizes of BFDs are available to fit different line diameters. The lengths can range from 17.8 to 59.7 cm (7 to 23.5 in). The diameter of the spiral at the large end of the diverter ranges from 3.8 to 12.7 cm (1.5 to 5 in). UV stabilizers are added to the PVC to protect BFDs from sunlight. They are produced in a variety of colors, such as yellow, orange, red, green, brown, gray, and black, and some glow.

Spacing recommendations for BFDs vary (Table 6.7 and Table 6.8). In the Netherlands, wires have been marked in bird-collision zones using 10 cm (3.9 in) spirals at 5 m (16.4 ft) intervals. This reportedly has an average mortality reduction of approximately 90% (Koops 1993). For the United States, one manufacturer (Preformed™ Line Products) recommends 4.6 m (15 ft) spacing intervals depending upon local conditions. In studies conducted in the Netherlands, marking devices have been staggered on parallel shield wires so that the line marking devices appear to be 5 m (16.4 ft) apart (Koops 1979; Koops and de Jong 1982; Koops 1987). On each shield wire, however, they are 10 m (32.8 ft) apart. Staggering line marking devices on alternate lines reduces the loading that a single marked line would otherwise have to bear.

Considerations for Bird-Flight Diverters

- BFDs add some aeolian vibration stabilization since their profile changes the airflow over the line.
- BFDs are not recommended for use on transmission line phase conductors (AC or DC) with voltage ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Eskom has used BFDs in South Africa for years with no reports of mechanical failure (van Rooyen 2000) although some red PVC devices have faded.
- BFD installation is labor intensive whether by bucket truck, boat, helicopter, or line trolley. Robotic installation devices are being developed.

TABLE 6.8: Representative studies for Bird-Flight Diverters (BFDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
White BFD, 5 cm (1.9 in) diameter/ spacing: 5 m, 10 m, and 20 m (16.5, 32.8, and 65.6 ft) White BFD, 10 cm (3.9 in) diameter/spacing: 15 m (49.2 ft)	Netherlands/ various species	–	–	When spaced at 20 m (32.8 ft), they reduced collisions by 58%. Total mortality was reduced by 57% to 89%, depending upon the size and spacing	Koops 1987; Koops and de Jong 1982; Koops 1993 (cited in Janss and Ferrer 1998)
Red spiral BFD, 30 cm (11.8 in) maximum diameter, 1 m (3.3 ft) long/spacing:10 m (32.8 ft)	Spain/various species including cranes and bustards	Transmission, 380 kV with dual shield wires	61% reduction in birds crossing the lines, more birds flying over, fewer flying through lines	60% reduction in collisions	Alonso et al. 1994
Yellow and gray BFD	Indiana/ waterfowl	Transmission, 345 kV		Reduced bird collision by 73.3% compared to unmarked lines	Crowder 2000
Yellow PVC BFD spirals, 25 cm (9.8 in) diameter, 80 cm (31.5 in) length /spacing: 10 m (32.3 ft); staggered on both shield wires	Colombia/ night flying rallids, herons, and ducks	Transmission, 500 kV	Birds detected BFD line at a greater distance than unmarked line, fewer flew at conductor height	Reduction in collision frequency for marked versus unmarked lines, but collision rate was highly variable regardless of line condition	De La Zerda and Roselli 2003
Yellow and gray BFD/ spacing: 4.6 m (15 ft); staggered on 3 phase conductors	California/ waterfowl	Distribution	Birds exhibited greater reactive distances	Reduced waterfowl collisions, but not coot collisions (coots fly at night)	Ventana Wildlife Society 2009
Small spirals, 10 cm (3.9 in) diameter, 24 cm (9.4 in) long/ spacing was not provided	Spain/various species including bustards, storks, and doves	Distribution and transmission	–	Reduced collisions overall after line marking (9.6%)	Barrientos et al. 2012

Swan-Flight™ Diverter (SFD)

The SFD is another spiral design, which is also called a Double Loop Bird Flight Diverter (Figure 6.13 and Figure 6.14). SFDs have two gripping ends and a central spiral with a larger diameter.

Sizes are available to fit different conductor diameters. The lengths can range from 50.8 to 116.8 cm (20 to 46 in). The diameter of the central spiral can range from 17.8 to 20.3 cm (7 to 8 in). SFDs are extruded in yellow and gray high-impact PVC with UV



FIGURE 6.13: The Swan-Flight™ Diverter is a double-ended spiral device.

© PREFORMED LINE PRODUCTS, INC.



© JERRY LIGUORI

FIGURE 6.14: Swan-Flight™ Diverters installed on the phase conductors of a distribution line.

stabilization. Gray is the standard color but SFDs are available in: black, blue, brown, green, purple, red, orange, and pink, and some that glow.

Spacing depends upon local conditions (Table 6.9 and Table 6.10).

Considerations for Swan-Flight Diverters

- SFDs can be used on the shield wires of high-voltage lines.
- SFDs on the line add some aeolian vibration stabilization since their profile changes the airflow over the line.
- SFDs are not recommended for use on transmission line phase conductors (AC or DC) with voltages ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Wind and ice loading should be considered, as these have been a concern in Canada and the northern United States (N. Heck, pers. comm.).
- Colors of some SFDs may fade.
- Installation is labor intensive whether done from bucket truck, boat, helicopter, or line trolley. Robotic installation devices are also being developed.

TABLE 6.9: Spacing and positioning for Swan-Flight Diverters (SFDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Swan-Flight Diverter (SFD)	15.2 m (50 ft) (APLIC) 21 m (68.9 ft) (Iberdrola)	Spacing is not critical and will depend upon local conditions. The recommended ranges are 10 to 15 m (32.8 to 49.2 ft) (Preformed Line Products) up to 30 m (98.4 ft) (FCI)	5 m (16.4 ft), 10 m (32.8 ft), and 15 m (49.2 ft). Some studies staggered devices on parallel lines to increase visual density and distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.10 for study details and sources.

TABLE 6.10: Representative studies for Swan-Flight Diverters (SFDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
White spirals (SFD), 30 cm (11.8 in) diameter/ spacing: 10 m (32.8 ft)	Spain/various species including cranes, storks, and bustards	Various size distribution and transmission lines	–	Effective at reducing collisions	Roig-Soles and Navazo-Lopez 1997
White polypropylene spirals, 1 m (3.3 ft) long, 30 cm (11.8 in) maximum diameter/spacing: 10 m (32.8 ft); staggered on 2 shield wires for a visual effect of 5-m (16.4-ft) intervals	Spain/cranes	Transmission, 380 kV and 132 kV Distribution, 13 kV	–	Small sample size did not permit specific species evaluation. Reduced mortality for common cranes. The reduction in actual versus predicted mortality for all birds was 81%	Janss and Ferrer 1998
Yellow and gray SFD/spacing was not provided	Indiana/ waterfowl	Transmission, 345 kV	–	Reduced collisions by 37.5% on marked lines compared to unmarked lines	Crowder 2000
Yellow SFD/ spacing: 15.2 m (50 ft); staggered on parallel wires for a visual effect of 7.6-m (25-ft) spacing	Wisconsin/ trumpeter swans (*Cygnus buccinator*)	Distribution, 23.9 kV	–	Eliminated collisions completely	Rasmussen 2001, cited in Hunting 2002
Red SFD, 32 cm (12.6 in) for the gripping section and 17.5 cm (6.9 in) for the outside diameter of the central spiral/spacing: 5-m (16.4-ft) intervals on shield wire	England/ mute swans (*Cygnus olor*)	Transmission, 132 kV	–	Reduced collisions	Frost 2008
Gray SFD/ spacing: 4.6 m (15 ft); staggered on 3 phase conductors	California/ waterfowl	Distribution	Birds exhibited greater reactive distances	Reduced waterfowl collisions, but not coot collisions (coots fly at night)	Ventana Wildlife Society 2009
Large spirals, 35 cm (13.8 in) diameter, 1 m (3.3 ft) long/ spacing was not provided	Spain/various species including bustards, storks, and doves	Distribution and transmission	–	Reduced collisions overall after line marking (9.6%)	Barrientos et al. 2012



ESKOM 2009

FIGURE 6.15: Examples of suspended devices (swinging and fixed).

SUSPENDED DEVICES (SWINGING, FLAPPING, AND FIXED)

There are several types of suspended devices including general designs and branded designs (e.g., FireFly™ and BirdMark BM-AG), which are discussed separately on page 95 and page 96. They have a clamp that attaches to the power line so that the device can move in the wind. Some are designed to swing, flap, and spin, while others, for use in high wind locations, are nearly immobile but do allow some motion. Some have reflective and glow-in-the-dark properties.

General Designs

Suspended devices have a polycarbonate, UV stabilized, plastic flapper (swinging or fixed) connected to a clamp that attaches to the power line (Figure 6.15). The movement and reflectivity of the device enhances the visibility of the line. Suspended devices are available in many colors and shapes with panels that reflect visible and UV light and glow. They can be attached to distribution phase conductors up to 40 kV and to shield wires up to a diameter of 1.9 cm (0.75 in) (Table 6.11 and Table 6.12).

TABLE 6.11: Spacing and positioning for general designs of suspended devices.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Swinging or fixed device	5 m (16.4 ft), staggered (Eskom)	Staggering devices on parallel lines is recommended. The general spacing rule is 10 to 15 m (32.8 to 49.2 ft) (Preformed Line Products).	–

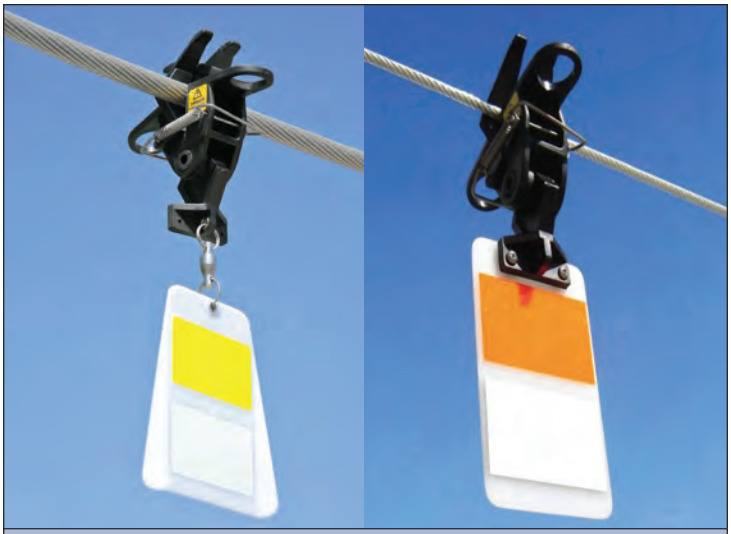
* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.

TABLE 6.12: Representative studies for general designs of suspended devices.

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Swinging or fixed device (specifications and spacing not provided)	South Africa/ bustards and cranes	Distribution, 22 kV Transmission, up to 440 kV	– –	Reduced collisions More effective than the BFD	van Rooyen 2000; Anderson 2001; McCann 2001
Yellow fiberglass swinging plate, 30.5 x 30.5 cm, (12 × 12 in) with a black stripe/ spacing: 20 to 30 m (65.6 to 98.4 ft) on shield wires or center phase conductor	Colorado/ sandhill cranes and waterfowl	Distribution, 7.2 kV Transmission, 69 kV to 115 kV	Birds reacted earlier and flew higher over marked lines than unmarked lines	63% reduction in mortality rates overall, but there was considerable seasonal variation. Over 30% of collisions in fall occurred at night.	Brown and Drewien 1995

FireFly™

There are several types of FireFlys, two of which (the FireFly FF and the FireFly HW) are designed as suspended devices (Figure 6.16). FireFlys have a strong spring-loaded clamp that attaches to the line so that the device can swing. The device increases the line profile slightly, but its motion and reflectivity attract attention and alert birds of the line's presence.



© P&R TECHNOLOGIES, INC.

FIGURE 6.16: The FireFly™ FF (left) has a swinging tag for use in light winds and the FireFly™ HW (right) has a fixed tag to withstand higher, sustained winds.

The FireFly FF has an acrylic plastic tag that measures 9 cm × 15 cm (3.5 in × 6 in), is 3 mm (0.13 in) thick, and is covered with yellow and orange reflective tape and photo-reactive coatings. They are UV light stabilized and constructed to be highly reflective during the day. According to the manufacturer they glow for up to 10 to 12 hours after sunset. They are attached to the clamp by swivels so they swing and spin in the wind.

The FireFly HW is similar in size to the FireFly FF but the HW model's plastic tag does not swivel and is designed to withstand higher, sustained winds. The manufacturer claims similar effectiveness. Results from installation in a high raptor use area on a new power line in central California have shown these devices to be effective without any damage to the line or failure of the devices (M. Schriner, pers. comm.).

FireFlys have been attached 4.6 to 15.2 m (15 to 50 ft) apart. For lines with parallel shield wires, they can be staggered so that the device density appears greater, e.g., when spaced at 12.2 m (40 ft) on each shield wire and staggered, they appear to be 6.1 m (20 ft) apart (Table 6.13 and Table 6.14).

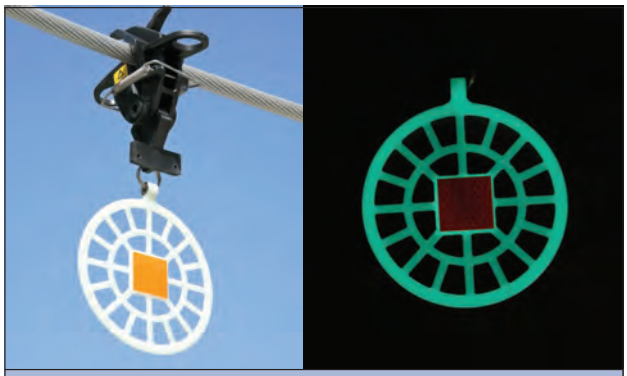
TABLE 6.13: Spacing and positioning for FireFlys.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
FireFly™	15.2 m (50 ft) spacing, staggered on alternating wires (PacifiCorp)	Recommendations depend on the tower height: 4.6 m (15 ft) apart for towers less than 30.5 m (100 ft) and 9.1 m (30 ft) apart for towers that are greater than 30.5 m (100 ft) tall (Birdbusters).	5 to 12 m (16.4 to 39.3 ft) apart. Some studies staggered devices on parallel lines to either increase visual density or distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.14 for study details and sources.

TABLE 6.14: Representative studies for FireFlys.

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
FireFly™, 9 cm × 15 cm (3.5 in × 6 in), 3 mm (0.13 in) thick, luminescent strip, spinning swivel, contrasting reflective colors on opposite sides/spacing: 5 m (16.4 ft); staggered on conductors	California/ sandhill crane, song birds, other species	Distribution, 12 kV	No changes in flight height or reaction distance	60% reduction in collision frequency on marked lines, collision frequency also decreased on adjacent spans	Yee 2008
FireFly™, acrylic plastic tag measures 9 cm × 15 cm (3.5 in × 6 in), 3 mm (0.13 in) thick, yellow and orange reflective tape and photo-reactive coatings/ spacing: 12-m (39.3-ft) intervals	Nebraska/ sandhill cranes	Transmission, 69 kV	Cranes reacted more quickly (mainly by gradually gaining altitude) to avoid the marked line than they did to unmarked lines	Reduced collisions by half	Murphy et al. 2009



© P&R TECHNOLOGIES, INC.

FIGURE 6.17: BirdMark BM-AG (After Glow) in daylight (left) and darkness (right).

BirdMark BM-AG (After Glow)

The BirdMark BM-AG (After Glow) has a perforated swinging disk that spins and flutters (Figure 6.17). This device is 29.21 cm (11.5 in) long with a 13.33 cm (5.25 in) diameter disk with a reflective center. The BirdMark BM-AG is designed with a strong spring-loaded clamp that attaches to wires up to a diameter of 6.4 cm (2.5 in). The reflective disks glow for up to 10 hours after sunset and are available in orange, white, and red.

The manufacturer recommends 4.6 m (15 ft) spacing (Table 6.15). The movement of the device adds to the visibility of the line.

TABLE 6.15: Spacing and positioning for BirdMark BM-AG.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies
BirdMark BM-AG	–	4.6 m (15 ft) (P&R Technologies)	No scientific studies on the BirdMark BM-AG were found.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.

Considerations for Suspended Devices

- In some of the earlier versions, there were problems with the device shifting (van Rooyen 2000).
- Depending upon the location, suspended devices can be targets for irresponsible shooters.
- The devices can be installed and removed from the ground or bucket truck with a hot stick. Two people are required for installation unless a special tool is used; homemade tools have worked better than some manufactured tools (S. Liguori, pers. comm.). New manufactured tools are being made and tested.
- Corona effects can occur depending upon the voltage (see *Corona Effects*, page 84).
- Installation cost increases with line height and in areas that are difficult to access such as river and lake crossings.
- Swivels have failed prematurely in high wind locations.

DEVICES AVAILABLE IN OTHER COUNTRIES

The following devices are not distributed in the United States at this time (2012).

Baliza Avifauna

The Baliza Avifauna is manufactured in Spain by Saprem. It is a variation of hanging strips that consists of two black neoprene crossed bands (measuring 6 cm × 28 cm [2.4 in × 11 in]). Some versions have a phosphorescent stripe.

Janss and Ferrer (1998) describe a similar device (with crossed bands measuring 5 cm × 35 cm [1.9 in × 13.8 in]) that was staggered on the conductors every 24 m (78.7 ft) (a visual effect of 12 m [39.3 ft] intervals). The device consisted of two black neoprene crossed bands slightly shorter than the com-



© DAVE BOUCHARD, AEP

FIGURE 6.18: Hanging strips of neoprene, such as this Spanish-made Baliza Avifauna, are being used as line marking devices in Europe and South Africa.



FIGURE 6.19: Baliza Avifauna installed on a power line in Europe.

© SAPREM



© ETIENNE FOLLET/RTE

FIGURE 6.20: The Avifaune Spiral is commonly used in France and other parts of Europe.



© DR/RTE

FIGURE 6.21: Avifaune Spirals installed.



© MACE TECHNOLOGIES

FIGURE 6.22: The Mace Bird Lite is a spiral device with a central fluorescent tube that is illuminated by the ambient electrical field.

mercially available strips. Janss and Ferrer (1998) found the device reduced collisions by 76% on transmission (380 kV and 132 kV) and distribution (13 kV) lines. The device pictured here is widely used in Europe and South Africa.

Avifaune Spiral

The Avifaune Spiral is used in France and other parts of Europe. These are preformed PVC similar to the SFDs described previously. Avifaune Spirals are 91 cm (36 in) long and have two 36-cm (14-in) spirals in the middle. They are produced in two UV light protected colors: red and white. French researchers recommend alternating the colors. Raevel and Tombal (1991) indicate that the color combination is effective in variable light conditions on transmission lines. Avifaune Spirals have been used on phase conductors and shield wires with a recommended spacing of 7 to 10 m (23 to 32.8 ft).

Mace Bird Lite

The Mace Bird Lite is a spiral vibration damper with a fluorescent light attached inside a plastic tube. The light is energized by a phase conductor's electrical field and can be seen at night. These were designed specifically for 132-kV lines, but it should be possible to use them with other voltages. Although no precise scientific data are available on its effectiveness, this technology has been successfully used in Botswana and South Africa (Eskom 2003) in reducing flamingo collisions (Eskom Transmission 2009). The potential issue of the light attracting birds to a line was not addressed.

RIBE Bird Flight Diverter Fittings

RIBE bird flight diverter fittings are available in two versions: a swinging rectangular tag and a series of 10 alternating black-and-white, rigid plastic pieces that swing on a rod attached at both ends to a shield wire or phase conductor.



FIGURE 6.23: The RIBE line marking device is available as a swinging triangular tag or as a series of black-and-white, rigid plastic pieces that swing (pictured).

© RIBE



FIGURE 6.24: The Inotec BFD 88, a South African device, is a reflective stainless steel sphere reported to be visible from all angles and in low-light conditions.

© INOTEC

According to the manufacturer, results from a three-year field trial on the Bernbrug-Susigke 110-kV line in South Africa showed that these are effective at reducing bird collisions with power lines when compared to lines without diverters. The information suggests that closer spacing (20 m versus 40 m [65.6 ft versus 131.2 ft] apart) is more effective. However no description of the study design nor specific data was provided.

Inotec BFD 88

The Inotec BFD 88 is a relatively new device with characteristics of both suspended devices and spheres. It is a reflective stainless steel sphere, 7 cm (2.8 in) in diameter, attached to a metal spiral, which is attached to the wire. When installed they appear as small metal spheres suspended from the wire.

This device is made of 316-grade stainless steel and is naturally reflective and corrosion resistant. The crimp is made from marine-grade aluminum, a highly durable adhesive, and conductive rubber. According to the manufacturer, the clamp does not come into contact with the phase conductor, so there is no chance of galvanic cell reaction or mechanical damage to the power line. The stainless steel sphere does not sway and cannot touch the power line.

Eskom Transmission (2009) indicates that these metal spheres are visibly superior to colored (red, yellow, white, or black) objects in low light, especially at dawn and dusk when birds are flying between roosting and feeding areas. The spherical shape reflects available light and is claimed to be visible from all directions including above or below the diverter. When viewed during low-light conditions, the device is visible against dark backgrounds such as the ground, trees, or high ground. It is also visible against bright clouds when viewed from below (Eskom Transmission 2009).

The diverter can be attached while a line is energized and installed from the ground with a hot stick. Because of the spherical design, it does not display corona. It was developed in South Africa for use on shield wires and phase conductors up to 88 kV, and no radio interference was detected up to 88 kV.

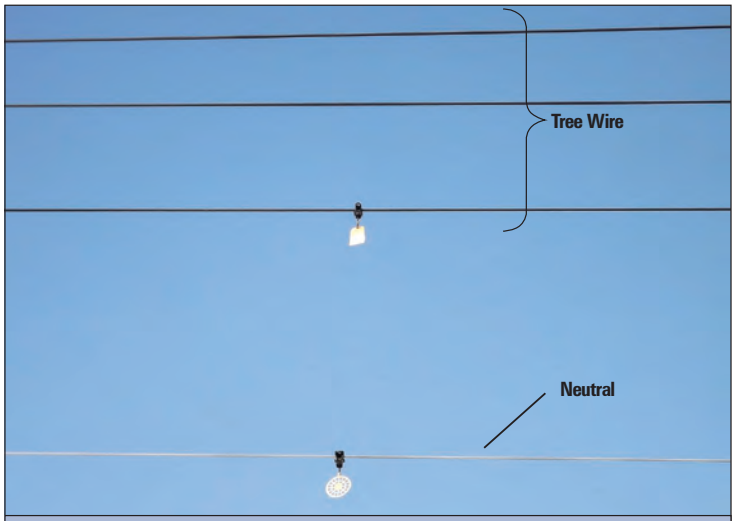
PLASTIC TUBES

Archibald (1987) reported that yellow plastic tubes placed on power lines near Hokkaido, Japan, in 1982 reduced mortality of red-crowned cranes (*Grus japonensis*). Plastic tubes along with various versions of ribbons, however, are not durable enough for use.

LARGE DIAMETER WIRE

OVERSIZED SHIELD WIRE FOR TRANSMISSION LINES

A limited study compared the use of an oversized shield wire with a conventional shield wire (Brown et al. 1987; Miller 1990). The oversized wire was 2.52 cm (1 in) in diameter, or 2.6 times greater than standard shield wire (0.95 cm [0.4 in]). Researchers found that there was no significant difference between these wires. Other studies have identified the conventional, small-diameter shield wire as the highest risk wire for collisions with transmission lines (e.g., Savereno et al. 1996), which suggests that diameter and distance visibility are factors involved in collision risk. The use of larger-diameter shield wire is considerably more expensive. Though anecdotal reports suggest larger diameter shield wire is effective, studies of its effectiveness are needed before it can be recommended for reducing collision risk.



© MEL WALTERS, PUGET SOUND ENERGY

FIGURE 6.25: Tree wire on all three phases of a distribution line marked with suspended devices.

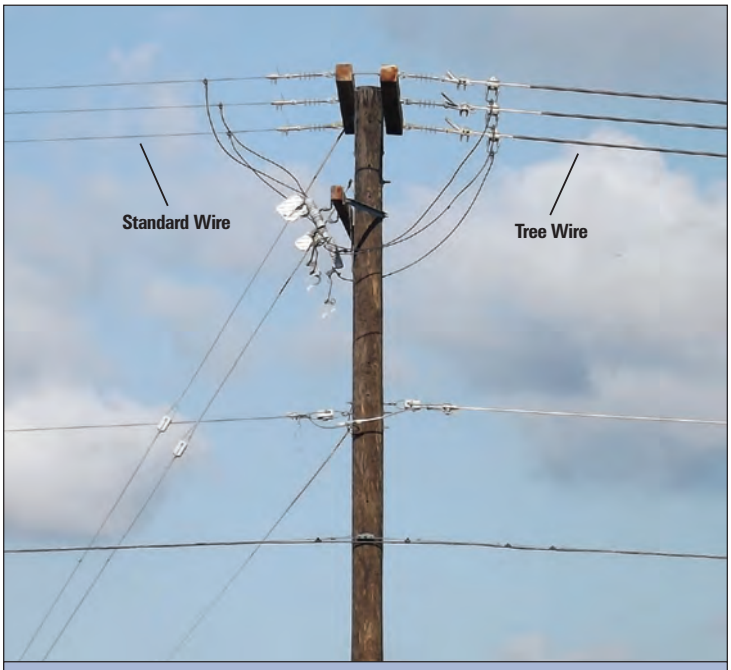
TREE WIRE TO PREVENT COLLISION-ELECTROCUTIONS ON DISTRIBUTION LINES

Tree wire is a type of insulated phase conductor used on distribution lines to provide protection from momentary contact with tree branches, which would otherwise cause an electric arc (Figure 6.25, Figure 6.26, and Figure 6.27). The insulation is also sufficient[17] to protect birds from collision-electrocutions, which are caused by phase-to-phase contact when large birds, such as eagles and swans, brush phase conductors while flying between them. The electric arc created in collision-electrocutions can kill multiple birds in a flock, even if only one bird makes phase-to-phase contact. Because tree wire can prevent collision-electrocutions, it has even been used in some open areas for rebuilt and new distribution lines (M. Walters, pers. comm.).

Tree wire may also be an effective means of reducing collision incidence because the insulated covering increases the diameter of the wire, making the line more visible. However, no scientific studies were found to verify this.

Retrofitting a line with tree wire is usually only a consideration when outages are caused by tree branches. It would be unusual to retrofit an existing line with tree wire to prevent collisions because line marking devices are more cost effective. However, when a distribution line is being upgraded or a new line is being built, tree wire may be a cost-effective option when used for the center

[17] The insulation on tree wire is not considered protective for human safety.



© MEL WALTERS, PUGET SOUND ENERGY

FIGURE 6.26: Tree wire (right of pole) and standard wire (left of pole) on a distribution line.



© ROBERT LAWTON, WIKIMEDIA COMMONS

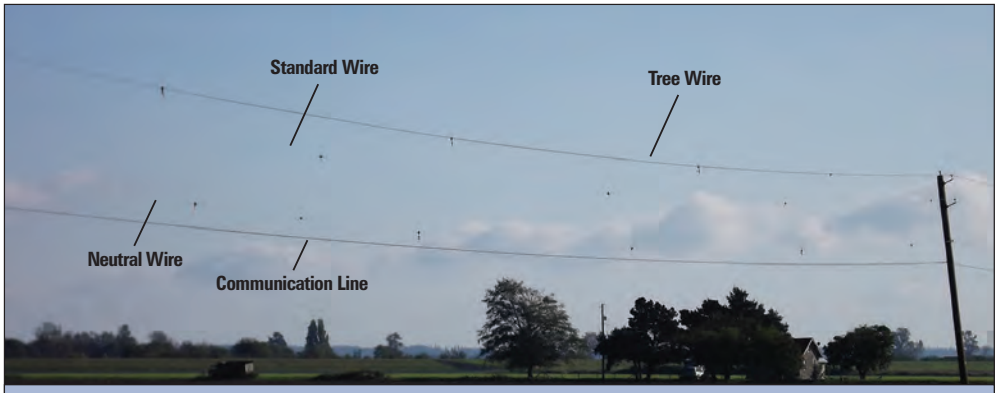
FIGURE 6.27: Collision-electrocutions cause an electrical short, like this one caused by tree branches, and can kill two or three birds in a flock even if only one bird makes phase-to-phase contact.

phase. The difference in cost (2011 $) between tree wire (336ACSR TW= $0.89 per 30.5 cm [12 in]) and standard wire (397KCM = $0.77 per 30.5 cm [12 in]) is approximately $0.12 per 30.5 cm (12 in) or $1,900 per 1.6 km (1 mi) for a standard three-phase distribution feeder. Tree wire is also heavier than standard wire and may require higher class poles, more poles (1 to 2 per 1.6 km [1 mi]), and possibly additional guying. The average lifespan of tree wire is 40 years. The advantages to tree wire are that it reduces the risk of collision-electrocution at mid-span for flying birds, reduces the risk of electrocution for perching birds, and reduces the maintenance requirements usually associated with suspended devices.

Unpublished observations show that tree wire used in conjunction with line marking devices, such as the FireFly™ and/or Bird-Mark BM-AG, is effective at reducing collision-electrocutions and collisions for trumpeter swans (*Cygnus buccinator*), waterfowl, and raptors (M. Walters, pers. comm.). When rebuilding lines already equipped with flight diverters, the diverters are reinstalled on the new tree wire lines. The increased visibility of tree wire reduces the risk, which is further reduced by installing FireFlys (M. Walters, pers. comm.).

In the Chimacum Valley, Washington, from 2000 to 2007, an eight-span lateral line averaged three bird-caused outages per year due to swan and waterfowl collisions, including 10 swan mortalities in 2006 alone. In 2007, the line was modified with tree wire to prevent collision-electrocutions and with FireFlys to reduce collision risk. No swan mortalities or outages have occurred since the line was modified in spite of increasing swan populations and their continued use of this flight corridor. The landowner reported that the swan flight path is much higher over the lines since these modifications were made (M. Walters, pers. comm).

At another site in western Washington's Skagit Valley, five swan mortalities occurred on a single-phase line in the winter of 2008–2009, and others had been documented in previous years. The line was rebuilt in a three-phase configuration during the summer of 2009, which included tree wire on the center phase along with alternating FireFly™ and BirdMark BM-AG devices on all three phase conductors. In the following winter season, no mortalities or outages occurred, although swan populations continue to increase. Between 1,000 and 2,000 swans forage in this area throughout the winter (M. Walters, pers. comm.).



© MEL WALTERS, PUGET SOUND ENERGY

FIGURE 6.28: Tree wire on the top phase conductor of a two-phase distribution line (vertical configuration) with line marking devices.



CHAPTER 7

Avian Protection Plans

IN THIS CHAPTER

- Overview of Avian Protection Plans
- Components of an Avian Protection Plan
- Creating and Implementing an Avian Protection Plan

An Avian Protection Plan is a voluntary, utility-specific plan that provides a framework for reducing bird mortalities, documenting utility actions, and improving service reliability. In 2005, the U.S. Fish and Wildlife Service and the Avian Power Line Interaction Committee jointly published Avian Protection Plan Guidelines to provide utilities with resources and guidance for developing Avian Protection Plans. This chapter is based on those guidelines.

OVERVIEW OF AVIAN PROTECTION PLANS

An Avian Protection Plan (APP) is a utility-specific program for reducing the operational and avian risks that result from avian interactions with electric utility facilities. 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 APPs and provide a toolbox from which utilities may select and tailor APP components to fit their needs. An APP should provide the framework necessary for developing a program to reduce bird mortalities, document utility actions, and improve service reliability. The APP components are summarized in this section. The complete version of the *Guidelines* can be obtained from either the APLIC (www.aplic.org) or USFWS (www.fws.gov) websites.

An APP represents a utility's commitment to reducing its avian impacts. Since they are created by a utility, APPs are more easily modified to address newly developing or unforeseen problems. Despite the fact that APPs are generally initiated by utilities, a cooperative dialog between the utility and the USFWS is encouraged during development and implementation. This sets the tenor for those conversations that will inevitably follow as the APP is implemented and refined over time.

Implementing the *Guidelines* will reduce avian collision and electrocution risks. An APP represents responsible environmental practices to all stakeholders, and a utility that creates an APP to address its specific avian issues can benefit through regulatory compliance, reliability improvements, potential long-term cost savings, and positive recognition from regulators, employees, and customers.

COMPONENTS OF AN AVIAN PROTECTION PLAN

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 an APP to best fit its needs. Because of utility-specific circumstances, some of the *Guidelines*' elements may not be applicable. The *Guidelines* present a comprehensive overview of the elements that should be considered in an APP. The APP should also be a "living document" that is modified over time to improve its effectiveness. Some or all of the following elements may be implemented:

- 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

Details on the nature of these elements and how they may be developed by a utility are discussed on the following pages.



© JERRY LIGUORI

FIGURE 7.1: Utility employee training should include the reasons and methods for reporting bird mortalities, nest management protocols, proper disposal of carcasses, applicable regulations, and the consequences of non-compliance.

CORPORATE POLICY

An APP usually includes a statement that balances the company's commitment to minimizing its impact on migratory birds, complying with bird-protection regulations, and 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 integral component of an APP. Workshops and short courses on avian/power line interactions are provided by APLIC (www.aplic.org) and Edison Electric Institute (EEI) (www.eei.org). A two-hour overview of avian electrocutions and collisions intended for training use is also available to APLIC members through the APLIC website as part of the APP toolbox. Each company will have its own approach to training. All appropriate utility personnel, including managers, supervisors, line crews, engineering, dispatch, design personnel, and vegetation management personnel should be trained in avian issues. This training should encompass the reasons, needs, and methods for reporting avian mortalities, following nest management protocols, disposing of carcasses, complying with applicable

regulations, and understanding the potential consequences of non-compliance. Supplemental training also may be appropriate when there are changes in regulations, personnel, permit conditions, construction standards, bird protection materials, or internal policies.

PERMIT COMPLIANCE

Each utility developing an APP should familiarize itself with the different avian regulations and permit types and should work with wildlife agencies to determine whether permits are required for operational activities that may affect protected avian species (see Chapter 3). An APP should discuss how this is done and identify company permits. 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 or disposal, scientific collection, and miscellaneous. State permits may also be required to manage protected bird nests or for temporary possession of nests, birds, or their parts.

CONSTRUCTION DESIGN STANDARDS

To improve system reliability, avian interactions should be considered when siting and designing new facilities and when operating and maintaining existing facilities. For those reasons the accepted standards for both new construction and retrofitting for risk minimization should be included in an APP. Companies can either rely upon the recommendations in APLIC documents for electrocutions and collisions or develop their own standards that meet or exceed these guidelines.

An APP may indicate that all new or rebuilt lines in identified avian-use areas or potential problem areas be built to current standards for minimizing electrocutions and collisions. Employing avian-safe construction standards in such areas will reduce future legal and public relations problems and will enhance service reliability.

NEST MANAGEMENT

An APP may include procedures for managing nests on utility structures and in power line rights-of-way (ROW). This could include procedures for handling problem nests (ones that need to be relocated or removed) as well as for creating safe nest sites. These procedures should be explained to company employees during training to ensure uniform treatment of avian nest issues and compliance with regulations or permits related to nest management. For more detailed guidance regarding nest management, see *Suggested Practices for Avian Protection on Power Lines* (APLIC 2006).

AVIAN REPORTING SYSTEM

An avian reporting system is used for documenting bird injuries, fatalities, and nest management activities. This system should be described in the APP and designed to meet the needs of the utility and applicable avian permit reporting requirements. The reporting system should be compatible with a utility's other data management and analysis programs so this information can be effectively collected and recorded. The system could be based on paper forms or may be an internal web-based program. The information collected should be used to help a utility conduct risk assessments of avian problem areas and high risk structures or lines. To protect birds and minimize outages, these data can be prioritized for corrective actions. Avian information collected by a utility should be maintained internally. Reporting is required as a condition of the USFWS permit for direct *take* of birds or their nests (see Chapter 3).

The USFWS Office of Law Enforcement also maintains a voluntary, internet-based Bird Fatality/Injury Reporting Program.[18]

[18] The USFWS (2012) has been internally referring to this as the Bird Information and Mortality Reporting System. The title on the web page may assume this title as well (A. Manville pers. comm.).

This program provides a clearinghouse of useful information for the electric utility industry to mitigate the impacts of energy delivery systems on birds and to address specific bird/power line problems on an incident-specific basis (USFWS 2009b). This database was designed to collect information about bird collisions and electrocutions to help with preventing future bird/power line incidents. It is also intended for utilities to see which structures pose a greater risk than others and under what conditions they occur. Utilities can establish a password-protected account with this voluntary program, and privacy and confidentiality are protected including several exemptions from the Freedom of Information Act (FOIA). The data collected include the characteristics of the fatality or injury, location, configuration of the equipment, environmental conditions, etc. To date (2012), at least 33 electric utilities have been voluntarily reporting through this program.

RISK ASSESSMENT METHODOLOGY

A utility can cost-effectively reduce avian mortalities by focusing its efforts on the areas of greatest risk. Therefore, an APP should include a method for evaluating and prioritizing the risks that a company's operations pose 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, migration corridors, concentration and staging areas, other 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 choose an optimal route during corridor and ROW siting and to prioritize existing poles and lines most in need of modification. A risk assessment may also provide data about the various causes of avian mortality as well as the benefits birds receive from utility structures. For more discussion on avian risk assessment, see Chapter 5.

MORTALITY REDUCTION MEASURES

As a part of an APP, a mortality reduction process is described. A utility can use the results of an avian risk assessment to focus its efforts on areas of concern, ensure that its responses are not out of proportion to the risks presented to protected birds, and determine whether avian mortality reduction plans need to be implemented.

Mortality reduction plans may use strategies that include preventive, 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.

- **Preventive**: Construct all new or rebuilt lines in high avian-use areas to avian-safe standards. Apply collision minimization measures for new construction in high risk areas. Ensure that the 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 utility's permits and policies.
- **Proactive**: Provide resources and training to improve employees' knowledge and awareness. Partner with organizations that conduct research on effects of bird interactions with power lines. Evaluate risks of existing lines in high avian-use areas and prioritize structures or lines for retrofitting or mitigation according to their risk level.

A successful APP and mortality reduction plan requires management support as well as the following:

- Assessment of facilities to identify risks
- Allocation of resources
- Standards for new or retrofit construction
- Budget for operation and maintenance and capital investment
- System for tracking remedial actions and associated costs
- Timely implementation of remedial measures
- Positive working relationships with agencies

An APP should be reviewed annually in the context of risk assessment and modified as appropriate, ideally with wildlife agency input.

AVIAN ENHANCEMENT OPTIONS

In addition to reducing avian mortality risk, an APP also may include descriptions of opportunities for a utility to enhance avian populations or habitat. These opportunities may include installing nest platforms, managing habitats to benefit migratory birds, or working with agencies or organizations in these efforts. Where feasible, new ideas and methods for protecting migratory birds should be encouraged and explored.

There are also opportunities to collaborate with agencies or organizations and to educate the public about the company's APP and its partnerships. USFWS and state wildlife agencies, as well as other experts, can be consulted for recommendations on habitat enhancement projects. Nest box construction, maintenance, and monitoring can be done in conjunction with volunteers, such as Boy Scouts, Girl Scouts, and avian/wildlife conservation organizations.



© JERRY LIGUORI

FIGURE 7.2: An Avian Protection Plan may include opportunities to enhance avian populations or habitat with nesting structures, habitat restoration, or other projects.

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 the following:

- Effectiveness of remedial actions in reducing avian mortality
- Effectiveness of avian protection devices as well as their 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 and timely actions are taken
- Compliance with company policy to ensure that personnel are consistently following company procedures for avian-safe construction, mortality reporting, nest management, training, etc.
- Public and agency feedback and opinions on system reliability and avian protection

The quality control component of an APP is a continuous process that is used to ensure that a company's APP is accomplishing what

it is intended to do. 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.



© PACIFIC GAS AND ELECTRIC COMPANY

FIGURE 7.3: Raising public awareness about avian collisions and the utility's commitment to avian protection can increase support for an Avian Protection Plan.

PUBLIC AWARENESS

An APP may include a method for educating the public about avian collision issues, the company's avian protection program, and its successes in avian protection. A public awareness program can be an integral part of an APP and can be used to enhance public awareness and support for a company's APP. Public participation 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 (see Chapter 5). 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.

Communicating an APP can be accomplished through a variety of public outreach tools, including fact sheets, newsletters, brochures, videos, websites, public workshops, short courses, special training sessions, and speaker bureau presentations. These tools can also be used to record the success 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 environmental stewards working cooperatively with wildlife agencies towards reducing avian mortalities while continuing to provide safe, reliable, and 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. For more information, see *Public Participation* in Chapter 5.

KEY RESOURCES

An APP should identify the key resources that address avian protection issues. Key resources include utility personnel and external contacts. This would include a list of experts who may be called upon to help resolve avian-caused problems. Experts could include company specialists, consultants, state and federal resource agents, university faculty, or other biologists. Internal personnel may include representatives from environmental, engineering, operations and maintenance, standards, procurement, outage management, etc. Engineers may find that company personnel such as environmental specialists (or biologists) can help find creative solutions to avian interaction problems. An understanding of avian behavior can also 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.

Members of organizations like APLIC can help with workshops, materials, and contacts. External resources may include biologists and law enforcement agents from wildlife agencies, avian specialists from NGOs or universities, wildlife rehabilitators, and industry consultants. Utility industry resources include APLIC, EEI, Electric Power Research Institute, Institute of Electrical and Electronics Engineers, National Rural Electric Cooperative Association, and the Rural Utilities Service. Contact information and websites for a number of resources are available in the *Guidelines* (see www.aplic.org).

CREATING AND 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 the avian-related science, engineering, and laws. It will also need to satisfy utility employees, utility customers, investors, and other stakeholders.

The ease of creating and implementing an APP will depend on a utility's size, the location of its 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.

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

Creating and implementing an APP will be more successful if all the affected departments 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, operations 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



© USFWS

FIGURE 7.4: Integrating an Avian Protection Plan into an electric utility's operations will help the utility meet demands for reliable, cost-efficient, and environmentally compatible power delivery while protecting and enhancing bird populations.

best fit the operations of each department. Solutions to reduce 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 a 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 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 departments to reduce actual and potential avian/power line conflicts. As with any project, better planning yields better results. The goals of an APP are a measurable decrease in avian/power line injuries and mortalities and an increase in electric service reliability—ultimately benefiting the birds, the utility, its customers, the regulators, and the affected public.



APPENDIX A

Literature Cited and Bibliography

*Abdunazarov, B. B. 1987. Prevention of death of birds at power supply lines in Uzbekistan. Information message No. 411. Tashkent, Fan. Page 11.

*Alonso, J. C., J. A. Alonso, and R. Munoz-Pulido. 1994. Mitigation of bird collisions with transmission lines through groundwire marking. Biol. Conserv. 67:129–134.

*Alonso, J. A., and J. C. Alonso. 1999. Mitigation of bird collisions with transmission lines through groundwire marking. Chapter 5 *in* M. Ferrer and G. F. E. Janns (eds.), Birds and Power Lines. Quercus: Madrid.

*____, and C. A. Martin. 2005. The great bustard (*Otis tarda*) in Andalusia, southern Spain: status, distribution, and trends. Ardeola 52(1):67–78

Anderson, B. A., and S. M. Murphy. 1988. Lisburne terrestrial monitoring program—1986 and 1987. The effects of the Lisburne power line on birds. Final Report. Prepared by Alaska Biological Research, Inc. for ARCO Alaska, Inc., Anchorage, AK 99510. 60 pp.

*Anderson, M. D. 2001. The effectiveness of two different marking devices to reduce large terrestrial bird collisions with overhead electricity cables in the eastern Karoo, South Africa. Draft Report to Eskom Resources and Strategy Division, Johannesburg, South Africa.

Anderson, S. H., K. Mann, and H. H. Shugart, Jr. 1977. The effect of transmission-line corridors on bird populations. Am. Midl. Nat. 97:216–221.

*Anderson, W. L. 1978. Waterfowl collisions with power lines at a coal-fired power plant. Wildlife Soc. B. 6:77–83.

____, and S. S. Hurley. 1974. Waterfowl studies at Lake Sangchris: an in-progress report. Illinois Natural History Survey, Urbana.

____, ____, and J. W. Seets. 1975. Section 8 waterfowl studies at Lake Sangchris. Illinois Natural History Survey, Urbana.

* Indicates references that have been cited in the text.

*Archibald, K. 1987. The conservation status of the breeding ground of the red-crowned crane in Hokkaido, Japan. Pages 64–86 *in* G. Archibald and R. Pasquier (eds.), Proc. International Crane Workshop, Bharatpur, India, 1983. Intl. Crane Foundation, Baraboo, WI.

Arnett, E. B. 2006. A preliminary evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Soc. B. 34:1440–1445.

Avatar Environmental, LLC, EDM International, Inc., and Pandion Systems, Inc. 2004. Notice of inquiry comment review avian/communication tower collisions, final. Prepared for the Federal Communications Commission. 223 pp.

*Avery, M. L. (ed.). 1978. Impacts of transmission lines on birds in flight: Proceedings of a workshop. U.S. Fish and Wildlife Service, Biological Services Program, FWS/OBS-78/48. 151 pp.

_____, and T. Clement. 1972. Bird mortality at four towers in eastern North Dakota: fall 1972. The Prairie Naturalist 4:87–95.

_____, P. F. Springer, and J. F. Cassell. 1975. Progress report on bird losses at the Omega Tower, southeastern North Dakota. Proc. North Dakota Academy of Science, Part II 27:40–49.

*_____, _____, and _____. 1977. Weather influences on nocturnal bird mortality at a North Dakota tower. Wilson Bull. 89:291–299.

*_____, _____, and N. S. Dailey. 1980. Avian mortality at man-made structures: an annotated bibliography (revised). U.S. Fish and Wildlife Service, Biological Services Program, National Power Plant Team. FWS/OBS-80/54, 152 pp.

*Avian Power Line Interaction Committee (APLIC). 1994. Mitigating bird collisions with power lines: the state of the art in 1994. Edison Electric Institute, Washington, D.C. 78 pp.

*_____. 2006. Suggested practices for avian protection on power lines: the state of the art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission, Washington, D.C., and Sacramento, CA.

*_____. 2007. Causes of avian collisions with power lines and methods for collision reduction. *In* APLIC Avian Protection Short Course/Workshop, Collisions Section.

_____ . 2008. Avian interactions with power lines: an overview of avian protection plan guidelines, laws, and techniques for the protection of avian species. Two-hour short course.

*_____ and U.S. Fish and Wildlife Service (USFWS). 2005. Avian protection plan (APP) guidelines. Washington, D.C. 88 pp.

Bahat, O. 2008. Wintering black storks (*Ciconia nigra*) cause severe damage to transmission lines in Israel: a study on the risk and mitigation possibilities. *In* Proc. of the EDM and EPRI Internatl. Conf. on Overhead Lines. 31 March–3 April 2008. Fort Collins, CO.

Baines, D., and R. W. Summers. 1997. Assessment of bird collisions with deer fences in Scottish forests. J. Appl. Ecol. 34:941–948.

*Banko, W. E. 1956. The trumpeter swan: its history, habits, and population in the United States. N. Amer. Fauna 63:325–326.

*Barrett, G. C., and D. V. Weseloh. 2008. Bird mortality near high voltage transmission lines in Burlington and Hamilton, Ontario, Canada. Pages 421–428 *in* J. W. Goodrich-Mahoney, L. P. Abrahamson, J. L. Ballard, and S. M. Tikalsky (eds.), Proc. of the Eighth International Symposium on Environmental Concerns in Rights-of-Way Management. 12–16 September 2004, Saratoga Springs, NY. Elsevier, Amsterdam, The Netherlands.

*Barrientos, R., J. C. Alonso, C. Ponce, and C. Palacín. 2011. Meta-analysis of the effectiveness of marked wire in reducing avian collisions with power lines. Conserv. Biol. 25:893–903

*____, C. Ponce, C. Palacín, C. A. Martín, B. Martín, and J. C. Alonso. 2012. Wire marking results in a small but significant reduction in avian mortality at power lines: A BACI designed study. PLoS ONE 7(3): e32569.

Bart, J., K. P. Burnham, E. H. Dunn, C. M. Francis, and C. J. Ralph. 2004. Goals and strategies for estimating trends in landbird abundance. J. Wildlife Manage. 68:611–626.

Bayle 1999. Preventing birds of prey problems at transmission lines in Western Europe. J. Raptor Res. 33:43–48.

Beason, R. C. 2003. Through a bird's eye: exploring avian sensory perception. USDA Wildlife Services, National Wildlife Research Center, Sandusky, Ohio, Special Scientific Report.

*Beaulaurier, D. L. 1981. Mitigation of bird collisions with transmission lines. Bonneville Power Admin., U.S. Department of Energy, Portland, OR. 82 pp.

*Beer, K. V., and M. A. Ogilvie. 1972. Mortality. Pages 125–142 *in* Peter Scott and the Wildfowl Trust, the swans, Houghton Mifflin Co., Boston.

*Bennett, A. T. D., and M. Thery. 2007. Avian color vision and coloration: multidisciplinary evolutionary biology. Am. Nat. 169: S1–S6.

Berger, R. P. 1995. Fur, feathers, and transmission lines: how rights of ways affect wildlife. Second edition. Manitoba Hydro. www.hydro.mb.ca/environment

*Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. Ibis 136:412–425.

*____. 1995. Estimates and population consequences of tetraonid mortality caused by collisions with high tension power lines in Norway. J. Appl. Ecol. 32:745–753.

*____. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. Biol. Conserv. 86:67–76.

*____. 1999. Estimating bird mortality caused by collision and electrocution with power lines: a review of methodology. Pages 29–56 *in* M. Ferrer and G. F. E. Janss (eds.), Birds and Power Lines: Collision, Electrocution, and Breeding, Quercus, Madrid, Spain.

____, and H. Broseth. 2001. Bird collisions with power lines: an experiment with ptarmigan (*Lagopus* spp.). Biol. Conserv. 99:341–346.

*____, and ____. 2004. Impact of power lines on bird mortality in a subalpine area. Animal Biodiversity and Cons. 27:67–77.

BioResource Consultants. 2009. Identifying electric distribution poles for priority retrofitting to reduce bird mortality. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-08-055.

*BirdLife International. 2003. Protecting birds from power lines: a practical guide on the risks to birds from electricity transmission facilities and how to minimise any such adverse effects. 31 pp.

*____. 2007. Position statement on birds and power lines on the risks to birds from electricity transmission facilities and how to minimise any such adverse effects. 12 pp.

Birkhead, M. E., and C. Perrins. 1986. The Mute Swan. Croom-Helm, London.

Bishop, J. A., and W. L. Myers. 2004. Associations between avian functional guild response and regional landscape properties for conservation planning. Ecol. Indic. 5:33–48.

*Black, B. B., and M. W. Collopy. 1982. Nocturnal activity of Great Blue Herons in a north Florida salt marsh. J. Field Ornithol. 53:403–406.

Blackwell, B. F., and G. E. Bernhardt. 2004. Efficacy of aircraft landing lights in stimulating avoidance behavior in birds. J. Wildlife Manage. 68:725–732.

____, E. Fernandez-Juricic, T. W. Seamans, and T. Dolan. 2009. Avian visual system configuration and behavioural response to object approach. Anim. Behav. 77:673–684.

*Blair, R. B. 1996. Land use and avian species diversity along an urban gradient. Ecol. Appl. 6:506–519.

Blokpoel, H. 1971. A preliminary study on height and density of nocturnal fall migration. Canadian Wildlife Service Report Series, Number 14:95–104.

*____, and P. R. M. Hatch. 1976. Snow geese, disturbed by aircraft, crash into power lines. Can. Field Nat. 90:195.

Boren, J. C., D. M. Engle, M. W. Palmer, R. E. Masters, and T. Criner. 1999. Land use change effects on breeding bird community composition. J. Range Manage. 52:420–430.

Bourne, W. R. P. 1976. Petrels and lights at night. Notornis 23:201–202.

*Boyd, H. 1961. Reported casualties to ringed ducks in the spring and summer. Wildfowl Trust Ann. Rep. 12:144–146.

Bridges, J. M., and T. R. Anderson. 2002. Mitigating the impacts of electric facilities to birds. *In* J. W. Goodrich-Mahoney, D. Mutrie, and C. Guild (eds.), Proc. of the Seventh International Symposium Environmental Concerns in Rights-of-Way Management. 9–13 September 2000, Calgary, Alberta, Canada. Elsevier, Oxford, UK.

____, and R. Lopez. 1995. Reducing large bird electrocutions on a 12.5 kV distribution line originally designed to minimize electrocutions. Pages 263–265 *in* G. J. Doucet, C. Séguin, and M. Giguère (eds.), Proc. of the Fifth International Symposium on Environmental Concerns in Rights-of-Way Management. 19–22 September 1993, Montreal, Canada. Hydro-Quebec, Montreal, Canada.

____, and D. McConnon. 1981. Use of raptor nesting platforms in a central North Dakota high voltage transmission line. Pages 46–49 *in* W. R. Byrnes and H. A. Holt (eds.), Proc. of the Fourth Symposium on Environmental Concerns in Rights-of-Way Management. 25–28 October 1987, Indianapolis, IN. Purdue University, West Lafayette, IN.

*____, T. R. Anderson, D. Shulund, L. Spiegel, and T. Chervick. 2008. Minimizing bird collisions: what works for the birds and what works for the utility? Pages 331–335 *in* J. W. Goodrich-Mahoney, L. P. Abrahamson, J. L. Ballard, and S. M. Tikalsky (eds.), Proc. of the Eighth International Symposium on Environmental Concerns in Rights-of-Way Management. 12–16 September 2004, Saratoga Springs, NY. Elsevier, Amsterdam, The Netherlands.

Brittain, C. C., and P. Jelen. 2006. Bird on a wire: an elevated state. Arizona Public Service. Unpubl. rep. Prescott, AZ. 6 pp.

*Brown, W. M. 1993. Avian collisions with utility structures: biological perspectives. *In* Proc. of the Intl. Workshop on Avian Interactions with Utility Structures, 13–16 September 1992, Miami, Florida. Electric Power Research Institute and Avian Power Line Interaction Committee, Palo Alto, CA.

*____, and R. C. Drewien. 1995. Evaluation of two power line markers to reduce crane and waterfowl collision mortality. Wildlife Soc. B. 23:217–227.

*____, ____, and D. L. Walker. 1984. Crane flight behavior and mortality associated with power liners in the San Luis Valley, Colorado. Forest, Wildlife and Range Experiment Station, University of Idaho, Moscow, ID. 16 pp.

*____, ____, ____, and E. G. Bizeau. 1987. Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. Pages 128–136 *in* J. C. Lewis (ed.), Proc. 1985 Crane Workshop. Platte River Whooping Crane Maintenance Trust, Grand Island, NE.

Brunetti, O. A. 1965. Supplementary report. Cause of death of the Pinehurst condor. California Dept. Fish and Game, Unpubl. rep.

*Bumby, S., K. Druzhinina, R. Feraldi, and D. Werthmann. 2009. Life cycle assessment (LCA) of overhead versus underground primary power distribution systems in Southern California. Donald Bren School of Environmental Science and Management, University of California, Santa Barbara, CA. 125 pp.

Buffington, J. P. 1976. A synthetic definition of biological significance. Pages 319–327 *in* Proc. of the Workshop on the Biological Significance of Environmental Impacts. U.S. Nuclear Reg. Comm., Washington, D.C.

Burnham, J., R. Carlton, E. A. Cherney, G. Couret, K. T. Eldridge, M. Farzaneh, S. D. Frazier, R. S. Gorur, R. Harness, D. Shaffner, S. Siegel, and J. Varner. 2004. Preventive measures to reduce bird-related power outages—part I: electrocution and collision. IEEE Transactions on Power Delivery 19:1843–1847.

Byrne, S. 1999. Avian Power Line Interaction Committee, consultant report. California Energy Commission, PIER Energy-Related Environmental Research. Contract no. 500-97-010, project no. 06, San Francisco, CA.

____. 2000. Bird strike monitor, consultant report. California Energy Commission, PIER Energy-Related Environmental Research. Contract no. 500-97-010, project no. 05, San Ramona, CA.

*California Energy Commission (CEC). 2005. Guide to raptor remains. www.energy.ca.gov

*____. 2011. On-line annotated bibliography of avian interactions with utility structures. www.energy.ca.gov/research/environmental/avian_bibliography

*California Wind Energy Association (CalWEA). 2011. Improving methods for estimating fatality of birds and bats at wind energy facilities in California. Public Interest Energy Research Program, Environmental Area, Contract Number: PIR-08-028.

Casado, E., J. Balbontin, and M. Ferrer. 2002. Plasma chemistry in booted eagle (*Hieraaetus pennatus*) during breeding season. Comp. Biochem. Physiol., Part A: Molecular and Integrative Physiol. 131:233–241.

*Catron, J., R. Rodríguez-Estrella, R. C. Rogers, L. B. Rivera, and B. Granados. 2004. Raptor and raven electrocutions in northwestern Mexico: A preliminary regional assessment of the impact of concrete power poles. Report prepared for the Avian Power Line Interaction Committee.

*Chace, J. F., and J. J. Walsh. 2006. Urban effects on native avifauna: a review. Landscape Urban. Plan. 74:46–69. Elsevier Science, Amsterdam, The Netherlands.

Chalfoun, A. D., M. J. Ratnaswamy, and F. R. Thompson, III. 2002. Songbird nest predators in forest-pasture edge and forest interior in a fragmented landscape. Ecol. Appl. 12:858–867.

Clarke, T. L. 2004. An autonomous bird deterrent system. Unpubl. dissertation. University of Southern Queensland, Australia. 110 pp.

Cochran, W. W., and R. R. Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bull. 70:378–380.

Cohen, D. A. 1896. California department. Osprey 1:14–15.

*Colorado Public Utility Commission. 1982 [January 21]. Decision No. R82-93. Public Service Company of Colorado, Clark-Jordan Road 230-kV Cable Project.

*Colson, E. W., and E. H. Yeoman. 1978. Routing transmission lines through water bird habitat in California. Pages 87–90 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. FWS/OBS 778/48. U.S. Fish and Wildlife Service, Washington, D.C.

*Committee on the Status of the Endangered Wildlife in Canada (COSEWIC). 2009. About COSEWIC. www.cosewic.gc.ca/eng/sct6/sct6_3_e.cfm#hist

*Cooper, B. 2004. Radar studies of nocturnal migration at wind sites in the eastern U.S. *In* Proc. of the Wind Energy and Birds/Bats Workshop: Understanding and Resolving Bird And Bat Impacts. RESOLVE, Inc. Washington, D.C. 66–71pp.

Cooper, B. A., and R. H. Day. 1992. Interaction of Newell's shearwaters and dark-rumped petrels with utility structures on Kauai, Hawaii: Results of pilot study, all 1992. Prepared for the Electric Power Research Institute, Palo Alto, CA. 51 pp.

*____, and ____. 1998. Summer behavior and mortality of dark-rumped petrels and Newell's shearwater at power lines on Kauai. Col. Waterbird 21:11–19.

____, ____, R. H. Ritchie, and C. L. Cranor. 1991. An improved marine radar system for studies of bird migration. J. Field Ornithol. 62:367–377.

Cornwell, G., and H. A. Hochbaum. 1971. Collisions with wires: a source of anatid mortality. Wilson Bull. 83:305–306.

*Coues, E. 1876. The destruction of birds by telegraph wire. Am. Nat. 10:734–736.

*Convention on Migratory Species (CMS). 2011a. Review of the conflict between migratory birds and electricity power grids in the African-Eurasian region. Prepared for the UNEP African-Eurasian Waterbirds Agreement and CMS. Prepared by Bureau Waardenburg, Boere Conservation Consultancy, STRIX Ambiente e Inovação, and Endangered Wildlife Trust—Wildlife & Energy Program.

*____. 2011b. Guidelines for mitigating conflict between migratory birds and electricity power grids. First draft for consultation with the AEWA Technical Committee and the CMS Scientific Council. Prepared by Bureau Waardenburg, Endangered Wildlife Trust—Wildlife & Energy Program, Boere Conservation Consultancy, and STRIX Ambiente e Inovação.

Cousquer, G. 2005. Ophthalmological findings in free-living tawny owls (*Strix aluco*) examined at a wildlife veterinary hospital. Vet. Rec. 156:734–739.

*Curtis, C. 1997. Birds and transmission lines. Blue Jay 55:43–47.

*Crawford, R. L., and R. T. Engstrom. 2001. Characteristics of avian mortality at a north Florida television tower: a 29-year study. J. Field Ornithol. 72(3):380–388.

Critchlow, R., K. Collins, R. Sharp, and D. Bradley. 2008. Use of methyl anthranilate fog to haze nuisance birds at high-voltage electric substation. *In* Proc. of the EDM and EPRI Internatl. Conf. on Overhead Lines. 31 March–3 April 2008. Fort Collins, CO.

*Crivelli, A. J., H. Jerrentrup, and T. Mitchev. 1988 . Electric power lines: a cause of mortality in *Pelecanus crispus* Bruch, a world endangered species, in Porto-Lago, Greece. Col. Waterbird 11:301–305.

*Crowder, M. R. 2000. Assessment of devices designed to lower the incidence of avian power line strikes. Master's Thesis, Purdue University.

*____, and O. E. Rhodes, Jr. 2002. Relationships between wing morphology and behavioral responses to unmarked power transmission lines. *In* J. W. Goodrich-Mahoney, D. Mutrie, and C. Guild (eds.), Proc. of the Seventh International Symposium Environmental Concerns in Rights-of-Way Management. 9–13 September 2000, Calgary, Alberta, Canada. Elsevier, Oxford, UK.

*Day, R. H., B. A. Cooper, and T. C. Telfer. 2003. Decline of Townsend's (Newell's) shearwaters (*Puffinus auricularis newelli*) on Kauai, Hawaii. Auk 120:669–679.

De La Zerda, S., and L. Rosselli. 2002. Mitigating collision of birds against transmission lines in wetland areas in Colombia, by marking the ground wire with bird flight diverters (BFD). *In* J. W. Goodrich-Mahoney, D. Mutrie, and C. Guild (eds.), Proc. of the Seventh International Symposium Environmental Concerns in Rights-of-Way Management. 9–13 September 2000, Calgary, Alberta, Canada. Elsevier, Oxford, UK.

*____, and ____. 2003. Mitigación de colisión de aves contra líneas de transmisión eléctrica con marcaje del cable de guarda [Mitigation of collisions of birds with high-tension electric power lines by marking the ground wire]. Ornitología Colombiana 1:42–62.

DeLong, J. P., S. W. Cox, and N. S. Cox. 2005. A comparison of avian use of high- and low-elevation sites during autumn migration in central New Mexico. J. Field Ornithol. 76:326–333.

De Lucas, M., G. F. E. Janss, D. P. Whitfield, and M. Ferrer. 2008. Collision fatality of raptors in wind farms does not depend on raptor abundance. J. Appl. Ecol. 45:1695–1703.

*Deng, J., and P. Frederick. 2001. Nocturnal flight behavior of waterbirds in close proximity to a transmission power line in the Florida Everglades. Waterbirds 24:419–424.

Dieni, J. S., and S. L. Jones. 2002. A field test of the area search method for measuring breeding bird populations. J. Field Ornithol. 73:253–257.

Dillingham, P. W., and D. Fletcher. 2008. Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relationships. Biol. Conserv. 141:1783–1792.

*Dodd, S. L., and M. A. Colwell. 1998. Environmental correlates of diurnal and nocturnal foraging patterns of nonbreeding shorebirds. Wilson Bull. 110(2):182–189.

*Dorin, M., and L. Spiegel. 2005. Assessment of avian mortality from collisions and electrocutions. California Energy Commission, Sacramento, CA. Technical Report CEC-700-2005-015.

*Drewitt, A. L., and R. H. W. Langston. 2008. Collision effects of wind-power generators and other obstacles on birds. Annals NY Acad. Sci. 1134:233–266.

Dunn, E. H. 1993. Bird mortality from striking residential windows in winter. J. Field Ornithol. 64:302–309.

Dwyer, J. F. 2004. Investigating and mitigating raptor electrocutions in an urban environment. M.S. Thesis, Univ. of Arizona. 71 pp.

*____, and R. W. Mannan. 2007. Preventing raptor electrocutions in an urban environment. J. Raptor Res. 41:259–267.

E. Oppenheimer & Son and BirdLife. 2010. Bustard beat, no. 1. South Africa. 21 pp.

Eastwood, E. 1967. Radar ornithology. Methuen & Co. Ltd., London. 287 pp.

*Edison Electric Institute. 2001. Introduction to public participation, revised third edition. Prepared by James L. Creighton, Creighton & Creighton, Inc. www2.eei.org/products_and_services/descriptions_and_access/intro_pub_partic.htm

*____. 2010. Statistical yearbook of the electric utility industry. Edison Electric Institute. Available from: http://www.eei.org

*EDM International, Inc. (EDM). 2004. Corona testing devices used to mitigate bird collisions. California Energy Commission, PIER Energy-Related Environmental Research. Technical Report 500-04-086F.

Electric Power Research Institute (EPRI). 1993. Proceedings: avian interactions with utility structures. International Workshop, 13–16 September 1992. EPRI Technical Report TR-103268.

*____. 2001. Avian interactions with utility and communication structures workshop proceedings. 2–3 December 1999. Charleston, SC. EPRI Technical Report No. 1006907. R. Carlton, Project Manager.

*____. 2003. Bird strike indicator/bird activity monitor and field assessment of avian fatalities. EPRI, Palo Alto, CA; Audubon National Wildlife Refuge, Coleharbor, ND; Edison Electric Institute, Washington, D.C.; Bonneville Power Administration, Portland, OR; California Energy Commission, Sacramento CA; NorthWestern Energy, Butte, MT; Otter Tail Power Company, Fergus Falls, MN; Southern California Edison, Rosemead, CA; Western Area Power Administration, Lakewood, CO.

*____. 2006. EPRI-GTC overhead electric transmission line siting methodology. EPRI, Palo Alto, CA, and Georgia Transmission Corporation, Tucker, GA. 1013080.

____. 2010. 2010 Research portfolio. Rights-of-way: siting, vegetation management, and avian issues, program 57. http://portfolio.epri.com/ProgramTab.aspx?sId=ENV&rId=134&pId=5117

Electrical World. July 1986. Boost visibility of OH conductors. 44 pp.

*Emerson, W. O. 1904. Destruction of birds by wires. Condor 6:37–38.

Endler, J. A., and M. Thery. 1996. Interacting effects of Lek placement, display behavior, ambient light, and color patterns in three neotropical forest-dwelling birds. Am. Nat. 148:421–452.

*Endangered Wildlife Trust (EWT). 2011. Wildlife & Energy Programme (WEP). www.ewt.org.za/WHATWEDO/OurProgrammes/WildlifeEnergyProgramme.aspx

*Erickson, W. P., G. D. Johnson, M. D. Strickland, D. P. Young Jr., K. J. Sernka, and R. E. Good. 2001. Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of avian collision mortality in the United States. National Wind Coordinating Committee, RESOLVE, Inc., Washington, D.C.

*____, ____, and D. P. Young, Jr. 2005. A summary and comparison of bird mortality from anthropogenic causes with an emphasis on collisions. USDA USFS Gen. Tech. Rep. PSW-GTR-191.

*Erwin, R. M. 1977. Foraging and breeding adaptations to different food regimes in three seabirds: the common tern (*Sterna hirundo*), royal tern (*Sterna maxima*), and black skimmer (*Rynchops niger*). Anim. Behav. 27:1054–1062.

*Eskom. 2003. The management of wildlife interactions with overhead power lines. African Centre for Energy and Environment (ACEE). Johannesburg, South Africa. 72 pp.

Eskom Transmission. 2005. Transmission bird collision guidelines. Johannesburg, South Africa. 21 pp.

____. 2008. Specifications for bird flight diverter installation on a transmission line. Johannesburg, South Africa. 1 p.

*____. 2009. Transmission bird collision prevention guidelines. Johannesburg, South Africa. 10 pp.

Evans, W. R., Y. Akashi, N. S. Altman, and A. M. Manville, II. 2007. Response of night-migrating birds in clouds to colored and flashing light. North American Birds 60:476–488.

Faanes, C. A. 1983. Assessment of power line siting in relation to bird strikes in the northern Great Plains. U.S. Fish and Wildlife Service, Jamestown, ND. 105 pp.

*____. 1987. Bird behavior and mortality in relation to power lines in prairie habitats. U.S. Fish and Wildlife Service. Serv. Gen. Tech. Rep. 7. 24 pp.

Finger, E., and D. Burkhardt. 1994. Biological aspects of bird colouration and avian colour vision including ultraviolet range. Vision Res. 34:1509–1514.

*Frost, D. 2008. The use of 'flight diverters' reduces mute swan (*Cygnus color*) collision with power lines at Abberton Reservoir, Essex, England. Conservation Evidence 5:83–91.

*García-Montijano, M., A. M. Tébar, B. Barreiro, P. Rodríguez, J. C. Alonso, C. Martín, M. Magaña, C. Palacín, J. Alonso, A. Montesinos, and I. Luaces. 2002. Postmortem findings in wild great bustards (*Otis tarda*) from Spain: a clinical approach. European Association of Zoo and Wildlife Veterinarians (EAZWV) 4th scientific meeting, joint with the annual meeting of the European Wildlife Disease Association (EWDA). May 8–12, 2002, Heidelberg, Germany.

Gauthreaux, S. A., Jr. 1970. Weather radar quantification of bird migration. BioScience 20:17–20.

_____. 1972. Behavioral responses of migrating birds to daylight and darkness: a radar and direct visual study. Wilson Bull. 84:136–148.

*_____. 1978a. Migratory behavior and flight patterns. Pages 23–50 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. FWS/OBS-78/48. U.S. Fish and Wildlife Service, Washington, D.C.

_____. 1978b. The impact of transmission lines on migratory birds: assessment of completed, ongoing, and planned research and an analysis of future research needs. Consultant's Report. Prepared for the Electric Power Research Institute, Palo Alto, CA. 43 pp.

_____. 1980. Direct visual and radar methods for the detection, quantification, and prediction of bird migration. Special Publication No. 2, Department of Zoology, Clemson University, Clemson, SC. 67 pp.

_____. 1981. Avian interactions with transmission lines: radar and direct visual methods of study, phase I. Final Technical Report. Electric Power Research Institute, Palo Alto, CA. 42 pp.

_____. 1984. The use of small mobile radars to detect, monitor, and quantify bird movement. Pages 121–131 *in* M. J. Harrison, S. A. Gauthreaux, and L. A. Abron-Robinson (eds.), Proc. of the Wildlife Hazards to Aircraft Conference and Training Workshop, Charleston, SC. Federal Aviation Administration. DOT/FAA/AAS/84-1.

_____. 1985. Radar, electro-optical, and visual methods of studying bird flight near transmission lines. Electric Power Research Institute. EPRI EA-4120. 76 pp.

_____. 1988. The behavioral responses of migrating birds to aircraft strobe lights: attraction or repulsion? Final Technical Report. Headquarters, United States Air Force/Air Force Systems Command, Air Force Engineering and Services Center, Tyndall Air Force Base, FL 32403.

_____. 1991. Low altitude movements of birds through the corridor for the Isle of Palms 115 kV TAP. Prepared for The South Carolina Electric & Gas Company, Columbia, SC. 121 pp.

_____. 1995. Suggested practices for monitoring bird populations, movements and mortality in wind resource areas. *In* Proc. of the National Avian-Wind Power Planning Meeting, 20–21 July 1994. Lakewood, CO.

*_____, and C. G. Belser. 2003. Overview radar ornithology and biological conservation. Auk 120(2):266–277.

*Gehring, J., P. Kerlinger, and A. M. Manville, II. 2009. Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. Ecol. Appl. 19:505–514.

*_____, _____, and _____. 2011. The role of tower height and guy wires on avian collisions with communication towers. J. Wildlife Manage. 75(4):848–855.

Gilbert Commonwealth, Inc. 1985. A review of available bird collision information and description of submarine cable crossing impacts. Conducted for Central Power and Light Company. Jackson, MI. 16 pp.

*Gill, F. B. 1995. Ornithology. Second edition. W. H. Freeman and Company, New York.

Gill, J. A., W. J. Sutherland, and A. R. Watkinson. 1996. A method to quantify the effects of human disturbance on animal populations. J. Appl. Ecol. 33:786–792.

*Gill, J. P., M. Townsley, and G. P. Mudge. 1996. Review of the impacts of wind farms and other aerial structures upon birds. Scottish Natural Heritage Review No. 21. Scottish Natural Heritage, Edinburgh.

*Gombobaatar, S., R. Harness, and P. Amartuvshin. 2010. Raptor surveys of high power electric lines and avian protection plans in the Mongolian steppe. National University of Mongolia, Asia Research Center. Report 2009.04.01-2010.04.01.

Hager, S. B. 2009. Human-related threats to urban raptors. J. Raptor Res. 43:210–226.

Halverson, P. G., S. J. Syracuse, R. Clark, and F. M. Tesche 2008. Non-contact sensor system for real-time high-accuracy monitoring of overhead transmission lines. *In* Proc. of the EDM and EPRI Internatl. Conf. on Overhead Lines. 31 March–3 April 2008. Fort Collins, CO.

Hamer Environmental, L.P. 2008. Use of modified horizontal and vertical radar to investigate avian collision potential near proposed or existing overhead lines. Pages 137–141 *in* Proc. of the EDM and EPRI Internatl. Conf. on Overhead Lines. 31 March–3 April 2008. Fort Collins, CO.

Harden, J., 2002. An overview of anthropogenic causes of avian mortality. J. Wildlife Rehabil. 25:4–11.

*Harmata, A. R., K. M. Podruzy, J. R. Zelenak, and H. Gabler. 1997. Temporal and spatial profile of avian movement and mortality before and after installation of a 100 kV transmission line over the Missouri River. Montana Fish and Wildlife Program, Montana State University, Bozeman, MT. 42 pp.

*Harness, R., S. Milodragovich, and J. Schomburg. 2003. Raptors and power line collisions. Colorado Birds 37(3).

_____, S. Gombobaatar, and R. Yosef. 2008. Mongolia distribution power lines and raptor electrocutions. Institute of Electrical and Electronics Engineers 52:1–6.

Harrison, J. 1963. Heavy mortality of Mute Swan from electrocution. Wildfowl Trust Ann. Rep. 14:164–165.

*Hart, N., J. Partridge, and I. Cuthill. 1998. Visual pigments, oil droplets and cone photoreceptor distribution in the European starling (*Sturnus vulgaris*). J. Exp. Biol. 201:1433–1446.

*Hartman, P. A., S. Byrne, and M. F. Dedon. 1992. Bird mortality in relation to the Mare Island 115-kV transmission line: final report 1988–1991. Prepared for Department of the Navy, Western Division, San Bruno, CA 94066-2402. PG&E Report Number 443-91.3. 118 pp.

*Heck, N. 2007. A landscape-scale model to predict the risk of bird collisions with electric power transmission lines in Alberta. M.E. Des Thesis, University of Calgary, Calgary, Alberta Canada.

Heijinis, R. 1976. Vogels onderweg [Birds underway]. Ornithological mortality and environmental aspects of aboveground high tension lines. Koog aan de Zaan, Holland. 160 pp.

____. 1980. Vogeltod durch Drahtanflüge bei Hochspannungsleitungen [Bird death by wire approaches in high-voltage lines]. Ökol. Vögel 2:111–129.

*Henderson, I. G., R. H. W. Langston, and N. A. Clark. 1996. The response of common terns (*Sterna hirundo*) to power lines: an assessment of risk in relation to breeding commitment, age and wind speed. Biol. Conserv. 77:185–192.

Herbert, A. D. 1970. Spatial disorientation in birds. Wilson Bull. 82:400–419.

*Herren, H. 1969. The status of the peregrine falcon in Switzerland. Pages 231–238 *in* Peregrine Falcon Population: Their Biology and Decline. University of Wisconsin Press, Madison.

*Hiltunen, E. 1953. On electric and telephone wire incidents in birds. Suomen Riista 8: 70–76, 222–223.

*Homan, H. J., G. Linz, and B. D. Peer. 2001. Dogs increase recovery of passerine carcasses in dense vegetation. Wildlife Soc. B. 29:292–296.

Houston, C. S., and F. Scott. 2006. Entanglement threatens ospreys at Saskatchewan nest. J. Raptor Res. 40:226–228.

Howard, R. P., B. L. Keller, F. L. Rose, J. Connley, Jr., and J. Hupp. 1987. Impacts of the Tincup Loop transmission line on cranes in Caribou County, Idaho. Pages 140–144 *in* J. C. Lewis (ed.), Proc. 1985 Crane Workshop. Platte River Whooping Crane Maintenance Trust, Grand Island, NE.

Hugie, R. D., J. M. Bridges, B. S. Chanson, and M. Skougard. 1992. Results of a post-construction bird monitoring study on the Great Falls-Conrad 230-kV transmission line. Prepared by BIO/WEST, Inc., Logan, UT for Western Area Power Administration. 17 pp.

Hunt, F. R. 1975. Automatic radar equipment to determine bird strike probability, part I. Night-time passerine migration. National Research Council of Canada, Ottawa, Field Note No. 69, p. 24.

*Hunting, K. 2002. A roadmap for PIER research on avian collisions with power lines in California. California Energy Commission, PIER Energy-Related Environmental Research. Technical Report P500–02–071F.

*Hurst, N. 2004. Corona testing of devices used to mitigate bird collisions. EDM International, Inc. California Energy Commission, PIER Energy-Related Environmental Research. 500-04-086F.

*Huso, M. P. 2011. An estimator of wildlife fatality from observed carcasses. Environmetrics 22:318–329.

Hylton, R. A., P. C. Frederick, T. E. De La Fuente, and M. G. Spalding. 2006. Effects of nestling health on postfledging survival of wood storks. Condor 108:97–106.

Igl, L. D., and D. H. Johnson. 1985. Migratory bird population changes in North Dakota. *In* E. T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac (eds.), Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Imber, M. J. 1975. Behavior of petrels in relation to the moon and artificial lights. Notornis 22:302–306.

Inouye, D. W., B. Barr, K. B. Armitage, and B. D. Inouye. 2000. Climate change is affecting altitudinal migrants and hibernating species. Proc. of National Academy of Sciences 97:1630–1633.

*James, B. W., and B. A. Haak. 1979. Factors affecting avian flight behavior and collision mortality at transmission lines. Bonneville Power Administration, U.S. Department of Energy, Portland, OR. 109 pp.

*_____, and _____. 1980. Impact of the Ashe-Slatt 500-kV transmission line on birds at Crow Butte Island: pre-construction study. Bonneville Power Administration, U.S. Department of Energy, Portland, OR. 98 pp.

*Janss, G. F. E. 2000. Avian mortality from power lines: a morphologic approach of a species-specific mortality. Biol. Conserv. 95:353–359.

*_____, and M. Ferrer. 1998. Rate of bird collision with power lines: effects of conductor-marking and static wire-marking. J. Field Ornithol. 69:8–17.

*_____, and _____. 2000. Common crane and great bustard collision with power lines: collision rate and risk exposure. Wildlife. Soc. B. 28:675–680.

_____, A. Lazo, and M. Ferrer. 1999. Use of raptor models to reduce avian collisions with power lines. J. Raptor Res. 33:154–159.

*Jenkins, A. R., J. J. Smallie, and M. Diamond. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conserv. Int. 20:263–278.

*Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, D. A. Shepherd, and S. A. Sarappo. 2002. Collision mortality of local and migrant birds at a large-scale wind-power development on Buffalo Ridge, Minnesota. Wildlife Soc. B. 30:879–887.

Jones, J., and C. M. Francis. 2003. The effects of light characteristics on avian mortality at lighthouses. J. Avian Biol. 34:328–333.

*Jones, M. P., K. E. Pierce, Jr., and D. Ward. 2007. Avian vision: a review of form and function with special consideration to birds of prey. J. Exot. Pet Med. 2:69–87.

Kabouche, B., J. Bayeul, L. Zimmermann, and P. Bayle. 2006. La mortalité des oiseaux sur le réseau électrique aérien: enjeux et perspectives en Provence-Alpes-Côte d'Azur [The mortality of birds on aerial power lines: challenges and prospects in Provence-Alpes-Cote d'Azur]. Rapport DIREN PACA - LPO PACA, Hyères. 109 pp.

*Kelly, A., and S. Kelly. 2005. Are mute swans with elevated blood lead levels more likely to collide with overhead power lines? Waterbirds 28:331–334.

*Kerlinger, P. 2003. Addendum to the phase I avian risk assessment for the Flat Rock Wind Power Project, Lewis County, New York: phase one and phase two. Prepared for Atlantic Renewable Energy Corporation, William Moore, Project Manager. Prepared by Curry & Kerlinger, LLC, Cape May, NJ.

*Kessler, A. 2007. Great bustard in Central Asia: Tsengel died due to collision with power line. www.public.asu.edu/~aekessle

Kjaersgaard, A., C. Pertoldi, V. Loeschcke, and D. W. Hansen. 2008. Tracking the gaze of birds. J. Avian Biol. 39:466–469.

Klem, D., Jr. 1990. Collisions between birds and windows: mortality and prevention. J. Field Ornithol. 61:120–128.

_____. 2009. Avian mortality at windows: the second largest human source of bird mortality on earth. Pages 244–251 *in* T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson (eds.), Tundra to tropics: connecting habitats and people. Proc. of the 4th International Partners in Flight Conference, 13–16 February 2008, McAllen, TX.

_____, D. C. Keck, K. L. Marty, A. J. Miller Ball, E. E. Niciu, and C. T. Platt. 2004. Effects of window angling, feeder placement, and scavengers on avian mortality at plate glass. Wilson Bull. 116:69–73.

_____, C. J. Farmer, N. Delacretaz, Y. Gelb, and P. G. Saenger. 2009. Architectural and landscape risk factors associated with bird-glass collisions in an urban environment. Wilson J. Ornithol. 121:126–134.

Klimentjew, D., N. Hendrich, J. Zhang. 2010. Multi sensor fusion of camera and 3D laser range finder for object recognition. *In* proceedings of Multisensor Fusion and Integration for Intelligent Systems, 2010 IEEE Conference. 5–7 September 2010, Salt Lake City, UT.

Koford, C. B. 1953. The California condor. Natl. Audubon Soc. Res. Rep. 4. 154 pp.

*Koops, F. B. J. 1979. Een miljoen draad-slachtoffers wat kunnen we ertegen doen? [One million bird collisions: what can we do to improve this situation?] De Lepelaar, No. 63:20-21.

*_____. 1987. Collision victims of high-tension lines in the Netherlands and effects of marking. KEMA Report 01282-MOB 86-3048.

*_____. 1993. Collision victims of high-tension lines in the Netherlands and effects of marking. Unpubl. rep., N. V. KEMA, Arnhem. 6 pp.

*_____, and J. de Jong. 1982. Vermindering van draadslachtoffers door markering van hoogspanningsleidingen in de omgeving van Heerenveen [Reducing the number of bird collisions by marking high-voltage lines in the Heerenveen area]. Overdruk uit: Elektrotechniek 60(12):641–646.

Korschgen, C. D., W. L. Green, W. L. Flock, and E. A. Hibbard. 1984. Use of radar with a stationary antenna to estimate birds in a low-level flight corridor. J. Field Ornithol. 55:369–375.

*Kostecke, R. M., G. M. Linz, and W. J. Bleier. 2001. Survival of avian carcasses and photographic evidence of predators and scavengers. J. Field Ornithol. 72:439–447.

*Krapu, G. L. 1974. Avian mortality from collisions with overhead wires in North Dakota. The Prairie Naturalist 6:1–6.

Krochko, N. 2005. Bird collisions with electric power transmission lines: frequently asked questions (FAQs). AltaLink, Calgary, Alberta, Canada. 5 pp.

Kroodsma, R. L. 1978. Evaluation of a proposed transmission line's impact on waterfowl and eagles. Pages 69–76 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. FWS/OBS-78/48. U.S. Fish and Wildlife Service, Washington, D.C.

Krüger, O. 2002. Analysis of nest occupancy and nest reproduction in two sympatric raptors: common buzzard (*Buteo buteo*) and goshawk (*Accipiter gentilis*). Ecography 25:523–532.

_____, R. Liversidge, and J. Lindström. 2002. Statistical modeling of the population dynamics of a raptor community in a semi-desert environment. J. Anim. Ecol. 71:603–613.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Assessing impacts of wind energy development on nocturnally active birds and bats: a guidance document. J. Wildlife Manage. 71:2249–2486.

*Kuyt, E. 1992. Aerial radio-tracking of whooping cranes migrating between Wood Buffalo National Park and Aransas National Wildlife Refuge, 1981–84. Occasional Paper Number 74. Canadian Wildlife Service. Ottawa, Canada.

Larkin, R. P., and P. J. Sutherland. 1977. Migrating birds respond to project seafarer's electromagnetic field. Science 195:777–779.

*Lasch, U., S. Zerbe, and M. Lenk. 2010. Electrocution of raptors at power lines in Central Kazakhstan. Waldökologie, Landschaftsforschung, und Naturschutz 9 (2010) [Forest Ecology, Landscape Research, and Nature Conservation 9 (2010)] http://afsv.de/download/literatur/waldoekologie-online/waldoekologie-online_heft-9-2.pdf

Lawson, A. B., and M. J. Wyndham. 1993. A system of monitoring wildlife interactions with electricity distribution installations in a supply region of the Cape Province in Southern Africa. *In* Proc. of the Avian Interactions with Utility Structures International Workshop, 13–16 September 1992. Electric Power Research Institute and the Avian Power line Interaction Committee. EPRI Technical Report TR-103268.

Ledger, J. A., J. C. A. Hobbs, and T. V. Smith. 1993. Avian interactions with utility structures: southern African experiences. *In* Proc. of the Avian Interactions with Utility Structures International Workshop, 13–16 September 1992. Electric Power Research Institute and the Avian Power line Interaction Committee. EPRI Technical Report TR-103268.

*Lee, J. M., Jr. 1978. A summary of reports of bird collisions with power and communication lines. Bonneville Power Administration, Portland, OR. 8 pp.

_____. 1983. Site visit and data analysis: waterfowl collisions at the Missouri River. Bonneville Power Administration, Portland, OR. 14 pp.

*____, and J. R. Meyer. 1977. Work plan for a study of the effects of Bonneville Power Administration transmission lines on bird flight behavior and collision mortality. Unpubl. Research Proposal, Bonneville Power Administration, Portland, OR. 9 pp.

____, and ____. 1978. Effects of transmission lines on bird flights: studies of Bonneville Power Administration Lines. Pages 93–116 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. U.S. Fish and Wildlife Service, Washington, D.C.

Lehman, R. N., P. L. Kennedy, and J. A. Savidge. 2007. The state of the art in raptor electrocution research: a global review. Biol. Conserv. 136:159–174.

Leitner, P., and G. S. Grant. 1978. Preliminary observations of waterbird flight patterns at Salton Sea, California, October 1976–February 1977. Prepared jointly for the Department of Energy and Southern California Edison. 34 pp.

Leppers, P. H. 1966. Hoogspanningsdraden: doodsvijand nr. 1 [High-voltage wires: deadly enemy no. 1]. Duivengazet 19:16–17.

*Lewis, J. C. 1992. The contingency plan for Federal-State cooperative protection of whooping cranes. Pages 293–300 *in* D. A. Wood (ed.), Proc. 1988 N. Am. Crane Workshop. Florida Game and Fresh Water Fish Commission, Tallahassee.

Liguori, S., and J. Burruss. 2008. PacifiCorp's bird management program: integrating reactive, proactive, and preventative measures to reduce avian mortality on power lines. Pages 325–329 *in* J. W. Goodrich-Mahoney, L. P. Abrahamson, J. L. Ballard, and S. M. Tikalsky (eds.), Proc. of the Eighth International Symposium on Environmental Concerns in Rights-of-Way Management. 12–16 September 2004, Saratoga Springs, NY. Elsevier, Amsterdam, The Netherlands.

Linz, G. M., J. E. Davis, Jr., R. M. Engeman, D. L. Otis, and M. L. Avery. 1991. Estimating survival of bird carcasses in cattail marshes. Wildlife Soc. B. 19:195–199.

*Lislevand, T. 2004. Fugler og kraftledninger: metoder for å redusere risikoen for kollisjoner og elektrokusjon [Birds and power lines: methods to reduce the risk of collisions and electrocutions]. Norsk Ornitologisk Forening. Rapport nr 2-2004. 40 s.

Longcore, T., C. Rich, and S. A. Gauthreaux, Jr. 2008. Height, guy wires, and steady-burning lights increase hazard of communication towers to nocturnal migrants: a review and meta-analysis. Auk 125:485–492.

*____, ____, P. Mineau, B. MacDonald, D. G. Bert, L. M. Sullivan, E. Mutrie, S. A. Gauthreaux Jr., M. L. Avery, R. L. Crawford, A. M. Manville II, E. R. Travis, and D. Drake. 2012. An estimate of avian mortality at communication towers in the United States and Canada. PLoS ONE 7(4), April 25th.

*Longridge, M. W. 1986. The impacts of transmission lines on bird flight behaviour, with reference to collision mortality and systems reliability. Bird Res. Comm., ESCOM. Report: 1-279.

Luman, I. D. 1978. The Klamath Basin case. Pages 91–104 *in* M. L. Avery (ed.), Impacts on transmission lines on birds in flight. U.S. Fish and Wildlife Service, Washington, D.C. FWS/OBS-78/48.

*Mabee, T. J., and B. A. Cooper. 2002. Nocturnal bird migration at the Stateline and Vansycle Wind Energy Projects, 2000–2001. Prepared for CH_2MHILL and FPL Energy Vansycle, LLC, Juno Beach, FL, by ABR, Inc., Forest Grove, OR. 16 p.

*____, ____, and J. H. Plissner. 2004. Radar study of nocturnal bird migration at the proposed Mount Storm Wind-Power Development, West Virginia, fall 2003. Final Report. Prepared for Western EcoSystems Technology (WEST), Inc., Cheyenne, WY, and NedPower US LLC, Chantilly, VA, by ABR, Inc., Forest Grove, OR.

Maehr, D. S., A. G. Spratt, and D. K. Voights. 1983. Bird casualties at a central Florida power plant. Florida Field Nat. 11:45–49.

*Magyar Madártani és Természetvédelmi Egyesület (MME). 2011. Budapest declaration on bird protection and power lines. Adopted by the conference, Power lines and bird mortality in Europe; Budapest, Hungary; 13 April 2011. www.mme.hu/termeszetvedelem/budapest-conference-13-04-2011/1429.html

*Malcolm, J. M. 1982. Bird collisions with a power transmission line and their relation to botulism at a Montana wetland. Wildlife Soc. B. 10:297–304.

*Mañosa, S., and J. Real. 2001. Potential negative effects of collisions with transmission lines on a Bonelli's Eagle population. J. Raptor Res. 35:247–252.

Mantyla, E., T. Klemola, P. Sirkia, and T. Laaksonen. 2008. Low light reflectance may explain the attraction of birds to defoliated trees. Behav. Ecol. 19:325–330.

*Manville, A. M., II. 2002. Protocol for monitoring the impact of cellular telecommunication towers on migratory birds within the Coconino, Prescott, and Kaibab National Forests, Arizona. Research Protocol Prepared for U.S. Forest Service Cellular Telecommunications Study. U.S. Fish and Wildlife Service, Division of Migratory Bird Management.

*____. 2005a. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: state of the art and state of the science, next steps toward mitigation. Pages 1051–1064 *in* C. J. Ralph and T. D. Rich (eds.), Bird conservation implementation in the Americas. Proc. of the 3rd International Partners in Flight Conference 2002. USDA Forest Service General Technical Report PSW-GTR-191, Pacific Southwest Research Station, Albany, CA.

*____. 2005b. Seabird and waterbird bycatch in fishing gear: next steps in dealing with a problem. Pages 1071–1082 *in* C. J. Ralph and T. D. Rich (eds.), Bird conservation implementation in the Americas. Proc. of the 3rd International Partners in Flight Conference 2002. USDA Forest Service General Technical Report PSW-GTR-191, Pacific Southwest Research Station, Albany, CA.

*____. 2007a. Comments of the U.S. Fish and Wildlife Service submitted electronically to the FCC on 47 CFR parts 1 and 17, WT Docket 03-187, FCC 06-164, Notice of Proposed Rulemaking, "Effects of Communication Towers on Migratory Birds." February 2, 2007. 32 pp.

____. 2007b. Briefing paper on the need for research into the cumulative impacts of communication towers on migratory birds and other wildlife in the United States. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, VA, for Public Release.

*____. 2009a. Towers, turbines, power lines, and buildings: steps being taken by the U.S. Fish and Wildlife Service to avoid or minimize take of migratory birds at these structures. Pages 262–272 *in* T. D. Rich, C. Arizmendi, D. Demarest, and C. Thompson (eds.), Tundra to tropics: connecting habitats and people. Proc. of the 4th International Partners in Flight Conference, 13–16 February 2008, McAllen, TX.

*____. 2009b. Briefing paper on the need for research into the cumulative impacts of communication towers on migratory birds and other wildlife in the United States: document for public release. U.S. Fish and Wildlife Service, Division of Migratory Bird Management.

Manville, R. H. 1963. Accidental mortality in bats. Mammalia 27:361–366.

Martin, G. R. 2010. Bird collisions: a visual or a perceptual problem? *In* Proc. of the British Ornithologists' Union 2010 Conference: Climate Change and Birds. 6–8 April 2010. University of Leicester, Leicester, UK.

*____. 2011. Understanding bird collisions with man-made objects: A sensory ecology approach. Ibis 153:239–254.

*____, and J. M Shaw. 2010. Bird collisions with power lines: failing to see the way ahead? Biol. Conserv. 143: 2695–2702.

*Mathiasson, S. 1999. Swans and electrical wires, mainly in Sweden. Pages 83–111 *in* M. Ferrer and G. F. E. Janss (eds.), Birds and power lines; collision, electrocution and breeding. Servicios Informativos Ambientales/Quercus, Madrid, Spain.

*McCann, K. 2001. Eskom/EWT partnership: the wattled crane marking project in South Africa. *In* Avian Interactions with Utility and Communication Structures Workshop Proceedings. 2–3 December 1999. Charleston, SC. EPRI Technical Report No. 1006907. R. Carlton, Project Manager.

McCrary, M. D., R. L. McKernan, and R. W. Schreiber. 1981. Nocturnal bird migration in the Coachella Valley, spring 1981. Prepared for Southern California Edison Company, Rosemead, CA. 42 pp.

____, ____, ____, and S. D. Wagner. 1988. Assessment of bird collisions along the Devers-Valley 500-kV transmission line in the San Jacinto Valley. Final Report. Southern California Edison, 88-RD-5.

McKernan, R., M. McCrary, W. Wagner, R. Landry, and R. Schreiber. 1982. Observations on nocturnal and diurnal bird use in relation to the Devers-Valley 500-kV transmission line in the San Jacinto Valley, winter 1981–82. Prepared for Southern California Edison Company, Rosemead, CA. 63 pp.

*McNeil, R., J. R. Rodriguez, and H. Ouellet. 1985. Bird mortality at a power transmission line in Northeastern Venezuela. Biol. Conserv. 31:153–65.

____, A. McSween, and P. Lachapelle. 2005. Comparison of the retinal structure and function in four bird species as a function of the time they start singing in the morning. Brain Behav. Evolut. 65:202–214.

*Mead, C. J., P. M. North, and B. R. Watmough. 1979. The mortality of British grey herons. Bird Study 26:13–22.

*Meyer, J. R. 1978. Effects of transmission lines on bird flight behavior and collision mortality. Prepared for Bonneville Power Administration, U.S. Department of Energy, Portland, OR. 200 pp.

*Miller, A. D. 1990. A study to determine the effectiveness of power line marking systems to reduce avian collision mortality. Unpublished report for APLIC. 15 pp.

*Mojica, E. K., B. D. Watts, J. T. Paul, S. T. Voss, and J. Pottie. 2009. Factors contributing to bald eagle electrocutions and line collisions on Aberdeen Proving Ground, Maryland. J. Raptor Res. 43:57–61.

*Morkill, A. E., and S. H. Anderson. 1991. Effectiveness of marking power lines to reduce sandhill crane collisions. Wildlife Soc. B. 19:442–449.

*Murphy, R. K., S. M. McPherron, G. D. Wright, and K. L. Serbousek. 2009. Effectiveness of avian collision averters in preventing migratory bird mortality from power line strikes in the Central Platte River, Nebraska. 2008–2009 Final Report. 30 September 2009, Dept. of Biology, University of Nebraska- Kearney, Kearney, NE. 32 pp.

*National Park Service (NPS). 2011. California condor (*Gymnogyps californianus*) recovery program: population size and distribution, December 31, 2011. Available from: www.nps.gov/pinn/naturescience/upload/Condor-Program-Monthly-Status-One-Page-Summary-2011-12-3134.pdf

Negro, J. J., and M. Ferrer. 1995. Mitigating measures to reduce electrocution of birds on power lines: a comment on Bevanger's review. Ibis 137:423–424.

New York Power Authority (NYPA). 2005. Estimates of bird mortality associated with transmission lines. Niagara Power Project, FERC #2216. Prepared for NYPA by URS Corporation.

Newton, I. 2007. Weather-related mass-mortality events in migrants. Ibis 149:453–467.

*____. 2008. The migration ecology of birds. Academic Press, Amsterdam, The Netherlands.

Nielson, L. 2010. Bird collision monitoring with a BSI. Northwest Public Power Association, Avian Protection Plan Workshop. 16–17 March 2010. Seattle, WA.

Niemi, G. J., and J. M. Hanowski. 1984. Effects of a transmission line on bird populations in the Red Lake Peatland, northern Minnesota. Auk 101:487–498.

*NUS Corporation. 1979. Impacts of overhead wires on birds: a review. Unpublished report. Prepared for the Electric Power Research Institute, Palo Alto, Calif. 47 pp. Summary available from www.energy.ca.gov/research/environmental/avian_bibliography

Nygård, T., K. Bevanger, and O. Reitan. 2008. Forholdet mellom fugler og vindmøller og andre lufthindringer. En litteraturoversikt [The relationship between birds and wind turbines and other air barriers. A literature review]. NINA Rapport 413. 167 s.

Office of the President. 2001. Executive Order 13186 of January 10, 2001. Responsibilities of federal agencies to protect migratory birds. Federal Register 66:11 (17 January 2001). Pp 3853-3856. Available from: http://www.archives.gov/federal-register/executive-orders/2001-clinton.html

*Ogilvie, M. A. 1966. Population changes and mortality of the mute swan in Britain. Wildfowl Trust Ann. Rep. 18:64–73.

Olendorff, R. R., A. D. Miller, and R. N. Lehman. 1981. Suggested practices for raptor protection on power lines: the state of the art in 1981. Raptor Research Report No. 4, Raptor Research Foundation, Inc. 111 pp.

*____, ____, and ____. 1986. Raptor collisions with utility lines: an analysis using subjective field observations. Pacific Gas and Electric Co., San Ramon, CA. 73 pp.

*Olson, C. 2001. Human-related causes of raptor mortality in western Montana: things are not always as they seem. *In* Avian Interactions with Utility and Communication Structures Workshop Proceedings. 2–3 December 1999. Charleston, SC. EPRI Technical Report No. 1006907.

Padding, P. I., and H. H. Prince. 1991. Final report: Karn-Weadock transmission line mortality study. Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI. 12 pp.

*Pandey, A. K., R. E. Harness, and M. K. Schriner. 2008. Bird strike indicator field deployment at the Audubon National Wildlife Refuge in North Dakota: phase two. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-020.

Patten, M. A., and D. T. Bolger. 2003. Variation in top-down control of avian reproductive success across a fragmentation gradient. Oikos 101:479–488.

*Peterson, C. A., S. L. Lee, and J. E. Elliott. 2001. Scavenging of waterfowl carcasses by birds in agricultural fields of British Columbia. J. Field Ornithol. 72:150–159.

Philibert, H., G. Wobeser, and R. G. Clark. 1993. Counting dead birds: examination of methods. J. Wildlife Dis. 29:284–289.

Ping, F., M. Farzaneha, and G. Boucharda. 2006. Two-dimensional modeling of the ice accretion process on transmission line wires and conductors. Cold Reg. Sci. Technol. 46:132–146.

*Podolsky, R., D. G. Ainley, G. Spencer, L. Deforest, and N. Nur. 1998. Mortality of Newell's shearwaters caused by collisions with urban structures on Kauai. Colon. Waterbird 21:20–34.

*Prather, P. R., and T. A. Messmer. 2010. Raptor and corvid response to power distribution line perch deterrents in Utah. J. Wildlife Manage. 74(4):796–800.

Prinsen, H., and R. Smits. 2009. Collision risk of birds with a 150 kV power line: a case study from the Netherlands. Bureau Waardenburg, Ltd., The Netherlands.

*Prosser, P., C. Nattrass, and C. Prosser. 2008. Rate of removal of bird carcasses in arable farmland by predators and scavengers. Ecotox. Environ. Safe. 71:601–608.

*Quinn, M., N. Heck, S. Alexander, and G. Chernoff. 2011. Identification of bird collision hotspots along transmission power lines in Alberta: an expert-based geographic information system (GIS) approach. Journal of Environmental Informatics 18(1):12–21.

*Raevel, P., and J. C. Tombal. 1991. Impact des lignes haute-tension sur l'avifaune [Impact of high-voltage lines on birds]. Les Cahiers de L'A.M.B.E. et Environment, Vol. 2. 31 pp.

*Rasmussen, P. J. 2001. Problem resolutions for avian interactions at two NSP facilities. *In* Proc. Avian Interactions with Utility and Communication Structures Workshop. 2–3 December 1999. Charleston, SC. EPRI Technical Report No. 1006907.

*Rayner, J. M. V. 1988. Form and function in avian flight. Curr. Ornithol. 5:1–77.

Reijnen, R., R. Foppen, and G. Veenbaas. 1997. Disturbance by traffic of breeding birds: evaluation of the effect and considerations in planning and managing road corridors. Biodivers. Conserv. 6:567–581.

Reiter, A. S. 2000. Casualties of great bustards on overhead power lines in the western Weinvertel (Lower Austria). Egretta 43:37–54.

*Renssen, T. A., A. Bruin, J. H. van de Doorn, A. Gerritsen, H. C. Greven, and J. Kamp. 1975. Vogelsterfte in Nederland tengevolge van aanvaringen met hoogspanningslijnen [Bird mortality in the Netherlands due to collisions with power lines]. Rijksinstitut voor Naturbeheer. 65 pp.

Richardson, W. J. 2000. Bird migration and wind turbines: migration timing, flight behavior, and collision risk. Pages132–140 *in* National Avian-Wind Power Planning Meeting III. San Diego, CA, LGL Ltd., Environmental Research Associates, King City, Ontario, Canada.

*Rigby, R. W. 1978. October 19 letter from refuge manager, Bosque del Apache National Wildlife Refuge, Socorro, NM, to Michael Avery, National Power Plant Team, Ann Arbor, MI. 1 p.

*Rivera-Milan, F. F., M. E. Zaccagnini, and S. B. Canavelli. 2004. Field trials of line-transect surveys of bird carcasses in agro-ecosystems of Argentina's Pampas region. Wildlife Soc. B. 32:1219–1228.

Robbins, C. 2002. Direct testimony of Chandler S. Robbins Dec. 6, 2002, in the matter of the application of Clipper 101 MW generating facility in Garrett County, MD, Windpower, Inc. Case #8938.

*Robert, M., R. McNeil, and A. Leduc. 1989. Conditions and significance of night feeding in shorebirds and other water birds in a tropical lagoon. Auk 106:94–101.

*Rocke, T. E., and Friend, M. 1999. Avian botulism. Chapter 38 *in* Field manual of wildlife diseases: General field procedures and diseases of birds. U.S. Department of the Interior. U.S. Geological Survey.

*Roig-Soles, J., and V. Navazo-Lopez. 1997. A five-year Spanish research project on bird electrocution and collision with electric lines. Pages 317–325 *in* J. R. Williams, J. W. Goodrich-Mahoney, J. R. Wisniewski, and J. Wisniewski (eds.), Environmental Concerns in Rights-of-Way Management. 22–26, February. New Orleans, LA. Elsevier Science Ltd., Amsterdam, The Netherlands.

Ross, R. C. 1946. People in glass houses should draw their shades. Condor 48:142.

RTE. 2009. RTE Rhône-Alpes Auvergne: pose de balises de protection de l'avifaune par RTE dans la réserve naturelle régionale des étangs de Mépieu [RTE Rhône-Alpes Auvergne: Attaching tags to protect the birds by RTE in the regional natural reserve of ponds Mépieu]. Paris, France. 7 pp.

*Rubolini, D., M. Gustin, G. Bogliani, and R. Garavaglia. 2005. Birds and power lines in Italy: an assessment. Bird Conserv. Int. 15:131–145.

*Rusz, P. J., H. H. Price, R. D. Rusz, and G. A. Dawson. 1986. Bird collisions with transmission lines near a power plant cooling pond. Wildlife Soc. B. 14:441–444.

*Savareno, A. J., L. A. Savareno, R. Boettcher, and S. M. Haig. 1996. Avian behavior and mortality at power lines in coastal South Carolina. Wildlife Soc. B. 24:636–648.

*Schroeder, C. H. 1977. Geese hit power transmission line. North Dakota Outdoors 40(2): inside cover.

*Schuerenberg, B., R. Schneider, and H. Jerrentrup. 2009. Follow-up of recommendation No. 110 (2004) on minimising adverse effects of above-ground electricity transmission facilities (power lines) on birds. Council of Europe, Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee, 29th Meeting, 23–26 November. Bern, Switzerland. 39 pp.

*Scott, R. E., L. J. Roberts, and C. J. Cadbury. 1972. Bird deaths from power lines at Dungeness. Brit. Birds 65:273–286.

Seamans, T. W., S. C. Barras, and A. J. Patton. 2003. Are birds scared by rotating mirrors? *In* Proc. of the 2003 Bird Strike Committee USA/Canada, 5th Joint Annual Meeting, Toronto, Ontario, Canada.

Sergio, F., P. Pedrini, and L. Marchesi. 2003. Spatio-temporal shifts in gradients of habitat quality for an opportunistic avian predator. Ecography 26:243–255.

*Shamoun-Baranes, J., E. van Loon, H. van Gasteren, J. van Belle, W. Bouten, and L. Buurma. 2006. A comparative analysis of the influence of weather on the flight altitudes of birds. B. Am. Meteorol. Soc. 87:47–61.

*____, W. Bouten, and E. van Loon. 2010. Integrating meteorology into research on migration. Integr. Comp. Biol. 50:280–292.

*Shaw, J., A. Jenkins, J. Smallie, and P. Ryan. 2010. Modeling power-line collision risk for the blue crane (*Anthropoides paradiseus*) in South Africa. Ibis 152:590–599.

*Shernazarov, E., and E. N. Lanovenko. 1994. Assessment of impact of anthropogenic loads on ornithological fauna of Uzbekistan. Pages 32–35 *in* materials of seminar "Environmental Impact Assessment procedure during development of Feasibility Study and Designs of Construction of Economic Facilities and Complexes" Tashkent.

*Shimada, T. 2001. Choice of daily flight routes of greater white-fronted geese: effects of power lines. Waterbirds 24:425–429.

*Shire, G. G., K. Brown, and G. Winegrad. 2000. Communication towers: a deadly hazard to birds. Report Documents. A Report Compiled by American Bird Conservancy, June 2000.

Siegfried, W. R. 1972. Ruddy ducks colliding with wires. Wilson Bull. 84:486–487.

Simmons, R. E. 2002. Siblicide provides food benefits for raptor chicks: re-evaluating brood manipulation studies. Anim. Behav. 64:F19–F24.

*Smallie, J., and M. Z. Virani. 2010. A preliminary assessment of the potential risks from electrical infrastructure to large birds in Kenya. Scopus 30:32–39.

Smith, J. R., and J. T. Schletz. 1991. Bird/power line collision detection system. Final Report. Pacific Gas and Electric Company, Department of Research and Development.

Sorenson, K. J., L. J. Burnett, and J. R. Davis. 2001. Status of the California condor and mortality factors affecting recovery. Endangered Species Update, July–August 2001.

Stallknecht, D. E. 2007. Impediments to wildlife disease surveillance, research, and diagnostics. Curr. Top. Microbiol. 315:445–461.

Steenhof, K., M. N. Kochert, and J. A. Roppe. 1993. Nesting by raptors and common ravens on electrical transmission line towers. J. Wildlife Manage. 57:271–281.

*Stehn, T., and T. Wassenich. 2007. Whooping crane collisions with power lines: an issue paper. 2006 North American Crane Workshop.

Stout, J., and G. W. Cornwell. 1976. Non-hunting mortality of fledged North American waterfowl. J. Wildlife Manage. 40:681–693.

*Sundar, K. S. G., and B. C. Choudhury. 2005. Mortality of sarus cranes (*Grus antigone*) due to electricity wires in Uttar Pradesh, India. Environ. Conserv. 32:260–269.

Sundararajan, R., and R. Gorur. 2005. When birds and power lines collide. Transmission and Distribution World, December 2005:16–26.

Synder, L. L. 1946. "Tunnel fliers" and window fatalities. Condor 48:278.

*Tacha, T. C., D. C. Martin, and C. G. Endicott. 1979. Mortality of sandhill cranes associated with utility highlines in Texas. Pages 175–176 *in* J. C. Lewis (ed.), Proc. 1978 Crane Workshop. National Audubon Society, NY.

Thompson, L. S. 1977. Overhead transmission lines: impact on wildlife. Montana Department of Natural Resources & Conservation, Helena, MT. 60 pp.

*____. 1978. Transmission line wire strikes: mitigation through engineering design and habitat modification. Pages 51–92 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. U.S. Fish and Wildlife Service, Washington, D.C.

Todd, L. D., R. G. Poulin, and R. M. Brigham. 1997. Diet of common nighthawks (*Chordeiles minor*: Caprimulgidae) relative to prey abundance. Am. Midl. Nat. 139:20–28.

Tucker, W. A. 1975. Flight energetics. Pages 49–63 *in* M. Peaker (ed.), Avian physiology. Academic Press, London.

U.S. Department of Agriculture (USDA). 1985. USDA handbook 478. National Forest Landscaped Management, Volume 2, Chapter 2, Utilities.

U.S. Department of Energy (USDOE). 2007. National electric transmission corridor report and the ordered national corridor designations. http://nietc.anl.gov/nationalcorridor/index.cfm

*U.S. Environmental Protection Agency (USEPA). 1998. Guidelines for ecological risk assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, D.C. EPA/630/R095/002F.

U.S. Fish and Wildlife Service (USFWS). Undated. Bird fatality/injury reporting program filer instructions. 16 pp.

*____. 2005a. Final list of bird species to which the Migratory Bird Treaty Act does not apply. Federal Register 70:49 (15 March 2005). Pp 12710–12716. Available from: www.federalregister.gov/articles/2005/03/15.

____. 2005b. Collisions: Clear the way for birds. International Migratory Bird Day. 8 pp.

*____. 2009a. Final environmental assessment. Proposal to permit take as provided under the Bald and Golden Eagle Protection Act. Available from: http://www.fws.gov/migratorybirds/CurrentBirdIssues/BaldEagle/FEA_EagleTakePermit_Final.pdf

*____. 2009b. Standard recommendations to avoid, minimize and mitigate potential impacts of wind energy projects in Oklahoma. Oklahoma Ecological Services Field Office, Tulsa, OK. 5 pp.

____. 2010. Species profile: California condor (*Gymnogyps californianus*). http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B002

*____ and National Marine Fisheries Service (NMFS). 1998. Consultation handbook: Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act.

*U.S. Geological Survey (USGS). 2011. National wildlife health center. www.nwhc.usgs.gov

*Utah Wildlife in Need (UWIN). 2010. Contemporary knowledge and research needs regarding the potential effects of tall structures on sage-grouse (*Centrocercus urophasianus* and *C. minimus*). Available from: http://utahcbcp.org/htm/tall-structure-info

*____. 2011. Protocol for investigating the effects of tall structures on sage-grouse (*Centrocercus* spp.) within designated or proposed energy corridors. Available from: http://utahcbcp.org/htm/tall-structure-info

van Rooyen, C. Undated. Bird impact scoping study Gerus-Mururane Gate 350kV DC transmission line. Endangered Wildlife Trust, South Africa. 19 pp.

*____. 2000. An overview of vulture electrocutions in South Africa. Vulture News 43: 5–22. Vulture Study Group, Johannesburg, South Africa.

____. 2001. Bird impact assessment study cape strengthening programme gamma-omega 765kV transmission line. Endangered Wildlife Trust, South Africa. 12 pp.

____. 2006. Environmental assessment addendum of the proposed Otjikoto–Katima Mulilo 350kV DC, ornithological component. Endangered Wildlife Trust, South Africa. 8 pp.

*____, and J. A. Ledger. 1999. Birds and utility structures: developments in South Africa. Pages 205–230 *in* M. Ferrer and G. F. E. Janss (eds.), Birds and power lines: collision, electrocution and breeding. Madrid: Quercus.

*Ventana Wildlife Society. 2009. Evaluating diverter effectiveness in reducing avian collisions with distribution lines at San Luis National Wildlife Refuge complex, Merced County, California. California Energy Commission, PIER Energy-Related Environmental Research. CEC-500-2009-078.

Verhiejen, F. J. 1958. The mechanisms of the trapping effect of artificial light sources upon animals. Arch. Neer. Zool.13:1–107.

Virginia Joint Commission on Technology and Science. Undated. Dominion estimated transmission costs: overhead vs. underground cost comparison 5 mile, 230 kV single circuit line example 1035 MVA capacity initial cost analysis. Richmond, VA. 9 pp. http://jcots.state.va.us/pdf/CostAnalysis.pdf

Viverette, C. B., S. Struve, L. J. Goodrich, and K. L. Bildstein. 1996. Decreases in migrating sharp-shinned hawks (*Accipiter striatus*) at traditional raptor-migration watch sites in eastern North America. Auk 113:32–40

*Walkinshaw, L. H. 1956. Sandhill cranes killed by flying into a power line. Wilson Bull. 68:325–326.

Weir, R. D. 1976a. Annotated bibliography of bird kills at man-made obstacles: a review of the state of the art and solutions. Can. Wildl. Serv., Ont. Reg., Ottawa. 85 pp.

_____. 1976b. Bird kills at the Lennox Generating plant: spring and autumn 1976. Blue Bill 23:41–43.

West, H. J., and G. G. Stults. 1980. A bird flight theodolite tracking system. Division of Laboratories Report No. ERFE-80-23. Bonneville Power Administration, U.S. Dept. of Energy, Portland, OR. 17 pp.

*Western Area Power Administration (WAPA). 2011. Line marking study near Coleharbor, ND, 2006–2008: data and summary [webpage]. www.wapa.gov

Western Systems Coordinating Council. December 1971. Environmental guidelines.

*Wheeler, R. H. 1966. Sandhill crane casualties in the blizzard of March 22, 1966. Nebr. Bird Rev. 34:69–70.

Wiese, J. C. 1979. Study of the reproductive biology of herons, egrets, and ibis nesting on Pea Patch Island, Delaware. Prepared for Delmarva Power and Light Company, Wilmington, DE. 255 pp.

*Willard, D. E. 1978. The impact of transmission lines on birds (and vice versa). Pages 3–7 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight: proc. of a workshop. Oak Ridge Associated Universities, Oak Ridge, TN. 31 January–2 February, 1978. U.S. Fish and Wildlife Service, Biological Services.

_____, and B. J. Willard. 1978. The interaction between some human obstacles and birds. Environ. Manage. 2:331–340.

*_____, J. T. Harris, and M. J. Jaeger. 1977. The impact of a proposed 500-kV transmission route on waterfowl and other birds. A Report for the Public Utility Commissioner of the State of Oregon. Salem, OR. 89 pp.

_____, _____, and _____. 1978. The impact of transmission lines on birds (and vice versa). Pages 5–13 *in* M. L. Avery (ed.), Impacts of transmission lines on birds in flight. U.S. Fish and Wildlife Service, Washington, D.C.

*Willdan Associates. 1981. Impact of the Ashe-Slatt 500-kV transmission line on birds at Crow Butte Island: postconstruction study year 1. Prepared for Bonneville Power Administration, U.S. Dept. of Energy, Portland, OR. 110 pp.

*_____. 1982. Impact of the Ashe-Slatt 500-kV transmission line on birds at Crow Butte Island: postconstruction study final report. Prepared for Bonneville Power Administration, U.S. Dept. of Energy, Portland, OR. 155 pp.

Williams, T. 2000. Zapped! Audubon: January/February: 32–34.

Williams, T. C., J. Settel, P. O'Mahoney, and J. M. Williams. 1972. An ornithological radar. American Birds 26:555–557.

_____, _____, _____, and _____. 1984. How to use marine radar for bird watching. American Birds 38:982–983.

Wilmore, S. B. 1974. Swans of the world. Taplinger Publishing, New York.

Wiltschko, R., T. Ritz, K. Stapput, P. Thalau, and W. Wiltschko. 2005. Two different types of light-dependent responses to magnetic fields in birds. Curr. Biol. 15:1518–1523.

Wiltschko, W., and R. Wiltschko. 1999. The effect of yellow and blue light on magnetic compass orientation in European robins (*Erithacus rubecula*). J. Comp. Physiol. 184:295–299.

____, U. Munro, H. Ford, and R. Wiltschko. 1993. Red light disrupts magnetic orientation of migratory birds. Nature 364:525–527.

Winkelman, J. E. 1992. De invloed van de Sep-proefwindcentrale te Oosterbierum op vogels [The impact of the September trial wind power station at Oosterbierum on birds]. 2. Nachtelijke aanvaringskansen. IBN-DLO, RIN-rapport 92/3.

*____. 1995. Bird/wind turbine investigations in Europe. Pages 43-47 *in* Proc. of the National Avian-Wind Power Planning Meeting. 20–21 July 1994. Lakewood, CO.

Wobeser, G., and A. G. Wobeser. 1992. Carcass disappearance and estimation of mortality in a simulated die-off of small birds. J. Wildlife Dis. 28:548–554.

Wolfe, D. H., M. A. Patten, E. Shochat, C. L. Pruett, and S. K. Sherrod. 2007. Causes and patterns of mortality in lesser prairie-chickens *Tympanuchus pallidicinctus* and implications for management. Wildlife Biol. 13:95–104.

*Yee, M. L. 2007. Evaluating and reducing avian collisions with distribution power lines at Cosumnes River Preserve. California Energy Commission, Public Interest Energy Research (PIER) Program and California State University, Sacramento, CA.

*____. 2008. Testing the effectiveness of an avian flight diverter for reducing avian collisions with distribution power lines in the Sacramento Valley, CA. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-122.

Zapata-Sánchez, J. A., M. Carrete, A. Gravilov, S. Sklyarenko, O. Ceballos, J. A. Donázar, and F. Hiraldo. 2003. Land use changes and raptor conservation in steppe habitats of eastern Kazakhstan. Biol. Conserv. 111:71–77.

Zimmerman, A. L., B. E. Jamison, J. A. Dechant, D. H. Johnson, C. M. Goldade, J. O. Church, and B. R. Euliss. 2002. Effects of management practices on wetland birds: sora. Northern Prairie Wildlife Research Center, Jamestown, ND. 31 pp.



APPENDIX B

Designing Site-Specific Studies for Collision Monitoring

With any study design for collision monitoring it is important that the resulting data can be compared to similar studies (see *Variability of Reported Mortality Rates* in Chapter 4 and *Effectiveness of Designs* in Chapter 6). The information in this appendix will help you design site-specific study methods that produce useful and comparable results. Table B.1 summarizes the considerations and issues presented in this appendix.

TABLE B.1: Summary of considerations and issues for designing site-specific collision monitoring.

Considerations for Site-Specific Collision Monitoring	Issues Related to Estimating Mortality Rates
Behavioral Monitoring • Bird density • Evaluation criteria • Estimating bird flight height • Radar observation and detection • Metrics • Study segments	Equations for Calculating Mortality Rate • Accuracy • Variability in methods
Mortality Monitoring • Differences in sampling design • Questions to ask • Data to record • Remote sensing	Sampling Biases • Crippling loss • Searcher efficiency • Scavenger removal • Habitat differences

CONSIDERATIONS FOR SITE-SPECIFIC COLLISION MONITORING

BEHAVIORAL MONITORING SURVEYS

The most direct way to determine how collisions are occurring is to observe behavior as birds are approaching, crossing, or colliding with power lines. Behavioral monitoring is used to characterize the birds' reaction to lines by giving each reaction a behavioral avoidance value. In line modification studies, behavioral monitoring can be used to measure the effectiveness of line marking devices.

Bird Density

Past studies (e.g., Bevanger 1999; Janss 2000) have counted collisions per flyby (observed collisions per number of birds flying by a line). With high bird density, counting collisions per flyby is feasible. But with low bird density, counting flybys is not practical because so few observations can be made, even over an extended period of time. Direct observation can be especially time consuming with low bird density or intermittent high bird density. Observations may also be restricted by poor visibility due to weather or time of day. In such cases, the most feasible method may be to conduct mortality monitoring to estimate collisions (see *Mortality Monitoring Surveys* on page 141). Bird collisions with power lines can also be detected with remote sensing devices (see *Remote Sensing* on page 142), although they do not yield behavioral and species data.

Evaluation Criteria

A study's behavioral criteria may include the type of reaction to lines, distance from the line when the reaction occurred, and height above the line when crossing. Because estimates are provided by different observers, all observers must be trained and given time to practice before the study begins, and the same observers should be used throughout the study when possible to minimize observer bias. Records of approach, crossing, and departure heights should be kept. If behavioral avoidance is observed, the reaction to and distance from the line should be recorded. The following are possible reaction categories and definitions:

- No reaction—Birds maintain constant altitude and unaltered flight
- Swerve and over—Birds turn from course, flying up and over line
- Swerve and under—Birds turn from course, flying down and under line
- Over and swerve—Birds flying over line swerve immediately after crossing the lines
- Turn and leave—Birds turn and retreat from the line after approaching within 50 meters (m) (164 feet [ft]) of the line
- Collision and fly—Birds in flight hit a line but keep flying outside of the transect boundaries
- Collision and fall—Birds in flight hit a line and drop within the study transect (the specific line should be noted in the comments section)
- Land on line—Birds land on line or pole

Estimating Bird Flight Height

Bird flight altitude information should be estimated relative to the structure height and the height of phase conductors, neutral wires, and shield wires. Height classes will vary depending on the type of power line (e.g., conductor arrangement, voltage) and the species studied. Figure B.1 provides an example of altitude classes for transmission lines. Since power lines will vary in design, site-specific altitude criteria should be developed.

The manner of recording flight altitude should be modified according to line configuration and the species studied. If the wires are in the same horizontal plane, then the area included in the study is above and below the line for a certain number of meters (feet). If the wires are in a vertical configuration, then the area observed is above and below the multiple planes including the shield wire and a distribution underbuild if present. If the structure type is an H-frame, then the obser-

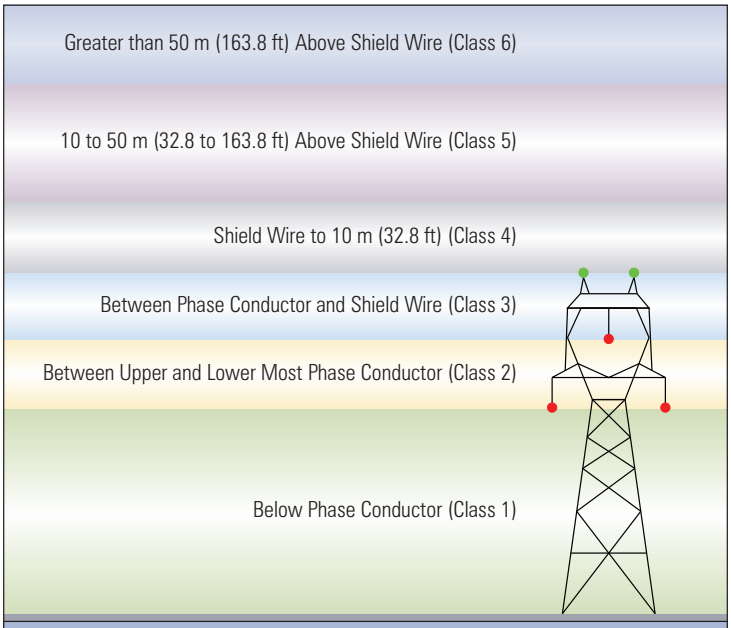


FIGURE B.1: Classes used to describe birds' approach, crossing, and departure altitudes in collision studies on transmission lines (after James and Haak 1979).

vational box might be different than if the tower is steel lattice or a V-shape supported by guy wires. The size of the line structure may warrant extending the observational area farther from the poles (i.e., begin recording at 30.5 m (100 ft) away from a distribution single pole, but 152.4 m (500 ft) from a steel lattice transmission tower) in order to account for reaction times related to the size of the structure and the height and arrangement of the lines.

Bird flight height can be estimated and measured in various ways with varying degrees of expense, effort, accuracy, and efficiency. Visual categorization, rangefinders, and radar systems can all collect data on the flight height and each approach has its advantages and disadvantages (see *Radar Observation and Detection* on page 140). When choosing which techniques to use, the following must be considered: project goals, species identification and concentration, migration data, and project budget. For example, if the major bird migration occurs in spring, data needs to be collected for a sufficient period in the spring to characterize bird movement and behavior. If you need to estimate the overall impacts of the mortality to the local bird population, you will need an understanding of that population in the area surrounding the study site throughout its seasonal fluctuations including breeding, migration, and wintering.

One of the simplest field techniques for estimating flight height is to visually categorize height, such as above the lines, below the lines, etc. This approach only requires a known reference point in the field. Survey flags and reaction zones can help observers estimate the distance from the line and the section of the line as they record behavioral avoidance. For example, survey flags can be placed 5 m (16.4 ft), 5 to 25 m (16.4 to 82 ft), and >25 m (>82 ft) from the line (Brown and Drewien 1995). This technique works well in terrestrial situations and eliminates the need for a rangefinder. In another approach, a reaction zone of 200 m (656.2 ft) on each side of a 500-kV transmission line has been used (Willdan Associates 1981, 1982).

This approach can be expanded by using visual estimation in conjunction with electronic rangefinders, which are used to measure the height of reference structures in the field. Electronic rangefinders come equipped with a laser and built in clinometers, which measure straight line distance to the bird and the angle of the measurement above horizontal. The measurements can be used to estimate an object's (bird's) height above ground. Height is calculated as:

SIN([Angle[1]])*[Distance to Object] = Flight height

[1] if calculating in Excel use the radian function to convert degree units into radians so the number will be compatible with the SIN function

Once the heights are known for several tall objects in the area, bird flight heights can be estimated. This approach can be further expanded by directly measuring the flight heights of birds using an electronic rangefinder. This approach can be effective if birds are in close range and are big and reflective enough to bounce a signal back to the rangefinder. Other factors that affect successful measuring of flight height using the rangefinder include:

- Distance of the observer to the bird (shorter distances reflect better signals)
- Size of the bird (larger birds reflect the laser better than smaller birds)
- Reflectivity of the bird (white birds reflect the signal better than dark birds; Klimentjew et al. 2010; M. Schriner, pers. comm.)

A limitation of measuring bird flight height directly is that it is difficult to record multiple heights simultaneously. In areas where bird passage rates are high, multiple observers, digital tape recorders, or video cameras may be needed to adequately capture multiple measurements of flight height.

Radar Observation and Detection

Although the use of radar in power line studies is not common, it is a useful tool for characterizing bird movements. Two types of radar, Nexrad and portable radar, have been used in bird studies to collect data on nocturnal movements and broad front migrations, which may be missed by field observations. Nexrad radar (Next-Generation Radar) is a network of Doppler weather radars operated by the National Weather Service. Nexrad radar has the advantage of being able to collect data on the density of targets within an area and examine the temporal variation in target activity over many years. Portable radars are smaller and include systems such as modified marine, pencil beam tracking, and other specialized radar systems. Portable radar collects data on flight height, direction, and speed of targets and can distinguish different size classes of targets which provides some level of certainty as to what is being detected (e.g., songbirds versus herons).

Despite the unique information that radar can collect, it does have limitations. Nexrad cannot distinguish between birds, bats, and insects, and the height of airspace that is surveyed is dependent on the distance from the Nexrad station. Portable radar detects targets (e.g., birds, bats, insects, weather, etc.) in flight and can classify them by size and speed and movement patterns (R. Larkin, pers. comm.). Software filters can help refine target specificity by removing weather images, leaving images of desired targets. While size classes can be used to indicate species groups to some extent, distinguishing between species groups that are of similar size is not possible. Ground clutter, visual obstructions, and inclement weather can also limit the ability of radar to detect objects at a distance. The longer the distance between radar and subject, the more likely ground clutter will interfere. Finally, the cost of radar systems can be high, which limits their applicability.

Metrics

Metrics used in behavioral observations of collisions are generally expressed as the number of observed collisions per number of birds flying by a line (flybys), often expressed as a percentage. For example, Meyer (1978, cited in Bevanger 1998) observed the number of collisions to be 0.003% to 0.07% of flybys for waders and gulls. Janss and Ferrer (2000) reported collisions per flyby as 3.93×10^{-5} for the common crane (*Grus grus*) and 6.34×10^{-3} for the great bustard (*Otis tarda*).

Study Segments

It is essential that study segments represent the line as a whole (unless there is a need to identify high risk areas), that test and control segments be of comparable length, and that

they have as much environmental homogeneity as possible. Variability will be reduced by including an adequate number of test and control segments. Contiguous segments are convenient but not essential. Koops and de Jong (1982) marked alternating spans, and Brown and Drewien (1995) marked alternate 0.8-kilometer (km) (0.5-mile [mi]) segments of eight different test lines. The length of study segments may vary according to bird density, seasonal use, habitat type, size of the power line, etc. However, in line modification studies it is important that test and control segments are separated sufficiently so control segments are not affected by the presence of markers on the test segments. Thus, when evaluating markers on small distribution lines that have short spans (pole to pole distance), each test and control segment should consist of several spans. Barrientos et al. (2011) provides recommendations on reasons for standardizing segment length.

MORTALITY MONITORING SURVEYS

The most common way to determine if collisions have occurred is to survey the power line right-or-way (ROW) for dead and injured birds and attempt to identify the cause of injury or death. Mortality monitoring surveys provide a more accurate assessment of collision mortality.

Differences in Sampling Design

There are numerous monitoring approaches and each has different strengths and weaknesses (e.g., APLIC 1994; Bevanger 1999; Hunting 2002). Mortality surveys conducted through 2011 generally differ in sampling design including:

- Segment selection
- Lengths of lines sampled
- Width of the area sampled
- Duration and intensity of the study
- Seasonal sampling

The fact that all these considerations are not routinely included leads to difficulty in comparing studies (Hunting 2002; Barrientos et al. 2011). Typically the sampling biases (i.e., searcher efficiency, crippling loss, scavenger removal, and habitat differences; see *Sampling Biases* on page 143), which need to be accounted for to correct the estimated mortality rates, are not implemented systematically or in a manner that is consistent with the expected monitoring program survey designs. In addition, because of sampling uncertainty, a variety of statistical methods are applied to estimate the actual number of birds affected based on the number of birds found.

Site-specific study designs and correction factors need to be developed for mortality monitoring to account for these variables. Bevanger (1999) concluded that, given the site-specific factors and local conditions (e.g., biological, environmental, and engineering) that influence collision and mortality estimation, it is not expedient to develop a set of standard study design methods or use general correction factors. Barrientos et al. (2011) presented three recommendations for conducting line marking device effectiveness studies that also apply to mortality monitoring:

1. Collecting data on carcass counts and flight frequency for the same length of time and at the same time of the year at marked and unmarked wire segments
2. Studying marked (test segment) and unmarked (control segment) lines in areas with similar vegetation and topography, with similar lengths of time spent searching for carcasses, and with transects of equal lengths and widths
3. Standardizing the timing of carcass searches and search area widths

For search area width, searches should cover the width of ROW with reference to the height of the power line (James and Haak 1979; Raevel and Tombal 1991) and the zone in which carcasses are expected to fall.

Questions to Ask

The study design phase should focus on the questions being asked, the data needed to answer these questions, and the appropriate methods, including duration and intensity, to provide those data. A series of hierarchical questions that need to be considered may include the following:

1. Are collision injuries and/or mortalities occurring?
2. What species of birds are involved? Are they protected species?
3. Where along the power line are the birds colliding?
4. When are they being killed?
5. Under what circumstances (e.g., weather, time of day) are they being killed?
6. What biological, environmental, and engineering factors appear to be important in influencing collisions?
7. What line modification actions can be taken to reduce these collisions?

Questions 1 and 2 are the simplest to answer if the carcasses are detected. Many of the past studies have focused on answering the first two questions and sometimes 3 and 4. More recent studies have attempted to address questions 5, 6, and 7. There is a tendency to focus on sampling worst-case situations or locations where high numbers of collisions have occurred as opposed to sampling representative locations along a given power line to understand the overall collision risk. Although results from worst-case situations may skew general mortality risk, determining this information is still important because it provides data needed for reducing risk.

Data to Record

For each bird found, the following information should be gathered when possible:

- Location of the carcass in proximity to the power line (e.g., GPS position)
- Species
- Sex
- Age: adult or juvenile
- Date or approximate time of death
- Physical injuries and conditions (e.g., broken bones, lacerations, abrasions, blood, discolorations, gunshot wounds, decomposition, feather spots, feeding by scavengers)
- Probable cause of death
- Necropsy[19]

Environmental conditions should also be recorded, especially visibility, wind speed and direction, weather events, avian habitats, as well as the type and abundance of bird species in the study area.

Remote Sensing

An alternative to directly observing bird collisions is to use a Bird Strike Indicator (BSI). BSI is a vibration sensing and recording tool that is fitted to a power line to detect collisions with that line. It is especially useful for monitoring collisions in low-light or no-light conditions. However, BSI does not identify what species struck the line; mortality monitoring or field observations would be required to determine this. See Chapter 5 for a discussion on the BSI.

[19] In the United States, the possession of any protected migratory bird will require a Special Purpose or Scientific Collecting permit (see Chapter 3), unless otherwise instructed by an agent of U.S. Fish and Wildlife Service Office of Law Enforcement.

ISSUES RELATED TO ESTIMATING MORTALITY RATES

EQUATIONS FOR CALCULATING MORTALITY RATE

Accuracy

Few mathematical equations for estimating mortality have been tested for accuracy using experimentally designed, rigorous field studies (Bevanger 1999). Furthermore, there are no agreed upon methods that link the equation to the type of field trials necessary for site-specific calculation of mortality, nor are methods for incorporating uncertainty often provided.

These issues are not unique to power lines. Similar uncertainty is found in calculating actual mortality from estimates of bird carcasses collected from wind turbine collisions, building window collisions, pesticide application, and avian diseases. Although the causes of mortality are different, the ability to find bird carcasses in the field is affected by the same sampling biases (i.e., crippling loss, searcher efficiency, scavenger removal, and habitat differences; see discussion on this page). Huso (2011) evaluated the accuracy and precision of mortality estimators for power lines and other structures and proposed one that improves reliability. This limitation in calculating mortality rates is also presently being investigated by the wind industry, U.S. Fish and Wildlife Service, U.S. Geological Survey, and others. The California Energy Commission (CEC) is funding a controlled field study through the California Wind Energy Association strictly looking at the mathematical relationships of scavenger removal and searcher efficiency as they relate to calculating actual mortality rates. The study report should be available in 2012 (J. Newman, pers. comm.).

Variability in Methods

While designing a study, the most recent literature on mortality rate calculations should be reviewed before selecting a particular method. Bevanger (1999) and Hunting (2002) provide an excellent review of collision mortality for power lines. A mortality rate of the number of carcasses/distance of line surveyed/time period is the most commonly used metric found in the literature. However, the search area (i.e., estimated annual mortality/hectare/kilometer [/acre/mile]) also needs to be included (Hunting 2002).

Finally, as mentioned earlier, there is great variability in monitoring methods, which prevents useful comparison of mortality rates and effectiveness of markers to reduce collisions.

SAMPLING BIASES

When conducting mortality monitoring, the mortality rate calculation must take a number of sampling biases into account, including the following:

- Crippling loss
- Searcher efficiency
- Scavenger removal
- Habitat differences

Crippling Loss Bias

The crippling loss bias occurs when birds strike a line and fall outside the search area or when injured birds move out of the search area and are not observed by searchers. Bevanger (1999) cites several studies that found 22% (Hiltunen 1953) to 50% (Renssen et al. 1975) to 74% (Beaulaurier 1981) of birds fatally injured in power line collisions move far enough away from the power line before dying that they are not found during carcass searches.

In Beaulaurier's (1981) study, crippling loss bias was defined as the percent of observed collisions in which birds continued flying out of the study area after the collision. Because she did not observe a collision during her study, she used an estimate of 74%—the average measure of crippling loss bias calculated by Meyer (1978) as 75% and James and Haak (1980) as 73%. These authors assume

a worst-case estimate with all injured birds dying from their injuries. The estimates were also based on collisions with shield wires.

Because great time and effort are involved in monitoring flights and recording collisions, crippling loss bias estimates are extremely difficult to obtain and they are the least likely to be calculated in a study. Application of estimates from other studies is inappropriate, and, in fact, very misleading. Once again, the size of the bird may make a significant difference because of flight dynamics. A crane or swan that just tips a line is more likely to tumble to the ground and sustain fatal injuries than is a smaller, lighter bird that may be able to recover its flight mid-air and die later at some distance from the line (W. Brown, pers. comm.). Consequently, smaller birds might have a higher crippling loss bias than larger birds. This may need to be examined in future research.

Searcher Efficiency Bias

During carcass searches, some of the carcasses will be missed depending on several variables (e.g., number of observers, their skill and experience, and how the surveys are conducted). This is called searcher efficiency bias or searcher bias. Searcher bias is also influenced by vegetation type, height, and density, search pattern, presence of waterbodies, bird size, and other factors (Bevanger 1999; Erickson et al. 2005). Searcher bias in carcass detection must be carefully controlled (Bevanger 1999; Erickson et al. 2005). Searcher efficiency biases are specific to the site and the season. Bias needs to be determined while the mortality monitoring is taking place and not extrapolated from or to other locations, seasons, or studies (Bevanger 1999; Barrientos et al. 2011). APLIC (1994) and Bevanger (1999) give examples of the calculations for determining searcher bias. CEC is also studying searcher efficiency factors for calculating wind turbine-caused bird mortality.

The use of trained dogs in mortality monitoring studies can increase carcass recovery, particularly of small carcasses in dense vegetation (Homan et al. 2001; Anderson 1978; Rusz et al. 1986; Bevanger 1995, cited in Bevanger 1999). However, the availability of trained dogs is limited and their efficiency varies with individuals, seasons, weather conditions, vegetation structure, breed, length of use, and level of fatigue.

Scavenger Removal Bias

Scavengers may remove carcasses before a search is completed, which results in underestimating mortality. Scavenging rates are very important to include in mortality rate estimation (Bevanger 1999; Rivera-Milan et al. 2004; Erickson et al. 2005; Gehring et al. 2009). Bevanger (1999) gives an example of the calculation. Scavenging rate varies by habitat, season, time of day, scavenger type, bird size, bird species, etc. (Bevanger 1999; Erickson et al. 2005). Evidence of seasonal variation in scavenging rates in United Kingdom farmland is presented by Prosser et al. (2008).

In some cases scavenging can be a quick process, occurring in a matter of minutes depending on the scavenger species as well as the bird species involved. A review of the scavenging studies from various mortality monitoring studies (including power lines, communication towers, wind turbines, pesticide application, and bird disease) indicates that the majority of scavenging takes place within a short period of time after death for many species. For example, preliminary results of a scavenging removal study at one communication tower location on the Alaska Peninsula suggest that carcass removal from scavenging is as high as 50% removal per day (P. Flint, USGS pers. comm.; E. Lance, USFWS pers. comm.; USFWS 2007 unpubl. Data, cited in Manville 2007a); scavenged carcasses included eiders, waterfowl, and shorebirds,

among others. This degree of scavenging is consistent with what Herbert Stoddard (Crawford and Engstrom 2001) found in a 29-year study of a communication tower in Florida where about 92% of carcasses were removed by scavengers within 24 hours. Peterson et al. (2001) reported that in British Columbia, Canada, 52/54 poisoned waterfowl carcasses were discovered by avian scavengers within 72 hours. Kostecke et al. (2001) reported carcasses scavenged mostly by skunks with 66% of carcasses scavenged within five days in a South Dakota study. Erickson et al. (2005) cites a number of case studies with average carcass persistence times ranging from less than one to 28 days. In other cases it can be longer (Brown and Drewien 1995). They found that crane carcasses sometimes remained for as much as a year after death and that no crane carcasses were removed by scavengers during the removal studies. Likewise, large bird carcasses (e.g., raptors, pelicans) may persist for extended periods (several months to 32 months) without scavenger removal (S. Liguori, pers. comm.). Raevel and Tombal (1991) and others have noted that removal bias varies with the size of the birds (i.e., smaller birds usually disappear more quickly and more frequently). Consequently, the effects of size and perhaps species must be included in calculations of removal bias for a study. In controlled studies where a known number of carcasses were placed in the field showed that many carcasses were removed within a short period time, e.g. days; however, even small birds can persist in the field for long periods of time as they become desiccated and less preferred for scavenging.

Scavenger removal bias is site-specific and needs to be determined when the mortality monitoring is taking place rather than extrapolating it from other locations, seasons, or studies (Bevanger 1999). Scavengers can quickly learn where carcasses or injured birds are readily available, suggesting the need to update these bias correction factors throughout the study, as needed, to account for learning behavior.

Habitat Differences Bias

Habitat bias is used to account for unsearchable areas. Some portions of a study area may not be searchable because of water, bogs, dense vegetation, or topography. Researchers should not extrapolate beyond the area sampled because the rate of collision may vary with habitat type. Habitat bias should be used only in situations where unsearchable habitat is finely interspersed with searchable habitat and where researchers can demonstrate that the numbers of birds found in searchable and unsearchable habitats are similar.

THIS PAGE INTENTIONALLY LEFT BLANK



APPENDIX C

Glossary

adult
A bird that has acquired its final plumage.

aspect ratio
Aspect ratio is the wing breadth divided by wing length. A low aspect ratio generally correlates with relatively thin wings and high aspect ratio with relatively wide wings.

avian-safe
A power pole configuration designed to minimize avian electrocution risk.

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

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.

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 (AC, DC, and shield); a material that offers little resistance to the flow of electricity.

conductor gallop
Also known as galloping. The high-amplitude, low-frequency oscillation of overhead power lines often due to wind. The movement of the wires occurs most commonly in the vertical plane, although horizontal or rotational motion is also possible. Galloping can cause power lines to slap together, which results in outages and damage to the lines and equipment. Icing conditions, wind velocity, and conductor tension are some of the factors that interact to cause galloping.

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.

conspecific
Members of the same species.

corona
A process by which current in a conductor with a high potential ionizes the air surrounding it to create a plasma. The ions generated eventually pass charge to nearby areas of lower potential or recombine to form neutral gas molecules.

corridor
The broad area between the origin and termination of a new line, within which the potential routes lie. The area in which a new line's routing alternatives are proposed and evaluated before the final route is determined.

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. Usually made of wood, fiberglass, or steel, and manufactured in various lengths.

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

distribution line
Lower-voltage wires, energized at voltages from 2.4 kV to 60 kV, and used to distribute electricity to residential, industrial, and commercial customers, i.e., end users.

facility
As used in this manual, this term refers to all the equipment, wires, structures (e.g., poles and towers), etc., that are involved in carrying 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 collisions/electrocutions, or equipment failures. Also known as arc, short circuit, or flash.

flappers
Suspended collision reduction devices that clamp to and hang from a line and swing and spin in the wind. There are variations on this theme that have little or no motion, which are used when high winds cause moving parts to wear rapidly.

flaring
A sudden panic avoidance reaction to power lines, in which birds ascend almost vertically with rapid wing beats or fold their wings and fall down and backwards away from the obstacle.

fledgling
A bird that has recently learned to fly and left the nest, but may still be dependent on its parents for food.

ground
Material that conducts electricity and 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 the necessary parts of a facility can be physically connected to ground potential.

grounding conductor
A conductor used to ground the shield and neutral wires. Grounding conductors may be copper-clad, solid copper, or stranded galvanized wires and are attached to the structure. Sometimes also called a down wire. When steel structures are used the structure becomes the grounding conductor.

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.

immature
All plumages other than adult.

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

Kilovolt (kV)
1,000 volts

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. A day with one or more lightning storms would be classified as a lightning day.

maneuvering
Any change in flight behavior, height, or direction, and in this context, in response to obstacles such as power lines.

necropsy
Postmortem examination of wildlife often used to determine cause of death.

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

neutral wire
A non-energized conductor that carries the primary current back to its substation. The neutral is at ground potential (i.e., it grounds a distribution power line system).

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

overhead ground wire
See **shield wire**.

phase conductor
An energized power line that carries alternating current electricity.

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

pole

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

2. DC transmission lines use bundled conductors also known as poles, which refers to the positively and negatively charged conductors in a DC design.

power generation facility

The location where electricity is generated, which may be a power plant, station, wind turbines, solar farm, or hydro-electric dam, among others.

power line

A line made of conductive material that transmits electricity from its source to its point of use.

ramping

A contemplated maneuver frequently seen in wading birds approaching a power line at or below conductor levels. During their approach waders swerve and continue parallel to the power line until sufficient altitude is reached for crossing. Ramping is most frequently observed on clear days with moderate winds and apparently allows birds to assess and negotiate the power line before crossing.

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.

rebuild

The act of upgrading an existing line by replacing its wires and/or structures.

reliability

The percentage of time a line is delivering uninterrupted electricity.

reroute

The act of removing an existing line from the original right-of-way and rebuilding it along another route that will avoid the interactions encountered in the original route.

retrofit

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

right-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. The width of right-of-way required by each voltage level is generally dictated by state statutes and the National Electrical Safety Code (NESC) and is a function of span length, the conductor height above ground, and the conductor's low point of sag.

route

The pathway on which a right-of-way will be cleared and the new line constructed.

sailing

Crossing of conductors and shield wires with wings set. Most frequently seen in birds flying through or close to the conductor-shield wire complex.

separation
The physical distance between energized conductors or between energized and non-energized conductors.

shield wire
Also called static wire or overhead ground wire. A conductor that provides a path to ground for static electricity. Lightning is its most common source of static electricity. Since lightning follows pathways to ground, the shield wire protects phase (AC) and pole (DC) conductors from lightning strikes.

shortstopping
Wintering in more northerly latitudes than has been historic for the species.

siting
The process of identifying the points in the electrical system that need new lines of connection to deliver electricity to growing or new demand centers.

span
The pole-to-pole or tower-to-tower distance of a power line.

static wire
See **shield wire**.

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

subadult
Stage of a bird between juvenile and adult.

substation
A transitional point (where voltage is increased or decreased) in transmission and distribution systems.

transmission line
Power line that delivers electricity from its source over long distances to substations where the voltage is reduced for distribution. Transmission voltages range from 60 to 765 kV in the United States.

trust resource
Wildlife 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 can be expressed in volts. Power lines are rated and categorized by voltage.

voltage rating

The voltage rating of a transmission line depends on the utility's existing transmission system voltages, interconnections with other utilities, potential delivery points, and the amount of power that must be transmitted to meet load requirements. As voltages increase, the amount of power that can be transmitted increases. Various line-design parameters such as conductor size and configuration, spacing, and the number of conductors per phase (bundling) allow for increased transmission capability. Transmission voltages for carrying energy long distances are generally in the 115- to 765-kV range in North America.

wing loading

Wing loading is a bird's mass divided by its wing surface area. High wing loading describes a bird that is heavy relative to its wing area. Low wing loading describes a bird that is light relative to its wing area.



APPENDIX D

Acronyms

AC	Alternating Current
ACP	Advanced Conservation Practice
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
AWBP	Aransas-Wood Buffalo Population (whooping cranes)
BAMS	Bird Activity Monitoring System
BFD	Bird-Flight™ Diverter
BGEPA	Bald and Golden Eagle Protection Act (United States)
BSI	Bird Strike Indicator
CAP	Citizens Advisory Panel
CEC	California Energy Commission
cm	centimeter
CFR	Code of Federal Regulations (United States)
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DC	Direct Current
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute
ESA	Endangered Species Act (United States)
FAA	Federal Aviation Administration
ft	feet
GIS	Geographic Information Systems
GPS	Global Positioning System
HCP	Habitat Conservation Plan
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
in	inch
ITP	Incidental Take Permit
km	kilometer
kV	kilovolt
m	meter
mi	mile
MBCA	Migratory Birds Convention Act (Canada)
MBTA	Migratory Bird Treaty Act (United States)
MOU	Memorandum of Understanding
NESC	National Electrical Safety Code
NMFS	National Marine Fisheries Service (United States)
NRECA	National Rural Electric Cooperative Association
PVC	Polyvinyl Chloride
ROW	Right-of-Way (singular), Rights-of-Way (plural)
SARA	Species at Risk Act (Canada)
SFD	Swan-Flight™ Diverter
SVD	Spiral Vibration Damper

USEPA	U.S. Environmental Protection Agency	USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service	UV	Ultraviolet
		V	Volt



APPENDIX E

Resources

BIRD IDENTIFICATION AND NATURAL HISTORY

All About Birds
Cornell Lab of Ornithology
Includes bird identification information and bird songs.
www.allaboutbirds.org/Page.aspx?pid=1189

Birds of North America
Cornell Lab of Ornithology
Comprehensive reference covering the life histories of North America's breeding birds.
http://bna.birds.cornell.edu/bna

Tools for Learning About Birds
USGS Patuxent Wildlife Research Center
Includes bird pictures and songs.
www.mbr-pwrc.usgs.gov/bbs/ident.html

Bird Identification Pages
Idaho Museum of Natural History
Includes a visual key with silhouettes.
http://imnh.isu.edu/digitalatlas/bio/birds/main/birdid.htm

Florida Bird Sounds
Florida Museum of Natural History
www.flmnh.ufl.edu/birds/sounds.htm

BIRD DATABASES AND CONSERVATION INFORMATION

Migratory Bird Program
USFWS Division of Migratory Birds
Resources and regulations for the conservation and management of migratory birds.
www.fws.gov/migratorybirds

Migratory Bird Treaty Act (MBTA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/migtrea.html

Bald and Golden Eagle Protection Act (BGEPA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/baldegl.html

Endangered Species Act of 1973 (ESA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/esact.html

Endangered Species Consultation Handbook (1998)
USFWS and NMFS
Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act.
www.fws.gov/midwest/endangered/section7/index.html

North American Waterfowl Management Plan
USFWS Division of Bird Habitat Conservation
Includes waterfowl status reports.
www.fws.gov/birdhabitat/NAWMP/index.shtm

Bird Conservation Initiatives
U.S. Environmental Protection Agency
Portal to major United States bird conservation plans and organizations.
www.epa.gov/owow/birds/bird.html

Conservation Plans, Databases, Strategies, and Assessments
Partners in Flight—U.S.
www.partnersinflight.org

North American Landbird Conservation Plan (2004)
Partners in Flight
www.pwrc.usgs.gov/pif/cont_plan

U.S. Shorebird Conservation Plan (2001)
USFWS
www.fws.gov/shorebirdplan

North American Waterbird Conservation Plan (2002)
Waterbird Conservation for the Americas
www.pwrc.usgs.gov/nacwcp/nawcp.html

Migratory Birds (Canada)
Environment Canada
Conservation, monitoring and reporting, and regulations for Canadian migratory birds.
www.ec.gc.ca/nature/default.asp?lang=En&n=FDF836EF-1

Migratory Birds Convention Act and Regulations (Canada)
Environment Canada
Polices, regulations, and list of birds protected in Canada under the MBCA.
www.ec.gc.ca/nature/default.asp?lang=En&n=7CEBB77D-1

Species at Risk Public Registry (Canada)
Government of Canada
Information and regulations for at-risk species in Canada.
www.sararegistry.gc.ca/default_e.cfm

Committee on the Status of Endangered Wildlife in Canada
Committee of experts that assesses wildlife species in danger of disappearing.
www.cosewic.gc.ca/eng/sct5/index_e.cfm

North American Bird Conservation Initiative
Bird Studies Canada
Describes and maps the North American bird conservation regions.
www.bsc-eoc.org/nabci.html

Christmas Bird Counts
National Audubon Society
Annual "snapshot" of North American bird populations over many decades. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
http://birds.audubon.org/christmas-bird-count

eBird
Audubon and Cornell Lab of Ornithology
International database of bird observations with graphs and range maps. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
http://ebird.org/content/ebird

Avian Knowledge Network (AKN)
Downloadable version of the eBird reference dataset for the Western Hemisphere.
www.avianknowledge.net/content

National Biological Information Infrastructure: Bird Conservation
USGS Biological Informatics Program
Portal to maps, data, and bird conservation procedures for conservation of bird populations and their habitats in North America.
www.nbii.gov/portal/server.pt/community/bird_conservation/460

Ornithological Information System (ORNIS)
National Science Foundation
Data from collections of a network of museum and academic partners.
www.ornisnet.org

North American Breeding Bird Survey
U.S. Geological Survey
Data since 1966 on the status and trends of North American bird populations. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
www.pwrc.usgs.gov/BBS

Landbird Population Estimates Database
Partners in Flight/Rocky Mountain Bird Observatory
Based on the Breeding Bird Survey data of the 1990s.
www.rmbo.org/pif_db/laped/default.aspx

Raptor Information System
U.S. Geological Survey
Keyword catalog of over 32,000 references on the biology and management of raptors.
http://ris.wr.usgs.gov

BIRD/ENERGY PROGRAMS AND AVIAN PROTECTION PLANNING

Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006
Avian Power Line Interaction Committee
www.aplic.org/documents.php

Avian Protection Plan Guidelines 2005
Avian Power Line Interaction Committee and USFWS
www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf

Short Courses and Workshops on Avian-Power Line Interactions
Avian Power Line Interaction Committee
www.aplic.org (see Upcoming Events)

California Energy Commission
www.energy.ca.gov/index.html

On-Line Annotated Bibliography of Avian Interactions with Utility Structures
California Energy Commission
www.energy.ca.gov/research/environmental/avian_bibliography

Right-of-Way Siting, Vegetation Management, and Avian Issues—Program 57
Electric Power Research Institute
http://portfolio.epri.com/ProgramTab.aspx?sId=ENV&rId=134&pId=5117

Conserving Birds and Their Habitats on Department of Defense Lands
U.S. Department of Defense and Partners in Flight
Includes a variety of resources such as bird conservation maps and avian protection planning guidelines.
www.dodpif.org

Materials on Bird-Power Line Interactions for Electric Utilities and their Employees
New Mexico Avian Protection Working Group
http://nmavianprotection.org//resources.html

Wildlife and Energy Programme
Endangered Wildlife Trust
www.ewt.org.za/WHATWEDO/OurProgrammes/WildlifeEnergyProgramme.aspx

HIGH VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION SYSTEMS

Technology Information, Resource Library, and Student/Teacher Education
Clean Line Energy Partners
www.cleanlineenergy.com

AVIAN HEALTH, MORTALITY, AND CARCASS IDENTIFICATION

National Wildlife Health Center
U.S. Geological Survey
www.nwhc.usgs.gov

Field Manual of Wildlife Diseases, General Field Procedures and Diseases of Birds
U.S. Geological Survey
www.nwhc.usgs.gov/publications/field_manual

Wildlife Health Bulletin #06-02: Wild bird mortality reporting
U.S. Geological Survey
www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_06_02.jsp

Avian Necropsy Manual for Biologists in Remote Refuges
U.S. Geological Survey
http://www.nwhc.usgs.gov/publications/necropsy_manuals/index.jsp

Causes of Mortality in Common Loons
U.S. Geological Survey
www.nwhc.usgs.gov/publications/documents/92JCF.CLE01.pdf

Field Guide to Raptor Remains
California Energy Commission
www.energy.ca.gov/index.html

Wing and Tail Image Collection (Useful for Carcass Identification)
University of Puget Sound
www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/birds/wing-image-collection

PUBLIC PARTICIPATION RESOURCES

Introduction to Public Participation
Edison Electric Institute
Practical information for working with the public as a partner.
www2.eei.org/products_and_services/descriptions_and_access/intro_pub_partic.htm

Bird Education Network
Council for Environmental Education
Coalition developing a national strategy for bird education.
www.birdeducation.org

Flying Wild
Council for Environmental Education
Classroom bird education resources.
www.flyingwild.org

International Migratory Bird Day
Environment for the Americas
Annual event focusing on migratory birds of the Americas.
www.birdday.org

Project BEAK (Bird Education and Awareness for Kids)
Nebraska Partnership for All-Bird Conservation, Nebraska Environmental Trust, Nebraska Game and Fish Commission, U.S. Environmental Protection Agency
Exemplary bird education program.
http://projectbeak.org

National Wildlife Refuge System
U.S. Fish and Wildlife Service
552 refuges, many of which focus on bird conservation and public outreach.
www.fws.gov/refuges

FUNDING ORGANIZATIONS

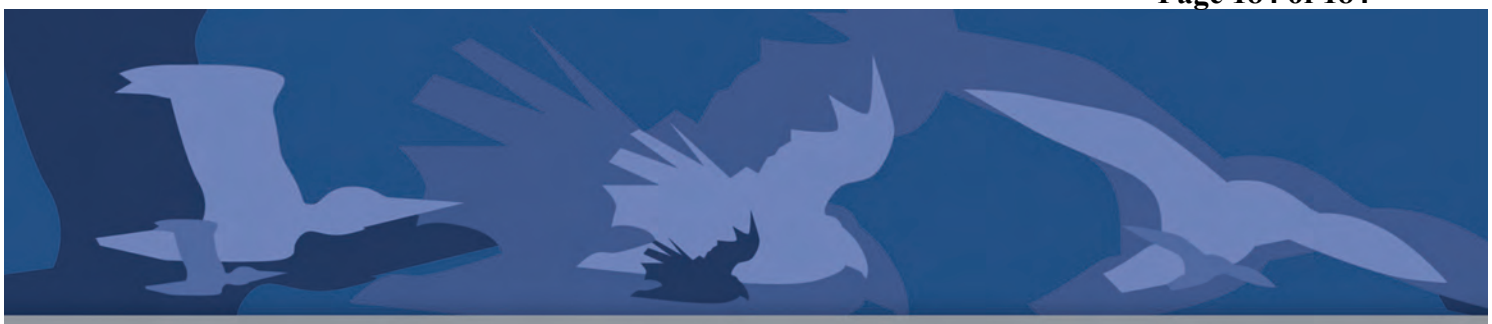
Avian Power Line Interaction Committee
APLIC funds research projects that further the knowledge of avian/power line interactions, including causes and solutions to avian mortalities due to power line electrocutions and collisions.
www.aplic.org/proposals.php

California Energy Commission
CEC funds various programs; see their website for a complete list.
www.energy.ca.gov/contracts/index.html

Electric Power Research Institute
EPRI funds research and development through competitive selection of contractors.
http://my.epri.com
(see About EPRI and Contractor Resources)

THIS PAGE INTENTIONALLY LEFT BLANK

THIS PAGE INTENTIONALLY LEFT BLANK



Edison Electric Institute
Power by Association℠

Avian Power Line Interaction Committee

Environmental Report

PNM Exhibit IE-4

Is contained in the following 263 pages.

Mid-State Transmission LLC

Mid-State Transmission Project

Environmental Report

September 2026

Document Distribution

Mid-State Transmission Project

Environmental Report

September 2026

Prepared for:

Mid-State Transmission LLC

Prepared by:

WSP USA Inc.
505 E Huntland Drive, Suite 250
Austin, Texas 78752
T +1 512-735-1868

Summary

Project Overview

On behalf of the Public Service Company of New Mexico, Mid-State Transmission LLC proposes to construct the Mid-State Transmission Project (Project), a new 345-kilovolt transmission line extending approximately 102.8 miles between the Western Spirit Switchyard in Torrance County and the Hidden Mountain Substation in Valencia County, New Mexico. The Project would provide additional transmission capacity to support the reliable delivery of electrical generation resources, strengthen regional grid reliability, and improve operational flexibility within the existing transmission system. The Project includes a new transmission line, associated access roads, optical ground wire, switchyard and substation improvements, and a new Fixed Series Compensation Station.

Environmental Review and Key Resources

The Transmission Study Corridor (0.5 mile on either side of the centerline) extends across approximately 66,000 acres of central New Mexico and traverses a diverse landscape that includes rangelands, grasslands, shrublands, pinyon-juniper woodlands, irrigated agricultural lands, the Rio Grande corridor, and developed areas near Los Lunas and Belen. The Transmission Study Corridor crosses portions of public lands administered by the Bureau of Land Management, United States Forest Service, New Mexico State Land Office, and the National Park Service, in addition to privately owned lands. Numerous natural and cultural resources occur within the corridor, including ephemeral stream systems, the Rio Grande, wildlife habitats, agricultural lands, archaeological sites, historic properties, scenic byways, and utility infrastructure.

This Environmental Report evaluates existing environmental conditions within the one-mile-wide Transmission Study Corridor and assesses the potential environmental effects of constructing, operating, and maintaining the Project within the proposed 200-foot-wide right-of-way resulting from construction and operation of the Project.

Resource areas evaluated include air quality, noise, geology and mineral resources, soils, paleontological resources, water resources, biological resources, cultural resources, visual resources, land use, socioeconomics, communication systems, hazardous materials, safety, transportation infrastructure, and other environmental values identified by the New Mexico Public Regulation Commission and stakeholders.

Key Environmental Effects

Potential environmental effects associated with the Project would occur primarily during construction and are expected to be temporary and localized. Construction activities would result in vegetation disturbance, soil disruption, temporary increases in noise and dust, localized effects on wildlife habitat, and temporary impacts to land use and transportation activities. Long-term impacts would primarily consist of limited habitat conversion associated with access roads and structure locations and visual changes to portions of the landscape. The Project has been designed to avoid and minimize impacts where practicable through route selection, micrositing of facilities, co-location with existing transmission facilities, use of existing disturbed corridors, and implementation of Project-specific protection measures.

Avoidance, Minimization, and Protection Measures

The Project has committed to implementing a comprehensive suite of protection measures and best management practices during construction and operation of the Project. These measures include but are not limited to erosion and sediment control practices, stormwater management, habitat avoidance buffers, migratory bird protection measures, cultural resource avoidance and discovery protocols, revegetation and reclamation requirements, hazardous material management procedures, wildfire prevention measures, and coordination with applicable federal, state, tribal, and local agencies. Project-specific surveys, permitting, and environmental compliance programs would further reduce potential impacts to sensitive resources.

Conclusions

Based on the analyses presented in this Environmental Report, implementation of the Mid-State Transmission Project, together with the Project's committed protection measures and applicable permit requirements, is not expected to result in undue environmental impacts. While some unavoidable environmental effects may occur, those effects are generally anticipated to be temporary, localized, and capable of being avoided, minimized, or mitigated through established engineering, environmental, and operational practices.

The Project would provide substantial electric reliability and transmission system benefits while minimizing environmental impacts through careful planning, design, and implementation of protection measures.

Table of Contents

Abbreviations ..... **xi**

1. Introduction **1**

1.1 Background 1
1.2 Proposed Project 1
1.3 Purpose and Need 3
1.4 Alternatives Considered 3
1.4.1 No-Action Alternative 3
1.4.2 Proposed Transmission Project Alternative 4

2. Project Description **5**

2.1 Transmission Structures 5
2.2 Conductors and Associated Hardware 5
2.3 Optical Ground Wire 6
2.4 Power System Facilities 6
2.5 Access Roads 6
2.6 Laydown / Material Staging Areas 7
2.7 Right-of-Way and Easements 7
2.8 Construction Activities 7
2.8.1 Sequence of Activities 8
2.8.2 Surveying 8
2.8.3 Drainage and Stormwater Management 8
2.8.4 Access Road Construction 9
2.8.5 Transmission Structure Foundations 10
2.8.6 Structure Framing and Assembly 10
2.8.7 Conductor and OPGW Installation 11
2.8.8 Helicopter Use 11
2.8.9 Decommissioning Existing Infrastructure 12
2.8.10 Power System Facilities 12
2.8.11 Construction Waste Disposal 12
2.8.12 Site Reclamation 13
2.8.13 Typical Construction Equipment 13
2.9 Operation and Maintenance 15

3. Affected Environment for the Transmission Study Corridor **17**

3.1 Introduction 17

3.2 Air Resources 17
3.2.1 Data Sources 17
3.2.2 Current Conditions and Trends, Regional Overview 17
3.3 Noise 18
3.3.1 Data Sources 18
3.3.2 Current Conditions and Trends, Regional Overview 18
3.4 Geology and Mineral Resources 19
3.4.1 Data Sources 19
3.4.2 Current Conditions and Trends, Regional Overview 20
3.5 Soil Resources 22
3.5.1 Data Sources 22
3.5.2 Current Conditions and Trends, Regional Overview 22
3.6 Paleontological Resources 23
3.6.1 Data Sources 23
3.6.2 Current Conditions and Trends, Regional Overview 24
3.7 Water Resources 28
3.7.1 Data Sources 28
3.7.2 Current Conditions and Trends, Regional Overview 28
3.8 Flora and Fauna 31
3.8.1 Data Sources 31
3.8.2 Current Conditions and Trends, Regional Overview 34
3.9 Archaeological and Historic-Age Cultural Resources 46
3.9.1 Data Sources 46
3.9.2 Current Conditions and Trends, Regional Overview 47
3.10 Religious and Cemetery Sites 51
3.10.1 Data Sources 51
3.10.2 Current Conditions and Trends, Regional Overview 51
3.11 Visual and Scenic Resources 52
3.11.1 Data Sources 52
3.11.2 Current Conditions and Trends, Regional Overview 53
3.12 Land Use, Including Farm, Range, and Recreational Resources 55
3.12.1 Data Sources 55
3.12.2 Current Conditions and Trends, Regional Overview 57
3.13 Socioeconomics 60
3.13.1 Data Sources 60
3.13.2 Current Conditions and Trends, Regional Overview 60
3.14 Communication Signals 68
3.14.1 Data Sources 68
3.14.2 Current Conditions and Trends, Regional Overview 68

3.15 Radioactive Waste and Radiation Hazards....69
3.15.1 Data Sources....69
3.15.2 Current Conditions and Trends, Regional Overview....69
3.16 Hazardous Materials....70
3.16.1 Data Sources....70
3.16.2 Current Conditions and Trends, Regional Overview....70
3.17 Safety....71
3.18 Geographic Resources....71
3.18.1 Data Sources....71
3.18.2 Current Conditions and Trends, Regional Overview....72
3.19 Military Activities and Aviation....73
3.19.1 Data Sources....73
3.19.2 Current Conditions and Trends, Regional Overview....73
3.20 Roads....73
3.20.1 Data Sources....73
3.20.2 Current Conditions and Trends, Regional Overview....74

4. Environmental Effects....75

4.1 Introduction....75
4.2 Cumulative Effects....76
4.3 Air Resources....76
4.3.1 Impacts Specific to the Project....77
4.3.2 Protection Measures....77
4.3.3 Conclusion....78
4.4 Noise....78
4.4.1 Impacts Specific to the Project....78
4.4.2 Protection Measures....79
4.4.3 Conclusion....79
4.5 Geology and Mineral Resources....79
4.5.1 Impacts Specific to the Project....80
4.5.2 Protection Measures....81
4.5.3 Conclusion....82
4.6 Soil Resources....82
4.6.1 Impacts Specific to the Project....83
4.6.2 Protection Measures....84
4.6.3 Conclusion....84
4.7 Paleontological Resources....85
4.7.1 Impacts Specific to the Project....85
4.7.2 Protection Measures....86
4.7.3 Conclusion....86

4.8 Water Resources....86
4.8.1 Impacts Specific to the Project....86
4.8.2 Protection Measures....89
4.8.3 Conclusion....89
4.9 Flora and Fauna....90
4.9.1 Impacts Specific to the Project....90
4.9.2 Protection Measures....95
4.9.3 Conclusion....96
4.10 Archaeological and Historic-Age Cultural Resources....96
4.10.1 Impacts Specific to the Project....96
4.10.2 Protection Measures....97
4.10.3 Conclusion....97
4.11 Religious and Cemetery Sites....97
4.11.1 Impacts Specific to the Project....97
4.11.2 Protection Measures....98
4.11.3 Conclusion....98
4.12 Visual and Scenic Resources....98
4.12.1 Impacts Specific to the Project....99
4.12.2 Protection Measures....99
4.12.3 Conclusion....100
4.13 Land Use, Including Farm, Range, and Recreational Resources....100
4.13.1 Impacts Specific to the Project....100
4.13.2 Protection Measures....102
4.13.3 Conclusion....102
4.14 Socioeconomics....103
4.14.1 Impacts Specific to the Project....103
4.14.2 Protection Measures....103
4.14.3 Conclusion....104
4.15 Communication Signals....104
4.15.1 Impacts Specific to the Project....104
4.15.2 Protection Measures....104
4.15.3 Conclusion....105
4.16 Radioactive Waste and Radiation Hazards....105
4.16.1 Impacts Specific to the Project....105
4.17 Hazardous Materials....105
4.17.1 Impacts Specific to the Project....105
4.17.2 Protection Measures....106
4.17.3 Conclusion....107
4.18 Safety....107
4.18.1 Impacts Specific to the Project....107

4.18.2 Protection Measures 108
4.18.3 Conclusion 108
4.19 Geographic Resources 109
4.19.1 Impacts Specific to the Project 109
4.19.2 Protection Measures 110
4.19.3 Conclusion 110
4.20 Military Activities and Aviation 110
4.20.1 Impacts Specific to the Project 110
4.20.2 Protection Measures 110
4.20.3 Conclusion 111
4.21 Roads 111
4.21.1 Impacts Specific to the Project 111
4.21.2 Protection Measures 111
4.21.3 Conclusion 112

5. Consultation and Coordination 113

5.1 List of Preparers and Reviewers 113
5.1.1 Mid-State Transmission Project Companies 113
5.1.2 WSP USA Inc. 113
5.2 Technical Reports Contributing to the Environmental Report 114

6. Literature Cited 115

List of Tables

Table 3-1 Socorro and Valencia Counties Vehicular Noise Levels 19
Table 3-2 Socorro and Valencia Counties Non-Vehicular Noise Levels 19
Table 3-3 Summary of Soil Resources in the Transmission Study Corridor 23
Table 3-4 Soil Coverage Types within the Transmission Study Corridor B-2
Table 3-5 Geology Units and Paleontological Sensitivity in Transmission Study Corridor and Project ROW 26
Table 3-6 Transmission Study Corridor Watersheds 29
Table 3-7 Transmission Study Corridor Wetlands based on NWI Data 30
Table 3-8 Wetland Probability Ranking for the Transmission Study Corridor 31
Table 3-9 GAP Land Cover within the Transmission Study Corridor 35
Table 3-10 Field Verified Habitat within the 300-foot survey corridor. 35
Table 3-11 Federally Listed Species with potential to occur in the Transmission Study Corridor 37
Table 3-12 State-listed Species with potential to occur in the Transmission Study Corridor 39

Table 3-13 USFS-listed Sensitive Species with the Potential to Occur within the Transmission Study Corridor B-7
Table 3-14 BLM-listed sensitive species with the potential to occur in the Transmission Study Corridor B-11
Table 3-15 Migratory Birds with the Potential to Occur in the Transmission Study Corridor 41
Table 3-16 Archaeological Resources within Transmission Study Corridor B-15
Table 3-17 Historic Cultural Properties Inventory Resources within Transmission Study Corridor 48
Table 3-18 Religious Sites within the Transmission Study Corridor 51
Table 3-19 Cemeteries within the Transmission Study Corridor 52
Table 3-20 National Land Cover Database Summary for the Transmission Study Corridor 57
Table 3-21 Population Profile (by County) 62
Table 3-22 Population Profile (by Census Block Group) 62
Table 3-23 Socioeconomic Profile (by County) 63
Table 3-24 2022 USDA Agricultural Profile for Torrance, Socorro and Valencia Counties 65
Table 3-25 Industry Profile – Employment by Industry (2010-2022) 66
Table 3-26 Industry Profile – Labor Earnings by Industry (2010-2022) 66
Table 3-27 Housing Characteristics 67
Table 3-28 County Profile – Gross Receipts 68
Table 3-29 County Profile – 2020 Largest Economic Sectors (Top 3 Gross Receipts by NAICS Code) 68
Table 3-30 Signaling Structures within the Transmission Study Corridor 69

List of Appendices

Appendix A - Exhibits

Exhibit 1 Project Overview Map
Exhibit 2 Geologic Resources Map
Exhibit 3 Oil & Gas Resources Map
Exhibit 4 Mineral Resources Map
Exhibit 5 Soil Resources Map
Exhibit 6 Paleontological Resources Map
Exhibit 7 Paleontological Fossil Yield Classification Map
Exhibit 8 Ecoregions Map
Exhibit 9 Surface Waters Map
Exhibit 10 Flood Zone Map
Exhibit 11 National Wetland Inventory Map
Exhibit 12 Sensitive Habitat Map

Exhibit 13 GAP Analysis Map
Exhibit 14 Field Verified Habitat Map
Exhibit 15 Religious Sites and Cemeteries Map
Exhibit 16 Public Lands and Easements Map
Exhibit 17 Elevation Map
Exhibit 18 Visual Resources Map
Exhibit 19 Land Cover Map
Exhibit 20 State-Owned Lands Map
Exhibit 21 American Indian Areas Map
Exhibit 22 Communications Map
Exhibit 23 Public Land Survey System (PLSS) Map
Exhibit 24 Public Facilities Map
Exhibit 25 Visual Flight Rules Map

Appendix B - Oversized Tables

Table 3-4 Soil Coverage Types within the Transmission Study Corridor
Table 3-13 USFS-listed Sensitive Species with the Potential to Occur in the Transmission Study Corridor
Table 3-14 BLM-listed Sensitive Species with the Potential to Occur in the Transmission Study Corridor
Table 3-16 Archaeological Resources within Transmission Study Corridor

Appendix C - Permit Matrix

Appendix D - Sandhill Crane Collision Risk Assessment

Abbreviations

Abbreviation	Description
ACSR	aluminum conductor steel-reinforced
ACSS	aluminum conductor steel-supported
APLIC	Avian Power Line Interaction Committee
ATSF	Atchison, Topeka and Santa Fe
BISON-M	Biota Information System of New Mexico
BLM	Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
CO	carbon monoxide
Commission	New Mexico Public Regulation Commission
DOE	United States Department of Energy
ER	Environmental Report
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FCS	Fixed Series Compensation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FUSRAP	Formerly Utilized Sites Remedial Action Program
GIS	geographic integration systems
HCPI	Historic Cultural Properties Inventory
I-	Interstate
IPaC	Information for Planning and Consultation
IUCN	International Union for Conservation of Nature
kcmil	thousand circular mil
kV	kilovolt
LA	Laboratory of Anthropology
LandCAN	Land Conservation Assistance Network
MBTA	Migratory Bird Treaty Act
MLTS	Material Licensing Tracking System
MRLC	Multi-Resolution Land Characteristics Consortium
MW	megawatts

Abbreviation	Description
NAIP	National Agriculture Imagery Program
NESC	National Electrical Safety Code
NHD	National Hydrography Dataset
NLCD	National Land Cover Database
NMAC	New Mexico Administrative Code
NMCRIS	New Mexico Cultural Resources Information System
NMDGF	New Mexico Department of Game and Fish
NMDOT	New Mexico Department of Transportation
NMEMNRD	New Mexico Energy, Minerals, and Natural Resources Department
NM MMD	New Mexico Mining and Minerals Division
NM OCD	New Mexico Oil Conservation Division
NMRPTC	New Mexico Rare Plant Technical Council
NMSA 1978	New Mexico Statutes Annotated 1978
NMSLO	New Mexico State Land Office
NMTRD	New Mexico Taxation & Revenue Department
NO_2	nitrogen dioxide
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
O&M	Operation and maintenance
O_3	ozone
OPGW	Fiber optic ground wire
Pb	lead
pCi/l	picocurie per liter
PFYC	Potential Fossil Yield Classification
PLJV	Playa Lakes Joint Venture
$PM_{2.5}$ and PM_{10}	particulate matter pollution
PNM	Public Service Company of New Mexico
Project	Mid-State Transmission Project
RADINFO	Radiation Information Database
ROW	right-of-way
SH	State Highway
SHPO	State Historic Preservation Office

Abbreviation	Description
SIO	Scenic Integrity Objective
SO_2	sulfur dioxide
SPCC	Spill Prevention, Control, and Countermeasure
Staff	Commission Staff
SWPPP	Stormwater Pollution Prevention Plan
UDP	Unanticipated Discoveries Plan
UMTRA	Uranium Mill Tailings Remedial Action
USACE	United States Army Corps of Engineers
USCB	United States Census Bureau
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
US Hwy	United States Highway
WOTUS	waters of the United States

1. Introduction

On behalf of the Public Service Company of New Mexico (PNM), Mid-State Transmission LLC is developing and intends to construct the “Mid-State Transmission Project” (Project) a 345-kilovolt (kV), high-voltage transmission line to be located in Torrance, Socorro, and Valencia Counties, New Mexico.

The New Mexico location control statute, New Mexico Statutes Annotated 1978, Section 62-9-3, Subsection F (NMSA 1978 §62-9-3.F), provides that the New Mexico Public Regulation Commission (Commission) shall approve the location of any transmission line of 230 kV or greater associated with a large-capacity power plant capable of 300 megawatts (MW) or more of generation unless the Commission finds that the location would unduly impair important environmental values. This Environmental Report (ER) responds to the requirement of the Commission for a report, in the form provided in Code of Federal Regulations, Title 40, Section 1502.10, as outlined in New Mexico Administrative Code (NMAC) (17.9.592.10 (E)).

Further, this ER addresses the environmental resource categories identified by the Commission in 17.9.592 New Mexico Administrative Code (NMAC), as well as other issues identified by Commission Staff (Staff), applicable stakeholders, and the Project.

1.1 Background

The Project would serve as a system upgrade to the existing PNM transmission system within New Mexico and would allow for optimal delivery of up to 800 MW of new generation resources. This ER includes location analysis of the proposed 102.8-mile transmission line within a one-mile-wide “Transmission Study Corridor” (0.5 mile on either side of the centerline), encompassing approximately 66,000 acres. The Transmission Study Corridor traverses a mix of federal, state, and privately-owned lands, including approximately 1,625 acres of federal land, 10,340 acres of state land, and 53,815 acres of privately owned land. Construction is anticipated to start in Q4 2027 with a proposed commercial operation date of Q4 2029.

1.2 Proposed Project

The Project would be located in Torrance, Socorro, and Valencia Counties, and would consist of a new, 102.8-mile (542,608.7linear feet), 345-kV transmission line connecting the existing Western Spirit Switchyard (Torrance County) and the existing Hidden Mountain Substation (Valencia County). The Project would be located within the Transmission Study Corridor analyzed in this ER. The Project would traverse approximately 2.1 miles of United States Forest Service (USFS) land, 16.5 miles of New Mexico State Land Office (NMSLO) land, 0.3 miles of New Mexico Department of Game and Fish (NMDGF) land, 0.3 miles of Middle Rio Grande

Conservancy District (MRGCD) land, 0.1 miles of New Mexico Department of Transportation (NMDOT) land, and 83.4 miles of privately owned property. In addition, the Project would include an aerial crossing of approximately 0.02 miles over land administered by the Bureau of Land Management (BLM). No Project facilities or ground-disturbing activities are proposed on BLM-administered lands.

Exhibit 1 in Appendix A provides a geographic overview of the Project vicinity.

The Project would be constructed in two primary configurations:

- To the extent practicable, the Project would be constructed by rebuilding portions of the existing PNM WL 115-kV transmission line that connects the existing Willard and Los Morros substations. These portions would expand the existing WL 115-kV right-of-way (ROW) to accommodate the additional infrastructure and result in a shared ROW and new, shared structures for the new Mid-State Transmission 345-kV and the existing WL 115-kV circuit.
- Where co-location of the Project with the WL 115-kV is not practicable given engineering, environmental, land use, construction, cost, or other constraints, the Project would be constructed as a new, stand-alone 345-kV transmission line and ROW.

For the purposes of this ER, a maximum ROW width of 200 feet has been assumed for the impact analysis (hereby referred to as the Project ROW). The actual permanent ROW may be narrower in some locations along the proposed alignment to accommodate site-specific engineering requirements, existing infrastructure, land ownership, terrain, and environmental constraints. Accordingly, the Project would utilize a variable-width ROW where appropriate rather than a uniform corridor width. For portions of the Project co-located with the existing WL 115-kV transmission line, the ROW would be configured to accommodate both facilities within a single, shared corridor. The 200-foot ROW represents the maximum anticipated permanent ROW and serves as the conservative (“worst-case”) assumption for evaluating potential environmental impacts.

This ER provides a review of the existing environment within the Transmission Study Corridor and analyzes the potential environmental impacts within the Project ROW resulting from construction and operation of the Project. The affected environment (existing condition) for the environmental values provided in NMSA 1978 § 62-9-3.M, Commission Rule 17.9.592 NMAC, and additional resource areas identified to be of interest by Staff, applicable stakeholders, and the Project are evaluated in this ER. The resources addressed in this ER include: air quality; noise levels; geology and mineral resources; soils; paleontological resources; water resources; flora and fauna (biological resources); cultural, historic, and archaeological resources; religious resources, including cemeteries; visual resources and scenic areas; land use (including farm, range, and recreational use); socioeconomic conditions; communication signals; radioactive waste and radiation hazards; hazardous materials; safety; geographic resources (access to infrastructure); military activities and aviation; and roads.

The discussion of each resource includes data sources used, regional baseline conditions, and existing conditions within the Transmission Study Corridor, a one-mile-wide corridor encompassing approximately 66,000 acres along the total length of the Project. The environmental consequences (potential impacts) for the resources identified above were evaluated to determine whether the proposed Project within the 200-foot ROW would "unduly impair important environmental values," as stated in NMSA 1978 § 62-9-3.F. Impact analyses for each resource are discussed in the context of the Project alongside typical construction practices and specific protection measures that the Project has committed to implement.

1.3 Purpose and Need

The Project is essential for integrating new generation resources located in eastern New Mexico into the existing PNM grid, enabling delivery to the Albuquerque area. The Project would facilitate the efficient utilization of current transmission and generation assets while enhancing overall system reliability.

1.4 Alternatives Considered

The Project is proposing to construct the Project, consisting of a new 345-kV transmission line that would connect to the existing electric grid. The final locations of Project facilities within the Transmission Study Corridor would be determined based on several factors, including landowner coordination; geographic features; environmental constraints; and micrositing of transmission structures. To the extent practicable, the Project would implement measures to reduce potential impacts to important environmental resources from the Project.

1.4.1 No-Action Alternative

Under the No-Action Alternative, the Project would not be constructed, and the potential environmental impacts associated with the Project would not occur. However, selection of the No-Action Alternative would not meet the purpose and need of the Project and would limit the Project's ability to develop and support sufficient power reliability for customers in the region. Furthermore, the benefits of the Project, including enhanced grid reliability and resilience, increased employment, secondary spending, and increased tax revenues, would not be realized under the No-Action Alternative. If the Project is not constructed, similar transmission and power infrastructure would be expected to be developed in the same region to meet the demand for additional power supply to end users. As a result, the environmental impacts and benefits associated with meeting this purpose and need would likely be shifted to alternative projects and delayed in time rather than avoided altogether. Additionally, such projects may not incorporate the same comprehensive protection measures described herein.

1.4.2 Proposed Transmission Project Alternative

The Project would result in an action to construct, operate, and maintain a new 345-kV transmission line located within the region of the Transmission Study Corridor. It is anticipated that there would be 102.8 miles (542,608.7 feet) of 345-kV transmission line, along with access roads and other associated facilities, described further in Section 2.

2. Project Description

The Mid-State Transmission Project would include 102.8 miles of new and upgraded steel-pole transmission infrastructure between the Western Spirit Switchyard and Hidden Mountain Substation. The Project would consist of a new 345-kV transmission line, conductors, optical ground wire, switchyard expansions, a Fixed Series Compensation (FSC) Station, access roads, and temporary construction support facilities. Typical structure spans would range from approximately 600 feet to 1,200 feet, and the Project is anticipated to require approximately 750 structures. The following sections provide a description of the major Project components, supporting facilities, and associated infrastructure.

2.1 Transmission Structures

The proposed transmission structure types for the 345-kV transmission line would be steel monopole, two-pole H-frame, and/or three-pole angle structures. For portions of the Project to be co-located with the existing WL 115-kV, project structures would be designed to accommodate both the WL 115-kV and the Mid-State Transmission 345-kv circuits on the same structures. Most structures would be self-supporting; although guy wires may be used in some locations to provide additional support. Taller or larger structures may be required where longer spans are needed, such as at riparian areas or stream crossings. In areas where the line turns, the transmission line would be supported by three-pole angle structures or guyed structures. Typical structure heights would range from approximately 80 feet to 150 feet above existing ground surface, depending on terrain and the span length between adjacent structures. This range applies to tangent structures, which primarily support the line with minimal tension; dead-end structures, which carry line tension; and angle structures, which support changes in line direction and also carry tension.

In many locations, transmission structures would be directly embedded into the ground; however, drilled-pier concrete foundations would be used where geotechnical conditions require them. Transmission structure pole diameters would typically range from approximately three feet to five feet, depending on framing configuration and the angle to adjacent structures.

2.2 Conductors and Associated Hardware

The 345-kV transmission line would consist of three electrical phases, with each phase consisting of bundled conductors composed of two 1,272 thousand circular mils (kcmil) aluminum conductor steel-supported (ACSS) cables. Each conductor is approximately 1.2 inches in diameter. Minimum conductor height above ground surface for the 345-kV transmission line is 30.3 feet at 167 degrees Fahrenheit based on National Electrical Safety Code (NESC) and Special Protection System standards. At road crossings, minimum clearance

would typically increase to approximately 37.3 feet above ground surface. Similar sized aluminum conductor steel-reinforced cables or conductors may also be utilized.

2.3 Optical Ground Wire

Optical ground wire (OPGW) 72 core single mode fiber would be installed on top of each transmission structure for the entire length of the line. The OPGW serves a dual purpose; the internal fiber optic cable provides substation-to-substation communications and system control, while the outer steel core acts as a shield wire to protect the conductors from lightning strikes. The overall cable diameter would be approximately 0.55 inch.

2.4 Power System Facilities

The Project would include expansions of both the existing Western Spirit Switchyard and Hidden Mountain Substation, and construction of a new FSC Station. The substation and switchyard expansions would accommodate interconnection of the new 345-kV transmission line and would include installation of electrical equipment, foundations, control and protection systems, communications infrastructure, and associated support facilities. The FSC Station would be located approximately midway between the Western Spirit Switchyard and Hidden Mountain Substation, immediately adjacent to the Transmission Line, and would provide series compensation to enhance transmission system performance and power transfer capability. The FSC Station would occupy approximately four acres. Final facility layouts, equipment configurations, and ratings would be determined during detailed engineering and system studies.

2.5 Access Roads

The Project would use existing roads and overland travel routes where practicable to reduce the need for new access routes and minimize surface disturbance. New temporary or permanent access roads, including short spur roads, may be needed to reach transmission structure locations within the ROW. Portions of existing roads outside the proposed ROW may also require improvements, and additional temporary or permanent access may be developed as needed to support construction, operation, and maintenance of the Project.

Permanent access roads would be retained only where needed for long-term Project operation and maintenance and may include existing roads, improved roads, or newly constructed roads, depending on site-specific requirements.

New access not needed for long-term Project operation and maintenance would be coordinated with the affected landowner. Existing and newly installed gates would be closed and/or locked consistent with landowner agreements. Access roads on private property may be maintained with landowner consent.

2.6 Laydown / Material Staging Areas

Temporary laydown and material staging areas would be needed during Project construction to store equipment and materials and to support structure assembly. These areas would be located on existing disturbed lands or other suitable private property along the Project ROW. Laydown areas would be used for material and equipment storage prior to transport to structure sites, vehicle parking, and, where necessary, placement of portable construction trailers. Prior to use, each area would be assessed for potential environmental constraints. If sensitive resources are identified, the location would be adjusted or designed to avoid impacts. Following construction, all staging and laydown areas would be reclaimed and revegetated. Potential impacts and mitigation measures associated with the micrositing of staging areas, as well as ground-disturbing activities, are discussed further in Section 4.0 (Environmental Effects).

2.7 Right-of-Way and Easements

As outlined in Section 1.2, for the purposes of this ER, a maximum ROW width of 200 feet has been assumed for the environmental effects analysis (Section 4.0). The permanent ROW may vary along the alignment to accommodate site-specific engineering requirements, existing infrastructure, land ownership, terrain, and environmental constraints. In areas where the proposed 345-kV transmission line is co-located with the existing WL 115-kV transmission line, the final 200 ft ROW for the Project would include the current 50 ft ROW for the WL 115-kV, with both circuits sharing the same, new structures.. The ROW would accommodate the anticipated transmission structure types, span lengths, and heights for the transmission line; provide compliance with applicable electrical safety codes; provide adequate logistical space for construction, operations, and maintenance of the line; and provide sufficient flexibility for siting structures within the ROW. Final design would determine specific structure locations and characteristics.

Easements or leases from private landowners, and agencies such as the BLM, USFS, the NMSLO, New Mexico Department of Game and Fish, and Middle Rio Grande Conservancy District may be required for the transmission line ROW, temporary work areas, and temporary access roads. Some upgrades to existing public roads may be necessary to support delivery of equipment and would be negotiated through the appropriate county agencies and administrative departments, as applicable.

2.8 Construction Activities

The Project would be constructed, operated, and maintained using standard engineering, construction, and operational practices commonly employed for other high-voltage transmission projects throughout the western United States. Construction of the Project is expected to take approximately 18 to 24 months, beginning in Q4 2027. The commercial operation date of the Project is expected to occur by Q4 2029.

2.8.1 Sequence of Activities

The construction of the Project is expected to proceed in the following sequence:

1. Surveying and staking of new structure locations.
2. Clearing and preparation of laydown/materials staging and work areas, as needed.
3. Construction or improvement of access roads, where necessary.
4. Distribution of materials along the transmission centerline.
5. Installation of structure foundations or direct embedment of poles.
6. Assembly/installation of transmission structures.
7. Installation of conductors and communication lines.
8. Decommissioning and removal of existing WL 115-kV facilities within co-located rebuild segments.
9. Site cleanup, reclamation, and reseeding.

Construction activities may occur concurrently at multiple locations along the Project alignment, requiring several construction crews to operate simultaneously.

2.8.2 Surveying

Construction-related survey activities for the Project would include evaluation of soil and geotechnical conditions to support foundation design, identification of final transmission structure locations, delineation of ROW and work area boundaries, establishment of access routes, and flagging and/or staking of avoidance areas and other construction constraints, as necessary.

2.8.3 Drainage and Stormwater Management

Construction activities would be conducted in accordance with applicable federal, state, and local stormwater management requirements. Where Project construction results in the disturbance of one acre or more, the Project would obtain coverage under the applicable National Pollutant Discharge Elimination System (NPDES) Construction General Permit prior to the initiation of construction. A Stormwater Pollution Prevention Plan (SWPPP) would be prepared and implemented to identify potential pollutant sources and establish best management practices (BMPs) to minimize erosion, sedimentation, and stormwater runoff associated with construction activities.

Appropriate erosion and sediment controls would be installed prior to land-disturbing activities. BMPs would be maintained (or repaired and replaced as necessary) throughout construction until permanent vegetative cover or another form of site stabilization has been established.

BMPs installed prior to land-disturbing activities may include but are not limited to: perimeter and downgradient sediment controls such as silt fence and fiber logs; slope stabilization controls; ditch checks; culvert extensions as necessary for turning radii, temporary intersections, and crane walks; and construction mats to facilitate access across sensitive resources.

Additional BMPs to be utilized prior to or during construction activities may include, but are not limited to: segregation of topsoil and subsoil; stockpiling and temporary stabilization of spoils or loose soil; repair or cleanout of existing culverts to accommodate construction-related discharge volume and flow; use of dewatering bags or other settling mechanisms for groundwater pumping or stormwater diversion; use of concrete washout basins; construction entrances/exits to public roads; proper replacement of soil and decompaction of topsoil following construction; seeding of disturbed areas to establish temporary or permanent vegetation cover; application of mulch; and installation of erosion-control blankets.

For any construction work area, temporary stabilization would be implemented prior to any planned pause in activities spanning 14 days or longer, including seasonal work stoppages. Temporary stabilization measures may include installation of erosion and sediment controls, temporary seeding, mulch application, soil stabilization products, runoff control features, and other BMPs appropriate for site conditions. Upon completion of construction, temporary construction work areas, staging areas, and laydown areas would be reclaimed and restored to conditions compatible with surrounding land uses.

2.8.4 Access Road Construction

Portions of the Project would be near public roads. Where practicable, existing overland disturbances, including two-track roads, trails, and other previously disturbed routes, would be used to access the ROW and limit the need for new routes. Where existing access is unavailable, overland drive-and-crush travel may be used, where practicable, to reduce surface disturbance and avoid new road construction. Temporary access roads or overland travel may be needed for construction equipment to reach transmission structure locations. Construction may require localized vegetation clearing, mowing, or crushing. Where recontouring is unnecessary, disturbance would generally be limited to overland travel, where feasible, to minimize changes to existing contours. Large rocks and vegetation may be temporarily moved to allow vehicle and equipment access.

Where practicable, new temporary roads and cross-country routes would follow existing topography and landform contours. Temporary access roads no longer needed after construction would be reclaimed and revegetated. Where substantial ground disturbance occurs, reclamation may include loosening compacted soils, reseeding with native species or approved seed mixes, installing erosion-control features such as water bars or cross drains, and restoring temporary ditches or swales as needed to reestablish drainage and stabilize the site.

Access road construction equipment would include hand tools, bulldozers, and graders. Specific BMPs would be implemented to reduce construction impacts. For example, access roads would

be located and constructed to cross streams at or near right angles, where practicable, to minimize crossing length and potential impacts. Existing public roads would be used to the extent possible, appropriately sized culverts would be installed where needed, and dust-control measures would be implemented during construction, as required. Standard erosion-control techniques, including water bars and dips, would be used on slopes. Additional measures would reduce rutting and soil compaction in sensitive areas and during periods when soils are particularly susceptible to damage.

Public road use, road crossings, and required roadway improvements would be coordinated with the New Mexico Department of Transportation (NMDOT) and applicable county road and public works departments. Access locations and roadway crossing designs would be developed during final engineering and permitting and would comply with applicable agency requirements and safety standards. Final engineering would determine the location and design of specific road crossings and related improvements (see Section 4.21 for additional discussion of potential roadway impacts and protection measures).

2.8.5 Transmission Structure Foundations

Excavations for foundations and structure holes would generally be completed using track mounted power auger equipment, a standard-sized backhoe, or large excavator. A truck-mounted power auger would be utilized for structure holes where soil and geotechnical conditions permit. Structure hole excavation and installation would require access for a power auger or drill, a crane, and material trucks. The foundation excavation and installation would require equipment access to the foundation sites.

Foundation excavations and structure holes temporarily left open or unguarded during construction would be covered and/or fenced, where practical, to protect the public, livestock, and wildlife. Soil removed from foundation excavations would be stockpiled within the structure work area and replaced or disposed of, in consultation with landowners.

2.8.6 Structure Framing and Assembly

Structural materials, including, but not limited to pole sections and framing, anchors, and guy wires and associated hardware, would be transported to each laydown/materials yard site by truck. Structures may be assembled off-site and transported to the appropriate pole locations by truck or helicopter. Insulator strings and stringing sheaves would be installed at each ground wire and conductor position while the pole is on the ground. Stringing sheaves (pulleys) would be used to guide the conductor during the stringing process for attachment onto the insulator strings. The assembled pole or tower would then be hoisted into place by a crane. Helicopter assisted construction may be utilized for portions of the line.

2.8.7 Conductor and OPGW Installation

Once structures are in place, a pilot line would be pulled (strung) from structure to structure and threaded through the stringing sheaves on each insulator. The pilot line would then be used to pull progressively larger and stronger lines, culminating in a pulling line capable of supporting the installation of the overhead ground wire and conductors. This process is repeated until the ground wire and conductor are pulled through all insulator sheaves.

Conductors would be strung using powered pulling equipment at one end and powered braking or tensioning equipment at the other end. To protect the public during wire installation, temporary guard structures would be erected over roadways, transmission and distribution lines, structures, and other obstacles. Guard structures would typically consist of H-frame poles temporarily placed on either side of an obstacle. These structures prevent ground wire, conductor, or equipment from falling on an obstacle. Augers, line trucks, pole trailers, and cranes would be used to install the guard structures. Guard structures may not be needed at minor road crossings where barriers, flaggers, or other traffic control measures would provide adequate protection.

For segments of the Project co-located with the existing WL 115-kV line, new 115-kV conductor would be installed on the Project structures following the methodology described above. The new 115-kV conductor would connect to the existing 115-kV conductor only at the start and end of co-located portions of the Project. The 115-kV conductor and structures currently existing in these co-located segments would be decommissioned, removed from site, and disposed of appropriately.

2.8.8 Helicopter Use

Access to each transmission structure location would be required to support construction activities. In areas where terrain, environmental constraints, or limited accessibility restrict the use of conventional ground-based equipment, helicopters may be used to facilitate construction activities and reduce the need for additional surface disturbance. Potential helicopter-supported construction activities may include:

- Transport of equipment and materials to transmission structure sites.
- Placement and installation of transmission structures and associated components.
- Installation of hardware and insulator assemblies.
- Wire and conductor stringing operations.

All helicopter operations would be conducted in compliance with applicable Federal Aviation Administration (FAA) requirements and coordinated as necessary to ensure safe and efficient Project construction.

2.8.9 Decommissioning Existing Infrastructure

Decommissioning of the existing WL 115-kV circuit in the rebuild areas would include the removal of Project-associated facilities and implementation of appropriate reclamation and restoration measures. The Project would take appropriate measures to restore disturbed areas to pre-existing conditions. Removal and restoration efforts would generally involve:

- **Tower foundations:** All foundations installed in the ground would be cleared, cleaned, and removed from the ground to at least four feet below the grade of the land affected. Holes or cavities created in the ground as a result of such removal would be filled with native material or topsoil of the same or similar type of material as that found at the site.
- **Tower direct embedment:** Direct-embedded structures would be removed by excavating around the pole until it can be safely extracted. Excavations would be approximately 8 feet in diameter and up to 10 feet deep, depending on the depth of embedment and site-specific conditions. Once the structure has been removed, the excavation would be backfilled with native material or topsoil of the same or similar type as that found at the site. The restored area would be graded to match surrounding conditions and stabilized as necessary to prevent erosion.
- **Conductor and/or communication lines:** Overhead power and/or communication lines for the WL 115-kV line no longer in use would be cleaned and removed from the Project footprint.

2.8.10 Power System Facilities

Construction of power system facilities would generally include site grading, excavation, installation of drainage and stormwater controls, foundation construction, grounding systems, underground conduit and cable installation, erection of steel structures, installation of electrical equipment, control buildings, security fencing, and placement of aggregate surfacing. Major equipment may include circuit breakers, switches, disconnects, instrument transformers, surge arresters, capacitor banks, reactors, control and protection systems, station service equipment, communication systems, and associated electrical infrastructure. Construction equipment may include excavators, dozers, graders, cranes, concrete trucks, drill rigs, dump trucks, line trucks, boom lifts, and other specialized equipment necessary for installation and commissioning activities.

2.8.11 Construction Waste Disposal

Construction sites, laydown and material storage yards, and access roads would be kept in an orderly condition throughout the construction period. Refuse and trash generated during construction would be regularly collected, removed from the Project, and disposed of or recycled at approved facilities, as appropriate. Where Project-specific assessments indicate a moderate to high potential for bear activity, bear-resistant waste containers would be used for

refuse and food-related waste, as applicable. Oils, fuels, and other regulated wastes would be properly contained, transported, and disposed of at approved facilities in accordance with applicable federal, state, and local regulations. Open burning of construction debris or waste materials would not be permitted at any time.

2.8.12 Site Reclamation

Topsoil and subsoil would be segregated and clearly identified, where practicable, to preserve soil productivity, maintain native seedbanks, and support successful reclamation. A noxious weed management plan would be implemented to minimize the introduction and spread of noxious and invasive plant species during construction, operation, and reclamation activities.

Temporary work areas and other disturbed sites would be reclaimed using stockpiled topsoil, excess suitable native materials, and native or approved seed mixes compatible with surrounding vegetation communities. Excess soil, rock, construction debris, and other unsuitable materials that cannot be used for reclamation would be removed and disposed of in accordance with applicable regulations and permit requirements.

Reclamation of temporary disturbance areas would be initiated as soon as practicable following completion of construction activities and would continue into Project operations, as necessary, to achieve reclamation objectives. Although reclamation efforts would seek to meet applicable performance standards as expeditiously as practicable, the timing and implementation of specific reclamation measures would be adapted to site-specific conditions, including seasonal constraints, precipitation patterns, soil moisture conditions, vegetation establishment requirements, and ongoing stabilization and stormwater management needs identified in the Project SWPPP.

2.8.13 Typical Construction Equipment

Construction of the Project would require the use of a variety of light-duty vehicles, heavy equipment, and specialized transmission line construction equipment. The specific equipment utilized at any given time would depend on the construction activity, site conditions, access constraints, and final engineering requirements. Equipment may be used at multiple locations throughout the Project, and several construction crews may operate simultaneously during peak construction periods.

The equipment identified below in Table 2-1 represents the principal equipment anticipated for construction of the transmission line, access roads, laydown areas, and power system facilities. Additional support vehicles, tools, and specialty equipment may be utilized as necessary to safely and efficiently complete the work.

Table 2-1 Typical Construction Equipment Required

Vehicle/Equipment Type	Construction Activity
Backhoe (10- to 20-ton) - with bucket	Transmission Structure Foundations
Backhoe (7- to 9-ton) - with bucket	Transmission Structure Foundations Site Reclamation Conductor Installation
Crane (150- to 250-ton)	Structure Framing and Assembly
Crane RT (20-ton)	Transmission Structure Foundations Structure Framing and Assembly
Crane RT (35-ton)	Conductor Installation
Crane RT (75-ton)	Structure Framing and Assembly
Dozer - with blade	Access Road Construction Site Reclamation Conductor Installation Transmission Structure Foundations
Drill rig - digger	Transmission Structure Foundations Conductor Installation
Forklift (10-ton)	Material Hauling Transmission Structure Foundations
Grader - road	Access Road Construction
Helicopter - pilot line (small)	Conductor Installation
Loader - Skid steer	Transmission Structure Foundations
Loader - with bucket	Transmission Structure Foundations Site Reclamation
Puller - single drum	Conductor Installation
Puller - triple drum	Conductor Installation
Tensioner - conductor	Conductor Installation
Tensioner - shield wire	Conductor Installation
Tractor - 4-wheel-drive with chisel and/or seeder	Site Reclamation
Trailer - flatbed	Material Hauling Conductor Installation Transmission Structure Foundations
Trailer - lowboy	Site Reclamation Conductor Installation Access Road Construction
Trailer - reel stand	Conductor Installation
Truck - concrete	Transmission Structure Foundations
Truck - flatbed with boom (5-ton)	Conductor Installation
Truck - fuel	Access Road Construction Transmission Structure Foundations
Truck - pickup	All - Activities
Truck - semi-trailer	Transmission Structure Foundations Material Hauling Conductor Installation

Vehicle/Equipment Type	Construction Activity
Truck - splicing	Conductor Installation
Truck - water	Access Road Construction Transmission Structure Foundations Site Reclamation Conductor Installation
Truck (10 cubic yard) - dump	Transmission Structure Foundations
Truck (1-ton) - flatbed	All - Activities
Truck (2-ton) - flatbed	Access Road Construction Transmission Structure Foundations Material Hauling Site Reclamation Structure Framing and Assembly Conductor Installation
Truck (5-ton) - flatbed with boom	Material Hauling Transmission Structure Foundations
Vibratory roller (9- to 10-ton)	Transmission Structure Foundations
Wheel loader (7- to 9-ton)	Transmission Structure Foundations

2.9 Operation and Maintenance

Following construction and energization of the Project, land uses that are compatible with applicable safety requirements and operation and maintenance (O&M) activities for the Project would be permitted within and adjacent to the transmission line ROW. Existing land uses, including agriculture, livestock grazing, recreation, and other compatible uses, generally may continue within the ROW, provided they do not interfere with the safe operation, maintenance, or reliability of the transmission facilities. Incompatible land uses include the construction of permanent structures intended for human occupancy and activities that alter surface elevations in a manner that could reduce required electrical clearances or otherwise conflict with NESC requirements.

Safety is a primary concern in the planning and design of the Project. The transmission line would be protected with power circuit breakers and related line relay protection equipment. If a conductor failure occurs, power would be automatically removed from the line. The transmission line also would incorporate lightning protection through the use of overhead shield wires and grounding systems installed along the length of the line. All fences, metal gates, pipelines etc., that cross or are within the ROW or easement of transmission line would be grounded to prevent electrical shock and to meet NESC requirements.

Maintenance of the transmission line would be performed as needed to ensure the continued safe and reliable operation of the Project. Routine maintenance activities may include inspections, access road maintenance, repair or replacement of transmission line components, vegetation management, and emergency repairs. When access is required for non-emergency maintenance and repairs, existing roads and established access routes would be used to the maximum extent practicable to minimize disturbance.

Vegetation management may be conducted periodically within the transmission line ROW to maintain required electrical clearances, preserve safe access to facilities, and support reliable system operation. Vegetation management activities may include mechanical mowing, trimming, selective removal of woody vegetation, and treatment of noxious or invasive plant species, as appropriate. Vegetation management practices would be implemented in accordance with applicable landowner agreements, agency requirements, and utility safety standards.

Emergency maintenance and repair activities may require the immediate mobilization of personnel, equipment, and materials to address outages, damaged facilities, or conditions affecting public safety and system reliability. During emergency response activities, crews would take reasonable measures to avoid and minimize impacts to vegetation, wildlife, cultural resources, water resources, and other environmental features while restoring service as quickly and safely as possible. Because regular and emergency access requirements for O&M are generally infrequent and involve a limited number of personnel and vehicles, traffic-related impacts are anticipated to be minor.

Following completion of any maintenance or repair activities, any areas temporarily disturbed would be restored, stabilized, and reclaimed, as appropriate. Reclamation measures would generally be consistent with those implemented during Project construction and may include grading, soil stabilization, erosion control, revegetation, and restoration of affected access routes and work areas.

3. Affected Environment for the Transmission Study Corridor

3.1 Introduction

The affected environment is described below for the environmental values provided in NMSA 1978 §62-9-3.M, Commission Rule 17.9.592 NMAC, and additional resource areas identified to be of interest by Staff, relevant stakeholders, and the Project. These are: air resources; noise, geology and mineral resources; soil resources; paleontological resources; water resources; flora and fauna, including biodiversity; archaeological and historic-age cultural resources; religious and cemetery sites; visual and scenic resources; socioeconomics; communication signals; radioactive waste and radiation hazards; hazardous materials; safety; geographic resources; military activities and aviation; and roads.

This section of the ER describes the existing conditions of these resources within the Transmission Study Corridor, defined as a one-mile-wide area (extending 0.5 miles from each side of the Project centerline) and associated facilities, including substations and access roads for maintenance or operation of the line. The Transmission Study Corridor and an overview of the Project vicinity are shown in Exhibit 1.

3.2 Air Resources

3.2.1 Data Sources

The following data sources were reviewed to assess the current air quality conditions of the Transmission Study Corridor across Torrance, Socorro, and Valencia Counties correlated with the Project.

- AirNow. 2026. *U.S. Air Quality Index*. Accessed June 2026. https://www.airnow.gov/?city=false&country=false.
- United States Environmental Protection Agency (USEPA). 2026a. *Nonattainment areas for criteria pollutants (Green Book)*. Accessed June 2026. https://www.epa.gov/green-book.
- USEPA. 2026b. *Criteria Air Pollutants.* Accessed June 2026. https://www.epa.gov/criteria-air-pollutants.

3.2.2 Current Conditions and Trends, Regional Overview

The Clean Air Act requires the USEPA to set National Ambient Air Quality Standards for six principal pollutants, carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone (O_3),

particulate matter pollution ($PM_{2.5}$ and PM_{10}) and sulfur dioxide (SO_2). Using technical information provided by each state, counties are designated as nonattainment, attainment, or attainment/unclassifiable to indicate whether it meets the standards (USEPA 2026a). Available resources, including real-time air quality data from USEPA's AirNow platform (AirNow 2026), do not identify any unique air quality conditions within the Transmission Study Corridor for the Project. The Project crosses Valencia, Socorro, and Torrance Counties, all of which are designated attainment/unclassifiable because available data indicate they meet the National Ambient Air Quality Standards (USEPA 2026b). These designations are consistent with the counties' low population density and predominantly agricultural or rural land uses.

3.3 Noise

3.3.1 Data Sources

The following data source was reviewed to assess the existing noise conditions of Socorro, Torrance, and Valencia Counties for the Mid-State Transmission Project.

- Socorro County InfoNet. 2021. Public Nuisance Ordinance of Socorro County. Accessed August 2026. https://www.socorrocounty.net/general-information/ordinances
- United States Census Bureau (USCB). 2020a. *Decennial Census Data Tables*. Accessed June 2026. https://data.census.gov/table/DECENNIALPL2010.P1.
- American Legal Publishing Code Library. 2023. Valencia County, New Mexico Code of Ordinances. Accessed August 2026. https://codelibrary.amlegal.com/codes/valenciacounty/latest/valenciaco_nm/0-0-0-1939#JD_92.21

3.3.2 Current Conditions and Trends, Regional Overview

Torrance and Socorro Counties in central New Mexico are rural, sparsely populated areas with relatively low ambient noise levels. Valencia County is more densely populated, has a rural-suburban character, and is growing rapidly (USCB 2020a). Higher population density typically contributes to elevated ambient noise from increased vehicle traffic and concentrated residential and commercial development. Noise levels within the Transmission Study Corridor range from quiet in rural areas to higher near towns, highways, and agricultural operations during cultivation. Aircraft using nearby airspace may also contribute to local noise. Socorro and Valencia Counties have noise ordinances outlining acceptable decibel levels for vehicular and non-vehicular noise (see Tables 3-1 and 3-2). Both county ordinances have exceptions for construction noise between 7 a.m. and 10 p.m. (Socorro County InfoNet 2021; and American Legal Publishing Code Library 2023). Torrance County does not have any noise or nuisance ordinances.

Table 3-1 Socorro and Valencia Counties Vehicular Noise Levels

Type of Vehicle	Speed Limit of 35 MPH hour or less	Speed Limit of More than 35 MPH
Vehicles with a manufacturer's gross vehicle rating of 10,000 lbs. or more, and any combination of vehicles towed by such a vehicle	90 dB(A)	90 dB(A)
All other vehicles	80 dB(A)	84 dB(A)

Table 3-2 Socorro and Valencia Counties Non-Vehicular Noise Levels

Time of Day	Intrusive Noise Level
7 a.m. to 10 p.m.	80 dB(A) or 10 dB(A) above ambient noise level
10 p.m. to 7 a.m.	70 dB(A) or 10 dB(A) above ambient noise level

3.4 Geology and Mineral Resources

3.4.1 Data Sources

The following data sources were reviewed to assess the geological and mineral resource conditions within the Transmission Study Corridor:

- New Mexico Mining and Minerals Division (NM MMD). Mine Registrations and Permits Database. Accessed June 2026. https://wwwapps.emnrd.nm.gov/MMD/MMDWebInfo/
- New Mexico Oil Conservation Division (NM OCD). Oil and Gas Map Viewer. Accessed June 2026. https://nmemnrd.maps.arcgis.com/apps/webappviewer/index.html?id=4d017f2306164de29fd2fb9f8f35ca75
- United States Geological Survey (USGS) Mineral Resources Data System (USGS 2026a). Accessed June 2026. https://mrdata.usgs.gov/mrds/map-graded.html
- United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Web Soil Survey. Accessed June 2026. https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx
- USGS U.S. Landslide Inventory and Susceptibility (USGS 2026b). Accessed June 2026. https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=ae120962f459434b8c904b456c82669d
- USGS Volcano Hazards Program (USGS 2026c). Accessed June 2026. https://www.usgs.gov/programs/VHP
- USGS Quaternary Fault Viewer (USGS 2026d). Accessed June 2026. https://apps.usgs.gov/earthquakes/faults/qfault_index.html

- National Park Service (NPS). 2026d. NPMS Public Viewer. Accessed August 2026. https://pvnpms.phmsa.dot.gov/PublicViewer/
- Karst Landscapes - Caves and Karst (U.S. National Park Service). Accessed August 2026. https://www.nps.gov/subjects/caves/karst-landscapes.htm

3.4.2 Current Conditions and Trends, Regional Overview

This section summarizes existing geology and mineral resources within the Transmission Study Corridor. Topics include regional geologic conditions, oil and gas resources and infrastructure, mineral resource occurrences and mining activities that characterize the Transmission Study Corridor and provide the baseline conditions for the impact analysis presented in Section 4.0.

Geologic Setting

Regional Geology and Soils

The Transmission Study Corridor is located in central New Mexico, generally within the western portion of the Great Plains Physiographic Province and transitioning toward the Basin and Range margins. The landscape is characterized by thin soils over gently sloping bedrock surfaces, with localized uplifts and volcanic features. The Transmission Study Corridor is underlain primarily by Permian-aged sedimentary formations, including sandstone, limestone, siltstone, and dolomite consistent with regional deposition on an ancient continental shelf. In select areas, igneous intrusions and volcanic flows occur, particularly near uplifted ridges and isolated highlands.

Soils across the Transmission Study Corridor are typically shallow, with caliche-rich horizons, sandy loams, and cobbly to gravelly textures. Soil type parent materials as mapped by the USDA's NRCS are shown in Exhibit 2 (USDA NRCS 2026). Remnants of the Ogallala Formation and younger alluvial deposits may be present in drainage corridors or erosional benches.

Landslides and Slope Stability

Most of the Transmission Study Corridor occurs within areas of relatively low landslide susceptibility. However, localized areas of steeper terrain occur within portions of the corridor, particularly between the Manzano and Los Pinos Mountains and near El Cerro de Los Lunas. These areas exhibit a greater potential for slope instability compared to surrounding terrain.

Seismic and Volcanic Hazards

Regional seismic activity within central New Mexico is generally low to moderate. Available mapping indicates no major active faults occur within the immediate vicinity of the Transmission Study Corridor. The corridor is also located near El Cerro de Los Lunas, a volcanic butte of

historic geologic origin. No active volcanic features or volcanic hazards have been identified within the Transmission Study Corridor.

Karst and Subsurface Conditions

Portions of the Transmission Study Corridor overlie limestone and dolomite formations where karst features may develop through the dissolution of soluble bedrock. Karst refers to a landscape formed by the dissolution of limestone, dolomite, or other soluble rocks and may include sinkholes, caves, fractures, and subsurface voids. Although no extensive mapped karst systems occur within the Transmission Study Corridor, isolated dissolution features or subsurface voids may be present.

Flooding and Erosion

Seasonal monsoon storms can produce localized flooding, arroyo flows, and erosion throughout central New Mexico. Portions of the Transmission Study Corridor, particularly near drainage crossings and areas associated with the Rio Grande watershed, may be subject to periodic flooding and erosion processes. These conditions represent the primary geologic hazards within the study area.

Oil and Gas Resources

No active oil or natural gas wells occur within or immediately adjacent to the Transmission Study Corridor (Exhibit 3) (NM OCD 2026). While historic leases exist across central New Mexico, most are closed or inactive, and the region does not contain major producing hydrocarbon basins.

Pipeline infrastructure is present within Torrance, Socorro, and Valencia Counties. National Pipeline Mapping System data indicate that active natural gas transmission pipelines and hazardous liquid pipelines occur within or adjacent to the Transmission Study Corridor. In Socorro County, the Transmission Study Corridor is located near interstate natural gas transmission pipelines operated by El Paso Natural Gas Company and Transwestern Pipeline Company. In Valencia County, the Transmission Study Corridor intersects an active natural gas transmission pipeline operated by New Mexico Gas Company and a hazardous liquid pipeline operated by Magellan Pipeline Company, LP. In Torrance County, the Transmission Study Corridor intersects active natural gas transmission pipelines operated by E.M.W. Gas Association.

Mineral Resources

Mining has historically contributed to the economy of central New Mexico, but active mining operations are limited within the Transmission Study Corridor. Based on New Mexico Mining and Minerals Division records:

- Most mining registrations in the region involve aggregate, caliche, and dimension stone.
- A smaller number involve metallic minerals such as iron, copper, gold, and silver.
- Only a few mines within the broader region remain active, primarily aggregate operations.

The USGS' Mineral Resources Data System indicates that several past producers, prospects, and mineral occurrences are located within or near the Transmission Study Corridor (Exhibit 4). In addition, NM MMD records identify several registered mining facilities within the corridor. These include the permanently closed Abo Viejo Quarry in Valencia County, the Valencia County Pit in Valencia County, and the Sais Quarry and Socorro County Pit in Socorro County. Mining activities associated with these facilities are primarily related to aggregate and construction materials. No major mineral deposits or large-scale active mining operations occur within the Transmission Study Corridor.

3.5 Soil Resources

3.5.1 Data Sources

The following data sources were reviewed to assess the existing soil resources of the portions of Torrance, Socorro, and Valencia Counties where the Project is proposed.

- USDA NRCS. 2026. *Web Soil Survey*. Accessed June 2026 from: https://websoilsurvey.nrcs.usda.gov/.

3.5.2 Current Conditions and Trends, Regional Overview

The corridor encompasses approximately 66,000 acres. For the purposes of this analysis, Table 3-3 below focuses on soil resource characteristics with the greatest relevance to transmission line siting, construction, operation, and maintenance. Prime Farmland and Farmland of Statewide Importance are identified because of their agricultural value and potential implications for land use and construction activities. Hydric soils are included due to their association with wetland conditions and potential considerations related to drainage, soil disturbance, and permitting. Rock outcrop, steep, and stony soils are identified because they may influence access, foundation design, construction methods, and reclamation activities. Table 3-4 (located in Appendix B) identifies all existing soil resources located within the Transmission Study Corridor. For a visual representation of the soil resources within the Transmission Study Corridor, refer to Exhibit 5.

Table 3-3 Soil Resource Characteristics Relevant to Transmission Line Development in the Transmission Study Corridor

Category	Estimated Acreage	Percent of Transmission Study Corridor
Farmland of Statewide Importance	13,200	20%
Prime Farmland	5,940	9%
Rock Outcrop/Steep/Stony Soils	4,620	7%
Hydric Soils	330	0.5%
Total	24,090	36.5%

Source: USDA NRCS. 2026. *Web Soil Survey*. Accessed June 2026 from: https://websoilsurvey.nrcs.usda.gov/.

3.6 Paleontological Resources

3.6.1 Data Sources

The following data sources were reviewed to assess paleontological resources of the portions of Torrance, Socorro, and Valencia Counties where the Project is proposed:

- BLM National Potential Fossil Yield Classification (PFYC) MapServer. 2023. U.S. Department of the Interior, BLM. Accessed: June 2026.
- BLM. 2026a. Handbook 8270 – Paleontological Resource Management. Accessed: June 2026.
- Paleobiology Database. Accessed June 2026 from: https://paleobiodb.org. Search Terms – State New Mexico / County: Socorro, Torrance, and Valencia.
- Society of Vertebrate Paleontology. 2026. *Best Practice Guidelines for Mitigation of Adverse Impacts on Paleontological Resources*. First edition released October 2025; revised May 2026
- Society of Vertebrate Paleontology. 2021. *Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources*. Impact Mitigation Guidelines Revision Committee.
- Tedford, R.H., L.B. Albright III, A.D. Barnosky, I. Ferrusquia-Villafranca, R.M. Hunt Jr., J.E. Storer, C.C. Swisher III, M.R. Voorhies, S.D. Webb, and D.P. Whistler. 2004. *Mammalian Biochronology of the Arikareean Through Hemphillian Interval in Late Cretaceous and Cenozoic Mammals of North America – Biostratigraphy and Geochronology.* M.O. Woodburne, editor. Columbia University Press, New York.

3.6.2 Current Conditions and Trends, Regional Overview

Geology within the three counties crossed by the Transmission Study Corridor includes Proterozoic-, Paleozoic-, and Cenozoic-aged rocks with varying degrees of potential for containing paleontological resources, the fossilized evidence of life on Earth including body fossils, plant fossils, trackways, etc. (Exhibit 6). Paleontological resources have been collected from each of the three counties crossed (Torrance, Socorro, and Valencia Counties) by the Transmission Study Corridor (Paleobiology Database 2026).

Potential Fossil Yield Classification System

The BLM uses the PFYC system as a uniform tool to assess potential occurrences of paleontological resources and evaluate possible impacts using mapped geologic units (Exhibit 7) (BLM 2023). The PFYC system provides baseline guidance for assessing paleontological resources as part of initial planning efforts and determining the need for further assessment of Project impacts on resources. The primary PFYC categories are as follows:

Class 1 – Very Low. Geologic units that are not likely to contain recognizable paleontological resources. Units assigned to Class 1 typically have one or more of the following characteristics:

- Geologic units are igneous or metamorphic, excluding air-fall and reworked volcanic ash units.
- Geologic units are Precambrian in age.

Class 2 – Low. Geologic units that are not likely to contain paleontological resources. Units assigned to Class 2 typically have one or more of the following characteristics:

- Field surveys have verified that significant paleontological resources are not present or are very rare.
- Units are generally younger than 10,000 years before present.
- Recent aeolian deposits.

Class 3 – Moderate. Sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence. Units assigned to Class 3 have some of the following characteristics:

- Marine in origin with sporadic known occurrences of paleontological resources.
- Paleontological resources may occur intermittently, but abundance is known to be low.
- Units may contain significant paleontological resources, but these occurrences are widely scattered.
- The potential for unauthorized land use to impact a significant paleontological resource is known to be low to moderate.

Class 4 – High. Geologic units that are known to contain a high occurrence of paleontological resources. Units assigned to Class 4 typically have the following characteristics:

- Significant paleontological resources have been documented but may vary in occurrence and predictability.
- Surface-disturbing activities may adversely affect paleontological resources.
- Rare or uncommon fossils, including nonvertebrate (such as soft body preservation) or unusual plant fossils, may be present.
- Illegal collecting activities may impact some areas.

Class 5 – Very High. Highly fossiliferous geologic units that consistently and predictably produce significant paleontological resources. Units assigned to Class 5 have some or all of the following characteristics:

- Significant paleontological resources have been documented and occur consistently.
- Paleontological resources are highly susceptible to adverse impacts from surface-disturbing activities.
- Unit is frequently the focus of illegal collecting activities.

Beyond the five-part classification scheme, geologic units may be assigned to Class U – Unknown where there is not sufficient data to make a uniform paleontological potential classification. Class U assigned geologic units may be assigned a provisional PFYC Class on a project-by-project basis based on local information and literature and refined by ground-truthing field surveys.

Geologic Units

Rocks within the Transmission Study Corridor were deposited during four different time periods from oldest to youngest: Proterozoic, Paleozoic (Pennsylvanian to Permian), Tertiary, and Quaternary and include metamorphic, igneous, and sedimentary rocks.

The oldest rocks in the Transmission Study Corridor are Proterozoic-aged metamorphic rocks that are present where the alignment crosses from Valencia and Socorro Counties into Torrance County. These rocks are composed of volcanic rocks that have been metamorphosed into gneiss rock (BLM 2023). Metamorphic rocks do not typically contain paleontological resources and are assigned to PFYC 1 with very low paleontological sensitivity.

The Paleozoic-aged rocks within the Transmission Study Corridor include the Abo, Bursum, and Yeso Formations and are mapped in the extreme eastern portions of Valencia and Socorro Counties and the western part of Torrance County in the Manzano Mountains. These rock units together record a transition from marine environments with ammonites, brachiopods, and sea scorpions (Pennsylvanian) to terrestrial environments with amphibians and early reptiles

(Permian) on what was once the west coast of the continent. These older rocks have been uplifted and occur at higher elevations than the younger rocks that fill the Rio Grande Valley.

The Tertiary-aged rocks of the Transmission Study Corridor are present in the Rio Grande Valley and generally include the rocks of the Santa Fe Group, a broad term that includes many different formations but mapped generally by the BLM as a single, undifferentiated unit. Santa Fe Group rocks in the Transmission Study Corridor have been assigned the highest PFYC of 5 based on the number and diversity of localities and their fossils that record the evolutionary history, mostly of mammals, during the Miocene of North America. The Tertiary-aged fossils of the Santa Fe Group include early representatives of modern mammal groups including camels, early pronghorns, dogs, rhinoceroses, hedgehogs, and horses along with extinct lineages including catlike carnivores and horned rodents (Paleobiology Database 2026; Tedford et al. 2004).

The youngest rocks in the Transmission Study Corridor were deposited during the Quaternary and include recent river deposits of the Rio Grande, active eolian dune fields, and alluvial fans. Many of these deposits are young enough to not contain paleontological resources and Quaternary-aged rocks like these typically receive PFYC ratings of 2 unless there is substantial evidence of local paleontological resources that warrant elevated PFYC ratings.

The geologic units crossed by the Transmission Study Corridor and ROW are summarized in Table 3-5 organized by youngest (top) to oldest (bottom) including the geologic unit name and symbol, age, PFYC, any known fossils from the three counties, and assigned paleontological sensitivity.

Table 3-5 Geology Units and Paleontological Sensitivity in Transmission Study Corridor and Project ROW

Name (Map Symbol)	Transmission Study Corridor / ROW	Age	PFYC	Known Fossils	Paleontological Sensitivity
Alluvium (Qa)	Both	Quaternary	U (2)	None	Low
Undivided alluvium of broad swales (Qayu)	Both	Quaternary	2	None	Low
Lacustrine and playa lake deposits (Qpl)	Both	Quaternary	2	None	Low
Dune Sands (Qedy)	Both	Quaternary	U (2)	None	Low
Low-relief sand sheets (Qesy)	Both	Quaternary	2	None	Low
Low-relief sand sheets (Qeso)	Both	Quaternary	U (2)	None	Low

Name (Map Symbol)	Transmission Study Corridor / ROW	Age	PFYC	Known Fossils	Paleontological Sensitivity
Younger Rio Grande alluvium (Qrdy)	Both	Quaternary	2	None	Low
Axial fluvial facies along Abo Arroyo (Qsx)	Both	Quaternary	U (2)	None	Low
Abo Arroyo-derived piedmont facies (Qsa)	Transmission Study Corridor	Quaternary	U (2)	None	Low
Piedmont alluvial deposits: upper and middle Quaternary (Qp)	Both	Quaternary	2	None	Low
Older alluvial deposits of upland plains and piedmont areas (Qoa)	Both	Quaternary	2	None	Low
Axial fluvial facies along Rio Grande (QTsx)	Both	Pliocene to Quaternary	U (3)	None	Moderate
Santa Fe Group (QTs)	Both	Miocene	5	Camel, early pronghorn, canid, felid, rhinoceros, horned rodent, hedgehog, horse	High
Basalt Flows (Tnb)	ROW	Oligocene-Miocene	1	None	Very Low
Abo Formation (Pa)	Both	Permian	4	Plants, amphibians, early reptiles	High
Yeso Formation (Py)	Both	Permian	3	Gastropods, ammonites, bivalves	Moderate
Bursum Formation (Pb)	Both	Pennsylvanian to Permian	3	Plants, brachiopods, ammonites, sea scorpions, insects	Moderate
Pennsylvanian rocks, undivided (IP)	Both	Pennsylvanian	U (2)	None	Low
Middle Proterozoic plutonic rocks (Yp)	Both	Proterozoic	1	None	Very Low
Metamorphic rocks	Both	Proterozoic	1	None	Very Low

Note: Geologic units in the Project area with PFYC U-Unknown designations have been assigned provisional PFYC ratings specific to this Project based on the local geology and review of publicly available literature and locality information.

3.7 Water Resources

3.7.1 Data Sources

The following data sources were reviewed to assess the existing water resources of the portions of Torrance, Socorro, and Valencia Counties in the Transmission Study Corridor where the Project is proposed.

- Burns & McDonnell Engineering Company, Inc. (Burns & McDonnell). 2026. *Desktop Wetland Evaluation Dataset*
- USEPA 2026c. Ecoregions of North America. Accessed June 2026 from: https://www.epa.gov/eco-research/ecoregions-north-america.
- USEPA 2026d. WATERS GeoViewer 2.0. Accessed June 2026 from: https://www.epa.gov/waterdata/waters-watershed-assessment-tracking-environmental-results-system.
- Federal Emergency Management Agency (FEMA). 2026. Flood Map Service Center. Accessed June 2026 from: https://msc.fema.gov/portal/search.
- Playa Lakes Joint Venture (PLJV). 2026. Playas. Accessed June 2026 from: https://pljv.org/playas/.
- United States Fish and Wildlife Service (USFWS). 2026a. National Wetlands Inventory (NWI) Data Mapper. Accessed June 2026 from: https://www.fws.gov/wetlands/data/mapper.html.
- USGS. 2026e. National Hydrography Dataset (NHD). Accessed June 2026 from: https://nhd.usgs.gov/tools.html.
- Western Regional Climate Center. 2026. Climate of New Mexico. Accessed June 2026 from: https://wrcc.dri.edu/Climate/narrative_nm.php.

3.7.2 Current Conditions and Trends, Regional Overview

The Transmission Study Corridor is within the Albuquerque Basin, Rio Grande Floodplain, Conifer Woodlands and Savannas, Pinyon-Juniper Woodlands and Savannas, Central New Mexico Plains, and Pluvial Lake Basins Level IV Ecoregions, which are all included in the Arizona/New Mexico Plateau and the Southwestern Tablelands Level III Ecoregions (USEPA 2026c) (Exhibit 8). Summer precipitation in central New Mexico occurs primarily as short-duration, often intense thunderstorms associated with the North American Monsoon. July and August are the wettest months, typically accounting for approximately 35% to 45% of annual precipitation. Overall, the majority of annual moisture, generally on the order of 70% to 80%, falls during the warm season, with peak contributions occurring between June and September (Western Regional Climate Center 2026).

Flooding in New Mexico is typically localized. Intense summer thunderstorms associated with the North American Monsoon can produce heavy rainfall over small areas in a short period of time. Due to steep terrain, sparse vegetation, and soils with limited infiltration capacity, these storms often generate rapid runoff that results in flash flooding. Normally dry arroyos can experience sudden flows and may overtop banks for several hours, disrupting transportation corridors and damaging infrastructure such as bridges, culverts, and roadways, particularly in developed areas. In addition to monsoon-driven events, flooding can also occur from spring snowmelt between April and June, especially when combined with rainfall, and from broader-scale precipitation events during late summer and early fall that affect larger river systems (Western Regional Climate Center 2026).

Playas, also referred to as playa lakes, are shallow, clay-lined depressions located at the lowest point of a watershed across the Great Plains region. These basins capture and temporarily hold water from precipitation and surface runoff, forming ephemeral wetlands that typically dry out through evaporation and infiltration. Although playas are hydrologically closed and often dry for much of the year, they play a critical role in regional groundwater recharge. Water stored in playas gradually infiltrates underlying soils and contributes to the High Plains (Ogallala) Aquifer, with recharge rates estimated to be 10 to 1,000 times greater than those observed in surrounding croplands and rangelands. A series of dry lake beds and playas occur in the Estancia Basin known as the Pinos Wells Playa. The Laguna del Perro, located east of Willard, New Mexico, is the largest feature of this type, located in the Pluvial Lake Basins USEPA Level IV Ecoregion (USEPA 2026c). No playas have been identified within the defined Transmission Study Corridor (PLJV 2026).

The Transmission Study Corridor crosses ten watersheds (Exhibit 9; Table 3-6). According to the USGS NHD, the Transmission Study Corridor crosses a total of approximately 65 perennial, intermittent, and ephemeral stream crossings, including overlap of approximately 4.3 linear miles of Abo Arroyo and approximately 1.1 miles of the Rio Grande (USGS 2026e; USEPA 2026d).

Table 3-6 Transmission Study Corridor Watersheds

Watershed	HUC 10*
Canon Monte Largo-Rio Grande	1302020306
Pino Draw-Rio Grande	1302020307
Abo Arroyo	1302020305
Arroyo de Manzano	1305000110
Chavez Draw-Frontal Laguna del Perro	1305000109
Laguna de Perro	1305000112
Pueblo Blanca Canyon	1305000107
McGillivray Draw	1305000106
City of Encino	1305000201

Watershed	HUC 10*
Town of Cedarvale	1305000202

*10-digit Hydraulic Unit Code (HUC)
Source: USEPA 2026d

The Transmission Study Corridor overlaps approximately 2.3 miles of FEMA-designated Flood Zone A in Valencia County, representing areas with a 1% annual chance of flooding (FEMA 2026) (Exhibit 10). These areas occur primarily within or immediately adjacent to the Rio Grande and its associated floodplain. The Transmission Study Corridor also overlaps approximately 35.4 miles of FEMA-designated Flood Zone X within Valencia County, which indicates minimal to moderate flood risk (FEMA 2026). FEMA floodplain mapping is limited in Socorro County (with no mapped floodplains within the Transmission Study Corridor) and is not available for Torrance County.

The USFWS NWI identifies five surface water feature types within the Transmission Study Corridor: freshwater wetlands, freshwater forested/shrub, freshwater ponds, lakes, and riverine features (Exhibit 11). Approximately 488.9 acres, (less than 1%) of the Transmission Study Corridor overlaps NWI-mapped resources, which are predominantly ephemeral riverine features (Table 3-7).

Table 3-7 Transmission Study Corridor Wetlands based on NWI Data

Wetland Type	Estimated Acreage	Percentage of Transmission Study Corridor
Riverine	373.1	0.56%
Freshwater Forested/Shrub	54.9	0.08%
Lake	38.5	0.06%
Freshwater Emergent Wetland	13.5	0.02%
Freshwater Pond	8.9	0.01%
Total	**488.9**	**<1%**

Source: USFWS 2026a

Burns & McDonnell conducted a desktop assessment to identify areas within the Transmission Study Corridor with the potential to support wetlands and other aquatic resources. The assessment incorporated data from multiple geospatial sources, which were integrated into a single GIS layer and overlaid on the Transmission Study Corridor. Wetland occurrence potential was then classified based on the degree of overlap among the datasets. Ratings ranged from Improbable, where no desktop data sources indicated the presence of a wetland or waterbody, to High, where hydric soils, interpreted wetlands, and NWI features overlapped. The results of the assessment are summarized in Table 3-8.

Table 3-8 Wetland Probability Ranking for the Transmission Study Corridor

Wetland Probability Occurrence Ranking	Estimated Acreage	Percentage of Transmission Study Corridor
High	120	0.18%
Medium/High	358	0.54%
Medium	1,081	1.64%
Subtotal	1,559	2.36%
Medium/Low	26	0.04%
Low	159	0.24%
Subtotal	185	0.28%
Improbable	64,044	97.36%
Total	**65,788**[a]	**100%**

[a]Transmission Study Corridor acreage totals may vary due to differences in data sources, spatial accuracy, and methodologies.
Source: Burns & McDonnell 2026

The majority of the Transmission Study Corridor received a designation of "Improbable" wetland occurrence (Burns & McDonnell 2026). While the actual location and extent of wetlands and waterbodies, as determined by on-site wetland delineation, may differ from the desktop evaluation, the results of the desktop evaluation are useful to indicate areas where impacts to probable wetlands and waterbodies should be avoided or minimized.

3.8 Flora and Fauna

3.8.1 Data Sources

The following data sources were reviewed to assess the existing biological resources of the portions of Torrance, Socorro, and Valencia Counties in the Transmission Study Corridor where the Project is proposed.

- Avian Conservation Partners. 2017. Bald Eagle. http://avianconservationpartners-nm.org/wp-content/uploads/2017/01/Bald-Eagle.pdf. Accessed 22 June 2026.
- Avian Power Line Interaction Committee (APLIC). 2026. *Suggested Practices for Avian Protection on Power Lines*. https://www.aplic.org/documents. Accessed June 2026.
- BLM. 2024. BLM NM Sensitive Species Update. https://www.blm.gov/programs/fish-and-wildlife/threatened-and-endangered/state-te-data/new-mexico. Accessed August 2026.
- Chung-MacCoubrey, Alice L. 2025. "Use of Pinyon-Juniper Woodlands by Bats in New Mexico." *Forest Ecology and Management,* vol. 204, nos. 2–3, pp. 209–220, https://research.fs.usda.gov/treesearch/61127.

- DeLong, John P., and Sartor O. Williams III. 2006. *Status Report and Biological Review of the Gray Vireo in New Mexico.* NMDGF. https://www.unm.edu/~jdelong/NM%20Gray%20Vireo%20Review%20Final.pdf.
- eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. Accessed August 2026.
- GeoSystems Analysis, Inc. 2026. Habitat Assessment for Mid-State Transmission.
- International Union for Conservation of Nature (IUCN). 2025. The IUCN Red List of Threatened Species, Version 2025-2. https://www.iucnredlist.org/. Accessed 22 June 2026.
- Middle Rio Grande Endangered Species Collaborative Program. 2025. *2024 Middle Rio Grande Southwestern Willow Flycatcher Study Results, Middle Rio Grande Project, New Mexico, Upper Colorado Basin Region*; Technical Report No. ENV-2025-059. Prepared by Bureau of Reclamation, Technical Service Center, Denver, Colorado. Available at: https://webapps.usgs.gov/mrgescp/documents/2024-Middle-Rio-Grande-Southwestern-Willow-Flycatcher-Study-Results.pdf. Accessed June 2026.
- Natural Atlas. 2026. Southwestern Tablelands Ecoregion. https://naturalatlas.com/ecoregions/southwestern-tablelands-2767690. Accessed 18 June 2026.
- NMDGF. 2026a. New Mexico Crucial Habitat Assessment Tool (NM CHAT). https://nmchat.org/. Accessed 22 June 2026.
- NMDGF. 2026b. New Mexico Environmental Review Tool (NMERT). Natural Heritage New Mexico, and NatureServe. https://nmert.org/. Accessed June 2026.
- New Mexico Rare Plant Technical Council (NMRPTC). 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. https://nmrareplants.unm.edu. Accessed 22 June 2026.
- RJH Consultants, Inc., and Tetra Tech, Inc. 2025. *2024 Southwestern Willow Flycatcher Survey Results – Belen Reach, Middle Rio Grande, New Mexico.* Prepared for Bureau of Reclamation, Albuquerque Area Office, New Mexico. Available at: https://webapps.usgs.gov/mrgescp/documents/2024-Belen-Reach-SWFL_Report_Final_TetraTech.pdf. Accessed June 2026.
- Bureau of Reclamation. 2024. *Middle Rio Grande Yellow-billed Cuckoo Study Results – 2023: Isleta Pueblo to Elephant Butte Reservoir, New Mexico, Upper Colorado Basin Region.* U.S. Department of the Interior, Bureau of Reclamation, Technical Report No. Authors Rebecca Siegle, Rebecca Siegle, Stanton Moore, and Ethan Reibsome. ENV-2024-020, August, https://webapps.usgs.gov/mrgescp/documents/2023-Middle-Rio-Grande-Yellow-billed-Cuckoo-Study-Results.pdf.

- USFS. 2013a. R3 Regional Forester's Sensitive Species: Animals. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r03/complete-animals.pdf. Accessed August 2026.
- USFS. 2013b. R3 Regional Forester's Sensitive Species: Plants. https://www.fs.usda.gov/sites/nfs/files/legacy-media/r03/complete-plant.pdf. Accessed August 2026.
- USFS. 2026a. Olive-sided Flycatcher (*Contopus cooperi*). Rio Grande National Forest. https://www.fs.usda.gov/sites/nfs/files/legacy-media/riogrande/fp%20ass5%20Olive-sided%20Flycatcher.pdf. Accessed June 2026.
- USFWS. 2026b. Southwestern Willow Flycatcher (*Empidonax traillii extimus*) species profile. https://www.fws.gov/species/southwestern-willow-flycatcher-empidonax-traillii-extimus. Accessed 22 June 2026.
- USFWS. 2026c. Yellow-billed Cuckoo (*Coccyzus americanus*), https://www.fws.gov/species/yellow-billed-cuckoo-coccyzus-americanus. Accessed 22 June 2026.
- USFWS. 2026d. Information for Planning and Consultation (IPaC), https://ipac.ecosphere.fws.gov/. Accessed 22 June 2026.
- USFWS. 2026e. Monarch butterfly (*Danaus plexippus*), https://www.fws.gov/species/monarch-danaus-plexippus. Accessed June 2026.
- USGS. 2026f. Western Migrations. Accessed August 2026. https://apps.usgs.gov/western-migrations/
- USGS. 2026g. Gap Analysis Project. Accessed June 2026. https://www.usgs.gov/programs/gap-analysis-project.Accessed
- Waters, Margaret. "Thamnophis proximus (Western Ribbon Snake)." Animal Diversity Web, University of Michigan Museum of Zoology. https://animaldiversity.org/accounts/Thamnophis_proximus/. Accessed 22 June 2026.
- Wickersham, Lynn E., Kristine Johnson, Giancarlo Sadoti, Teri Neville, John Wickersham. 2020. "Habitat Use at Multiple Scales by Nesting Gray Vireos in New Mexico." *Piñon-Juniper Habitats: Status and Management for Wildlife*, edited by Karl Malcolm et al., U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, pp. 31–33, https://www.fs.usda.gov/rm/pubs_series/rmrs/proc/rmrs_p077/rmrs_p077_031_033.pdf.
- Zwank, Phillip J., Billy L. Tarrant, Raul Valdez and Dennis L. Clason. 2026. "Wintering Bald Eagle Populations and Behavior in the Middle Rio Grande Basin, New Mexico." The Southwestern Naturalist, vol. 41, no. 2, June 1996, pp. 149–54. JSTOR, http://www.jstor.org/stable/30055099. Accessed 22 June 2026.

3.8.2 Current Conditions and Trends, Regional Overview

As discussed in Section 3.7.2, the Transmission Study Corridor is located within Arizona/New Mexico Plateau and the Southwestern Tablelands Level III Ecoregions Southwestern Tablelands Level III Ecoregion (Exhibit 8) (USEPA 2026c). The Southwestern Tablelands Ecoregion is a semi-arid, dissected plateau landscape characterized by mesas, canyons, and grassland-dominated vegetation. The Arizona/New Mexico Plateau Ecoregion is characterized by high-elevation mesas, plateaus, and broad valleys supporting semi-arid ecosystems dominated by pinyon-juniper woodlands, interspersed with shrublands and grasslands. Both Ecoregions support plant communities adapted to low precipitation and periodic drought. Land use is predominantly rangeland grazing, with only limited irrigated agriculture and other intensive agricultural uses occurring in localized areas, which is constrained by the region's arid climate, limited water availability, rugged topography, and the prevalence of shallow, rocky, or otherwise less productive soils. Hydrologic systems are generally ephemeral, and erosion processes have produced a more rugged terrain than adjacent High Plains regions (Natural Atlas 2026).

More specifically, the Transmission Study Corridor is within the Albuquerque Basin, Rio Grande Floodplain, Conifer Woodlands and Savannas, Pinyon-Juniper Woodlands and Savannas, Central New Mexico Plains, and Pluvial Lake Basins Level IV Ecoregions, which are all included in the Arizona/New Mexico Plateau and the Southwestern Tablelands Level III Ecoregion (USEPA 2026c). The Level IV ecoregions along the Rio Grande corridor and surrounding uplands in central New Mexico support a diverse assemblage of plant communities shaped by elevation, hydrology, and soil conditions. The Albuquerque Basin and Rio Grande Floodplain are dominated by riparian bosque vegetation, including Rio Grande cottonwood (*Populus deltoides ssp. wislizenii*), coyote willow (*Salix exigua*), and non-native species such as saltcedar (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*), with adjacent wetlands supporting cattail (*Typha* spp.) and bulrush (*Schoenoplectus* spp.).

Surrounding uplands transition into Central New Mexico Plains and Pluvial Lake Basin systems characterized by desert grasslands and shrublands, with blue grama (*Bouteloua gracilis*), galleta grass (*Pleuraphis jamesii*), fourwing saltbush (*Atriplex canescens*), and greasewood (*Sarcobatus vermiculatus*) in low-lying, saline areas. At higher elevations and more dissected terrain, pinyon-juniper woodlands and savannas and conifer woodlands and savannas are common, supporting pinyon pine (*Pinus edulis*), one-seed and Utah juniper (*Juniperus monosperma, J. osteosperma*), and, in cooler or higher settings, ponderosa pine (*Pinus ponderosa*) with an understory of shrubs such as mountain mahogany (*Cercocarpus* spp.) and Gambel oak (*Quercus gambelii*). Together, these ecoregions form a mosaic of riparian, grassland, shrubland, and woodland communities that reflect strong gradients in moisture availability and elevation across the landscape.

Known sensitive habitats for federal and state threatened and endangered species were reviewed using the IPaC and New Mexico Environmental Review tools (Exhibit 12). USFWS-designated Critical Habitat overlaps the Transmission Study Corridor for the following species:

Southwestern willow flycatcher (*Empidonax traillii extimus*), yellow-billed cuckoo (*Coccyzus americanus*), and Rio Grande silvery minnow (*Hybognathus amarus)*.

USGS Gap Analysis Project

The following table summarizes vegetation and land cover types within the Transmission Study Corridor based on the USGS Gap Analysis Project (GAP) land cover dataset (USGS 2026g). The GAP dataset includes mapped vegetation and land cover patterns based on satellite imagery, field-verified vegetation data, and standardized ecological classification systems. The distribution of the habitat types across the Transmission Study Corridor is shown in Table 3-9 and presented in Exhibit 13.

Table 3-9 GAP Land Cover within the Transmission Study Corridor

Habitat	Acres within Transmission Study Corridor
Shrubland & Grassland	29,753.9
Semi-Desert	23,121.4
Forest and Woodland	6,049.3
Nonvascular and Sparse Vascular Rock Vegetation	5,386.0
Developed and Other Human Use	1,057.3
Agricultural Vegetation	348.4
Open Water	65.1
Total	**65,781.4[a]**

[a]Transmission Study Corridor acreage totals may vary due to differences in data sources, spatial accuracy, and methodologies.
Source: USGS 2026g

Field Verified Habitat Data

GeoSystems Analysis conducted a site reconnaissance from July 27, 2026, to August 7, 2026, to verify habitat data within the 300-foot survey corridor (150 feet on each side of the proposed transmission centerline). Table 3-10 shows the habitats observed and their associated acreage within the 300-foot survey corridor. The field verified distribution of the following habitat types is presented in Exhibit 14.

Table 3-10 Field Verified Habitat within the 300-foot Survey Corridor

Habitat	Acres within 300-foot Survey Corridor
Grassland	1,628.6
Desert Scrub	1,398.5
Woodland	687.6

Habitat	Acres within 300-foot Survey Corridor
Agriculture/Developed	87.8
Riparian	16.9
Total	**3,819.4**

Source: GeoSystems Analysis 2026

The field reconnaissance effort confirmed that grassland, shrubland/semi-desert scrub, and woodlands are the most common habitat types across the survey corridor. Dominant species observed during field surveys include juniper (*Juniperus* spp.), soaptree yucca (*Yucca elata*), fourwing saltbush (*Atriplex canescens*), western honey mesquite (*Prosopis glandulosa var. torreyana*), pinyon pine (*Pinus edulis*), Indian ricegrass (*Achnatherum hymenoides*), and blue grama (*Bouteloua gracilis*)(GeoSystems Analysis, Inc. 2026).

Sensitive Species

Given the habitat types present within the relevant ecoregions, the potential for occurrence of special-status plant and wildlife species was evaluated based on species range, habitat suitability, mobility, population characteristics, and documented occurrences within the Transmission Study Corridor (USFWS 2026b, 2026c, and 2026d). Based on these factors, the likelihood of occurrence was defined for each special-status species using the following categories:

None – outside the species known range, no suitable habitat within the Transmission Study Corridor, restricted mobility, and small population size.

Not Likely – outside the species known range and suitable habitat appears absent within the Transmission Study Corridor; however, due to the species mobility and population size, species may occur within the Transmission Study Corridor during migration or other times of the year.

Possible – is located within the range of the species but contains marginal suitable habitat; species highly mobile and may occur year-round.

Likely – is located within the range of the species and contains suitable habitat; records of species occurrence in the surrounding area, but no records from the Transmission Study Corridor.

Occurs – records of species occurrence within the Transmission Study Corridor based on USFWS/NMDGF data or other survey data.

Brief species accounts are written for special-status and other protected species whose likelihood of occurrence was either possible, likely, or known to occur.

Migratory birds are federally protected by the Migratory Bird Treaty Act (MBTA) and may forage, nest, or migrate or occur through the Transmission Study Corridor. Under the MBTA, it is illegal

for anyone to “take” migratory bird species except under the terms of a valid permit issued pursuant to federal regulations.

Federally Listed Species

Eleven species that are federally listed under the Endangered Species Act (ESA) as threatened, endangered, proposed, or experimental (nonessential) may occur within the Transmission Study Corridor. Table 3-11 summarizes the list of federally protected species with potential to occur, and an analysis of potential occurrence based on literature review of species’ specific habitat requirements (USFWS 2026d). The GAP map (Exhibit 13) depicts the vegetation types present in the vicinity of the Transmission Study Corridor, which are discussed below as potential suitable species habitats.

Table 3-11 Federally Listed Species with potential to occur in the Transmission Study Corridor

Common Name	Scientific Name	Federal Status*	IUCN Status	Likelihood of Occurrence
Birds				
Mexican Spotted Owl	*Strix occidentalis*	T	NT	**None;** the Transmission Study Corridor does not include high mixed conifer forests or canyonland habitat.
Northern Aplomado Falcon	*Falco femoralis septentrionalis*	EXPN	LC	**Not likely;** the Transmission Study Corridor is located north of the species known range, however, potential suitable habitat, including yucca grasslands and low shrublands does exist within the Transmission Study Corridor.
Piping Plover	*Charadrius melodus*	T	NT	**None;** the species does not breed in New Mexico, and suitable stopover habitat, such as sandy or gravelly shorelines associated with lakes and reservoirs, is limited within the Transmission Study Corridor.
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E	LC	**Likely;** the Transmission Study Corridor overlaps USFWS-designated Critical Habitat for this species along the Rio Grande, which includes dense riparian stands of willows, salt cedar, box elder, and cottonwood trees.
Yellow-billed Cuckoo	*Coccyzus americanus*	T	LC	**Likely;** the Transmission Study Corridor overlaps USFWS-designated Critical Habitat for this species along the Rio Grande, which includes riparian woodlands dominated by cottonwood, willows, and dense mesquite.

Common Name	Scientific Name	Federal Status*	IUCN Status	Likelihood of Occurrence
Mammals				
Mexican Wolf	*Canis lupus baileyi*	EXPN	LC	**Not Likely**; the species population is almost entirely confined to the Mexican Wolf Experimental Population Area in SW NM and eastern AZ.
New Mexico Meadow Jumping Mouse	*Zapus hudsonius luteus*	E	LC	**Not Likely;** the Transmission Study Corridor does not support high-quality wet meadow or riparian habitat, and the species is largely absent from the Middle Rio Grande. The nearest known population occurs approximately 30 miles south near Bosque del Apache, where habitat consists of dense herbaceous wetlands and irrigated floodplain areas.
Plants				
Pecos Sunflower	*Helianthus paradoxus*	T	LC	**Not Likely;** the Transmission Study Corridor crosses permanently saturated soils that the species require; however, the species typically prefers spring-fed systems with saline/alkaline conditions which are rare/absent across the Transmission Study Corridor.
Insects				
Monarch Butterfly	*Danaus plexippus*	PT	LC	**Possible;** milkweed (*Asclepias* sp.) individuals, the host plant for monarch butterflies, were observed throughout the Transmission Study Corridor during field surveys.
Suckley's Cuckoo Bumble Bee	*Bombus suckleyi*	PE	CR	**Not Likely;** the species has been documented in NM, though occurrence is primarily in northern, higher-elevation areas (e.g., Sangre de Cristo Mountains).
Fish				
Rio Grande Silvery Minnow	*Hybognathus amarus*	E	EN	**Likely;** the Transmission Study Corridor overlaps with USFWS-designated Critical Habitat for this species, which is limited to water with slow to moderate flow in sections of the Rio Grande that have perennial flows of water.

*E = Endangered; T = Threatened; PE = Proposed Endangered; PT = Proposed Threatened; EXPN = Experimental Population, nonessential

**LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered

USFWS-designated Critical Habitat overlaps portions of the Transmission Study Corridor for the following species: Rio Grande silvery minnow, southwestern willow flycatcher, and yellow-billed cuckoo.

State-Listed Species

The NMDGF Biota Information System of New Mexico (BISON-M) online inventory was accessed in February 2026 and was reviewed for state-listed species that may potentially occur within the Transmission Study Corridor (NMDGF 2026b). Nine state-listed endangered or threatened wildlife species were identified by NMDGF as potentially occurring within the Transmission Study Corridor; one state of New Mexico Rare Plant Conservation Strategy plant species was identified as potentially occurring within the Transmission Study Corridor. State-listed species, and their likelihood of occurring in the Transmission Study Corridor, are shown in Table 3-12 below.

Table 3-12 State-listed Species with potential to occur in the Transmission Study Corridor

Common Name	Scientific Name	State Status	IUCN Status	Likelihood of Occurrence
Birds				
Bald Eagle	*Haliaeetus leucocephalus*	T	LC	**Likely;** Occurrence possible along the Rio Grande and there is wintering and foraging habitat across central NM.
Northern Aplomado Falcon	*Falco femoralis*	E	LC	**Not Likely;** refer to Table 4-6 above.
Peregrine Falcon	*Falco peregrinus*	T	LC	**Not Likely;** generally occupies mountain and canyon habitats and prefers tall cliffs for nesting terrain.
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	E	LC	**Likely;** refer to Table 4-6 above.
Gray Vireo	*Vireo vicinior*	T	LC	**Likely;** the Transmission Study Corridor supports pinyon-juniper woodlands, foothills, and mesas that provide suitable habitat for the species.
Mammals				
Spotted Bat	*Euderma maculatum*	T	LC	**Possible;** likely absent from open plains

Common Name	Scientific Name	State Status	IUCN Status	Likelihood of Occurrence
				without rock features; potential presence where cliff faces, escarpments, or canyon walls occur.
New Mexican Meadow Jumping Mouse	*Zapus hudsonius luteus*	E	LC	**Not Likely**; refer to Table 4-6 above.
Reptiles				
Western Ribbon Snake	*Thamnophis proximus*	T	LC	**Likely;** species prefers streams, wetlands, and irrigation features; likely present along the Rio Grande, irrigation ditches, or other perennial drainages.
Plants				
Tall Bitterweed	*Hymenoxys brachyactis*	SS	N/A	**Likely;** the Transmission Study Corridor supports dry, coarse, rocky and sandy soils within pinyon-juniper woodlands.
Fish				
Rio Grande Silvery Minnow	*Hybognathus amarus*	E	EN	**Likely;** refer to Table 4-6 above.

*E = Endangered; T = Threatened; SS = NM Rare Plant Conservation Strategy Species
**LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered

USFS and BLM-Listed Species

A list of sensitive animal and plant species was obtained for the Cibola National Forest from the USFS (USFS 2013a, USFS 2013b), and for the Rio Puerco Field Office from the BLM (BLM 2024). The species were reviewed and assessed for potential to occur within the Transmission Study Corridor. Thirty-two USFS-listed sensitive species were identified as potentially occurring within the Cibola National Forest; 28 BLM-listed sensitive species were identified as potentially occurring within the Rio Puerco Field Office. USFS and BLM-listed sensitive species only receive protections on lands that the respective agency manages. Therefore, each species' likelihood of occurrence was evaluated based on the habitat present on either BLM, or USFS-managed lands within the Transmission Study Corridor. Three USFS sensitive species were found to be "Likely" to occur: Gray vireo (*Vireo vicinor*), Northern goshawk (Accipiter gentilis), and tall bitterweed (*Hymenoxys brachyactis*). One BLM sensitive species was found to be "Likely" to occur: Pinyon jay (*Gymnorhinus cyanocephalus*) and Mexican whip-poor-will

(*Antrostomus arizonae*). USFS and BLM sensitive species, and their likelihood of occurring in the Transmission Study Corridor, are presented in Tables 3-13 and 3-14 in Appendix B.

Birds

Passerines, raptors, waterfowl, and other waterbirds may migrate through the Transmission Study Corridor, as grassland/shrubland habitats can provide stopover and post-breeding dispersal habitat for a variety of species. Waterfowl, waterbirds, and shorebirds are most likely to occur in association with emergent wetlands, open water, and other aquatic features used during migration; however, these habitat types comprise only a small portion of the Transmission Study Corridor. According to the USFWS IPaC system, the 18 migratory bird species with potential to occur within the Transmission Study Corridor are listed in Table 3-15. The IUCN status for each species is also included in the table below. “Vulnerable” indicates that the species meets one of the five IUCN criteria and is thus considered to be at high risk of unnatural (human-caused) extinction without further human intervention. “Least Concern” indicates the species is widespread and abundant in the wild globally. According to publicly available eBird data, all 18 migratory bird species have been recorded in Socorro, Valencia, and Torrance Counties (eBird 2026).

Table 3-15 Migratory Birds with the Potential to Occur in the Transmission Study Corridor

Common Name	Scientific Name	IUCN Status
Bald Eagle	*Haliaeetus leucocephalus*	Least Concern
Bendire’s Thrasher	*Toxostoma bendirei*	Vulnerable
Black-chinned Sparrow	*Spizella atrogularis*	Least Concern
Broad-tailed Hummingbird	*Selasphorus platycercus*	Least Concern
Cassin’s Finch	*Haemorhous cassinii*	Least Concern
Clark’s Grebe	*Aechmophorus clarkii*	Least Concern
Clark’s Nutcracker	*Nucifraga columbiana*	Least Concern
Evening Grosbeak	*Hesperiphona vespertina*	Vulnerable
Golden Eagle	*Aquila chrysaetos*	Least Concern
Grace’s Warbler	*Setophaga graciae*	Least Concern
Lesser Yellowlegs	*Tringa flavipes*	Vulnerable
Lewis’s Woodpecker	*Melanerpes lewis*	Least Concern
Long-eared Owl	*Asio otus*	Least Concern
Olive-sided Flycatcher	*Contopus cooperi*	Least Concern
Pectoral Sandpiper	*Calidris melanotos*	Least Concern
Pinyon Jay	*Gymnorhinus cyanocephalus*	Vulnerable
Virginia’s Warbler	*Leiothlypis virginiae*	Least Concern
Western Grebe	*Aechmophorus occidentalis*	Least Concern

Source: USFWS 2026d; IUCN 2026

Southwestern Willow Flycatcher: The southwestern willow flycatcher (*Empidonax traillii extimus*) is a federally endangered species that nests in dense riparian vegetation, typically

where cottonwood (*Populus* spp.), willow (*Salix* spp.), tamarisk (*Tamarix* spp.), and similar woody vegetation occur in association with surface water, saturated soils, or other mesic conditions. Habitat that does not meet nesting criteria may still be used during migration or foraging.

Within the Transmission Study Corridor, the potential for southwestern willow flycatcher occurrence is expected to be concentrated in the Rio Grande floodplain and associated riparian corridor, whereas the more upland portions of the route have low potential to support nesting habitat because they generally lack dense riparian vegetation and persistent hydrologic conditions. There are areas of revised designated critical habitat for the species in New Mexico including Socorro and Valencia Counties, and recent Middle Rio Grande monitoring has documented southwestern willow flycatcher territories in the Bosque del Apache, Sevilleta/La Joya, and Belen reaches, indicating the species occurs along portions of the Rio Grande in the broader Project region.

Yellow-Billed Cuckoo: The western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) is a federally threatened riparian bird that is most closely associated with dense, multi-layered woody vegetation near water, particularly willow- and cottonwood-dominated floodplain and streamside habitats. In the western United States, nests are typically placed in dense riparian vegetation along streams and rivers, and the species' current range in New Mexico is strongly tied to riparian habitat, including the Rio Grande corridor.

Within the Transmission Study Corridor, the potential for western yellow-billed cuckoo occurrence is expected to be highest within the Rio Grande floodplain and associated riparian corridor near Bosque and Los Lunas, where suitable wooded riparian habitat may be present, and low in the more upland portions of the route, which generally lack the dense mesic riparian vegetation typically used for breeding. There is designated critical habitat for the species along the Rio Grande within the proposed Transmission Study Corridor, and recent Middle Rio Grande monitoring confirms that the species occurs within the broader Project region, including documented territories in the Bosque del Apache and Sevilleta reaches and detections in the Belen Reach, indicating that suitable habitat and occasional occupancy occur along portions of the Middle Rio Grande relevant to the southern and western segment of the route.

Bald Eagle: The bald eagle (*Haliaeetus leucocephalus*) is a large raptor typically associated with rivers, reservoirs, lakes, and other open-water habitats that provide foraging opportunities, as well as large trees or snags suitable for nesting, roosting, and perching. The species breeds in in New Mexico but is more commonly encountered during winter and migration along major watercourses and reservoirs, including the Middle Rio Grande Basin, where riparian cottonwoods and other large trees provide important perch and roost sites.

For the proposed Transmission Study Corridor, the potential for bald eagle occurrence is expected to be highest near the Rio Grande floodplain and associated riparian corridor around Bosque and Los Lunas, where surface water, bosque habitat, wetlands, and adjacent foraging areas are present. The more upland portions of the route are less likely to support nesting or regular use because they generally lack large waterbodies and extensive riparian woodland,

although bald eagles could occur occasionally during movement or foraging. The broader Project region along the Middle Rio Grande is known to support wintering bald eagles (Zwank et al. 1996). Bald eagles have been recorded utilizing the Rio Grande riparian corridor south of Belen (eBird 2026).

Golden Eagle: The golden eagle (*Aquila chysaetos*) is a raptor federally protected by the Bald and Golden Eagle Protection Act and typically uses mountains and cliffs for nesting, often including rimrock terrain adjacent to open desert or grassland areas. The most common nesting areas in New Mexico are steep-walled mountain canyons. Suitable foraging habitat includes grasslands and plains which supports small to mid-sized prey, like rabbits, prairie dogs, coyote pups, and young deer.

Suitable foraging habitat for golden eagle occurs throughout the proposed Transmission Study Corridor. The potential for golden eagle is expected to be highest in the lower elevation grasslands, and lower in the riparian areas surrounding the Rio Grande. However, suitable nesting habitat, including cliffs and steep-walled mountain canyons, is not present anywhere within the Transmission Study Corridor.

Gray Vireo: The gray vireo (*Vireo vicinior*) is a small songbird that inhabits arid shrubland and woodland habitats, most commonly associated in New Mexico with pinyon-juniper woodlands, juniper savannas, foothills, canyons, mesas, and rolling hills, where it typically nests in juniper and other dense woody vegetation. Studies in New Mexico indicate the species is strongly tied to juniper-dominated sites, often with relatively low pinyon cover, and it generally occupies hot, dry upland settings rather than broad riparian floodplains.

Within the Transmission Study Corridor, the potential for gray vireo occurrence is expected to be highest in the upland portions of the corridor where pinyon-juniper woodland, juniper savanna, and shrub-covered mesas or canyon slopes may provide suitable breeding habitat. Gray vireo has been recorded in the mid-elevation woodlands of the Manzano Mountains (eBird 2026). In contrast, the species is expected to have lower potential within the Rio Grande floodplain, where habitat shifts toward riparian bosque, wetlands, and agricultural lands that are generally less consistent with the gray vireo's typical breeding habitat preferences.

Burrowing Owl: The western burrowing owl (*Athene cunicularia*) is a BLM sensitive species and a New Mexico Species of Greatest Conservation Need associated with open grasslands, shrublands, agricultural fields, and disturbed habitats containing suitable burrows for nesting and shelter. The species frequently relies on burrows excavated by prairie dogs, ground squirrels, badgers, or other fossorial mammals and may also occupy artificial structures. Suitable habitat occurs throughout portions of the Transmission Study Corridor characterized by open grassland, shrubland, rangeland, agricultural lands, and areas supporting prairie dog colonies or other burrowing mammals.

Sandhill Crane: The sandhill crane (*Antigone canadensis*) is not federally or state listed but is a species of local game management and conservation importance within the Transmission Study Corridor. Populations of two subspecies of sandhill cranes are present seasonally within the

Transmission Study Corridor, the Rocky Mountain Population of greater sandhill cranes (*A. c. tabida*) and lesser sandhill cranes (*A. c. canadensis*). Each year, sandhill cranes overwinter along the Rio Grande in the Middle Rio Grande Valley of New Mexico. They roost along the Rio Grande (which is crossed by the Transmission Study Corridor) and on public lands managed for waterbirds, and forage in surrounding agricultural lands, including on supplemental cereal grain crops (e.g., corn) grown and provisioned by a multiagency program. Sandhill cranes within the Transmission Study Corridor are known to be impacted by both existing infrastructure (including transmission lines) and hunting.

Mammals

Spotted Bat: The spotted bat (*Euderma maculatum*) is an uncommon bat of the western United States that is most strongly associated with prominent cliffs, canyon walls, rock outcrops, and other steep roosting features, while foraging in open habitats that may include shrublands, pinyon-juniper woodlands, riparian areas, wetlands, meadows, and other open landscapes. In New Mexico, the species is considered state threatened, and available sources indicate that it typically roosts in cliffs but may travel across a variety of habitat types to forage.

For the proposed Transmission Study Corridor, the potential for spotted bat occurrence is expected to be highest where the corridor approaches canyon terrain, cliff faces, rocky escarpments, or other prominent roost features, particularly in the more dissected upland portions and similar rocky landscapes. Potential for foraging use may also occur near open uplands, pinyon-juniper habitats, drainages, and the Rio Grande corridor, where water and insect prey could be available; however, the species' likelihood of regular use would generally be lower in broad valley bottoms or agricultural areas that lack nearby cliff roosting habitat.

Game Species: Five of the ten big game species managed by NMDGF have the potential to occur in the Transmission Study Corridor: elk (*Cervus canadensis*), mountain lion (*Puma concolor*), American black bear (*Ursus americanus*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*). Each of these species is known to inhabit pinyon-juniper and grassland habitats, though black bears typically inhabit the more mountainous regions to the north. Elk, mountain lion, and pronghorn have been documented in or near the Transmission Study Corridor.

The USGS manages the Western Migrations geospatial database of ungulate migrations developed in partnership with state agencies such as NMDGF and tracks 21 migratory herds of elk, mule deer, and pronghorn antelope, none of which occur within the Transmission Study Corridor (USGS 2026f). The Transmission Study Corridor is also located in NMDGF Game Management Units 9, 13, 14, and 38 and NMDGF issues licenses to hunt all three species in these Game Management Units.

Reptiles

Western Ribbon Snake: The western ribbon snake (*Thamnophis proximus*) is a semi-aquatic reptile that is typically associated with shrubby habitats near water, including streams, ponds, marshes, wetlands, and other riparian areas. In New Mexico, it is considered state threatened, and available species accounts indicate that it generally remains close to aquatic or mesic habitats where prey such as amphibians, fish, and aquatic invertebrates are available. For the proposed Transmission Study Corridor, the potential for western ribbon snake occurrence is expected to be lowest across the upland portions, where open grassland, pinyon-juniper, and drier upland habitats generally lack the persistent water and dense riparian cover this species typically uses. Potential for occurrence would be highest near the Rio Grande floodplain and associated wetlands, irrigation features, and riparian habitats, where aquatic and riparian conditions are more consistent with the species' habitat requirements.

Flowering Plants

Tall Bitterweed: Tall bitterweed (*Hymenoxys brachyactis*) is a state of New Mexico Rare Plant Conservation Strategy Species and USFS sensitive species. The New Mexico Rare Plant Conservation Strategy is a part of New Mexico's Energy, Minerals, and Natural Resources Department (NMEMNRD) Forestry Division's Forest Action Plan, which identifies natural resource conditions, needs and opportunities across all land ownerships in the state. USFS sensitive species are those that occur on National Forest Service lands and that have been identified as of concern for reduction in population viability. Tall bitterweed is a biennial species that inhabits dry sites with coarse soils in pinyon-juniper woodland and lower montane coniferous forest between 6,900 and 8,200 feet above mean sea level. The species is known from Torrance and Socorro Counties, and although it is endemic, can be locally abundant and will occupy disturbed sites (NMRPTC 1999). Within the Transmission Study Corridor, the potential for tall bitterweed occurrence is expected to be highest in the pinyon-juniper woodland and lower montane coniferous forests habitats which occur in and around the southern Manzano Mountains. Potential for occurrence would be unlikely across the areas of lower elevations that lack woodland and coniferous forest habitats that the species requires.

Insects

Monarch Butterfly: The monarch butterfly (*Danaus plexippus*), a federally proposed threatened insect species, has the potential to occur in the Transmission Study Corridor. Monarch butterflies occur throughout the United States and are known to migrate seasonally between the United States, Canada, and Mexico. Monarch butterflies lay eggs primarily on milkweed (*Asclepias* spp.) host plants and seek out a variety of flowering plants for food. The Transmission Study Corridor appears to be dominated by herbaceous grasslands, shrub/scrub, and evergreen scrub-shrub. These vegetation communities have potential to support a diversity of blooming nectar resources, including milkweed, which is crucial for the species (USFWS

2026e). The monarch butterfly is currently listed as proposed threatened, which does not receive protection under the ESA.

3.9 Archaeological and Historic-Age Cultural Resources

3.9.1 Data Sources

The following data sources were reviewed to assess the archaeological and historic-age cultural resources in the portions of Socorro, Torrence, and Valencia Counties where the Project is proposed.

- New Mexico Cultural Resources Information System (NMCRIS). Accessed June 2026. https://nmcris.nmhistoricpreservation.org/.
- NPS. 2026a. “Abó.” Salinas Pueblo Missions National Monument, Accessed June 2026, https://www.nps.gov/sapu/learn/historyculture/abo.htm.
- “Socorro County History.” Socorro County. InfoNet, https://www.socorrocounty.net/general-information/history. Accessed June 2026.
- “The Socorro Chieftain Archive.” Newspapers.com, https://www.newspapers.com/paper/the-socorro-chieftain/13785/. Accessed June 2026.
- “Valencia County History.” Valencia County. 2026a. Genealogy Trails, https://genealogytrails.com/newmex/valencia/county_history.html. Accessed June 2026.
- “Valencia County, New Mexico.” Valencia County. 2026b. American History and Genealogy Project. https://ahgp.org/nm/cty/valencia_county_new_mexico.html. Accessed June 2026.
- “Torrance County, New Mexico.” Torrance County. 2026a. American History and Genealogy Project, https://ahgp.org/nm/cty/torrance_county_new_mexico.html. Accessed June 2026.
- “Torrance County History.” Torrance County. 2026b. Genealogy Trails, https://genealogytrails.com/newmex/torrance/history.html. Accessed June 2026.
- “Torrance County.” Torrance County. 2026c. New Mexico Counties, https://www.nmcounties.org/counties/torrance-county/. Accessed June 2026.
- “Torrance County, New Mexico: A Genealogical Overview.” U.S. County History Books 2026. Directory, https://uscountyhistorybooksdirectoryandlookup.com/states/nm/torrance-county-history/. Accessed June 2026.
- “Estancia.” Historical Marker Database, https://www.hmdb.org/m.asp?m=280257. Accessed June 2026.

3.9.2 Current Conditions and Trends, Regional Overview

Portions of the Transmission Study Corridor have previously been evaluated for cultural resources. To date, 146 archaeological surveys conducted within the corridor have documented 268 archaeological sites, designated as LA (Laboratory of Anthropology) sites, and 60 Historic Cultural Properties Inventory (HCPI) resources (NMCRIS 2026). Of the 268 total archaeological sites, as shown in Table 3-16 (located in Appendix B), there are 124 prehistoric sites, 84 historic-age, 32 multicomponent (both prehistoric and historic), and 28 of unknown temporal or cultural affiliation.

In order to be Eligible for listing on the National Register of Historic Places (NRHP), a resource must meet at least one of the register's four main criteria: Criterion A, the property marks an important moment of American prehistory or history and/or represents a major pattern or historic trend that made a significant contribution to the development of a community, a state, or the nation; Criterion B, the resource is associated with significant people of the American past; Criterion C, the resource embodies distinctive characteristics of a type, period, or method of construction including having great artistic value or being the work of a master; and/or Criterion D, a resource yields or may yield important information that contributes to our understanding of human history or prehistory. Of the 268 archaeological sites, 19 have been determined Eligible for listing on the NRHP, 26 have been determined Not Eligible for listing on the NRHP, and 223 remain Unevaluated by the New Mexico State Historic Preservation Office (SHPO) for NRHP inclusion. The Study Corridor intersects the Salinas Pueblo Missions National Monument, Abo (San Gregorio de Abo Mission) Mission National Historic Landmark, NR 66000497. Sites related to the monument that intersect the Transmission Study Corridor include LA 97, LA 203462, LA 203463, LA 203464, LA 203468, LA 203477, LA 203479, LA 203483, and LA 203490. Sites in the vicinity of the monument that may be related but have not been assessed for NRHP inclusion include LA 99210, LA 99211, and LA 99212.

The Abo (San Gregorio de Abo Mission) Mission National Historic Landmark (NR 66000497/ SR 1), part of the Salinas Pueblo Missions National Monument, covers about 370 acres and was a thriving Puebloan community when the Spanish arrived in 1581. Spanish mission work began in 1622 when Fray Francisco Fonte established an early convento using existing pueblo rooms and oversaw construction of a smaller church and convento by 1628, which notably included a circular kiva to support conversions. In 1640, Fray Francisco Acevedo expanded and renovated the complex, building a larger church around the original structure; these improvements were completed by 1658. Despite these efforts, disease, drought, famine, and Apache raids led to the site's abandonment in 1673 (NPS 2026a).

In addition to the archaeological sites and HCPI resources identified below, the Transmission Study Corridor also intersects three significant historic transportation routes: Route 66, the Burlington Northern Santa Fe (BNSF)/Atchison, Topeka and Santa Fe (ATSF) Railway, and the El Camino Real de Tierra Adentro. While the El Camino Real de Tierra Adentro has been recorded in multiple segments throughout the Rio Grande region and a general route is known going from Mexico City, Mexico to Santa Fe, New Mexico, there are no recorded segments of

the trail within the Transmission Study Corridor. There is a potential for cultural surveys to identify additional segments of the trail.

Of the 60 total HCPIs, as shown in Table 3-17, there are 26 identified as buildings, 24 recorded as linear resources, nine recorded as structures, and one recorded as a site. Fourteen of the HCPIs have been determined to be Eligible for listing on the NRHP, 23 have been determined to be Not Eligible for listing on the NRHP, and 23 remain Unevaluated by the SHPO for NRHP inclusion. Site types include historic structures and buildings, bridges, and linear resources such as acequias, irrigation ditches, canals, historic transportation routes, and historic transmission lines.

Table 3-17 Historic Cultural Properties Inventory Resources within Transmission Study Corridor

HCPI Number	Resource Type	Site Alias	NRHP Evaluation
30312	Building	-	Unevaluated
30387	Building	-	Unevaluated
30388	Building	-	Unevaluated
30389	Building	-	Unevaluated
30390	Building	-	Unevaluated
30391	Building	-	Unevaluated
30392	Building	-	Unevaluated
30393	Building	-	Unevaluated
30394	Building	-	Unevaluated
30514	Linear Resource	-	Unevaluated
31579	Linear Resource	Lower Peralta Drain, San Juan Feeder Canal, Lower Peralta Riverside Drain	Eligible
31580	Structure	Belen Highline Canal	Eligible
31896	Linear Resource	BNSF Railroad (Valencia County Portion), BNSF Railway, Burlington, Northern and Santa Fe Railroad, Burlington Northern Santa Fe (BNSF; current), Burlington Northern Santa Fe, BNSF, ATSF/BNSF, BNSF Railroad, ATSF/BNSF railway segment, in-use ATSF railway	Eligible
32263	Linear Resource	NM 41	Eligible
33977	Linear Resource	NM 6, Route 66/ NM Highway 6	Not Eligible
39355	Structure	-	Not Eligible
40216	Linear Resource	El Paso Electric Co Transmission Line	Not Eligible
41228	Structure	Windmill	Unevaluated
43231	Site	Burlington, Northern and Santa Fe Railroad, Burlington Northern Santa Fe Railroad	Eligible
43399	Linear Resource	Garcia Acquia / Garcia Ditch, Garcia Acequia; Garcia Ditch	Eligible

HCPI Number	Resource Type	Site Alias	NRHP Evaluation
44287	Linear Resource	-	Not Eligible
45666	Linear Resource	Old Jarales Acequia	Unevaluated
45667	Linear Resource	-	Not Eligible
46092	Building	-	Eligible
47808	Structure	-	Unevaluated
48477	Structure	-	Unevaluated
52039	Building	-	Not Eligible
52040	Building	-	Unevaluated
52041	Building	-	Unevaluated
52042	Building	-	Unevaluated
52043	Building	-	Not Eligible
52044	Building	-	Not Eligible
52045	Building	-	Not Eligible
52046	Building	-	Not Eligible
52047	Building	-	Not Eligible
52048	Building	-	Not Eligible
52049	Building	-	Not Eligible
52050	Building	-	Not Eligible
52051	Building	-	Not Eligible
52052	Building	-	Unevaluated
52059	Building	-	Not Eligible
52063	Building	-	Not Eligible
52065	Linear Resource	-	Unevaluated
52066	Linear Resource	-	Eligible
53631	Linear Resource	-	Unevaluated
54288	Linear Resource	-	Eligible
54289	Linear Resource	-	Not Eligible
54290	Linear Resource	-	Unevaluated
54291	Linear Resource	-	Not Eligible
54292	Structure	Half a Dam Site	Not Eligible
54293	Linear Resource	-	Not Eligible
54593	Structure	Scholle Bridge, NM DOT Bridge #2628	Eligible
54727	Linear Resource	Upper Sabinal Riverside Drain	Eligible
54728	Linear Resource	Lower Arroyos Acequia	Eligible
54729	Linear Resource	-	Eligible
55495	Linear Resource	-	Not Eligible
55496	Structure	-	Not Eligible
56736	Linear Resource	-	Eligible
56743	Linear Resource	Sanchez Feeder Ditch	Unevaluated

HCPI Number	Resource Type	Site Alias	NRHP Evaluation
57492	Structure	Jetty Jacks of the Middle Rio Grande Project	Unevaluated

The Transmission Study Corridor extends through Torrance, Socorro, and Valencia Counties. The sites discussed above, along with any additional sites and historic properties identified during cultural resource surveys conducted for the Project, may contribute to understanding the history and development of these counties.

Socorro County was established in 1852 as one of the original counties of the New Mexico Territory. Its boundaries were initially much larger but were reduced over time. Indigenous peoples, including Puebloan communities, the Navajo, and the Apache, inhabited the region before Spanish settlement. In 1598, Juan de Oñate entered the area, introducing Spanish missions and settlements along El Camino Real. Following the Pueblo Revolt of 1680, Spanish settlers temporarily abandoned the region but later returned, with settlement expanding during the Spanish and Mexican periods and continuing after the area became part of the United States in 1848. Economic growth was driven by ranching, mining, and transportation improvements, including the arrival of the railroad and the founding of the New Mexico School of Mines in 1889. During the twentieth century, agriculture remained important, while the county also became associated with scientific research, including the Trinity atomic test in 1945.

Torrance County was established in 1903–1904 from portions of Valencia County and neighboring areas. Its creation was closely linked to the expansion of railroad infrastructure across central New Mexico. Located in the Estancia Valley, the area was first occupied by native populations and later settled by Spanish and Mexican ranching communities. The arrival of the railroad in the early twentieth century encouraged homesteading, agricultural development, and the growth of towns such as Estancia and Willard as regional trade and transportation centers. As settlement increased, the county seat was moved to Estancia in 1905. The county subsequently developed around agriculture, ranching, and transportation networks, reflecting both its long-established rural communities and newer railroad-era settlements.

Valencia County, also established in 1852, is one of New Mexico's original counties and was historically part of the Rio Abajo region along the Middle Rio Grande. Puebloan agricultural communities occupied the area long before Spanish settlement. During the Spanish and Mexican periods, irrigation-supported agriculture sustained communities such as Los Lunas and Belen. After the United States acquired the region in 1848, continued growth was supported by transportation improvements, including the railroad, which strengthened trade and regional connectivity. Although its original boundaries were later reduced through the creation of additional counties, Valencia County has remained strongly associated with agriculture, particularly irrigated farming and orchard production within the Rio Grande Valley, as reflected in its extensive acequia, canal, and irrigation ditch systems.

A review of recorded cultural resources within the Transmission Study Corridor indicates that survey coverage remains limited relative to the corridor's overall acreage. Although 146 cultural

resource surveys have been conducted, approximately 90% of the Transmission Study Corridor has not been surveyed, leaving substantial gaps in resource identification and documentation. As a result, additional cultural resources are expected to be identified during surveys conducted in support of the proposed Project. Common resource types within the Transmission Study Corridor include prehistoric artifact scatters, artifact scatters with associated features, prehistoric habitation sites, historic homesteads and structures, and historic roads.

3.10 Religious and Cemetery Sites

3.10.1 Data Sources

The following data sources were reviewed to assess the existing religious and cemetery sites in the portions of Socorro, Torrence, and Valencia Counties where the Project is proposed.

- Esri. 2026. GIS data for religious sites and cemeteries in Socorro, Torrence, and Valencia, and Counties, New Mexico. Accessed June 2026. https://www.esri.com.
- American Cemeteries. 2026a. Socorro County, NM Cemeteries. Accessed June 2026. http://www.americancemeteries.org/new-mexico/socorro-county.
- American Cemeteries. 2026b. Torrence County, NM Cemeteries. Accessed June 2026 http://www.americancemeteries.org/new-mexico/torrence-county.
- American Cemeteries. 2026c. Valencia County, NM Cemeteries. Accessed June 2026 http://www.americancemeteries.org/new-mexico/valencia-county.
- Billion Graves. 2026. New Mexico Cemetery Search. Accessed June 2026. https://billiongraves.com/search/cemetery.
- Find a Grave. 2026a. La Puerta Natural Burial, Valencia County, New Mexico, USA. Accessed June 2026. https://www.findagrave.com/cemetery/2690214/la-puerta-natural-burial.
- Find a Grave. 2026b. Willard Cemetery, Torrence County, New Mexico, USA. Accessed June 2026. https://www.findagrave.com/cemetery/38514/willard-cemetery?.

3.10.2 Current Conditions and Trends, Regional Overview

One religious site, San Francisco Xavier Catholic Mission Church, Jarales, is located within the Transmission Study Corridor (Table 3-18). The Transmission Study Corridor may contain unknown or abandoned religious sites.

Table 3-18 Religious Sites within the Transmission Study Corridor

Name	Coordinates	County

San Francisco Xavier Catholic Mission Church	34.611683, -106.761205	Valencia

Two cemeteries, the La Puerta Natural Burial Ground and Willard Cemetery, are located within the Transmission Study Corridor (American Cemeteries 2026a-d; Esri 2026; Billion Graves 2026) (Table 3-19) (Exhibit 15).

Table 3-19 Cemeteries within the Transmission Study Corridor

Name	Coordinates	County	Cemetery ID	Recorded Burials	Headstone Range
La Puerta Natural Burial Ground	34.46694, -106.52827	Valencia	2690214	300	1923-2026
Willard Cemetery	34.59580, -106.03310	Torrence	38514	6	1844-2021

No additional religious sites are located within the Transmission Study Corridor (Billion Graves 2026; Esri 2026). No additional cemeteries are located within one mile of the Transmission Study Corridor (American Cemeteries 2026a-d; Esri 2026; Billion Graves 2026). None of the religious sites or cemeteries within the Transmission Study Corridor are recorded on NMCRIS as archaeological sites or HCPIs. The Transmission Study Corridor may contain unknown or abandoned cemeteries.

3.11 Visual and Scenic Resources

3.11.1 Data Sources

The following data sources were reviewed to assess the existing visual and scenic conditions of Socorro, Torrance, and Valencia Counties as related to the Transmission Study Corridor.

- BLM. 2026b. National Data Viewer. Accessed June 2026 https://experience.arcgis.com/experience/9a89ee80c604431e8f8d939a186fbdbb.
- NPS. 2017. Physiographic Provinces. Accessed June 2026. https://www.nps.gov/subjects/geology/physiographic-provinces.htm.
- New Mexico Scenic Byways Map. NMDOT. 2026a. Accessed June 2026 https://www.dot.nm.gov/travel-information/maps/.
- USEPA Level III Ecoregions, 2010 (USEPA 2026c). Accessed June 2026 https://www.epa.gov/eco-research/ecoregions-north-america.
- Cibola National Forest Land Management Plan 2022 (USFS 2022). Accessed June 2026 https://www.fs.usda.gov/sites/nfs/files/legacy-media/cibola/20220712_CibolaLMP_Final-WEB.pdf.

- BLM Manual H-8410-1 - Visual Resource Inventory 1986 (BLM 1986). Accessed 2026 https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_H-8410.pdf.
- Landscape Aesthetics, *A Handbook for Landscape Management* (USFS 1995). Accessed June 2026 https://www.fs.usda.gov/sites/default/files/ah-701-landscape-aesthetics-stelprdb5412126.pdf.
- NPS. 2026b. New Mexico National Monuments. Accessed 2026 https://www.nps.gov/state/nm/index.htm.

3.11.2 Current Conditions and Trends, Regional Overview

The Transmission Study Corridor contains lands administered by the USFS, the NPS, and the BLM in addition to NMSLO and private land across Torrance, Socorro, and Valencia Counties in central New Mexico (Exhibit 16).

The Project is located within two NPS-identified physiographic provinces. The NPS defines these physiographic provinces based on geomorphological characteristics such as climate, geologic history, and landform processes. A portion of the easternmost parts of the Project is located in the western edge of the Great Plains Physiographic Province while most of the Project is in the Basin and Range Physiographic Province. The Great Plains Physiographic Province extends east from the Rocky Mountains and is characterized by soils that are mostly remnants of alluvial sediments from the Rocky Mountains and glacial silt. The Basin and Range Physiographic Province extends across the southwestern United States from eastern California into New Mexico and Texas. The alternating mountain ranges and low valleys characteristic of this region are the result of cracks and fissures formed by a thinning crust (NPS 2026b).

To further characterize the landscape, USEPA defined Level III Ecoregions were reviewed for the Transmission Study Corridor. Three USEPA Level III Ecoregions occur, the Arizona/New Mexico Mountains ecoregion, the Arizona/New Mexico Plateau ecoregion, and the Southwest Tablelands ecoregion. The Arizona/New Mexico Mountains ecoregion extends from northwestern Arizona and into central and southern New Mexico and is characterized primarily by the presence of mountain ranges and mid-altitude steppes. The diverse topography leads to a range of climates and vegetation communities depending on altitude and water availability. The Arizona/New Mexico Plateau ecoregion includes northern Arizona, northwestern New Mexico and portions of southern Colorado. The ecoregion is characterized as a mid-altitude steppe that features landforms ranging from plateaus and mesas, to rolling plains and low valleys. Vegetation acts as a transitional zone between neighboring ecoregions, housing an array of communities ranging from semi-arid grasslands to arid scrub and sagebrush to woodlands. The Southwest Tablelands ecoregion is located between High Plains and the southern Rocky Mountains. The semi-arid landscape features a wide array of landforms including canyons, mesas, badlands, gorges, and rolling plains. Vegetation communities generally are dominated by chaparral and sagebrush steppes, giving way to pinyon-juniper woodlands at higher elevations (USEPA 2010).

The landscape setting for the Project consists of a mix of mountains and high desert, with riparian areas associated with the Rio Grande Valley. Elevation within the Transmission Study Corridor ranges from 4,791 feet to 6,766 feet (1,460 meters to 2,062 meters) above mean sea level (Exhibit 17). The Transmission Study Corridor begins at the Western Spirit Switchyard roughly 6,407 feet above sea level. The surrounding area is dominated by open prairie and range land. As the route travels west the Project traverses rolling hills before descending into a broad valley east of community of Willard. As the Project passes Willard it gains elevation until reaching the highpoint of approximately 6,624 feet near the community of Mountainair. Vegetation begins to transition from grassy plains to sparsely distributed scrub brush. From here the Project descends toward Abo Pass and the Rio Grande valley. Once the Transmission Study Corridor crosses the Rio Grande riparian corridor, vegetation transitions from sparse shrubs and open rangeland to irrigated fields and suburban developments. The route then crosses United States Highway (US Hwy) 25 where dominant vegetation returns to desert scrubland before continuing north until reaching the route terminus at the Hidden Mountain Substation.

The Transmission Study Corridor includes lands managed by the BLM and the USFS, both of which have Visual Resource Management objectives for areas under their jurisdiction. USFS lands within the corridor are managed by the Cibola National Forest, which uses the Scenery Management System to establish Scenic Integrity Objectives (SIOs) and guide implementation of scenic goals identified in the Land Management Plan. The corridor crosses areas designated as Low and Moderate SIO. A Low SIO allows projects to be visually prominent and potentially compete with the natural landscape, whereas a Moderate SIO allows projects to remain visible without dominating the view, enabling the landscape to retain its natural appearance (USFS 1995) (Exhibit 18).

The BLM uses Visual Resource Inventory classes to establish Visual Resource Management goals and objectives. Where Visual Resource Management classes are designated in Resource Management Plans, they guide management actions and allowable land uses. BLM-administered lands within the Transmission Study Corridor, managed by the Rio Puerco Field Office, are classified as Visual Resource Management Class III and Visual Resource Management Class IV. Class III areas are managed to partially retain the existing landscape character, allowing moderate levels of visual change that may attract attention but are not visually dominant. Class IV areas allow greater levels of change that may be visually dominant, provided reasonable efforts are made to minimize visual impacts. These Class III and Class IV areas are relatively limited in extent, occurring primarily in Torrance County east of Abo Pass (BLM 1986) (Exhibit 18).

There are several residential areas located within the Transmission Study Corridor. The majority of residences are generally associated with suburban areas along the Rio Grande such as Belen and Jarales. However, dispersed rural residents and residential clusters occur along State Highway (SH) 47, between Abo Pass and Mountainair, and on the eastern side of Willard.

Several designated scenic byways were identified within the Transmission Study Corridor. The Transmission Study Corridor intersects the Salt Missions Trail Scenic Byway west of Willard and north of Mountainair. On the other side of the Abo Pass the Transmission Study Corridor crosses the El Camino Real National Scenic Byway east of Jarales, and the New Mexico and Historic Route 66 National Scenic Byway near Los Lunas, New Mexico. The Transmission Study Corridor also parallels the Abo Pass Trail Scenic Byway for roughly 12.1 miles beginning north of the byway's intersection with US Hwy 60.

The Transmission Study Corridor crosses a portion of the Salinas Pueblo Missions National Monument, which is administered by the NPS. The monument preserves historic Spanish mission sites and Pueblo settlements across three units: Abo, Quarai, and Quivira. The Transmission Study Corridor extends into lands associated with the Abo unit but does not cross any developed National Monument facilities, including the visitor center or interpretive loop trail.

3.12 Land Use, Including Farm, Range, and Recreational Resources

3.12.1 Data Sources

The following data sources were reviewed to assess the existing land use, including farm, range, and recreational resources of the portions of Socorro, Torrance, and Valencia Counties where the Project is proposed.

- FAA. 2026. National Aeronautical Charting Office. Alburquerque Sectional Aeronautical Chart, Effective May 14, 2026.
- Land Conservation Assistance Network (LandCAN). 2026a. Socorro Soil & Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/Socorro-Soil-and-Water-Conservation-District/5133.
- LandCAN. 2026b. Claunch-Pinto Soil and Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/ClaunchPinto-Soil-and-Water-Conservation-District/5101.
- LandCAN. 2026c. Valencia Soil and Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/Valencia-Soil-and-Water-Conservation-District/5140.
- Mid-Region Council of Governments of New Mexico. 2003. Comprehensive Land Use Plan for Torrance County, New Mexico, August 2003. Accessed June 2026 from: https://www.mrcog-nm.gov/DocumentCenter/View/3124/Torrance-County- Comprehensive-Plan-August-2003-PDF.
- Middle Rio Grande Conservancy District. 2026. Water Data Map. Accessed August 2026 from: https://mrgcd.onerain.com/map/?view=d0d66eea-35a2-42ea-8ed9-1cc38ba58743.

- Multi-Resolution Land Characteristics (MRLC) Consortium. 2026. 2026 National Land Cover Database (NLCD) Land Cover. Accessed August 2026 from: https://www.mrlc.gov/.
- NPS. 2026c. National Monuments & Memorials. Accessed June 2026 from: https://www.nps.gov/subjects/monuments/index.htm.
- NMDOT. 2026b. Roads. Accessed June 2026 from: https://nmroads.com/default.html?v=2025012001&.
- NMEMNRD. 2026a. New Mexico Mining and Minerals Division. Mine Registrations and Permits Accessed June 2026 from: https://wwwapps.emnrd.nm.gov/MMD/MMDWebInfo/.
- Office of State Engineer. 2026a. Interstate Stream Commission. Acequias. Accessed August 2026 from: Ose.nm.gov/Acequias/isc_acequias.php.
- Office of State Engineer. 2026b. Acequias map. Accessed August 2026 from: https://gis.ose.nm.gov/ose_pod_locations/?page=Acequias.
- Socorro County. 2006. 2006 Socorro County Comprehensive Plan. Accessed June 2026 from: https://www.socorrocounty.net/administration/public-works#h.lbjye2lf6p5d.
- USCB. 2020b. GEO Geographic Information. Accessed June 2026 from: https://data.census.gov/table?d=GEO+Geography+Information.
- USDA National Agricultural Statistics Service (NASS). 2017a. 2017 Census of Agriculture County Profile – Socorro County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35053.pdf.
- USDA NASS. 2017b. 2017 Census of Agriculture County Profile – Torrance County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35057.pdf.
- USDA NASS. 2017c. 2017 Census of Agriculture County Profile – Valencia County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35061.pdf.
- United States Department of Transportation (USDOT). 2026. Federal Railroad Administration. Rail Network Development. Maps GIS. FRA Safety Maps. Accessed June 2026 from: https://fragis.fra.dot.gov/gisfrasafety/.
- Valencia County. 2022. 2022 Valencia County Comprehensive Plan. Accessed June 2026 from: https://www.co.valencia.nm.us/325/Comprehensive-Plan.

3.12.2 Current Conditions and Trends, Regional Overview

The Transmission Study Corridor is a largely rural region of central New Mexico, dominated by rangelands of the Middle Rio Grande and southern portion of the Cibola National Forest. Currently, land cover is primarily dominated by shrub/scrub (62%), followed by grassland/herbaceous areas (32%), with smaller pockets of evergreen forest along the Rio Grande River (Exhibit 19) (MRLC 2026). Table 3-20 below summarizes the NLCD cover types in the Transmission Study Corridor.

Table 3-20 National Land Cover Database Summary for the Transmission Study Corridor

Land Cover	Acres	Percent of Transmission Study Corridor[a]
Shrub/Scrub	40,515.7	62%
Grassland/Herbaceous	20,804.6	32%
Developed, Open Space	1,770.5	3%
Developed, Low Intensity	734.5	1%
Cultivated Crops	604.3	1%
Pasture/Hay	481.8	1%
Evergreen Forest	422.8	1%
Emergent Herbaceous Wetlands	181.6	<1%
Barren Land (Rock/Sand/Clay)	77.0	<1%
Developed, Medium Intensity	60.2	<1%
Woody Wetlands	58.2	<1%
Open Water	52.5	<1%
Developed, High Intensity	12.5	<1%
Total	**65,776.2[b]**	**100%**

[a] Percentages are rounded to the nearest whole number.
[b] Transmission Study Corridor acreage totals may vary due to differences in data sources, spatial accuracy, and methodologies.
Source: MRLC 2026

Socorro County

Socorro County covers approximately 6,646 square miles in south-central New Mexico (USCB 2020). Infrastructure within the Transmission Study Corridor includes a BNSF railroad in northeast Socorro County that runs in a northwest–southeast direction (USDOT 2026), as well as major highway transportation corridors including U.S. Hwy 60 and SH 47 (NMDOT 2026b).

Acequias are recognized under New Mexico law as political subdivisions of the state and have historically served as local government units responsible for the distribution and use of surface water (Office of State Engineer 2026a). These acequia systems are concentrated along the Rio Grande Valley and generally parallel the Rio Grande River and Interstate (I-) 25 corridor, where irrigated agriculture is most prevalent (Office of State Engineer 2026b). Several acequias within the Socorro County are administered through local acequia associations, including the Middle Rio Grande Conservancy District (Middle Rio Grande Conservancy District 2026). Supporting agricultural production, water resource management, and natural resource conservation within the county, the Socorro Soil & Water Conservation District promotes stewardship of natural resources by providing leadership, education, technical and financial assistance to the citizens of the district (LandCAN 2026a). The Transmission Study Corridor is within valleys and rangelands, where land is primarily used for cattle and horse ranching (USDA NASS 2017a). The Sais Quarry and Socorro County Pit are located within the northeastern portion of Socorro County within the Transmission Study Corridor; however, no significant adverse impacts are anticipated to these facilities (NMEMNRD 2026a).

In addition to these existing conditions, the 2006 Northern Socorro County Comprehensive Land Use Plan characterizes development of the north-central part of the County over the next 20 to 30 years. The plan serves as a general policy guide for County officials regarding the location, character, and type of growth in the community. It establishes a framework that documents existing community conditions, identifies issues and future preferences, and guides the desired development of Northern Socorro County. The plan identifies the portions of the Transmission Study Corridor within Socorro County are primarily characterized by agricultural and residential land uses, with limited areas associated with dairy operations, sand and gravel mine, public facilities, and other industrial uses. The Plan does not specifically address energy or utility facilities (Socorro County 2006).

Torrance County

Torrance County covers approximately 3,345 square miles in east-central New Mexico (USCB 2020). The western and southern portions of the county consist of the valleys within Cibola National Forest. Infrastructure within the Transmission Study Corridor includes a BNSF railroad in the southern portion of the County that runs in a northeast-southwest direction (USDOT 2026), as well as major highway transportation corridors including US Hwy 60, SH 41, SH 42, and SH 55 (NMDOT 2026b).

Agricultural and natural resource management in Torrance County is supported by the Claunch-Pinto Soil and Water Conservation District using conservation practices and resource management methods to enhance watershed health and productivity (LandCAN, 2026b). Land within Torrance County is primarily used for cattle and calf production (USDA NASS 2017b). A review of the NPS website identified Salinas Pueblo Missions National Monument within a portion of the Transmission Study Corridor along the north side of US Hwy 60 in Torrance County (NPS 2026). The Abo Viejo Quarry is located within the southwestern portion of the

County within the Transmission Study Corridor; however, no significant adverse impacts are anticipated due to its permanent closure in 2008 (NMEMNRD 2026a).

In addition to these existing conditions, the 2003 Torrance County Comprehensive Land Use Plan was prepared by the Mid-Region Council of Governments with support from New Mexico state agencies and the United States Department of Housing and Urban Development and was formally adopted by the Torrance County Commission on July 29, 2003. The plan guides decisions on public programs that shape the County's growth and development and reflecting community input on how development would be managed over the next 20 to 25 years. The plan identifies portions of the Transmission Study Corridor, particularly along US Hwy 60, as being characterized by irrigated agricultural and single-family residential. The Plan does not specifically address energy or utility facilities (Mid-Region Council of Governments of New Mexico 2003).

Valencia County

Valencia County covers approximately 1,066 square miles in west-central New Mexico (USCB 2020). The southeastern portion of the county consists of the valleys within southwestern portion of the Cibola National Forest. Infrastructure within the Transmission Study Corridor includes a BNSF railroad that runs through the County in a northwest–southeast direction (USDOT 2026), as well as major highway transportation corridors including I-25, SH 6, SH 47, and SH 116 (NMDOT 2026b). A public-use FAA-registered airport is located within the Transmission Study Corridor, with a portion of the Belen Regional Airport northeast-southwest runway within the Transmission Study Corridor (FAA 2026).

The South Valley Regional Acequia Association is located within Valencia County. In addition, several acequias administered by the Middle Rio Grande Conservancy District are located within the Transmission Study Corridor, particularly where it crosses the Rio Grande and the I-25 (Middle Rio Grande Conservancy District 2026 and Office of State Engineer 2026b). Supporting the county's agricultural and natural resource management efforts, the Valencia Soil and Water Conservation District is responsible for the conservation and sustainability of natural resources, including agriculture, soils, water, plants, and animals (LandCAN 2026c). Land in Valencia County is primarily used for dairy production (USDA NASS 2017c). The Valencia County Pit is located within the southeastern portion of the County within the Transmission Study Corridor; however, no significant adverse impacts are anticipated to this facility (NMEMNRD 2026a).

In addition to these existing conditions, the Valencia County Comprehensive Plan establishes general policy guidance and sets priorities for investments. The plan address growth in Valencia County with urban development and preserving rural and agricultural characteristics. It guides future decisions by supporting sustainable growth, accommodating changing population needs, and promoting flexible housing and development options. The plan identifies the portions of the Transmission Study Corridor within Valencia County as being characterized primarily by residential and agricultural land uses along the Rio Grande corridor, while commercial land uses

are concentrated along I-25 and other major transportation corridors. The plan references the 2020 Comprehensive Economic Development Strategy, which identifies Energy/Renewable Energy, including solar and wind energy development, as a key economic focus area for rural communities in central New Mexico. This focus area is consistent with Goal 3 of the Valencia County Comprehensive Plan, which seeks to reduce the environmental footprint of County facilities and vehicles through the use of renewable energy sources and improved energy efficiency (Valencia County 2022).

3.13 Socioeconomics

3.13.1 Data Sources

The following data sources were reviewed to characterize the socioeconomic conditions and trends in Socorro, Torrance, and Valencia Counties and in New Mexico for the Mid-State Transmission Project:

- New Mexico Municipal League. 1998. New Mexico Incorporated Municipalities. Accessed June 2026 from: https://nmml.org/DocumentCenter/View/1297/New-Mexico-Incorporated-Municipalities-Alpha-List-PDF.
- NMSLO. 2025. Land Status. Accessed June 2026 from: https://mapservice.nmstatelands.org/LandStatus/.
- USCB. 2024 American Community Survey, 5-Year Estimates, 2020-2024. Accessed June 2026 from: https://data.census.gov/.
- United States Department of Commerce (U.S. Commerce). 2023. Bureau of Economic Analysis. Accessed June 2026 from: www.bea.gov.
- USDA NASS. 2025. 2022 Census of Agriculture, New Mexico State and County Data. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/New_Mexico/nmv1.pdf.
- New Mexico Taxation & Revenue Department (NMTRD). 2025. Fiscal Year RP-80 Reports: Gross Receipts by Geographic Area and NAICS Code. Accessed June 2026 from: https://www.tax.newmexico.gov/all-nm-taxes/gross-receipts-taxes-overview/fiscal-year-rp-80-reports-gross-receipts-by-geographic-area-and-naics-code/.

3.13.2 Current Conditions and Trends, Regional Overview

The Project is located in central New Mexico and crosses Socorro, Torrance, and Valencia Counties. NMSLO (Exhibit 20) and federally owned or managed properties are scattered throughout the Transmission Study Corridor, where the Project is proposed. The Pueblo of

Isleta is a federally recognized Tribal Nation and is located in Valencia and Bernalillo Counties, south of Albuquerque along the Rio Grande (Exhibit 21).

Torrance County

Torrance County lies east-southeast of Albuquerque and is characterized by low-density settlement, broad rangelands, and a mix of private, state, and federal land ownership. Within the county, the Transmission Study Corridor is located south-southeast of the Manzano Mountains near Estancia and Mountainair-Encino, in a largely rural setting. Population is concentrated in the western half of the county, while the eastern and southern areas remain sparsely populated. Incorporated communities include Moriarty, Estancia, Mountainair, Encino, and Willard. Land use is dominated by ranching, scattered rural residential development, transportation corridors, and undeveloped open space. State and federal holdings, including portions of Cibola National Forest and other public lands, contribute to the county's largely open and rural character.

Socorro County

Socorro County covers a large area of central and southern New Mexico and is characterized by expansive open lands, widely dispersed settlements, and substantial federal and state land ownership. Within Socorro County, the Transmission Study Corridor is located near Socorro, the county seat and principal population center. Outside that area, the county is characterized by desert basins, mesas, rangelands, limited agriculture in river-adjacent areas, and extensive public lands, including areas associated with the Cibola National Forest, wildlife refuges, and BLM lands. These conditions give much of the county a remote and sparsely settled character.

Valencia County

Valencia County lies south of Bernalillo County in the Rio Grande Valley and contains the most densely populated and developed portion of the broader Project area outside the Albuquerque metropolitan core. Within the county, the Transmission Study Corridor is located near Los Lunas and Belen and passes through a mix of rural, semi-rural, and developing areas that include residential communities, agricultural lands, transportation corridors, and undeveloped tracts. Population and development are concentrated in and around Los Lunas, Belen, and other communities in the Rio Grande Valley, with additional growth occurring in unincorporated areas influenced by regional commuting patterns. Compared to Torrance and Socorro Counties, Valencia County is more urbanized and experiencing greater development pressure, although open space, agricultural land, and public land remain important parts of the county setting.

The Transmission Study Corridor is influenced by major economic and cultural centers, most notably the Albuquerque metropolitan area, which serves as a regional hub for employment, education, health care, and government services. Surrounding smaller cities and rural communities are comparatively more dependent on public-sector employment, agriculture, and service industries.

As of 2024, Valencia County had an estimated population of 78,458, an increase of 5.2% since 2010; closely tracking with the statewide growth rate of 5.3%. In contrast, Socorro County and Torrance County recorded population declines of 9.8% and 5.9%, respectively. These trends indicate uneven population change within the Project vicinity, with growth concentrated near urban centers and declines in rural counties.

Demographic patterns across the Transmission Study Corridor generally reflect broader statewide trends, with some variation among counties (Tables 3-21 and 3-22).

Table 3-21 Population Profile (by County)

Location	Geographic Area (square miles)	Total Population	Population Density (people/ square miles)
New Mexico	121,590	2,120,246	17.44
Socorro County	6,649	16,200	2.44
Torrance County	3,346	15,490	4.63
Valencia County	1,068	78,458	73.46

Source: U.S. Census, 2024.

Table 3-22 Population Profile (by Census Block Group)

Location	Municipalities	CBG within the Transmission Study Corridor	Total Population (CBG)	Total Population (County)	% County Population Residing in CBG
Socorro County	Socorro	Tract 9781; BG 1	2,914	16,200	23.4%
		Tract 9781; BG 3	869		
Torrance County	Estancia and Mountainair-Encino	Tract 9636.01; BG 3	1,319	15,490	29.3%
		Tract 9636.01; BG 5	1,000		
		Tract 9637; BG 1	359		
		Tract 9637; BG 2	1,858		
Valencia County	Los Lunas and Belen	Tract 9414; BG 1	4,329	78,458	22.6%
		Tract 9704.05; BG 1	2,101		
		Tract 9707.01; BG 2	1,758		
		Tract 9707.01; BG 3	1,949		
		Tract 9709.02; BG 1	1,683		
		Tract 9710; BG 3	1,086		
		Tract 9710; BG 4	1,527		
		Tract 9711; BG 1	1,533		
		Tract 9713.01; BG 1	1,790		
		Tract 9801; BG 1	7		

BG = Block Group; CBG = Census Block Group; Pop. = Population; Source: U.S. Census, 2024.

Since this analysis is intended to characterize communities crossed by the Transmission Study Corridor, county-level conditions provide the primary socioeconomic context, while block-group data help identify where the Transmission Study Corridor overlaps population concentrations. Based on 2020-2024 American Community Survey 5-year estimates, New Mexico had a poverty rate of 17.8%, median household income of $64,059, per capita income of $36,218, labor force participation of 61.7%, an unemployment rate of 4.1%, and 12.0% of residents age 25 and older without a high school diploma (Table 3-23).

Across the Transmission Study Corridor, socioeconomic indicators identify conditions that may influence how communities experience Project-related effects. In all three counties, at least some indicators reflect economic stress relative to statewide conditions, including poverty rates at or above the statewide level, median household and per capita incomes below statewide levels, and elevated shares of residents without a high school diploma. Labor force participation and unemployment patterns also indicate that some households may have limited flexibility to absorb changes in employment conditions, prices, or local service costs.

Within a broader context of the Transmission Study Corridor, Socorro County is characterized by high poverty, lower incomes, lower labor force participation, and a relatively large share of residents without a high school diploma. Torrance County is characterized by slightly elevated poverty, lower incomes, the highest unemployment rate, and a notable dependence on agriculture and retail activity. Valencia County includes a larger population base and a more diversified economy, but also includes poverty rates above the statewide average, incomes below statewide levels, and a substantial share of residents without a high school diploma.

Table 3-23 Socioeconomic Profile (by County)

Location	Individuals Living Below Poverty (%)	Median Household Income (2024 $s)	Per Capita Income (2024 $s)	Unemploy-ment Rate (%)	Less Than High School Degree (%)	Labor Force* (%)
New Mexico	17.8%	$64,059	$36,218	4.1%	12.0%	61.7%
Socorro County	33.2%	$36,570	$26,858	4.7%	14.7%	57.1%
Torrance County	18.3%	$57,842	$30,139	5.2%	13.1%	60.0%
Valencia County	18.1%	$58,933	$30,718	4.4%	13.9%	61.2%

*Labor force is defined as the population 16 to 64 as a proportion of total population.
Source: U.S. Census 2024.

Agriculture remains an important component of the local economy, particularly in Torrance and Socorro Counties. Across the three counties, there are approximately 2,008 farms supporting approximately 2,913 jobs and generating about $63.9 million in farm earnings (Table 3-24). Farming accounts for 11.3% of total employment and 11.6% of total earnings in Torrance County and 9.9% of employment and 6.6% of earnings in Socorro County, compared to 2.3% of employment and 1.3% of earnings statewide. Valencia County has the largest number of farms,

but agriculture represents a smaller share of county employment and earnings, consistent with its more diversified and increasingly developed economy.

Table 3-24 2022 USDA Agricultural Profile for Torrance, Socorro and Valencia Counties

	New Mexico	Socorro County	Torrance County	Valencia County	Total Across Counties
Number of Farms	20,976	453	577	978	2,008
Land in Farms (Acres)	3,488,246	1,345,407	1,692,413	450,426	-
% of Land Area in Farms	50.4%	31.6%	79.0%	66.0%	-
Employment by Farms	26,416	740	611	1,562	2,913
Employment by Farms (% of Total Employment)	2.3%	9.9%	11.3%	6.1%	-
Farm Earnings	$948,402,688	$25,198,432	$33,089,424	$5,646,224	$63,934,080
Farm Earnings (% of Total Earnings)	1.3%	6.6%	11.6%	0.5%	-
Total Net Income Including Corp. Farms	$771,308,288	$21,452,864	$30,603,456	$(4,861,520)	$47,194,800
Market Value of Agricultural Products Sold	$2,949,036,000	$57,928,000	$45,619,000	$33,264,000	136,811,000
Crops	$895,929	$6,323	$12,269	$9,290	$27,882
Livestock, poultry, and their products	$2,053,107	$51,606	$33,350	$23,973	$108,929

Source: USDA NASS 2025.

Employment in New Mexico and in the counties crossed by the Project is concentrated in a limited set of core industries, with government and service-related sectors accounting for a substantial share of both jobs and earnings. Government, health care and social assistance, and retail trade are the largest sources of employment statewide, while recent job growth has been strongest in transportation and warehousing, health care, and professional and technical services. Between 2010 and 2022, the industries adding the most jobs were transportation and warehousing, health care and social assistance, and professional and technical services. Earnings growth over the same period was strongest in professional and technical services, real estate and rental and leasing, and accommodation and food services, indicating that job growth and earnings growth were not concentrated in the same sectors.

County-level industry patterns help explain the socioeconomic differences observed across the Transmission Study Corridor (Table 3-25 and Table 3-26). In Socorro County, employment and earnings are concentrated in government, which accounts for 33% of employment and 48% of labor earnings. This concentration indicates a comparatively narrow economic base and may

reduce resilience to sector-specific changes. Torrance County has a comparatively larger role for retail trade and farming, while Valencia County has a broader mix of government, retail, health care, construction, and transportation-related activity. Several of the sectors accounting for recent growth in Torrance and Valencia Counties are relatively sensitive to business-cycle fluctuations, which is consistent with the moderate but persistent economic vulnerability reflected in poverty, income, and educational attainment indicators.

Table 3-25 Industry Profile – Employment by Industry (2010-2022)

Location	Top 3 Industries by Employment	Top 3 Industries by Percentage Change in Employment
New Mexico	Government (17.5%) Health care & social assistance (12.2%) Retail trade (9.8%)	Transportation & warehousing (26.8%) Health care & social assistance (25.1%) Professional & technical services (14.4%)
Socorro County	Government (33.0%) Health care & social assistance (11.1%) Farm (9.9%)	Government (81.5%) Professional & technical services (14.4%) Construction (9.5%)
Torrance County	Government (18.0%) Retail trade (13.0%) Farm (11.3%)	Health care & social assistance (38.9%) Transportation & warehousing (37.7%) Retail trade (29.9%)
Valencia County	Government (14.9%) Retail trade (13.5%) Health care & social assistance (11.9%)	Construction (40.2%) Transportation & warehousing (20.7%) Retail trade (16.2%)

Source: U.S. Commerce 2023.

Table 3-26 Industry Profile – Labor Earnings by Industry (2010-2022)

Location	Top 3 Industries by Earnings	Top 3 Industries by Percentage Change in Earnings
New Mexico	Government (24.8%) Health care & social assistance (11.7%) Professional & technical services (11.7%)	Professional & technical services (24.4%) Real estate & rental and leasing (24.3%) Accommodation & food services (17.1%)
Socorro County	Government (48.0%) Health care & social assistance (10.0%) Professional & technical services (9.0%)	Government (63.3%) Farm (14.1%) Professional & technical services (11.2%)
Torrance County	Government (24.2%) Farm (11.6%) Retail trade (8.4%)	Farm (56.3%) Manufacturing (27.5%) Professional & technical services (23.9%)
Valencia County	Government (23.6%) Construction (17.6%) Transportation & warehousing (11.3%)	Construction (75.0%) Retail trade (14.1%) Information (12.8%)

Source: U.S. Commerce 2023.

Overall, the Transmission Study Corridor includes a range of socioeconomic conditions that are relevant to understanding potential Project-related effects. The three counties include

communities with elevated poverty, lower incomes, variable labor force participation, and lower levels of educational attainment that indicate less capacity of households to respond to economic disruption. Industry structure also indicates reliance on government, agriculture, retail trade, construction, and other service-related sectors that may shape the way Project-related employment, spending, and indirect effects are experienced locally. These conditions support consideration of the different socioeconomic effects on the three counties crossed by the Project.

Housing conditions across the Transmission Study Corridor generally reflect the rural character of Socorro and Torrance Counties and the more developed setting of Valencia County (Table 3-27). Based on 2020-2024 American Community Survey estimates, rental housing represents a small share of the housing stock. Vacancy rates in Torrance County are high while Valencia County is influenced by its proximity to Albuquerque, has experienced more residential growth and development pressure.

Table 3-27 Housing Characteristics

Location	New Mexico	Socorro County	Torrance County	Valencia County	Total across Counties
Total Housing Units, 2024	956,964	7,293	7,693	30,756	45,742
Occupied	837,414 (87.5%)	6,052 (68.5%)	5,269 (83.0%)	27,583 (89.7%)	38,904
Vacant	119,550 (12.5%)	1,241 (17.0%)	2,424 (31.5%)	3,173 (10.3%)	6,838 (14.9%)
For rent	15,906	0	83	128	211
Rented, not occupied	2,910	14	19	0	33
For sale only	5,769	73	84	99	256
Sold, not occupied	4,124	197	2	0	199
Seasonal, recreational, occasional	36,548	327	619	743	1,689
For migrant workers	371	0	0	0	0
Other vacant	53,922	630	1,617	2,203	4,450

Source: U.S. Census 2024.

Gross receipts data indicate the scale and composition of local economic activity and offer additional context regarding the relative size of the taxable economic base within the counties crossed by the Project. In New Mexico, portions of gross receipts taxes are distributed to local governments; therefore, these data provide a general indication of the level of economic activity occurring within these counties. The data presented in Tables 3-28 and 3-29 are intended to characterize existing economic conditions.

Among the three counties, Valencia County reported the highest gross receipts in each year shown. Torrance County showed moderate year-to-year variability and Socorro County reported the smallest totals. In 2020, retail trade was the largest reported sector in all three counties, followed by construction. The third-largest reported sector differed by county: other services in

Socorro and Torrance Counties and wholesale trade in Valencia County. Together, the three counties reported approximately $3.0 billion in gross receipts in 2020, representing approximately 0.8% of statewide gross receipts. These data provide a measure of relative scale of taxable economic activity within the Transmission Study Corridor and indicate that Valencia County has the largest taxable economic base among the counties crossed by the Project.

Table 3-28 County Profile – Gross Receipts

Location	2020	2019	2018	2017	2016	2015
Socorro County	$373.34M	$350.89M	$289.87M	$324.97M	$288.02M	$314.64M
Torrance County	$540.72M	$431.51M	$476.31M	$605.13M	$390.75M	$456.08M
Valencia County	$2,085.45M	$2,399.71M	$1,851.57M	$1,444.04M	$1,314.55M	$1,274.22M
Subtotal	**$2,999.5M**	**$3,182.1M**	**$2,617.8M**	**$2,374.1M**	**$1,993.3M**	**$2,044.9M**

Source: NMTRD 2025

Table 3-29 County Profile – 2020 Largest Economic Sectors (Top 3 Gross Receipts by NAICS Code)

Location	44-45: Retail Trade	23: Construction	81: Other Services (except Public Administration)	42: Wholesale Trade
Socorro County	$110.36M	$50.79M	$50.05M	-
Torrance County	$200.09M	$125.31M	$22.67M	-
Valencia County	$670.35M	$522.51M	-	$118.81M

Source: NMTRD 2025

3.14 Communication Signals

3.14.1 Data Sources

The following date sources were reviewed to assess the existing communication signals in Torrance, Socorro, and Valencia Counties for the Project.

- Cavell, Mertz & Associates, Inc. 2026. FCCInfo: FCC database search. Accessed June 2026 from: https://www.fccinfo.com/cmdpro.php?sz=L&wd=1920.

3.14.2 Current Conditions and Trends, Regional Overview

Torrance, Socorro and Valencia Counties have population densities below the national average. Population densities in Torrance and Socorro Counties are also substantially below the

statewide average for New Mexico. Table 3-30 displays the signaling structures within the Transmission Study Corridor (Cavell, Mertz & Associates, Inc, 2026) (Exhibit 22).

Table 3-30 Signaling Structures within the Transmission Study Corridor

Tower Type	Number of Signaling Structures
Microwave	11
Cellular	4
Antenna Structure Registration (ASR)	1
FM	0
AM	0

Source: Cavell, Mertz, & Associates 2025.

3.15 Radioactive Waste and Radiation Hazards

3.15.1 Data Sources

- USEPA. 2026e. What is the Average Level of Radon Found in Homes in the US? Accessed June 2026. https://www.epa.gov/radon/what-average-level-radon-found-homes-us.
- USEPA. 2025f. USEPA Map of Radon Zones. Accessed June 2026. https://www.epa.gov/radon/epa-maps-radon-zones-and-supporting-documents-state.
- USEPA. 2026g. EnviroAtlas. Accessed July 2026. https://www.epa.gov/enviroatlas.
- Nuclear Regulatory Commission (NRC). 2020. Uranium Mill Tailings. Accessed June 2026. https://www.nrc.gov/waste/mill-tailings.
- United States Army Corps of Engineers (USACE). 2026. Formerly Utilized Sites Remedial Action Program (FUSRAP). Accessed June 2026. https://www.usace.army.mil/Missions/Environmental/FUSRAP/.
- United States Department of Energy (DOE). 2023. Long-Term Stewardship of Remediated Formerly Utilized Sites Remedial Action Program (FUSRAP) Sites. Accessed June 2026. https://www.energy.gov/lm/long-term-stewardship-remediated-fusrap-sites.

3.15.2 Current Conditions and Trends, Regional Overview

Transmission lines and substations do not create or hold radioactive waste or any radiation hazards. The geology of New Mexico and historical events that have occurred in New Mexico, however, suggest possible hazards of radiation. A review of available environmental records and databases were conducted to identify potential sources of radiation in the proximity of the Transmission Study Corridor. A review of available environmental records and databases was done to determine potential sources of radiation in the Transmission Study Corridor. Databases and are described below:

- FUSRAP: The DOE established FUSRAP in 1974 to remediate sites where radioactive contamination remained from the Manhattan Project and early United States Atomic Energy Commission operations (USACE).
- Uranium Mill Tailings Sites (UMTRA): Uranium ore was mined by private companies for federal government use in national defense programs. When the mills shut down, large piles of mill tailings remained after the uranium was extracted from the ore (NRC 2020).

Review of NRC, FUSRAP and UMTRA databases identified no potential radioactive waste or radiation hazards within the Transmission Study Corridor (USACE, NRC). Additional review of other potential sites containing radioactive waste was completed and no sites within the Transmission Study Corridor were found (USEPA 2026e).

Radon, a naturally occurring radioactive gas produced by the decomposition of uranium found in soil, rock, and water, has been assessed in the Transmission Study Corridor. Radon can enter indoor areas and cause damage to the lungs, when inhaled, and is the leading cause of lung cancer in non-smokers. The United States average concentration of radon in indoor air is 1.3 picocurie per liter (pCi/l). New Mexico's average indoor radon concentration is 3.9 pCi/L. The USEPA has set an action level of 4 pCi/L, at or above which the USEPA recommends radon reduction methods for homes and occupied buildings to minimize exposure to radiation (USEPA 2025e).

The USEPA classifies Torrance, Socorro, and Valencia Counties, which the Transmission Study Corridor passes through, as Zone 2, indicating an average indoor concentration of greater than or equal to 2 pCi/L or less than or equal to 4 pCi/L (USEPA 2025f).

3.16 Hazardous Materials

3.16.1 Data Sources

- USEPA. 2026g. Toxic Release Inventory Toolbox. Accessed June 2026 from: https://www.epa.gov/toxics-release-inventory-tri-program/tri-toolbox.
- USEPA. 2026h. EnviroAtlas. Accessed July 2026. https://www.epa.gov/enviroatlas.

3.16.2 Current Conditions and Trends, Regional Overview

A review of available environmental records and databases was conducted to identify potential sources of hazardous materials within the Transmission Study Corridor. After verification of business names and addresses, three facilities in Valencia County, Arcosa Wind Towers, Inc., Amazon.com Services LLC, and Highway Towing were identified to contain potential hazardous chemicals that are either stored, transferred to other sites or released into the air (USEPA 2026g). Arcosa Wind Towers, Inc. reports to the USEPA as being on the Toxic Release Inventory and as a Hazardous Waste Site. The other two facilities, Amazon.com Services LLC

and Highway Towing are active Hazardous Waste Sites reporting to the USEPA (USEPA 2026h).

Section 3.17 outlines potential safety considerations related to the potential hazardous materials used during the construction, operation, and maintenance of the transmission line, substation, and switchyard, as well as the mitigation measures proposed to minimize associated safety risks.

3.17 Safety

The Transmission Study Corridor does not contain any known safety concerns that would preclude construction, operation, or maintenance of the Project. Three facilities within or adjacent to the corridor, including Arcosa Wind Towers, Inc., Amazon.com Services LLC, and Highway Towing, have been identified as facilities that manage hazardous materials or hazardous wastes, as discussed in Section 3.16.2. These facilities would be considered during final design, construction planning, and operation to maintain appropriate clearances and safe working conditions. Section 4.17 discusses potential safety considerations associated with Project construction, operation, and maintenance, as well as the protection measures that would be implemented to minimize risks and maintain public and worker safety.

3.18 Geographic Resources

3.18.1 Data Sources

The following data sources were reviewed to assess the existing geographic resources within Valencia, Socorro, and Torrance Counties and the Project vicinity.

- BLM. 2026c. BLM Rights-of-Way Planning Tool. Accessed June 2026 from:https://webmaps.blm.gov/program_apps/BLM_Natl_ROW_368_Public/.
- Fenneman, N.M. 1931. Physiography of Western United States. Accessed June 2026 from: https://archive.org/details/physiographyofwe00fenn/page/n7/mode/2up.
- NPS. 2017. Physiographic Provinces. Accessed June 2026 from: https://www.nps.gov/subjects/geology/physiographic-provinces.htm.
- NMEMNRD. 2022. New Mexico State Parks. Accessed June 2026 from: https://www.emnrd.nm.gov/spd/.
- NMDOT Rail Bureau. 2019. New Mexico Railroad Map. Accessed June 2026 https://www.dot.nm.gov/planning-research-multimodal-and-safety/modal/transit-rail/rail-bureau/.
- Toll Free Airline. 2025. New Mexico Public and Private Airports by County. Accessed June 2026, https://www.tollfreeairline.com/newmexico.htm.

3.18.2 Current Conditions and Trends, Regional Overview

The Transmission Study Corridor passes through 16 different townships (T5NR12E, T4NR12E, T4NR11E, T4NR10E, T3NR10E, T3NR9E, T4NR9E, T5NR9E, T5NR8E, T4NR8E, T4NR7E, T4NR6E, T3NR6E, T3NR5E, T2NR5E, and T2NR4E) across Valencia, Socorro, and Torrance Counties in central New Mexico (Exhibit 23).

Vehicle access in the region is primarily US Hwy 60, in addition to SH 6, SH 47, and SH 314. The Transmission Study Corridor crosses these transportation thoroughfares multiple times, US Hwy 60 just east of Willard, SH 47 by the Rio Communities Tierra Grande Volunteer Fire Station, SH 314 at Jarales, and SH 6 west of Los Lunas.

The largest regional airport in the area is the Albuquerque International Sunport located southeast of Albuquerque. Smaller airstrips serve smaller communities in the area and include Burris Ranch airstrip, J and M Farms Airport, and the Mountainair Municipal Airport.

Multiple railroads pass under the Transmission Study Corridor, all owned and operated by BNSF and primarily dedicated to freight transport. The proposed route crosses the E Clovis-Belen line multiple times, just south of the substation, south of Willard, and again at the beginning of Abo Pass. The same rail line is crossed again north of the intersection of SH 47 and US Hwy 60, and again east of Jarales. The Isleta-El-Paso line is crossed just southeast of Pueblitos, and the Belen J-E Winslow rail line northwest of Los Chavez.

The Transmission Study Corridor crosses through the municipal boundaries of Willard, New Mexico, and passes within 3.0 miles of the towns of Mountainair, Belen, Los Chavez, and Los Lunas. The Study Corridor passes through smaller, census- designated places like Jarales and Pueblitos, within the Rio Grande Basin. The corridor passes over the Valencia County Fire Department Station 9 located in Jarales but does not pass over any schools or education facilities as they are concentrated within the larger populations of Los Lunas, Belen, and Mountain Air (Exhibit 24).

The Transmission Study Corridor crosses several utilities and infrastructure including transmission lines, natural gas pipelines, and railroads. The 115-kV Central New Mexico Electric Cooperative, Inc. transmission line owned by Touchstone Energy is crossed by the route in multiple locations, first just northwest of Progresso, and the rest on the northwestern and southeastern sides of Willard.

The Transmission Study Corridor passes over multiple natural gas pipelines, the E.M.W. Gas Association pipeline west of Willard, and the New Mexico Gas Company pipeline west of Belen. In both Abo Pass and west of Pueblitos, other natural gas pipelines operated by Transwestern Pipeline Company and El Paso Natural Gas Company cross the Transmission Study Corridor.

The Transmission Study Corridor crosses into the Abo section of the Salinas Pueblos Missions National Monument which is administered by the NPS. The Study Corridor also crosses into land administered by the US Forest Service just west of Abo. Protected areas outside of the Transmission Study Corridor include the Seville National Wildlife Refuge and the El Cerro de los

Lunas Preserve, located less than 1.0 mile south of the Transmission Study Corridor, and Manzano Mountains State Park, located roughly 5.0 miles northwest of the Transmission Study Corridor.

3.19 Military Activities and Aviation

3.19.1 Data Sources

The following data sources were reviewed to assess the existing military conditions of Socorro, Torrance, and Valencia Counties for the Project.

- BLM Rights-of-Way Planning Tool. 2026c. Accessed March 2026. https://webmaps.blm.gov/program_apps/BLM_Natl_ROW_368_Public/.
- Military Bases.com. 1998. New Mexico Military Bases. Accessed June 2026 from: https://militarybases.com/new-mexico/.

3.19.2 Current Conditions and Trends, Regional Overview

No United States Department of Defense installations occur within the area of the Transmission Study Corridor (MilitaryBases.com 1998). There are 10 military flight training routes that intersect the Transmission Study Corridor, including instrument, slow, and visual route corridors (BLM 2026c) (Exhibit 25). Instrument route corridors are a type of military training route designed for low-altitude, high-speed training under instrument flight rules. Instrument flight rules are FAA regulations that allow pilots to operate aircraft by referencing flight instruments rather than outside visual cues, which is necessary for flying in low visibility. A slow route corridor is a type of military training route designed for low-altitude, lower-speed flight training. Visual route corridors are military training routes operated under visual flight rules, which allow military aircraft to fly through a portion of airspace passing through restrictive Class B airspace without needing air traffic control clearance.

3.20 Roads

3.20.1 Data Sources

The following data sources were revied to assess the road conditions within the Transmission Study Corridor from Torrance, Valencia and Socorro Counties, New Mexico.

- NMDOT. 2026c. Interactive Transportation Maps. Accessed June 2026. https://www.dot.nm.gov/travel-information/maps/.

3.20.2 Current Conditions and Trends, Regional Overview

A scattered network of United States highways, county, and local roads are located in the Transmission Study Corridor. The Transmission Study Corridor crosses I-25 once and US Hwy 60 once. The Transmission Study Corridor also intersects SHs 6, 55, 41, 116, and 304 once and SH 47 three times (NMDOT 2026c). The Project would coordinate with NMDOT and the County Road Maintenance Departments for the three counties to assess existing roadway conditions prior to the commencement of construction activities.

4. Environmental Effects

4.1 Introduction

This chapter evaluates whether the Project would “unduly impair important environmental values,” consistent with NMSA 1978, § 62-9-3(F). The chapter describes the potential environmental consequences associated with the construction, operation, maintenance of the proposed transmission line and associated facilities. Impact analyses are intended to support the Commission’s review of the Project location application and the environmental reporting requirements for transmission lines set forth in 17.9.592.10 NMAC.

The analysis addresses the resource categories identified in NMSA 1978, § 62-9-3(M) and applicable Commission rules, as well as additional resource topics identified through agency and stakeholder coordination. Resource areas evaluated in this chapter include air resources; noise; geology and mineral resources; soils; paleontological resources; water resources; vegetation and wildlife resources; archaeological, historic, and cultural resources; religious and cemetery sites; visual and scenic resources; socioeconomics; communication systems; radioactive materials and radiation hazards; hazardous materials; public health and safety; geographic resources; military activities and aviation; and transportation facilities and roads. Impact evaluations for each resource are discussed below in the context of the Project with BMPs that can help manage impacts.

Implementation of the Project has the potential to affect existing environmental conditions. Environmental effects may occur as a direct or indirect result of Project construction, operation, maintenance, and eventual decommissioning activities. Direct effects are those caused by the Project and occurring at the same time and place as the activity causing the effect, such as vegetation clearing, ground disturbance, or habitat modification. Indirect effects are those caused by the Project but occurring later in time or farther removed in distance, such as changes in land use, wildlife behavior, or other secondary environmental responses.

For the purposes of this analysis, short-term impacts are those occurring during construction and the initial post-construction period and are generally expected to return to pre-construction conditions within approximately three to five years following construction, depending on the affected resource and site-specific conditions. Long-term impacts are those expected to persist throughout the operational life of the Project, which is anticipated to be approximately 40 years or longer. Permanent impacts are those that remain beyond the operational life of the Project and are not expected to return to pre-Project conditions, even following decommissioning and reclamation activities. The duration, intensity, and extent of potential impacts are discussed for each resource area in the sections that follow.

For each resource area evaluated in this ER, the analysis: identifies the potential ground disturbance and environmental effects that may result from construction, operation,

maintenance, and decommissioning of the Project within the proposed 200-foot-wide ROW and associated temporary work areas; describes the protection measures, BMPs, and design features the Project would implement to avoid, minimize, and mitigate impacts where practicable; and evaluates whether the Project has the potential to result in the undue impairment of important environmental values, consistent with the requirements of NMSA 1978, § 62-9-3(F).

The Project will obtain all federal, state, and local environmental permits or authorizations necessary to begin construction and operation of the transmission line. A permit matrix for the Project is provided in Appendix C.

Prior to the start of construction, all supervisory personnel and contractor staff would receive training regarding the identification and protection of sensitive environmental and cultural resources. Construction contracts and environmental compliance requirements would address: (1) applicable federal, state, tribal, and local laws and regulations pertaining to wetlands, water resources, vegetation, wildlife, and cultural resources; (2) the importance of protecting sensitive resources; and (3) procedures and BMPs designed to avoid, minimize, and mitigate impacts during construction and operation.

4.2 Cumulative Effects

Project-related impacts would occur within a landscape that contains existing infrastructure, ongoing land uses, and reasonably foreseeable future development. When considered in combination with these existing and anticipated activities, including transmission infrastructure and other regional development, the Project could contribute incrementally to cumulative effects on certain environmental resources (e.g. wildlife). Project design and routing resulting in colocation with or paralleling of existing transmission infrastructure effectively reduces cumulative effects on the environment. Furthermore, the implementation of the protection measures identified in this ER, along with applicable measures incorporated at existing and future transmission facilities (e.g., bird flight diverters, shared access roads), would serve to avoid, minimize, or mitigate potential combined effects and would be anticipated to reduce the Project's contribution to cumulative environmental impacts.

4.3 Air Resources

The assessment of potential impacts to air resources associated with the construction, operation, and maintenance of the Project is based on the impact assessment methodology described in Section 4.1 above and discussed further below. Impacts to air resources from construction, operation, and maintenance activities are anticipated to be short-term and temporary in nature.

4.3.1 Impacts Specific to the Project

Construction

The large equipment used during construction is powered by internal combustion engines and would likely use diesel or gasoline as fuel. The combustion of these fuels creates pollutants including nitrogen oxides, carbon monoxide, carbon dioxide, volatile organic compounds, particulate matter, small amounts of sulfur dioxide, and trace amounts of hazardous air pollutants. Construction contractors and their equipment are required to comply with all applicable emissions standards. If an on-site concrete batch plant is required, the proper state and county air quality permits would be obtained prior to construction.

Fugitive dust emissions would also contribute to temporary air resource impacts during construction. Sources of fugitive dust include land clearing, grading, excavation, and vehicle traffic on unpaved roads. The amount of fugitive dust generated depends on construction activity levels, vehicular traffic volume, soil moisture content, and wind speed. Dust generation is generally expected to be greatest during dry and windy conditions and less pronounced during periods of higher soil moisture or precipitation. Dust suppression methods, including water application or other approved dust suppressants, speed restrictions on unpaved roads, and other BMPs, are planned to be used in construction areas during dry periods to minimize fugitive dust emissions and associated air quality impacts.

Since the fugitive dust and combustion engine emissions would be temporary (limited to the construction period), localized to the construction area, and minimized to the extent practicable through BMPs, construction-related fugitive dust and combustion emissions are not expected to result in substantial or long-term adverse impacts on air quality within the Project vicinity or unduly impair air resources.

Operations and Maintenance

During operation of the transmission line, the primary emissions are expected to be fugitive dust from vehicles traveling intermittently on unpaved roads. In addition, there would be emissions from the vehicles themselves. Such emissions are not anticipated to be significantly above the baseline condition, and, therefore, only minimal impacts to air quality are anticipated.

4.3.2 Protection Measures

Protection measures would be implemented to reduce potential impacts to air resources from construction activities. The only expected emissions would come from ground-disturbing activities, equipment movement, fuel combustion, and a concrete batch plant, if necessary. These emissions would be temporary and localized to the construction areas. Protection measures to address impacts on air resources include:

Air-1: Maintaining all fossil fuel-fired construction equipment in accordance with manufacturers' recommendations to minimize construction-related combustion emissions.

Air-2: Controlling combustion emissions through engine manufacturing requirements for both mobile sources and portable equipment such as air compressors.

Air-3: Limiting the idling time of equipment, unless idling must be maintained for proper operation (e.g., drilling, hoisting, and trenching).

Air-4: Limit the speed of vehicles within construction sites and along the utility ROW during construction to reduce the amount of fugitive dust generated.

Air-5: Water trucks will be utilized as necessary to reduce fugitive dust from construction activities.

Air-6: All applicable water pollution control standards will be adhered to, and any necessary corresponding permits will be acquired.

4.3.3 Conclusion

Given the limited, localized, and temporary nature of emissions associated with Project construction, operation, and maintenance, including implementation of the protection measures described above, the Project is not expected to result in significant adverse impacts to air resources or unduly impair air resources.

4.4 Noise

The assessment of noise impacts associated with construction, operation, and maintenance of the proposed Project is based on the impact assessment methodology described in Section 4.1 and is presented below. Noise impacts are expected to be minor, localized, and temporary, occurring primarily during construction activities.

4.4.1 Impacts Specific to the Project

Construction

Existing ambient noise levels within the predominantly rural areas of Valencia, Torrance, and Socorro Counties are generally low. Primary sources of existing noise in the area include traffic on U.S. and state highways, local county roads, and agricultural and ranching activities. Construction of the Project would temporarily increase ambient noise levels in the vicinity of active work areas due to the operation of construction equipment, vehicles, and other construction-related activities. These noise increases would be localized, temporary, and limited to the duration of construction activities. Construction-related noise impacts would be managed in accordance with applicable state and local requirements.

Operations and Maintenance

Following construction, noise associated with operation of the Project would be minimal and generally limited to occasional corona noise that may occur under certain weather and operating conditions. Periodic maintenance activities may result in short-term, localized increases in noise levels; however, such activities would occur infrequently and are not expected to substantially affect ambient noise conditions. Consequently, noise impacts associated with construction, operation, and maintenance of the Project are expected to be minor, localized, and temporary and are not anticipated to unduly impair important environmental values.

4.4.2 Protection Measures

Protection measures that would be used to reduce any potential negative noise impacts from construction and operational activities include:

Noise-1: Restrict construction activity near residences to normal business hours.

Noise-2: Conduct a baseline noise modeling analysis to predict effect of facility operations above sound levels authorized in local ordinances.

4.4.3 Conclusion

Compliance with applicable noise standards and implementation of the protection measures described above, combined with the localized, low-intensity, and temporary nature of construction- and maintenance-related noise, indicate that the Project is not expected to result in substantial adverse noise. Operational noise from the transmission line would be minimal and limited primarily to occasional corona noise under certain environmental conditions. Accordingly, the Project is not expected to create a significant noise burden or unduly impair important environmental values related to noise.

4.5 Geology and Mineral Resources

Impact assessments of geologic and mineral resources associated with construction, operation, and maintenance of the Project follow the impact assessment methodology described in Section 4.1 and are discussed below. The assessment considers existing geologic conditions within the 200-foot ROW, including geologic hazards, topography, soil conditions, mineral resources, and other geologic constraints that may influence Project design, construction, operation, and maintenance. The assessment also evaluates the potential for Project activities to affect geologic and mineral resources.

4.5.1 Impacts Specific to the Project

This section summarizes the expected impacts of existing geologic and mineral resource conditions on Project construction, O&M, as well as the potential for Project activities to affect geologic and mineral resources.

Geologic Setting

As described in Section 3.4.2, the ROW traverses an area characterized by Permian-age sedimentary bedrock, shallow caliche-bearing soils, localized volcanic features, and generally limited geologic hazards. Existing geologic conditions that could influence Project design and construction include localized steep slopes, landslide-prone terrain, flooding and erosion hazards, and potential karst-related subsurface features.

Landslides and Slope Stability

As described in Section 3.4.2, portions of the ROW traverse areas of steep terrain and mapped landslide susceptibility, particularly between the Manzano and Los Pinos Mountains and near El Cerro de Los Lunas. Construction activities within these areas could require additional grading, slope stabilization measures, or specialized foundation design. During operation, transmission structures located on steeper slopes may be more susceptible to long-term stability concerns if site-specific geotechnical considerations are not incorporated into final design. These potential effects can be minimized through route refinement, engineering design, and implementation of appropriate construction practices.

Seismic and Volcanic Hazards

As discussed in Section 3.4.2, regional seismic activity is generally low to moderate, and no major active faults have been identified within the immediate vicinity of the ROW. Therefore, seismic hazards are not expected to represent a substantial constraint to Project construction, O&M.

Karst and Subsurface Conditions

Portions of the ROW overlie limestone and dolomite formations where isolated karst features or dissolution-related voids may occur. Although no extensive mapped karst systems have been identified within the Transmission Study Corridor, site-specific subsurface investigations may be necessary in some locations to identify and avoid potential foundation concerns. Implementation of appropriate engineering design measures is expected to reduce potential impacts associated with subsurface conditions.

Flooding and Erosion

Seasonal monsoon storms can result in localized flooding, arroyo flows, and erosion throughout central New Mexico. Portions of the ROW may be affected by these conditions, particularly near drainage crossings and flood-prone areas associated with the Rio Grande watershed. Construction activities could temporarily increase erosion potential if soils are disturbed, while operation-related impacts are expected to be limited. Transmission structure placement and access road design would consider drainage patterns, flood hazards, and erosion potential during final engineering and permitting.

Oil and Gas Resources

As described in Section 3.4.2, no active oil or natural gas wells occur within or immediately adjacent to the ROW. However, active natural gas transmission pipelines and hazardous liquid pipelines occur within portions of the study area and may intersect or occur near the ROW in Valencia, Torrance, and Socorro Counties.

Because active oil and gas production is absent within the ROW, construction and operation of the Project are not expected to result in substantial impacts on hydrocarbon resource development. Where Project facilities cross or occur in proximity to existing pipeline infrastructure, construction activities could require coordination with pipeline operators. Project design, engineering, and construction activities would be conducted in accordance with applicable crossing, setback, and safety requirements. Accordingly, impacts on existing oil and gas infrastructure are expected to be minor.

Mineral Resources

As described in Section 3.4.2, mining activity within the broader region is primarily associated with aggregate, caliche, dimension stone, and limited metallic mineral extraction. Active mining operations within the vicinity of the ROW are limited, and no major mineral deposits or active mining operations have been identified within the ROW.

Accordingly, construction and operation of the Project are not expected to result in substantial conflicts with existing mineral resource development. Localized contamination could be present near previously disturbed or abandoned mining areas, although no such sites have been identified within the ROW. Any previously unidentified mining-related features encountered during Project development would be evaluated and addressed through Project-specific design and environmental review processes.

4.5.2 Protection Measures

The following measures would be implemented, as appropriate, to reduce potential impacts related to geologic hazards and mineral resources associated with construction and operation of the Project:

Geo-1: Site transmission structures and associated access routes to avoid areas of moderate to high landslide susceptibility and steep slopes, to the extent practicable.

Geo-2: Placement of transmission structures will be designed to avoid operational hydrocarbon pipeline easements.

Geo-3: Site-specific geotechnical investigations will be conducted, as necessary, to evaluate subsurface conditions and inform foundation design, grading requirements, and construction methods.

Geo-4: Erosion and sediment control BMPs will be implemented during construction to minimize soil disturbance and reduce erosion caused by stormwater runoff and wind.

Geo-5: Drainage features, access routes, and transmission structures will be designed to minimize impacts from seasonal flooding, localized ponding, and stormwater runoff. Infrastructure will be located outside flood-prone areas where practicable.

Geo-6: Areas temporarily disturbed during construction will be stabilized and revegetated, to the extent practicable, to reduce erosion potential and promote long-term soil stability.

Geo-7: Construction activities in areas of steep or potentially unstable terrain will incorporate appropriate engineering controls, including slope stabilization, grading limitations, and drainage improvements where warranted by site conditions.

Geo-8: Placement of transmission poles/structures will be designed to avoid operational hydrocarbon pipeline easements.

4.5.3 Conclusion

The Project is located within a region characterized by predominantly Permian sedimentary bedrock, shallow caliche-bearing soils, localized volcanic features, and generally limited geologic hazards. Potential constraints include isolated areas of landslide susceptibility, steep terrain, localized flooding, and potential karst-related subsurface conditions. As described in Section 3.4, mineral resource development within the region is limited, and no major mineral resource conflicts have been identified within the ROW. Active oil and gas production is absent within the ROW, although existing natural gas transmission and hazardous liquid pipelines that occur within portions of the study area and would require coordination during final design and construction. With implementation of standard engineering design practices, Project-specific geotechnical investigations, and the protection measures identified above, significant adverse impacts related to geology and mineral resources are not anticipated for construction, operation, or maintenance of the Project.

4.6 Soil Resources

Assessment of impacts to soil resources from construction, operation, and maintenance of the Project follows the methodology described in Section 4.1. Impacts to soils are generally low,

short-term, and temporary, primarily associated with construction activities. Permanent impacts are limited to the footprint of Project components and are described below.

4.6.1 Impacts Specific to the Project

Construction-related soil disturbance includes both temporary and permanent activities, such as structure work areas, wire pulling, tensioning and splicing sites, construction yards, and temporary and permanent access roads.

Temporary Erosion

Ground disturbance during construction may increase erosion potential, particularly where removal of vegetation exposes soils to wind and water erosion. Certain soils within the transmission line ROW are more susceptible to erosion, with water and wind acting as the primary drivers on disturbed or bare surfaces.

Operational impacts would be limited to periodic soil disturbance associated with maintenance and repair activities. Stormwater BMPs, such as erosion and sediment control features and culverts, would require routine inspection and maintenance to minimize erosion and sedimentation. Temporary access routes not needed for long-term operations would be regraded, seeded with native vegetation, and allowed to revegetate, reducing exposed soil surfaces.

Disturbed areas would be reclaimed following construction, including recontouring, topsoil replacement, and revegetation. Implementation of a SWPPP under the USEPA's NPDES program, along with appropriate soil protection measures and BMPs, would minimize erosion and associated impacts.

Accidental Spills

During construction, the use of trucks, heavy equipment, and material storage presents the potential for accidental releases of fuel, lubricants, and other automotive fluids. Any such releases would be incidental, localized, and temporary in nature, and are expected to result in minor to negligible impacts to soils. BMPs for construction housekeeping, spill prevention, and response would be implemented to minimize the risk of releases and ensure prompt cleanup.

If applicable, a Spill Prevention, Control, and Countermeasure (SPCC) Plan would be developed and implemented in accordance with regulatory thresholds (i.e., oil storage capacity exceeding 1,320 gallons, including transformer oils). With these measures in place, accidental spills are not expected to result in widespread, long-term, or significant impacts to soil resources.

Permanent Soil Loss

The permanent footprint of the proposed transmission line would result in a minor, long-term reduction in soils available for other productive uses. Permanent impacts would be limited to areas occupied by structures, access roads retained for operations, and other ancillary facilities, and would represent a small proportion of the overall transmission line ROW. Although these areas would be removed from prior land uses, the overall extent of soil loss would be minimal relative to the surrounding landscape and would not substantially affect soil productivity or regional land use.

4.6.2 Protection Measures

The following measures would be implemented to minimize potential impacts to soil resources during construction of the transmission line:

Soil-1: Construction crews will reduce the amount of soil compaction by using equipment with more tires and wider tires to distribute the weight of the vehicle and tilling the severely compacted areas after construction is completed or using ground mats when the ground is wet.

Soil-2: Work areas will be surveyed and staked prior to construction to limit unnecessary disturbance to soils and established vegetation during the construction period.

Soil-3: Construction will be sequenced to minimize the area of disturbance to soils or established vegetation occurring at any one time during the construction period.

Soil-4: To the extent possible, topsoil will be placed separately from sub-soils/bedrock during excavation and not comingled. The Project will replace soil in reverse order, to help preserve topsoil.

Soil-5: The Project will reduce erosion by applying and maintaining standard erosion and sediment control methods. These may include, but are not limited to, use of certified weed-free straw wattles, bale barriers, and/or silt fencing, which would be placed at construction boundaries and where soil would be disturbed near a wetland or water body. Specific erosion and sediment control measures and locations will be specified in a SWPPP.

4.6.3 Conclusion

Based on the implementation of standard BMPs for erosion control, soil stabilization, and spill prevention, as well as the limited extent of permanent soil disturbance, the Project is not expected to result in substantial adverse impacts to soil resources. Temporary construction-related effects would be minimized and reclaimed through regrading, topsoil replacement, and revegetation, while long-term impacts would be confined to a relatively small footprint. With the application of the soil protection measures described above, the Project would not be expected to degrade soil productivity, increase erosion beyond manageable levels, or result in widespread or long-term impairment of soil resources.

4.7 Paleontological Resources

Assessment of impacts to paleontological resources from construction, operation, and maintenance of the Project follows the methodology described in Section 4.1. Potential impacts to paleontological resources are evaluated based on the potential for Project-related ground disturbance to adversely affect significant paleontological resources, the extent to which Project activities may affect fossil-bearing geologic units, and the implementation of avoidance, minimization, and mitigation measures designed to reduce adverse effects on paleontological resources.

4.7.1 Impacts Specific to the Project

Construction

Ground-disturbing construction activities including land clearing and grading for roads and tower sites, excavation, and trenching, have the potential to affect paleontological resources where those activities would directly affect geologic units that may contain paleontological resources. Specifically, geologic units that have been assigned PFYC ratings of 3-Moderate, 4-High, and 5-Very High (Exhibit 7) are the geologic units with the greatest potential for containing significant paleontological resources including vertebrate fossils and notable invertebrate and plant fossils, along with trackways or other trace fossils.

The Project would impact geologic units assessed across all PFYC ratings by construction activities that would generally occur at or near the land surface. Potentially significant impacts on paleontological resources could occur where ground-disturbing activities intersect with and affect geologic units with moderate to very high potential to contain paleontological resources. However, the implementation of protection measures, as summarized below, would ensure that any unanticipated discoveries of paleontological resources would be protected and the potential significant impact to the uncovered paleontological resource would be mitigated to a less than significant level.

Operations and Maintenance

Standard operations and maintenance activities would not result in additional impacts to paleontological resources beyond those occurring during construction so long as those operations and maintenance activities occur only within previously disturbed areas. In the event that operations and maintenance activities occur outside areas disturbed during construction, potential impacts on paleontological resources would be the same as during the construction phase and would be determined by the geology underlying where those activities would occur.

Beyond potential impacts associated with operations and maintenance activities, the addition of new access roads may indirectly improve access to fossiliferous geological units and increasing their exposure to poaching. However, the ROW parallels existing roads or would be developed in proximity to existing roadways, to the extent practicable. As such, there is limited potential for

the Project to expand access to any fossiliferous deposits beyond what already exists and indirect impacts from road access to the Project vicinity would not occur.

4.7.2 Protection Measures

Protection measures that would be implemented to reduce any potential impacts from construction activities on paleontological resources:

Paleo-1: Follow a Unanticipated Discoveries Plan (UDP), providing protection upon discovery of unknown sites.

4.7.3 Conclusion

The Project would cross geologic units assigned to a range of PFYC ratings, reflecting varying potential for the occurrence of scientifically significant paleontological resources and differing levels of susceptibility to impacts from Project-related ground-disturbing activities. Construction activities, including excavation, grading, and access road development, have the potential to affect previously undiscovered paleontological resources where fossil-bearing geologic units are present. Where applicable, paleontological surveys in known areas of Project ground disturbance will be completed before construction, and no ground-disturbing activities will occur in those areas until survey work is complete. Implementation of a UDP which may include paleontological monitoring, worker training, avoidance measures, and discovery protocols where appropriate, would avoid, minimize, and mitigate potential impacts to paleontological resources. As a result, impacts to paleontological resources are expected to be minor and would not result in the undue impairment of important environmental values.

4.8 Water Resources

Assessment of impacts to water resources from construction, operation, and maintenance of the proposed transmission line follows the methodology described in Section 4.1 and is summarized below. Potential impacts include temporary disturbance to surface water features, changes to drainage patterns, and increased risk of sedimentation during construction. With implementation of avoidance and minimization measures, impacts to water resources are expected to be low, localized, and primarily short-term in duration.

4.8.1 Impacts Specific to the Project

Potential impacts to water resources from construction, operation, and maintenance of the proposed transmission line would be associated primarily with temporary ground disturbance, stormwater runoff, accidental spills, floodplain encroachment, and stream or wetland crossings. Construction activities such as structure work areas, wire pulling, tensioning and splicing sites, construction yards, and temporary or permanent access roads could increase erosion, sediment transport, and runoff, particularly where vegetation is removed or soils become compacted.

Accidental releases of fuels, oils, or other hazardous materials from construction equipment or material storage areas could also affect nearby drainages or other surface waters if not properly contained and remediated. Because these effects would occur primarily during construction, they are expected to be localized, temporary, and short-term.

Where streams, wetlands, or other aquatic features are present, the transmission line would be designed to avoid and minimize impacts to the extent practicable. Waterbodies and wetlands would generally be spanned, and structures would be placed outside the ordinary high-water mark and other sensitive aquatic features where feasible. Existing road-stream crossings would be used for access where available; however, if new temporary or permanent crossings are required, they would be designed to minimize impacts and permitted through the appropriate agencies. Following route evaluation, a formal aquatic resource delineation would be conducted in accordance with applicable federal guidance to verify the presence and extent of potentially jurisdictional waters, wetlands, and other aquatic resources and to inform final design, permitting, and mitigation requirements.

Construction within or near flood-prone areas could increase the risk of erosion, localized flow diversion, or structural damage if facilities were placed within active conveyance areas. To minimize these risks, structures would be sited outside channels and flood-prone areas to the extent practicable, particularly near the Rio Grande and associated floodplain. Because floodplains overlap with some portions of the ROW, primarily in Valencia County and largely associated with the Rio Grande corridor, floodplain impacts are expected to be limited through route refinement and structure siting.

BMPs would be implemented during construction to reduce the potential for erosion, sedimentation, turbidity, and pollutant discharge to nearby water resources. These measures would be incorporated into a Project-specific SWPPP prepared in accordance with the federal NPDES construction stormwater permitting program. The SWPPP would identify runoff controls, erosion and sediment control measures, site stabilization requirements, inspection protocols, and corrective actions. Spill prevention and response measures would also be implemented during construction, and an SPCC Plan would be prepared if oil storage capacity exceeds applicable regulatory thresholds.

Groundwater impacts are expected to be minimal. Construction activities may encounter shallow groundwater in isolated locations, particularly near the Rio Grande floodplain or other low-lying drainages; however, such interactions would be temporary and are not expected to substantially affect groundwater resources. No permanent groundwater withdrawals are anticipated, and water used during construction, such as for dust suppression or concrete production, would be obtained from existing off-site sources.

The ROW overlaps approximately 2.5 miles of FEMA-designated Flood Zone A in Valencia County, which represents areas with a 1% annual chance of flooding (FEMA 2026). It is also reasonable to assume that all natural drainages capable of conveying flow, whether or not they are mapped by FEMA, present some degree of flood hazard. Placement of structures within a flood-prone area could increase the potential for erosion, flood damage, or flow diversion.

Accordingly, transmission structures would be set back from channel banks and flood-prone areas to the extent practicable to avoid channel alteration and disruption of flood flows; therefore, impacts to floodplains are expected to be low.

Based on the desktop assessment, potentially jurisdictional waters of the United States (WOTUS), including wetlands, may occur within the ROW. According to the USGS NHD, the ROW crosses approximately one perennial stream feature (the Rio Grande), one intermittent stream feature, and 45 ephemeral stream features. The ROW also crosses numerous ephemeral stream features across the entire length of the proposed Project. In addition, the USFWS NWI indicates that approximately 0.6 miles of the ROW overlaps mapped aquatic resources, including wetlands, riverine features, lakes, and ponds.

Because NWI mapping is intended as a screening-level tool, it should not be considered a definitive indicator of jurisdictional wetlands or other WOTUS as defined by the USACE. Wetland identification criteria used by the USFWS differ from those applied by the USACE, and mapped NWI features may not be jurisdictional, while some jurisdictional waters may not be reflected in the NWI dataset. To refine the desktop analysis, NWI data were reviewed in conjunction with other available geospatial resources, including NRCS hydric soils mapping, topographic contours, USGS hydrography, FEMA floodplain mapping, and aerial imagery. Areas where multiple data sources overlap are generally considered to have a greater likelihood of supporting wetlands or other aquatic resources than areas identified by a single source.

A formal aquatic resource delineation would be conducted in accordance with applicable federal and state guidance to verify the presence and extent of wetlands and other waterbodies that could be affected by the Project. The results of that delineation would be used to support final design and to avoid or minimize direct impacts to aquatic resources to the extent practicable.

To the extent practicable, streams, wetlands, ponds, and other aquatic features would be avoided or spanned by the transmission line, and permanent structures would be sited outside jurisdictional features. Temporary construction areas, including work areas and pulling or tensioning sites, would also be located to avoid aquatic resources where feasible. If temporary impacts cannot be avoided, appropriate protective measures, such as construction matting and other minimization practices, would be implemented and any necessary permits obtained (Appendix C).

Overall, with implementation of route refinement, feature spanning, floodplain avoidance to the extent practicable, and standard BMPs, impacts to water resources from construction, operation, and maintenance of the proposed transmission line are expected to be low, localized, and primarily temporary. Long-term impacts would be minimized through final design, avoidance of aquatic features where practicable, and compliance with applicable federal, state, and local permitting requirements.

4.8.2 Protection Measures

The following measures would be implemented to minimize potential impacts to water resources during construction of the transmission line:

Water-1: Develop and implement a Project-specific SWPPP. The SWPPP may include measures such as silt barrier fences to control runoff, sediment traps and basins, and minimizing exposed soils by using temporary and permanent seeding and mulching.

Water-2: Disturbed areas will be restored to their original condition to the extent practicable. Such areas shall be reseeded and reclaimed as practicable, with consideration of the growing season. Seed mix and seeding rates will be developed through consultation with the local agency and landowner preference.

Water-3: Equipment will be properly maintained and inspected regularly to minimize the potential for leaks of fuel, oil, hydraulic fluid, or other hazardous materials.

Water-4: Fuels, lubricants, and other petroleum products will be stored in designated areas away from drainages, wetlands, waterbodies, and excavated areas, and will be managed in accordance with applicable spill prevention requirements.

Water-5: Spills will be contained and cleaned up promptly using appropriate response procedures and materials. If oil storage capacity exceeds 1,320 gallons, an SPCC Plan will be developed to describe the procedures and measures that would be implemented on-site to contain and prevent the release of oil from reaching navigable waters.

Water-6: Matting and other temporary protective measures will be used on wetlands that cannot be avoided.

Water-7: Unavoidable impacts to potentially jurisdictional wetlands and waters will be evaluated against the requirement of the USACE for coverage under the Nationwide Permit Program.

Water-8: Appropriate buffer zones will be established around wetlands, waterbodies, and other aquatic features based on resource type, infrastructure, location, and proximity to other constraints. Buffers may utilize staking, flagging, and/or fencing around wetlands as necessary to prevent disturbance and minimize encroachment.

Water-9: Soil stockpiles, spoil areas, and other construction materials will not be located within 50 ft of stormwater inlets or water resources.

Water-10: All applicable water quality protection standards will be followed, and any applicable federal, state, and local permits or authorizations will be acquired prior to construction.

4.8.3 Conclusion

Based on the generally limited extent of aquatic resources within much of the ROW, the ability to avoid or span streams, wetlands, and other water features to the extent practicable, and the

implementation of the protection measures described above, the Project is not expected to result in substantial adverse impacts to water resources. Temporary construction-related effects, such as localized erosion, sedimentation, or accidental spills, would be minimized through implementation of BMPs, a Project-specific SWPPP, spill prevention measures, and site reclamation. With route refinement, appropriate permitting, and adherence to applicable water quality protection requirements, the Project is not expected to unduly impair surface waters, wetlands, floodplains, or groundwater resources.

4.9 Flora and Fauna

Assessment of impacts to biological resources from construction, operation, and maintenance of the proposed transmission line follows the methodology described in Section 4.1 and is summarized below. Construction and maintenance impacts would be generally short-term and temporary. Potential operational impacts include a small amount of permanent habitat loss due to the permanent footprint of access roads and transmission line structures.

4.9.1 Impacts Specific to the Project

Federally and State-Listed Species

According to the USFWS IPaC, federally listed species that may occur in the ROW include Mexican spotted owl, Northern aplomado falcon, piping plover, southwestern willow flycatcher, yellow-billed cuckoo, Mexican wolf, New Mexico meadow jumping mouse, Rio Grande silvery minnow, monarch butterfly, Suckley's cuckoo bumble bee, and Pecos sunflower. An evaluation of habitat conditions within the ROW determined that only the southwestern willow flycatcher, yellow-billed cuckoo, Rio Grande silvery minnow, and monarch butterfly have the potential to occur within the Project Area (Table 3-11). The southwestern willow flycatcher and Rio Grande silvery minnow are federally listed as endangered, while the yellow-billed cuckoo is listed as threatened under the ESA. The monarch butterfly is a proposed threatened species and is not currently protected under the ESA. In addition, designated critical habitat for the southwestern willow flycatcher, yellow-billed cuckoo, and Rio Grande silvery minnow intersects portions of the ROW.

Separately, the NMERT identifies state-listed endangered and threatened wildlife species that may occur within the ROW. These species include bald eagle, Northern aplomado falcon, peregrine falcon, southwestern willow flycatcher, gray vireo, Rio Grande silvery minnow, spotted bat, New Mexico meadow jumping mouse, and western ribbon snake. Using the same habitat-based screening approach, only the bald eagle, southwestern willow flycatcher, gray vireo, Rio Grande silvery minnow, and western ribbon snake were determined to have reasonable potential to occur within the ROW (Table 3-12).

If any individuals or suitable habitats for threatened and endangered species are identified during a field survey, the Project would coordinate with USFWS and NMDGF to determine avoidance or minimization strategies, as necessary. Field surveys would occur within the appropriate windows for species observation based on experience within the region and applicable agency guidance. Impacts to federal and state protected species are anticipated to be low based on the limited amount of high-quality habitat present; implementation of avoidance measures and BMPs; and the short construction duration for the transmission line.

USFS and BLM-Listed Species

A review of USFS and BLM-listed sensitive species lists found that there are 33 sensitive species present within Cibola National Forest, and 28 sensitive species within the BLM Rio Puerco Field Office. USFS and BLM-listed sensitive species only receive protections on lands that the respective agency manages. Therefore, each species' likelihood of occurrence was evaluated based on the habitat present on either BLM, or USFS-managed lands. Sensitive species that may occur in the transmission line ROW are included in Table 3-13 and Table 3-14 in Appendix B. Based on habitat requirements, only northern goshawk, gray vireo, and tall bitterweed are likely to occur on USFS-managed lands within the ROW. Only Mexican whip-poor-will and pinyon jay are likely to occur on BLM-managed lands.

If any individuals or suitable habitat are identified during a field survey, the Project would coordinate with either USFS or BLM, as applicable, to determine avoidance or minimization strategies. General field surveys or species specific surveys would occur within the appropriate windows for species observation based on experience within the region and applicable agency guidance. Impacts to BLM and USFS sensitive species are anticipated to be low based on the limited amount of high-quality habitat present on BLM and USFS-managed lands within the ROW; implementation of avoidance measures and BMPs; and the short construction duration for the transmission line.

Birds

Migratory bird species, including bald eagles, pinyon jay, broad-tailed hummingbird, and other raptors, could potentially utilize the ROW for breeding, foraging, and migration. If construction occurs during the migratory bird nesting season, potential impacts could occur to migratory bird eggs and/or nestlings. Increase in noise and equipment activity levels during construction could also potentially disturb breeding, nesting, or foraging activities of migratory birds and/or raptors in adjacent areas. The Project would conduct all vegetation clearing and construction activities in compliance with the MBTA and Bald and Golden Eagle Protection Act; activities would either occur outside of the applicable breeding season or pre-construction migratory bird surveys would be completed ahead of any construction activities that would take place within the breeding season. Active nests identified during pre-construction surveys would be recorded and given the appropriate species specific spatial and/or temporal buffer from construction activities.

Transmission lines can present additional collision hazards to birds, however electrocution is unlikely for perching birds, given the phase-to-phase and phase-to-ground clearances dictated by NESC standards. Wet weather can create a conductive environment in which birds could potentially be electrocuted on normally benign poles; however, avian-safe design features (Section 4.9.2) mitigate this risk (APLIC 2026). Birds may migrate through the area during the annual migration periods of spring and fall. The Project would follow appropriate APLIC guidance to implement measures to minimize collision risk with proper siting and electrocution risk with proper transmission line design. The electrocution risk to birds would be minimal since the engineering design distance between conductors, conductor to structure, or conductor to ground wire for the proposed transmission line is greater than the wingspan of any bird potentially within the area (i.e., greater than 8 feet). While the conductors are typically thick enough to be seen and avoided by birds in flight, the shield wire (upper most wire) is thinner and can present a risk for avian collision. Further, segments of the Project that are co-located with the existing WL 115-kV line combine what could be constructed as two independent collision hazards into a single hazard that birds in flight must avoid, reducing the overall combined collision risk for both powerlines if constructed and located independently. Additionally, segments of the Project constructed immediately adjacent and parallel to the existing WL 115-kV line or other existing transmission infrastructure may increase overall visibility of the combined hazard.

Specific to sandhill cranes, a separate study was completed to evaluate sandhill crane exposure probability (i.e., the probability of a sandhill crane passing through a volume of space surrounding the transmission line circuits) relevant to the existing WL 115-kV transmission line and construction of the Project (Appendix D). The results indicated that while exposure probability increased with the addition of the Project to the existing WL 115-kV transmission line, the combined exposure probability was lower than if the Project were to be built independently. Further, exposure probability does not account for collision avoidance behaviors. While sandhill cranes demonstrate natural avoidance behaviors to powerlines, collision risk would likely decrease materially by increasing visibility of the Project to birds in flight through the use of bird flight diverters.

Prior to construction, an avian risk assessment would be completed for the Project following APLIC guidance to identify areas where there is greater risk for avian collisions (e.g., near wetlands). The results of the assessment would help identify where the Project would install bird diverters to minimize collision risk for all avian species, including sandhill cranes.

Mammals

Temporary impacts may occur during construction due to direct habitat disturbance, noise in the vicinity, and vibrations. Impacts are anticipated to be low and short-term. For some mammalian species, displacement from increased traffic, noise, and vibration in the vicinity of the Project could occur for the duration of the construction period. After construction, noise generated during operations would be greatly reduced and cause negligible impacts. Most wildlife movements are expected to resume to pre-construction levels a short time after construction is

completed. Potential long-term impacts include those resulting from habitat modifications and/or fragmentation. The Project would work to minimize potential habitat fragmentation by paralleling the Project transmission lines with existing linear features (e.g., road and existing transmission lines) and avoid paralleling water features (such as streams or wetlands) when feasible. Construction activities might also impact small, immobile, or fossorial (living underground) mammal species through direct impact or from the alteration of local habitats. Direct impact on these species might occur due to equipment or vehicular movement within the area or due to the compaction of the soil if the species is fossorial. Potential impacts of this type are likely to be low and isolated to individuals. Population-level impacts are not likely. The Project would also aim to avoid direct impacts to these species from equipment or vehicular movement on the ROW by encouraging compliance with on-site or posted speed limits. Therefore, low impacts to local mammalian wildlife populations may occur due to habitat disturbance and localized potential for direct mortality to individuals during construction and operation.

As discussed in Section 3.8.2, five of the ten big game species managed by NMDGF have the potential to occur in the Transmission Study Corridor: mule deer, elk, black bear, mountain lion, and pronghorn (NMDGF 2026b). Each of these species is known to inhabit pinyon-juniper and grassland habitats, though black bears typically inhabit the more mountainous regions to the north (NMDGF 2026b). Elk, mountain lions, and pronghorn antelope have been documented in or near the Transmission Study Corridor.

Relatively little research to date has been done to assess the long-term impacts of transmission lines on big game species. However, habitat conversion and fragmentation; increased noise, light, and human activity during construction and maintenance; and visual changes to the landscape have been documented as potential impacts to big game from transmission line development (Jakes et al. 2024). However, the magnitude of these impacts appears to vary by species and may be mitigated by restoration efforts following construction, ROW management, and protection measures (Bramble and Byrnes 1972; Bartzke et al. 2014). Conversely, it is also documented that transmission line construction lines may benefit game animals with managed ROW serving as habitat corridors and/or creating feeding opportunities (Bartzke et al. 2014; Jakes et al. 2024).

Construction sites, staging areas, and work locations would be maintained in an orderly condition throughout Project construction. All waste materials, including food-related waste, would be collected in covered receptacles and regularly removed from the Project sites for disposal at appropriately permitted facilities. The Project overlaps areas of potentially suitable habitat for black bear (*Ursus americanus*) (New Mexico Department of Game and Fish [NMDGF] 2026a); however, documented black bear occurrences have not been identified within the Transmission Study Corridor. If Project-specific assessments indicate a moderate to high potential for bear activity, bear-resistant waste containers would be used, as appropriate, to minimize wildlife attractants.

Reptiles

Reptiles, including the federally threatened western ribbon snake, may experience temporary impacts during construction such as direct habitat disturbance, noise, and vibrations. Impacts are anticipated to be low and short-term. After construction is complete, noise generated during operation of the transmission line would be greatly reduced and create negligible impacts. Most wildlife movements are expected to resume to pre-construction levels after construction is completed. Potential long-term impacts include those resulting from habitat modifications and/or fragmentation. The Project would work to minimize potential habitat fragmentation by paralleling the transmission line with existing linear features (e.g., road and existing transmission lines) and avoid paralleling water features (such as streams or wetlands) when feasible. Construction activities also have the potential to impact small, immobile, or reptiles living underground, through direct impact from ground disturbance and alterations of local habitats. Direct impact on these species might occur due to equipment or vehicular movement within the area or due to the compaction of the soil if the species is fossorial (living underground). Potential impacts of this type are likely to be low and isolated to individuals; population-level impacts are not likely. The Project would minimize direct impacts to these species from equipment or vehicular movement on the ROW by encouraging compliance with on-site or posted speed limits. Therefore, low impacts to local reptile populations may occur due to habitat disturbance and localized potential for direct mortality to individuals during construction and operation.

Flowering Plants

The ROW is characterized by arid grassland, shrub/scrub, and pinyon-juniper habitats. The higher elevation, pinyon-juniper habitat located in and around the southern Manzano Mountains could potentially support the tall bitterweed, a New Mexico Rare Plant Conservation Strategy species. Impacts during construction would include temporary and permanent disturbance from vegetation removal. Adverse long-term impacts could occur through the introduction of invasive species that could exploit disturbed-ground conditions during construction, resulting in long-term alteration of community composition in those areas. A noxious weed plan would be developed for the Project to address protocols from treatment and removal of invasive and noxious plants. O&M activities are expected to occur infrequently during the operational lifetime of the Project and would not significantly disrupt established vegetation communities. The duration of these effects would be minimized through the protection measures proposed by the Project, designed to reduce impacts to vegetation.

Insects

Open grasslands and scrub/shrub habitat in the ROW have the potential to support a diversity of blooming nectar resources, including milkweed, which sustains many insect species including the monarch butterfly. Temporary and permanent disturbance from vegetation removal during construction may disrupt life cycles and migration patterns of insect species within the ROW. Adverse long-term impacts could occur through the introduction of invasive species (vegetative as well as insect species) that could exploit disturbed-ground conditions during construction,

resulting in long-term alteration of community composition. A noxious weed plan would be developed for the Project to address protocols for treatment and removal of invasive and noxious plants. The duration of these effects would be minimized through the following protection measures which are designed to minimize long-term impacts to the vegetation communities that support insects.

4.9.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative impacts to biological resources during construction activities include:

Bio-1: Prior to construction, an avian risk assessment will be completed for the Project following APLIC guidance to identify areas where there is relatively greater risk for avian collisions (e.g., near wetlands). The results of the assessment will help identify where the Project may install bird diverters to minimize collision risk.

Bio-2: Trash and food debris will be properly disposed of and secured.

Bio-3: Allowing wildlife that has entered the work area to leave the area on its own.

Bio-4: Providing environmental awareness training to all construction personnel working on the Project.

Bio-5: Vehicles and other construction equipment that have been stationary for more than one hour will be visually inspected for wildlife prior to moving or operation.

Bio-6: Checking trenches, excavations, and uncapped pipe segments for wildlife.

Bio-7: Project personnel will comply with posted speed limits.

Bio-8: Conducting tree/vegetation clearing outside the primary nesting season (March 1-August 31), where feasible, to discourage birds from establishing nests in Project work areas.

Bio-9: Conducting pre-construction nest surveys prior to initiating construction activities unless vegetation clearing has been completed prior to the nesting season. If nests are discovered, a species appropriate buffer will be implemented, and construction activities will be avoided within such buffer until the species has fledged.

Bio-10: Establishing an appropriate buffer around occupied raptor nests, as necessary to minimize disturbance. Buffers are species or group specific and are based on applicable agency coordination and/or other relevant guidance.

Bio-11: Design transmission line facilities to APLIC guidance or similar in order to minimize electrocution and collision risk.

Bio-12: Micrositing will be completed during engineering design to avoid sensitive biological resources.

Bio-13: Setbacks from sensitive biological resources will be implemented to protect species habitat and time critical periods (e.g., breeding season).

Bio-14: Field surveys will be conducted to determine the extent of potentially suitable habitat for listed species and/or probable presence/absence, where applicable. Known population concentrations (i.e., leks or other congregatory groups) will be avoided by project design using a species appropriate buffer determined through relevant agency coordination or other applicable guidance.

Bio-15: A noxious weed plan will be developed for the Project to address protocols for treatment and removal of invasive and noxious plants.

4.9.3 Conclusion

Based on the limited amount and quality of habitat present for sensitive species, as well as the protection measures detailed above, it is not expected that the Project would unduly impair biological resources. Direct effects during the construction phase include removal of vegetation and wildlife habitat, however these impacts would be short-term and low impact.

4.10 Archaeological and Historic-Age Cultural Resources

Assessment of impacts to archaeological and historic-age cultural resources from the Project construction, operation, and maintenance follows the impact assessment methodology described in Chapter 4.1 above and is discussed below. Construction, operations, and maintenance impacts are generally low, avoidable, short-term, and temporary in nature for archaeological and historic-age cultural resources. Cultural resources surveys would be completed for all areas of anticipated ground disturbance for the Project prior to any ground disturbance on public as well as private property, where permitted.

4.10.1 Impacts Specific to the Project

The ROW contains 41 archaeological sites and 11 HCPI resources. Of the archaeological sites, three have been determined Eligible for listing on the NRHP, four are Not Eligible for listing on the NRHP, and 33 remain Unevaluated for listing on the NRHP. Of the HPCIs, eight resources have been determined Eligible for listing on the NRHP, one is Not Eligible for listing on the NRHP, and two remain Unevaluated for the NRHP. Approximately 86% of the proposed Project ROW remains unsurveyed, leaving substantial gaps in resource identification and documentation.

Potential impacts to known cultural resources are anticipated to be minimal, as Project facilities would be sited and designed to avoid identified resources where practicable. Prior to the commencement of construction activities, intensive cultural resource surveys would be completed on federal lands, NMSLO lands, and, to the extent practicable, high probability areas

on privately owned land. The results of these surveys would be used to identify cultural resources and support impact avoidance and minimization efforts. Any inadvertent discoveries made during construction would be managed through coordination with the appropriate federal and state agencies and in accordance with applicable regulatory requirements, which would be outlined in a Project-specific UDP.

4.10.2 Protection Measures

Protection measures that would be implemented to the extent practicable to reduce any potential negative cultural, historic, and archaeological impacts from construction activities include:

Cul-1: The Project will be designed to avoid known sites, to the greatest extent practicable.

Cul-2: Cultural surveys in known areas of ground disturbance for the Project will be completed ahead of construction, where applicable. No ground disturbance activities in applicable areas will be completed prior to cultural survey work being completed.

Cul-3: If sites are found at the location of planned infrastructure, micrositing techniques will be used to move around and/or span sites to the greatest extent practicable.

Cul-4: The Project will engage with tribes that may have a cultural affiliation to areas within the Project ROW.

Cul-5: The Project will follow a UDP, providing protection upon discovery of unknown sites.

4.10.3 Conclusion

Based on the protection measures listed above, the proposed location of the Project would not unduly impair cultural, historic, and archaeological resources. Implementation of the proposed protection measures would avoid or minimize adverse effects on these resources.

4.11 Religious and Cemetery Sites

Assessment of impacts to religious and cemetery sites from construction, operation, and maintenance of the Project follows the impact assessment methodology described in Section 4.1 above and is discussed below. Construction, operations, and maintenance impacts are generally low, avoidable, short-term, and temporary in nature for religious resources.

4.11.1 Impacts Specific to the Project

No religious sites or cemeteries were identified within the ROW, though unknown or abandoned religious sites may exist within the ROW. Prior to the commencement of construction activities, intensive cultural resource surveys would be completed on federal lands, NMSLO lands, and, to the extent practicable, high probability areas on privately owned land in order to identify previously unrecorded religious and cemetery sites and reduce potential impacts from the Project. Siting of the Project would follow industry standard siting guidelines.

4.11.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative impacts to religious and cemetery sites from construction activities include:

Rel-1: The Project will be designed to avoid known religious and cemetery sites.

Rel-2: Cultural surveys in known areas of ground disturbance for the Project will be completed ahead of construction, where applicable. No ground disturbance activities will be completed in applicable areas prior to cultural survey work being completed.

Rel-3: If sites are found at the location of planned infrastructure, micrositing techniques will be used to move around and/or span sites to the greatest extent practicable.

Rel-4: The Project will follow a UDP, providing protection upon discovery of unknown religious and cemetery sites.

4.11.3 Conclusion

Based on the protection measures listed above, the proposed location of the Project would not unduly impair religious or cemetery sites.

4.12 Visual and Scenic Resources

Impacts to visual and scenic resources, both short-term and long-term would occur from construction, operation, and maintenance of the transmission line. These potential impacts are described for visual and scenic resources within the ROW. Potential short-term environmental impacts to visual and scenic resources generally would occur during construction and maintenance phases of the Project and include the presence of construction and operation personnel using equipment and working within the ROW. Potential long-term environmental impacts to visual and scenic resources are anticipated to be those that remain present for the anticipated 40-year lifespan of the Project. These potential long-term impacts are based on the visibility of the transmission structures, conductors, insulators, and associated access roads for operations of the Project. Potential impacts are anticipated to occur from the Project where there are:

- Residences and residential areas are in proximity to the Project;
- Changes to the existing visual landscape as seen from scenic byways (Salt Missions Trail Scenic Byway, Abo Pass Trail Scenic Byway, El Camino Real Scenic Byway, and the Historic Route 66 National Scenic Byway); or
- Diminishment of scenic resources from the addition of man-made elements to the natural landscape.

4.12.1 Impacts Specific to the Project

Construction activities, the addition of transmission structures, and O&M activities within the ROW change the existing visual characteristics of the landscape. Potential impacts would vary based on the context that the Project is viewed.

For residents in the vicinity of the Project, the potential visual impacts of the Project are dependent on several factors including distance, screening (trees, topography), presence of other existing structures (power lines, radio towers), the orientation of the proposed line to the home, and if the Project is backdropped by the existing landscape or if it is seen in a skyline condition.

The Project crosses several State and National Scenic and Historical Byways. At these crossings the transmission line would be immediately visible to travelers and would create extended viewing opportunities in locations where the transmission line parallels the roadway. For the crossings of the Abo Pass Trail and Salt Missions Trail Scenic Byways, new transmission infrastructure would be seen in the context of an existing transmission line within the same corridor. This would result in potential short-term and long-term visual impacts as the new structures would alter the existing landscape. Where the Project crosses US Hwy 60/ Historic Route 66 National Scenic Byway the Project would introduce additional infrastructure located in a distinctly separate corridor. The increased number of transmission structures would create more change to the existing landscape, but the Project would be viewed with the context of an existing transmission line.

SIOs identified for USFS lands within the ROW have the potential to experience long-term visual effects associated with the Project. The assessment of potential Project impacts on scenic resources does not include an evaluation of, or determination regarding, consistency with applicable USFS SIOs. As discussed above, visual impacts on USFS-managed lands may occur in both the short and long-term where Project facilities are visible from the surrounding landscape.

Potential long-term impacts to the visual landscape would also vary based on the segment of the Project. In particular, portions of the Project that would be co-located with the existing WL 115-kV line would result in a single set of larger structures than currently exist for the 115-kV line. However, this co-location avoids the need for two transmission lines (the Project and the WL-115kV) constructed as discrete sets of structures and in separate ROWs within the same visual landscape.

4.12.2 Protection Measures

Vis-1: Leave (where possible) plants shorter than eight feet in height within the ROW to help reduce the effect of the ROW of visual and aesthetic resources.

Vis-2: Keep the ROW free of construction debris and other litter during construction to further reduce visual intrusion to the surrounding landscape.

Vis-3: Transmission structures shall, to the extent reasonably possible, use materials, colors, textures, screening and landscaping that will blend the facility into the natural setting and existing environment.

Vis-4: Non-speculative conductors and equipment will be used to reduce glare from transmission infrastructure.

4.12.3 Conclusion

The Project would affect residences and scenic byways within the ROW and would cross USFS-, BLM-, and NMSLO-managed lands, in addition to private lands. Co-location, paralleling existing transmission lines, and the protection measures described above would reduce these effects over the short- and long-term.

4.13 Land Use, Including Farm, Range, and Recreational Resources

Assessment of impacts to land uses from construction, operation, and maintenance of the Project follows the impact assessment methodology described in Chapter 4.1 above and is discussed below. A land use impact is one that restricts the future use of land or conflicts with an existing use. The Project tends to restrict certain activities but may or may not change the land use. Construction, operation, and maintenance of the Project would result in both direct and indirect impacts to land use. The Project was evaluated to determine whether the following types of impacts would occur:

- Temporary and permanent land use changes.
- Restrictions on activities within the ROW.
- Inconsistency with local land use plans and zoning.
- Removal of land from future development.
- Potential use restrictions or conflicts on public lands.

4.13.1 Impacts Specific to the Project

Agricultural Land Use Impacts

The lands crossed by the ROW are primarily used for farmland, rangeland, and recreational resources. Long-term land use impacts on rangeland would primarily result from structure placement, ROW maintenance, and access roads. Current agricultural practices would be maintained for most of the ROW. Areas of pasture within the ROW could continue to be grazed. The only land that would be unavailable for agriculture would be the area occupied by transmission structures, which would be approximately three feet to five feet in diameter at

ground level, depending on the type of structure. The permanent footprint of transmission line structures would be removed from production, and structures would present obstacles that need to be avoided. The Project would work with landowners to reduce impacts to irrigation facilities, such as canals. However, overall, the transmission line would result in minimal reduction in agricultural production or land available for agricultural activities.

Easements or ROWs have been or would be obtained from landowners along the route for constructing and maintaining the line. The landowner would maintain ownership of the property and continue to pay taxes on the property, but the Project would acquire rights allowing construction, operation, and maintenance of the ROW in exchange for monetary payment to the landowner. The agreement between the landowner and the Project would outline any use restrictions applying to the agreement. The agreement would include certain restrictions on the continued use of the property, such as prohibiting permanent structures and establishment of certain types of vegetation within the ROW that could affect access to the line or safe and reliable operation.

During construction and maintenance activities, agricultural lands would be subject to temporary impacts. Depending on the time of year, access for construction may result in damage to crops, compaction and rutting of soil, restrictions on access to the ROW, and restrictions on general agricultural practices in and around the ROW (such as prescribed burning of grassland pasture). Landowners would be compensated for crop and forage loss, and damaged soils would be restored to arable condition. Cattle may need to be relocated or confined away from the ROW areas of pasture during construction. Following completion of construction, disturbance and disruption to agricultural activities would generally cease. Periodic maintenance activities and emergency repairs would result in impacts similar to those for construction. However, these activities would be infrequent over the life of the Project. Where agreements indicate, landowners would be compensated for any damage, and the ROW would be restored to its previous conditions.

In addition to the ROW, multiple temporary laydown areas for construction material and equipment would be necessary for the duration of construction. These laydown areas would each be up to 20 acres in size. Where feasible, construction laydown areas are typically located at previously disturbed or developed locations such as vacant lots, existing utility yards, or parking lots to reduce impacts to sensitive resources. If existing yard locations are not available, preferred locations for yards would be undeveloped areas that are cleared of woody vegetation, flat, have all-weather access, and do not contain streams, wetlands, or other environmentally sensitive resources. No topsoil would be removed, and minimal, if any, regrading is expected to take place at these facilities. Laydown areas generally would be returned to pre-construction conditions upon completion of construction.

Public Lands

The Project would traverse approximately 2.1 miles of USFS land, 16.5 miles of NMSLO land, 0.3 miles of NMDGF land, 0.3 miles of MRGCD land, 0.1 miles of NMDOT land, and an aerial

crossing of approximately 0.02 miles over land administered by the BLM. No Project facilities or ground-disturbing activities are proposed on BLM land. Easements or crossing agreements would be required for Project facilities or crossings from each of the agencies. The Project would coordinate with each agencies to ensure that easement agreements are consistent with applicable agency planning requirements and management objectives. The Salinas Pueblo Missions National Monument, discussed in Section 3.12, is outside of the ROW.

Recreation

No direct or indirect impacts on state or county recreation lands, local parks, trails, or hunting access lands would occur as a result of the construction, operation, and maintenance of the ROW. Existing recreational opportunities would continue as they currently exist, with minor temporary disturbances possible during construction.

4.13.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative land use impacts include:

Land-1: Coordinate with landowners for potential measures, including routing, to reduce Project impacts on uses on specific properties.

Land-2: Coordinate with appropriate state and federal land management agencies to obtain applicable permits and easements for portions of the transmission line traversing public lands.

Land-3: Plan and conduct construction activities to reduce temporary disturbance, displacement of crops, and interference with agricultural activities.

Land-4: Restore compacted cropland soils as close as possible to pre-construction conditions using tillage.

Land-5: Compensate landowners for any new land rights required for ROW or access road easements.

Rec-1: Plan and conduct construction activities to reduce temporary disturbance, displacement of recreationists, and interference with recreation activities.

4.13.3 Conclusion

Based on the compatibility of the ROW with the current land uses, impacts to land uses would be largely temporary and limited in area during construction. The majority of the Project area would remain in its pre-construction use. With inclusion of the protection measures detailed above, it is not expected that the proposed location of the ROW would unduly impair land use resources.

There would be no direct or indirect impacts of the construction, operation, and maintenance of the on schools, as most schools and daycare facilities are all greater than a half-mile from the Project. The nearest school, Gil Sanchez Elementary School, is approximately half-mile south of the ROW in Jarales. Therefore, it is not expected that the proposed location of the ROW would unduly impair school or educational resources.

Based on no direct or indirect impacts to state or county recreation lands, local parks, trails, or hunting access lands as a result of the construction, operation, and maintenance of Project components, it is not expected that the proposed location of the ROW would unduly impair recreation resources.

4.14 Socioeconomics

The assessment of potential impacts to socioeconomic resources associated with the construction, operation, and maintenance of the Project is conducted in accordance with the impact assessment methodology described in Section 4.1. Socioeconomic impacts associated with the construction, operation, and maintenance of the Project were evaluated based on population characteristics, employment and income, labor force participation, educational attainment, housing, public services, and local and regional economic conditions.

The analysis considers short-term effects associated with construction and long-term effects associated with operations within the Project vicinity, which includes Socorro, Torrance, and Valencia Counties. Direct, indirect, and induced effects were considered where relevant.

4.14.1 Impacts Specific to the Project

Construction of the Project would result in significant economic benefits both in the short-term related to capital investment, construction employment, and procurement of goods and services and long-term through operations over the lifespan of the Project.

The temporary construction workforce may increase demand for lodging, food services, fuel, and other local services. Temporary effects could include localized increases in traffic, noise, and demand on lodging or infrastructure, particularly in rural portions of Socorro, Torrance, and Valencia Counties. These effects would be temporary and would cease following completion of construction. O&M of the Project would result in ongoing regional and statewide socioeconomic benefits through permanent employment and operational expenditures spending.

The Project would not displace existing economic activities. Instead, it would introduce new short-term and long-term economic activity consistent with regional employment patterns. Over time, the Project could contribute incrementally to economic stability, particularly in counties with existing socioeconomic constraints.

4.14.2 Protection Measures

The following measures would be implemented to minimize adverse socioeconomic effects:

Socioeconomic-1: Coordinate construction activities with landowners and local authorities to minimize disruptions to access, transportation, and ongoing land uses, to the extent practicable.

Socioeconomic-2: Implement construction scheduling and traffic management measures to reduce short-term community disruptions, to the extent practicable.

Socioeconomic-3: The Project will make good faith efforts to enlist local skilled labor for temporary jobs associated with Project construction.

4.14.3 Conclusion

The Project would result in minor short-term adverse effects during construction and long-term beneficial socioeconomic effects: increased employment, income, and fiscal contributions. Construction-related disruptions would be temporary and localized.

The Project is needed to meet increased demand for energy in growing cities and to strengthen regional energy infrastructure and system reliability. By supporting these objectives, the Project would contribute to long-term economic stability and reliability benefits within the local and regional area.

Overall, the Project would contribute to local and regional economic activity without displacing existing activities, and it would provide sustained socioeconomic benefits over its operational life.

4.15 Communication Signals

The assessment of potential impacts to communication signal resources associated with the construction, operation, and maintenance of the Project is conducted in accordance with the impact assessment methodology described in Section 4.1 and is discussed further below. Impacts to communication signal resources from construction, operation, and maintenance activities are generally avoidable through appropriate planning and coordination.

4.15.1 Impacts Specific to the Project

The Project is designed to avoid interference with communication pathways. Signaling structures that were identified within the Transmission Study Corridor are listed in Section 3.14.2. The Project would avoid signaling structures to the extent practicable.

4.15.2 Protection Measures

Protection measures that would be used to reduce potential negative communication signal impacts from construction activities or operation include:

Comm-1: Transmission structures will be sited to maintain adequate separation from fixed broadcast, retransmission, or reception antennae used for radio, television, wireless

telecommunications, and other communication systems, thereby avoiding potential safety hazards in the event of electrical equipment, structure, or conductor failure.

Comm-2: Transmission structures will be sited to maintain adequate separation from fixed broadcast, retransmission or reception antenna for radio, television or wireless phone or other personal communications systems to prevent electromagnetic interference with signal transmission and reception.

4.15.3 Conclusion

Microwave paths, cellular and ASR towers, and AM and FM broadcast towers would be avoided to the extent practicable. Accordingly, the proposed location of the Project is not expected to result in undue interference with communication signals.

4.16 Radioactive Waste and Radiation Hazards

Assessment of impacts from radioactive waste or radiation hazards resulting from construction, operation, and maintenance of the Project follows the impact assessment methodology described above in Section 4.1 and is discussed below.

4.16.1 Impacts Specific to the Project

Transmission lines and associated Project facilities do not create or hold radioactive waste or any radiation hazards. The Project would not generate radioactive waste or radiation hazards.

4.17 Hazardous Materials

The evaluation of potential impacts related to hazardous materials associated with the construction, operation, and maintenance of the Project is based on the impact evaluation approach outlined in Chapter 4.1 and is summarized below. Accidental release of hazardous materials could occur during construction, operation, or maintenance activities; this potential risk is described in greater detail below.

4.17.1 Impacts Specific to the Project

During construction, the use of trucks, heavy equipment, and on-site material storage could present a risk of accidental releases of fuel, lubricants, or other automotive fluids. While such incidents are possible, they would be infrequent, limited in scope, and temporary in duration, and therefore anticipated to result in minor to negligible impacts.

The Project would prepare and implement an SPCC Plan outlining procedures for employee training, equipment inspection, maintenance and repair, availability of spill response materials, and refueling protocols, with a focus on spill prevention, if oil storage capacity exceeds 1,320 gallons. Hazardous materials would not be discharged onto the ground or into surface waters or

drainage features. All construction-related waste, including trash, solid waste, petroleum products, and other potentially hazardous materials, would be collected and transported on a weekly basis to a licensed facility authorized to accept such materials.

4.17.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative hazardous materials impacts include:

Haz-1: Prepare a SPCC Plan for oil storage capacity in excess of 1,320 gallons.

Haz-2: Hazardous materials will not be discharged onto the ground or into streams or drainage areas.

Haz-3: Construction waste including trash and litter, garbage, other solid waste, petroleum products, and other potentially hazardous materials will be removed to a disposal facility authorized to accept such materials on an as needed basis.

Haz-4: Hazardous materials, chemicals, fuels, and oils will not be stored within 100 feet of a water resource, including but not limited to streams, wetlands, wells and springs.

Haz-5: Fueling of construction equipment will not be conducted within 100 feet of a water resource when possible.

Haz-6: On-site materials will be stored in a neat, orderly manner, in appropriate containers, and contained in an enclosure to minimize exposure to weather elements.

Haz-7: Products will be kept in original containers with the original manufacturer's label when possible.

Haz-8: Substances will not be mixed with one another unless per manufacturer instructions and recommendations.

Haz-9: An efficient use of a container's contents will be made prior to container disposal or recycling efforts.

Haz-10: If surplus product must be disposed of, manufacturer-, local-, or state-recommended methods for proper disposal will be followed.

Haz-11: Safety Data Sheets of products used or stored on-site will be accessible at the Project worksite.

Haz-12: Equipment and on-site vehicles will be monitored for leaks and will receive regularly scheduled maintenance to reduce the chance of fluid leaks.

Haz-13: Bulk storage containers with a capacity of 55 gallons or more will have appropriate secondary containment and empty drums must be marked with signage.

Haz-14: Bulk fuel or lubricating oil dispensers will not have a self-locking mechanism that allows for unsupervised fueling and measure such as automatic shut-off systems or fail-safe mechanisms will be deployed as appropriate.

Haz-15: Spill response equipment suitable for containment of the volume of the largest single on-site petroleum storage container will be available during construction activities and as necessary for operations. All on-site personnel will be trained on cleanup & reporting procedures and location of spill response equipment.

4.17.3 Conclusion

Impacts from hazardous materials would be reduced through the implementation of proper construction practices, the development and implementation of a SPCC Plan, as well as the protection measures detailed above. It is not anticipated that the Project would unduly impair important environmental resources due to hazardous materials.

4.18 Safety

The assessment of impacts for safety from construction, operation, and maintenance of the Project follows the impact assessment methodology as described in Section 4.1 and is discussed below. Safety concerns that can occur during construction, operation, and maintenance are described in more detail below.

4.18.1 Impacts Specific to the Project

The Project would develop a safety plan prior to construction to reduce safety risks. Speed limits would be posted to reduce traffic safety concerns on roadways. Reducing injury to personnel and damage to property would be done by following proper construction practices. If a safety issue were to occur, the Project's safety plan would have procedures in place to address most safety situations. The Project would also comply with all manufacturer specifications and relevant Occupational Safety and Health Administration requirements to ensure the safety of residents, employees, contractors, livestock, and the public.

Construction for the Project could cause wildfire ignition. Operations and maintenance activities (welding, vehicle ignition, etc.), and the presence of energized transmission line facilities could also cause wildfire ignition. The Project and/or its contractors would notify federal, state, and local agencies of any fires and comply with all rules and regulations administered by those agencies concerning use, prevention, and suppression of fires. This includes any fire prevention orders that may be in effect at the time of construction, operation, or maintenance activities. Additionally, Socorro, Torrance, and Valencia Counties emergency responders and fire districts would be contacted to ensure appropriate plans are in place for the areas of Project to quickly respond to any emergencies. The Project would work with the departments to ensure the safety of firefighters, employees, landowners, neighbors, and livestock. The Project would have emergency response plans in place to respond to various natural disasters if ever needed. An

annual emergency response drill, which local responders would be invited to participate in, would be completed on-site to test the Project's emergency preparedness.

Safety risks associated with the Project would be minimized through the implementation of standard security and safety measures. Electrical substations and transformers would be enclosed within locked fences or secured facilities and clearly marked with warning signage indicating the presence of energized electrical equipment. In addition, the Project would maintain a 24-hour, seven-day-a-week monitoring center, with contact information posted on substation fencing to facilitate rapid response to potential incidents or emergencies.

4.18.2 Protection Measures

Protection measures that would be implemented to reduce any potential safety impacts include:

Safe-1: The Project and its contractors, as appropriate, will initiate discussions with local fire districts and regional fire prevention staff prior to construction to discuss emergency procedures and to provide transmission line safety training, including safety procedures for conducting fire suppression activities near a power line.

Safe-2: All vehicles will be equipped with appropriate fire suppression tools and equipment. Fire suppression equipment may include shovels, buckets, and extinguishers or other appropriate equipment.

Safe-3: Smoking and equipment parking will be restricted to designated areas.

Safe-4: The Project and its contractors will fuel all highway-authorized vehicles off-site to minimize the risk of fire. Fueling of construction equipment that is transported to the site via truck and is not highway-authorized will be done in accordance with regulated construction practices and federal, state, and local laws.

Safe-5: The Project will develop a safety plan prior to construction. The plan will include items such as medical emergency facilities and procedures, wildlife agency contacts and procedures, and inclement weather procedures.

Safe-6: Appropriate warning signage shall be placed on all electrical equipment prior to energization.

4.18.3 Conclusion

With implementation of applicable safety protocols and the protection measures identified in this report, the potential for safety-related impacts would be minimized. Therefore, the Project is not expected to substantially affect environmental resources as a result of construction or operational safety concerns.

4.19 Geographic Resources

The impacts of construction, operation, and maintenance of the Project were assessed regarding the geographic resources identified in the region. The assessment of short-term and long-term impacts to these resources from construction, operation, and maintenance of the transmission line were conducted within the ROW. Short-term impacts are those that occur mostly during the construction and maintenance phases of the Project and persist for roughly 3 to 5 years following construction. These impacts are more associated with temporary disturbances from maintenance crews and construction vehicles. Long-term impacts are those that remain present for the anticipated 40-year lifespan of the Project. These are mainly caused by introducing physical elements like transmission structures and access roads. The following criteria were evaluated to determine whether impacts would be expected:

- Obstruction of access to transportation corridors (US Hwy and SH), emergency services, or other community services as a result of construction and/or operation of the transmission line.
- Introduction of any other kind of impact on these resources.

4.19.1 Impacts Specific to the Project

The ROW crosses several major transportation routes including US Hwy 60, US Hwy 25, SH 6, SH 47, and SH 314. The required construction activities may cause temporary disruption of local traffic patterns, but any impacts would be low and short-term. However, local communities and emergency responders would be given advanced notice to minimize potential impacts from construction of the transmission line.

The Project crosses several rail lines throughout the area. These crossings were intentionally designed to be perpendicular to existing infrastructure to minimize span lengths. As a result, no impacts are anticipated during any phase of the Project lifecycle.

The ROW crosses through the municipal boundary of Willard, New Mexico and over Station 9 of the Valencia County Fire Department. Interruptions or interference with the function and accessibility of the building are not anticipated.

The ROW also crosses multiple existing transmission lines and natural gas pipelines. Transmission structures would be placed outside of pipeline and transmission line easements to prevent any potential impacts from construction, operation, and maintenance of the proposed transmission line.

Impacts to air traffic are unlikely as airfields in the area service local farms or small municipalities. Local authorities would be provided advance notice prior to construction as a precaution against any potential impacts.

4.19.2 Protection Measures

Protection measures that would be implemented to minimize any potential negative impacts to geographical resources from construction and operational activities are identified in the following sections:

- 4.4.2 (Noise)
- 4.12.2 (Visual and Scenic Resources)
- 4.17.2 (Hazardous Materials)
- 4.18.2 (Safety)

4.19.3 Conclusion

Impacts on geographic resources would be avoided to the extent possible. Any impacts would be short-term and limited to the construction and maintenance phases of the Project and would be unlikely to negatively impact access to these geographic resources.

4.20 Military Activities and Aviation

Assessments of impacts from military and aviation activities from construction, operations, and maintenance within the Project follows the impact assessment methodology as described above in Section 4.1 and is discussed further below. Construction, operations, and maintenance impacts are generally avoidable for military and aviation activities.

4.20.1 Impacts Specific to the Project

No military bases occur within the Project vicinity. Ten military flight training routes intersect the Project, including instrument, slow, and visual route corridors. Based on the height of the transmission structures and the location of military and aviation resources, construction, operation, and maintenance within Project would not impact military activities and aviation.

4.20.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative military or aviation impacts from construction activities include:

Mil-1: Coordinate with military bases and aviation facilities, as needed.

Mil-2: Use FAA approved lighting as required.

Mil-3: Any use of drones for the Project would be performed by appropriately licensed drone operators, as applicable.

4.20.3 Conclusion

Impacts to military operations and aviation resources would be avoided and minimized to the maximum extent practicable through Project siting, design, and coordination efforts. As a result, the Project is not expected to negatively affect or unduly interfere with military activities or aviation resources.

4.21 Roads

Impacts to roadways from construction, operation, and maintenance of the Project were evaluated using the approach outlined in Section 4.1 and are discussed further below. These impacts are expected to be low in magnitude, short-term, and temporary.

4.21.1 Impacts Specific to the Project

The Project crosses I-25 once, and US Hwy 6 once. The Project also crosses SH 6, SH 55, SH 41, and SH 116 once and SH 47 three times. Potential impacts for roads would be the greatest during construction, with construction equipment and temporary increases in traffic having the potential to degrade existing road conditions. Existing roads used for Project construction would be maintained and, where affected by construction activities, restored to a condition generally equal to or better than their pre-construction condition, to the extent practicable and in accordance with landowner agreements. Fences, gates, cattleguards, and other improvements damaged during construction would be repaired or replaced in coordination with the affected landowner. Temporary gates would be installed only with landowner approval and would be removed or restored to pre-construction conditions following completion of construction unless otherwise agreed upon.

The Project would document the pre-construction road conditions and return roads used during construction to their pre-construction conditions or better once construction is finished. Increased road traffic from construction would be localized and short-term, based on where construction is occurring and when. Minimal impacts to roads in the Project are anticipated.

4.21.2 Protection Measures

Protection measures that would be implemented to reduce any potential negative road impacts from construction activities include:

Road-1: Pre-construction conditions will be documented, and the Project will develop a road use agreement with NMDOT and the Road Maintenance Departments of Torrance, Socorro, and Valencia Counties, as necessary.

Road-2: Construction speed limits will be established.

4.21.3 Conclusion

Given the localized, minor, and short-term nature of impacts, along with the Project's commitment to restore roads used during construction to their pre-construction condition and the protective measures described above, the proposed location of the Project is not expected to cause undue impacts to roadways.

5. Consultation and Coordination

5.1 List of Preparers and Reviewers

5.1.1 Mid-State Transmission Project Companies

- Ian Evans, Senior Environmental Manager, Pattern
- Morgan Martin, Environmental Manager, Pattern
- Mitchell Applin, Senior Transmission Project Manager, Pattern
- Taylor Schendel, Business Development Senior Manager, Pattern
- Isabella Larsen, Business Development Analyst, Pattern
- Adam McClellan, Lands Manager, PNM
- Ashlee Rudolph, Environmental Scientist, PNM
- George Arms, Environmental Scientist, PNM
- Jennifer Jennings, Project Manager, Tierra Right of Way Services

5.1.2 WSP USA Inc.

- Anastacia Santos, Environmental Project Manager
- Marly Kapacinskas, Environmental Planner
- Lauren Martin, Environmental Planner
- Dustin Woods, Geotechnical Engineer
- Brackett Mays, Water Resources Specialist
- Kendall Rauch, Biological Resources Specialist
- Donald Purdon, Cultural Resources Specialist
- Nate Ferguson, Visual Resources Specialist
- Andy Hughes, Visual Resources Specialist
- Briana Henriques, Land Use Resources Specialist
- Jeraldine Herrera, Socioeconomics Resource Specialist
- Scott Woods, Senior GIS Analyst
- Andy Bartos, GIS Analyst

5.2 Technical Reports Contributing to the Environmental Report

- Desktop Wetland Evaluation Dataset, Burns & McDonnell Engineering Company, Inc. 2026
- Habitat Assessment for Mid-State Transmission, GeoSystems Analysis, Inc. 2026
- Sandhill Crane Collision Risk Assessment for the Mid-State Transmission Project, GeoSystems Analysis, Inc. 2026

6. Literature Cited

AirNow. 2026. *U.S. Air Quality Index*. Accessed June 2026. https://www.airnow.gov/?city=false&country=false.

American Cemeteries. 2026a. Socorro County, NM Cemeteries. Accessed June 2026. http://www.americancemeteries.org/new-mexico/socorro-county.

_____. 2026b. Torrence County, NM Cemeteries. Accessed June 2026 http://www.americancemeteries.org/new-mexico/torrence-county.

_____. 2026c. Valencia County, NM Cemeteries. Accessed June 2026 http://www.americancemeteries.org/new-mexico/valencia-county.

American Legal Publishing Code Library. 2023. Valencia County, New Mexico Code of Ordinances. Accessed August 2026. https://codelibrary.amlegal.com/codes/valenciacounty/latest/valenciaco_nm/0-0-0-1939#JD_92.21Avian Conservation Partners. 2017. Bald Eagle. http://avianconservationpartners-nm.org/wp-content/uploads/2017/01/Bald-Eagle.pdf. Accessed 22 June 2026.

Avian Power Line Interaction Committee (APLIC). 2026. *Suggested Practices for Avian Protection on Power Lines,* Delaware. https://www.aplic.org/pdf_view.php?file_url=https%3A%2F%2Fwww.aplic.org%2Fuploads%2Ffiles%2F15951%2FAPLIC-2026-Suggest-Practices-ENG.pdf Accessed June 2026

Bartzke, Gundula & May, Roel & Bevanger, Kjetil & Stokke, Sigbjørn & Røskaft, Eivin. (2014). The effects of power lines on ungulates and implications for power line routing and rights-of-way management. International Journal of Biodiversity and Conservation. 6. 647-662.10.5897/IJBC2014.0716.

Billion Graves. 2026. New Mexico Cemetery Search. Accessed June 2026. https://billiongraves.com/search/cemetery.

Bramble, W. C. and W. R. Byrnes. 1972. “A Long-Term Ecological Study of Game Food and Cover on a Sprayed Utility Right-of-Way.” Special Collections, USDA National Agricultural Library. Accessed April 3, 2026, https://www.nal.usda.gov/exhibits/speccoll/items/show/4155.

Burns & McDonnell Engineering Company, Inc. 2026. Desktop Wetland Evaluation Dataset, Prepared for Pattern Energy.

Bureau of Land Management (BLM). 1986. BLM Manual H-8410-1 - Visual Resource Inventory 1986. Accessed 2026. https://www.blm.gov/sites/blm.gov/files/uploads/Media_Library_BLM_Policy_H-8410.pdf.

_____. 2023. National Potential Fossil Yield Classification (PFYC) MapServer. 2023. U.S. Department of the Interior, BLM. Accessed: June 2026.

_____. 2026a. Handbook 8270 – Paleontological Resource Management. Accessed: June 2026.

_____. 2026b. National Data Viewer. Accessed June 2026. https://experience.arcgis.com/experience/9a89ee80c604431e8f8d939a186fbdbb.

_____. 2026c. Rights-of-Way Planning Tool. 2026. Accessed March 2026. https://webmaps.blm.gov/program_apps/BLM_Natl_ROW_368_Public/.

Bureau of Reclamation. 2024. *Middle Rio Grande Yellow-billed Cuckoo Study Results – 2023: Isleta Pueblo to Elephant Butte Reservoir, New Mexico, Upper Colorado Basin Region.* U.S. Department of the Interior, Bureau of Reclamation, Technical Report No. ENV-2024-020. Rebecca Siegle, Stanton Moore, and Ethan Reibsome. August 2024. https://webapps.usgs.gov/mrgescp/documents/2023-Middle-Rio-Grande-Yellow-billed-Cuckoo-Study-Results.pdf.

Cavell, Mertz & Associates, Inc. 2026. FCCInfo: FCC database search. Accessed June 2026 from: https://www.fccinfo.com/cmdpro.php?sz=L&wd=1920.

Chung-MacCoubrey, Alice L. 2025. “Use of Pinyon-Juniper Woodlands by Bats in New Mexico.” *Forest Ecology and Management,* vol. 204, nos. 2–3, pp. 209–220, https://research.fs.usda.gov/treesearch/61127.

Cibola National Forest Land Management Plan. 2022. Accessed June 2026 https://www.fs.usda.gov/sites/nfs/files/legacy-media/cibola/20220712_CibolaLMP_Final-WEB.pdf

City of Albuquerque. 2026. Flood Information and Resources. https://www.cabq.gov/planning/development-review-services/flood-information-and-resources. Accessed June 2026.

DeLong, John P., and Sartor O. Williams III. 2006. Status Report and Biological Review of the Gray Vireo in New Mexico. New Mexico Department of Game and Fish. https://www.unm.edu/~jdelong/NM%20Gray%20Vireo%20Review%20Final.pdf.

Esri. 2026. GIS data for religious sites and cemeteries in Socorro, Torrence, and Valencia, and Counties, New Mexico. Accessed June 2026. https://www.esri.com.

Federal Aviation Administration (FAA). 2026. National Aeronautical Charting Office. Alburquerque Sectional Aeronautical Chart, Effective May 14, 2026.

Federal Emergency Management Agency (FEMA). 2026. Flood Map Service Center. Accessed June 2026 from: https://msc.fema.gov/portal/search.

Fenneman, N.M. 1931. Physiography of Western United States. Accessed June 2026 from: https://archive.org/details/physiographyofwe00fenn/page/n7/mode/2up.

Find a Grave. 2026a. La Puerta Natural Burial, Valencia County, New Mexico, USA. Accessed June 2026. https://www.findagrave.com/cemetery/2690214/la-puerta-natural-burial.

_____. 2026b. Willard Cemetery, Torrence County, New Mexico, USA. Accessed June 2026. https://www.findagrave.com/cemetery/38514/willard-cemetery?

GeoSystems Analysis, Inc. 2026. Habitat Assessment for Mid-State Transmission.

Historical Marker Database. 2026. Estancia. https://www.hmdb.org/m.asp?m=280257. Accessed June 2026.

International Union for Conservation of Nature (IUCN). 2025. The IUCN Red List of Threatened Species, Version 2025-2. https://www.iucnredlist.org/. Accessed 22 June 2026.

Jakes, Andrew F., V. Ung-Kono, and E. Juno. 2024. Wires and Wildlife: Transmission Development and Western Migratory Species. Washington, DC: National Wildlife Federation

Land Conservation Assistance Network (LandCAN). 2026a. Socorro Soil & Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/Socorro-Soil-and-Water-Conservation-District/5133.

_____. 2026b. Claunch-Pinto Soil and Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/ClaunchPinto-Soil-and-Water-Conservation-District/5101.

_____. 2026c. Valencia Soil and Water Conservation District. Accessed June 2026 from: https://www.landcan.org/local-resources/Valencia-Soil-and-Water-Conservation-District/5140.

Middle Rio Grande Endangered Species Collaborative Program. 2025. *2024 Middle Rio Grande Southwestern Willow Flycatcher Study Results, Middle Rio Grande Project, New Mexico, Upper Colorado Basin Region*; Technical Report No. ENV-2025-059. Prepared by Bureau of Reclamation, Technical Service Center, Denver, Colorado. Available at: https://webapps.usgs.gov/mrgescp/documents/2024-Middle-Rio-Grande-Southwestern-Willow-Flycatcher-Study-Results.pdf. Accessed June 2026.

Mid-Region Council of Governments of New Mexico. 2003. Comprehensive Land Use Plan for Torrance County, New Mexico, August 2003. Accessed June 2026 from: https://www.mrcog-nm.gov/DocumentCenter/View/3124/Torrance-County-Comprehensive-Plan-August-2003-PDF.

Military Bases.com. 1998. New Mexico Military Bases. Accessed June 2026 from: https://militarybases.com/new-mexico/.

Multi-Resolution Land Characteristics Consortium (MRLC). 2026. 2026 NLCD Land Cover (CONUS). Accessed June 2026 from: https://www.mrlc.gov/.

National Park Service (NPS). 2017. Physiographic Provinces. Accessed June 2026 https://www.nps.gov/subjects/geology/physiographic-provinces.htm.

_____. 2026a. “Abó.” Salinas Pueblo Missions National Monument, Accessed June 2026, https://www.nps.gov/sapu/learn/historyculture/abo.htm.

_____. 2026b. New Mexico National Monuments. Accessed 2026 https://www.nps.gov/state/nm/index.htm.

_____. 2026c. National Monuments & Memorials. Accessed June 2026 from: https://www.nps.gov/subjects/monuments/index.htm.

_____. 2026d. NPMS Public Viewer. Accessed August 2026. https://pvnpms.phmsa.dot.gov/PublicViewer/Karst Landscapes - Caves and Karst (U.S. National Park Service). Accessed August 2026. https://www.nps.gov/subjects/caves/karst-landscapes.htm

Natural Atlas. 2026. Southwestern Tablelands Ecoregion. https://naturalatlas.com/ecoregions/southwestern-tablelands-2767690. Accessed 18 June 2026.

New Mexico Cultural Resources Information System (NMCRIS). Accessed June 2026. https://nmcris.nmhistoricpreservation.org/.

New Mexico Department of Game and Fish (NMDGF). 2026a. New Mexico Crucial Habitat Assessment Tool (NM CHAT). https://nmchat.org/. Accessed 22 June 2026.

_____. 2026b. New Mexico Environmental Review Tool (NMERT). 202b6. Natural Heritage New Mexico, and NatureServe. https://nmert.org/. Accessed June 2026.

New Mexico Department of Transportation (NMDOT). 2026a. NMDOT New Mexico Scenic Byways Map. Accessed June 2026 https://www.dot.nm.gov/travel-information/maps/.

_____. 2026b. Roads. Accessed June 2026 from: https://nmroads.com/default.html?v=2025012001&.

_____. 2026c. Interactive Transportation Maps. Accessed June 2026. https://www.dot.nm.gov/travel-information/maps/.

New Mexico Department of Transportation (NMDOT) Rail Bureau. 2019. New Mexico Railroad Map. Accessed June 2026 https://www.dot.nm.gov/planning-research-multimodal-and-safety/modal/transit-rail/rail-bureau/.

New Mexico Mining and Minerals Division (NM MMD). Mine Registrations and Permits Database. Mine Registrations and Permits - MMD Mine and Permits Searches. Accessed June 2026.

New Mexico Municipal League. 1998. New Mexico Incorporated Municipalities. Accessed June 2026 from: https://nmml.org/DocumentCenter/View/1297/New-Mexico-Incorporated-Municipalities-Alpha-List-PDF.

New Mexico Oil Conservation Division (NM OCD). Oil and Gas Map Viewer. NM OCD OIL AND GAS MAP.

New Mexico Rare Plant Technical Council (NMRPTC). 1999. New Mexico Rare Plants. Albuquerque, NM: New Mexico Rare Plants Home Page. https://nmrareplants.unm.edu. Accessed 22 June 2026.

New Mexico Taxation & Revenue Department (NMTRD). 2025. Fiscal Year RP-80 Reports: Gross Receipts by Geographic Area and NAICS Code. Accessed June 2026 from: https://www.tax.newmexico.gov/all-nm-taxes/gross-receipts-taxes-overview/fiscal-year-rp-80-reports-gross-receipts-by-geographic-area-and-naics-code/.

New Mexico Energy, Minerals, and Natural Resources Department (NMEMNRD). 2022. New Mexico State Parks. Accessed June 2026 from: https://www.emnrd.nm.gov/spd/.

_____. 2026. New Mexico Mining and Minerals Division. Mine Registrations and Permits Accessed June 2026 from: https://wwwapps.emnrd.nm.gov/MMD/MMDWebInfo/.

New Mexico State Land Office (NMSLO). 2025. Land Status. Accessed June 2026 from: https://mapservice.nmstatelands.org/LandStatus/.

Newpapers.com. 2026. “The Socorro Chieftain Archive.” https://www.newspapers.com/paper/the-socorro-chieftain/13785/. Accessed June 2026.

Nuclear Regulatory Commission (NRC). 2020. Uranium Mill Tailings. Accessed June 2026. https://www.nrc.gov/waste/mill-tailings.

Office of State Engineer. 2026a. Interstate Stream Commission. Acequias. Accessed August 2026 from: Ose.nm.gov/Acequias/isc_acequias.php.

Office of State Engineer. 2026b. Acequias map. Accessed August 2026 from: https://gis.ose.nm.gov/ose_pod_locations/?page=Acequias.

_____. 2026b. Acequias map. Accessed August 2026 from: https://gis.ose.nm.gov/ose_pod_locations/?page=Acequias.[Paleobiology Database. 2026. https://paleodb.org. Search Terms – State New Mexico / County: Socorro, Torrance, and Valencia. Accessed June 2026.

Playa Lakes Joint Venture (PLJV). 2026. Playas. Accessed June 2026 from: https://pljv.org/playas/.

RJH Consultants, Inc., and Tetra Tech, Inc. 2025. *2024 Southwestern Willow Flycatcher Survey Results – Belen Reach, Middle Rio Grande, New Mexico.* Prepared for Bureau of Reclamation, Albuquerque Area Office, New Mexico. Available at: https://webapps.usgs.gov/mrgescp/documents/2024-Belen-Reach-SWFL_Report_Final_TetraTech.pdf. Accessed June 2026.

Bureau of Reclamation. 2024. *Middle Rio Grande Yellow-billed Cuckoo Study Results – 2023: Isleta Pueblo to Elephant Butte Reservoir, New Mexico, Upper Colorado Basin Region.* U.S. Department of the Interior, Bureau of Reclamation, Technical Report No. ENV-2024-020. Rebecca Siegle, Stanton Moore, and Ethan Reibsome. August 2024. https://webapps.usgs.gov/mrgescp/documents/2023-Middle-Rio-Grande-Yellow-billed-Cuckoo-Study-Results.pdf.

Society of Vertebrate Paleontology (SVP). 2021. Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources. Impact Mitigation Guidelines Revision Committee.

_____. 2026. Best Practice Guidelines for Mitigation of Adverse Impacts on Paleontological Resources.

Socorro County. 2006. *2006 Socorro County Comprehensive Plan.* Accessed June 2026 from: https://www.socorrocounty.net/administration/public-works#h.lbjye2lf6p5d.

_____. Socorro County InfoNet. 2021. Public Nuisance Ordinance of Socorro County. Accessed August 2026. https://www.socorrocounty.net/general-information/ordinances

_____. 2026. “Socorro County History.” Socorro County InfoNet, https://www.socorrocounty.net/general-information/history. Accessed June 2026.

Tedford, R.H., L.B. Albright III, A.D. Barnosky, I. Ferrusquia-Villafranca, R.M. Hunt Jr., J.E. Storer, C.C. Swisher III, M.R. Voorhies, S.D. Webb, and D.P. Whistler. 2004. *Mammalian Biochronology of the Arikareean Through Hemphillian Interval in Late Cretaceous and Cenozoic Mammals of North America – Biostratigraphy and Geochronology.* MO Woodburne, editor. Columbia University Press, New York.

Toll Free Airline. 2025. New Mexico Public and Private Airports by County. Accessed June 2026, https://www.tollfreeairline.com/newmexico.htm.

Torrance County. 2026a. “Torrance County, New Mexico.” American History and Genealogy Project, https://ahgp.org/nm/cty/torrance_county_new_mexico.html. Accessed June 2026.

_____. 2026b. “Torrance County History.” Genealogy Trails, https://genealogytrails.com/newmex/torrance/history.html. Accessed June 2026.

_____. 2026c. “Torrance County.” New Mexico Counties, https://www.nmcounties.org/counties/torrance-county/. Accessed June 2026.

United States Army Corps of Engineers (USACE). 2026. Formerly Utilized Sites Remedial Action Program. Accessed June 2026. https://www.usace.army.mil/Missions/Environmental/FUSRAP/.

United States Census Bureau (UCSB). 2020a. *Decennial Census Data Tables*. Accessed June 2026. https://data.census.gov/table/DECENNIALPL2010.P1.

_____ 2020b. GEO Geographic Information. Accessed June 2026 from: https://data.census.gov/table?d=GEO+Geography+Information.

_____. 2024. American Community Survey, 5-Year Estimates, 2020-2024. Accessed June 2026 from: https://data.census.gov/.

United States County History Books Directory. 2026. "Torrance County, New Mexico: A Genealogical Overview." https://uscountyhistorybooksdirectoryandlookup.com/states/nm/torrance-county-history/. Accessed June 2026.

United States Department of Agriculture, Forest Service. 2026. Olive-sided Flycatcher (*Contopus cooperi*). Rio Grande National Forest. https://www.fs.usda.gov/sites/nfs/files/legacy-media/riogrande/fp%20ass5%20Olive-sided%20Flycatcher.pdf. Accessed June 2026.

United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS). 2017a. 2017 Census of Agriculture County Profile – Socorro County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35053.pdf.

_____. 2017b. 2017 Census of Agriculture County Profile – Torrance County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35057.pdf.

_____. 2017c. 2017 Census of Agriculture County Profile – Valencia County, New Mexico. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/New_Mexico/cp35061.pdf.

_____. 2025. 2022 Census of Agriculture, New Mexico State and County Data. Accessed June 2026 from: https://data.nass.usda.gov/Publications/AgCensus/2022/Full_Report/Volume_1,_Chapter_1_State_Level/New_Mexico/nmv1.pdf.

United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). 2026. *Web Soil Survey*. Accessed June 2026 from: https://websoilsurvey.nrcs.usda.gov/.

United States Department of Commerce (U.S. Commerce). 2023. Bureau of Economic Analysis. Accessed June 2026 from: www.bea.gov.

United States Department of Energy (DOE). 2026. Long-Term Stewardship of Remediated FUSRAP Sites. Accessed June 2026. https://www.energy.gov/lm/long-term-stewardship-remediated-fusrap-sites.

United States Department of Transportation (USDOT). 2026. Federal Railroad Administration. Rail Network Development. Maps GIS. FRA Safety Maps. Accessed June 2026 from: https://fragis.fra.dot.gov/gisfrasafety/.

United States Environmental Protection Agency (USEPA). 2026a. *Nonattainment areas for criteria pollutants (Green Book)*. Accessed June 2026. https://www.epa.gov/green-book.

_____. 2026b. *Criteria Air Pollutants.* Accessed June 2026. https://www.epa.gov/criteria-air-pollutants.

_____. 2026c. Ecoregions of North America. Accessed June 2026 from: https://www.epa.gov/eco-research/ecoregions-north-america.

_____. 2026d. WATERS GeoViewer 2.0. Accessed June 2026 from: https://www.epa.gov/waterdata/waters-watershed-assessment-tracking-environmental-results-system.

_____. 2026e. What is the Average Level of Radon Found in Homes in the US? Accessed June 2026. https://www.epa.gov/radon/what-average-level-radon-found-homes-us.

_____. 2025f. EPA Map of Radon Zones. Accessed June 2026. https://www.epa.gov/radon/epa-maps-radon-zones-and-supporting-documents-state.

_____. 2026g. TRI Toolbox. Accessed June 2026 from: https://www.epa.gov/toxics-release-inventory-tri-program/tri-toolbox.

_____. 2026h. EnviroAtlas. Accessed July 2026. https://www.epa.gov/enviroatlas

United States Fish and Wildlife Service (USFWS). 2026a. National Wetlands Inventory (NWI) Data Mapper. Accessed June 2026 from: https://www.fws.gov/wetlands/data/mapper.html.

_____. 2026b. Southwestern Willow Flycatcher (*Empidonax traillii extimus*) species profile. Accessed 22 June 2026.

_____. 2026c. Yellow-billed Cuckoo (*Coccyzus americanus*), https://www.fws.gov/species/yellow-billed-cuckoo-coccyzus-americanus. Accessed 22 June 2026.

_____. 2026d. Information for Planning and Consultation (IPaC). https://ipac.ecosphere.fws.gov/. Accessed 22 June 2026.

_____. 2026e. Monarch butterfly (*Danaus plexippus*), https://www.fws.gov/species/monarch-danaus-plexippus. Accessed June 2026.

United States Forest Service (USFS). 1995. Landscape Aesthetics, *A Handbook for Landscape Management.* https://www.fs.usda.gov/sites/default/files/ah-701-landscape-aesthetics-stelprdb5412126.pdf. Accessed June 2026.

_____. 2022. Cibola National Forest Land Management Plan. 2022. Accessed June 2026 https://www.fs.usda.gov/sites/nfs/files/legacy-media/cibola/20220712_CibolaLMP_Final-WEB.pdf.

_____. 2026. Olive-sided Flycatcher (*Contopus cooperi*). Rio Grande National Forest. https://www.fs.usda.gov/sites/nfs/files/legacy-media/riogrande/fp%20ass5%20Olive-sided%20Flycatcher.pdf. Accessed June 2026.

United States Geological Survey (USGS). 2026a. Mineral Resources Data System (MRDS). Accessed June 2026. https://mrdata.usgs.gov/mrds/map-graded.html.

_____. 2026b. U.S. Landslide Inventory and Susceptibility. https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=ae120962f459434b8c904b456c82669d.

_____. 2026c. Volcano Hazards Program. Accessed June 2026. https://www.usgs.gov/programs/VHP.

_____. 2026d. Quaternary Fault Viewer. Accessed June 2026. https://apps.usgs.gov/earthquakes/faults/qfault_index.html.

_____. 2026e. National Hydrography Dataset (NHD). Accessed June 2026 from: https://nhd.usgs.gov/tools.html.

_____. 2026f. Western Migrations. Accessed August 2026. https://apps.usgs.gov/western-migrations/

_____. 2026g. Gap Analysis Project (GAP). Accessed June 2026. https://www.usgs.gov/programs/gap-analysis-project.

Valencia County. 2022 Valencia County Comprehensive Plan. Accessed June 2026 from: https://www.co.valencia.nm.us/325/Comprehensive-Plan.

_____. 2026a. “Valencia County History.” Genealogy Trails, https://genealogytrails.com/newmex/valencia/county_history.html. Accessed June 2026.

_____. 2026b. “Valencia County, New Mexico.” American History and Genealogy Project, https://ahgp.org/nm/cty/valencia_county_new_mexico.html. Accessed June 2026.

Waters, Margaret. 2026. “Thamnophis proximus (Western Ribbon Snake).” Animal Diversity Web, University of Michigan Museum of Zoology. https://animaldiversity.org/accounts/Thamnophis_proximus/. Accessed 22 June 2026.

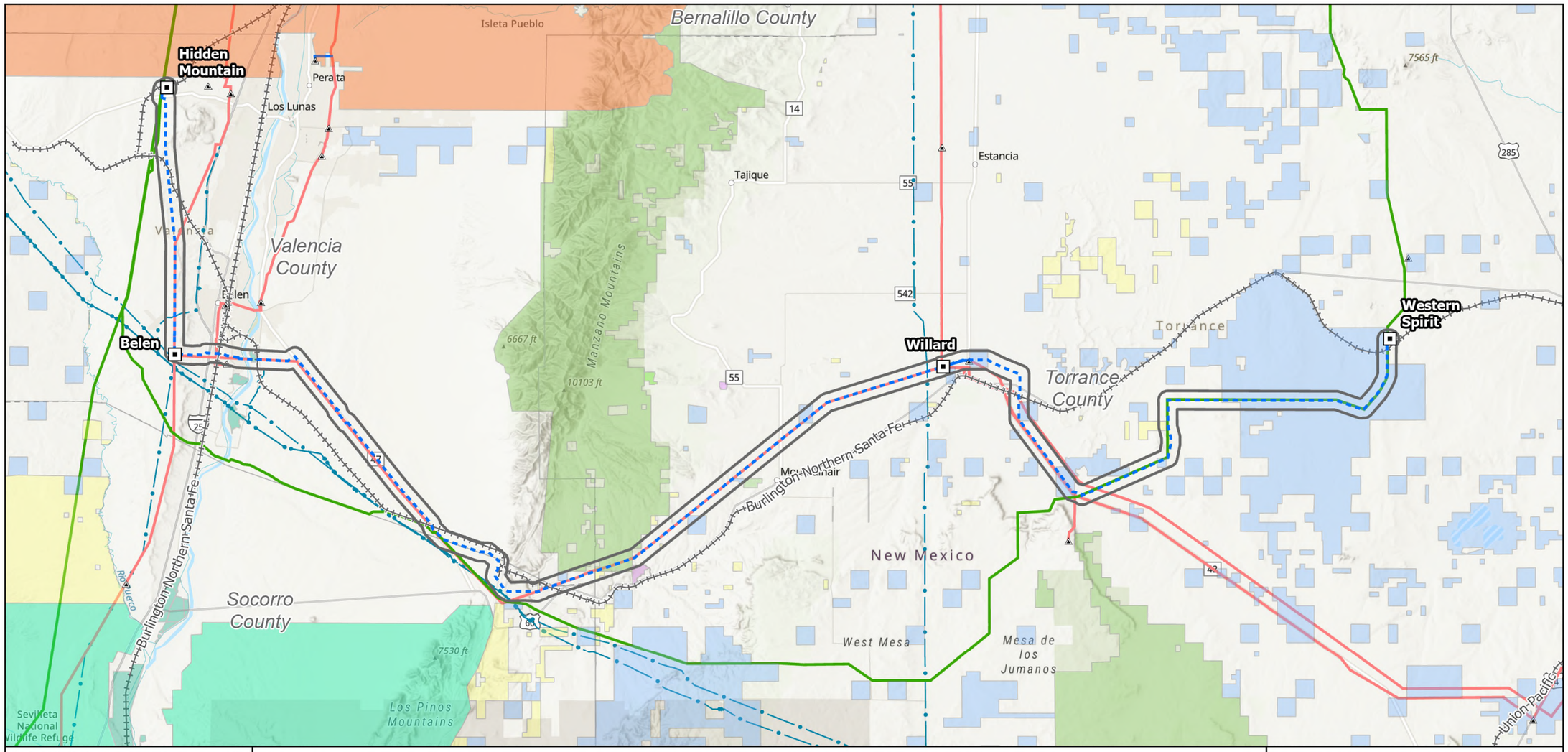
Western Regional Climate Center. 2026. Climate of New Mexico. Accessed June 2026 from: https://wrcc.dri.edu/Climate/narrative_nm.php.

Wickersham, Lynn E., Kristine Johnson, Giancarlo Sadoti, Teri Neville, and John Wickersham. 2020. “Habitat Use at Multiple Scales by Nesting Gray Vireos in New Mexico.” *Piñon-Juniper Habitats: Status and Management for Wildlife*, edited by Karl Malcolm et al., U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, pp. 31–33, https://www.fs.usda.gov/rm/pubs_series/rmrs/proc/rmrs_p077/rmrs_p077_031_033.pdf.

Zwank, Phillip J., Billy L. Tarrant, Raul Valdez and Dennis L. Clason. 1996. “Wintering Bald Eagle Populations and Behavior in the Middle Rio Grande Basin, New Mexico.” *The Southwestern Naturalist*, vol. 41, no. 2, June 1996, pp. 149–54. JSTOR, http://www.jstor.org/stable/30055099. Accessed 22 June 2026.

Appendix A - Exhibits

Exhibit 1 Project Overview Map
Exhibit 2 Geologic Resources Map
Exhibit 3 Oil & Gas Resources Map
Exhibit 4 Mineral Resources Map
Exhibit 5 Soil Resources Map
Exhibit 6 Paleontological Resources Map
Exhibit 7 Paleontological Fossil Yield Classification Map
Exhibit 8 Ecoregions Map
Exhibit 9 Surface Waters Map
Exhibit 10 Flood Zone Map
Exhibit 11 National Wetland Inventory Map
Exhibit 12 Sensitive Habitat Map
Exhibit 13 GAP Analysis Map
Exhibit 14 Field Verified Habitat Map
Exhibit 15 Religious Sites and Cemeteries Map
Exhibit 16 Public Lands and Easements Map
Exhibit 17 Elevation Map
Exhibit 18 Visual Resources Map
Exhibit 19 Land Cover Map
Exhibit 20 State-Owned Lands Map
Exhibit 21 American Indian Areas Map
Exhibit 22 Communications Map
Exhibit 23 Public Land Survey System (PLSS) Map
Exhibit 24 Public Facilities Map
Exhibit 25 Visual Flight Rules Map





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

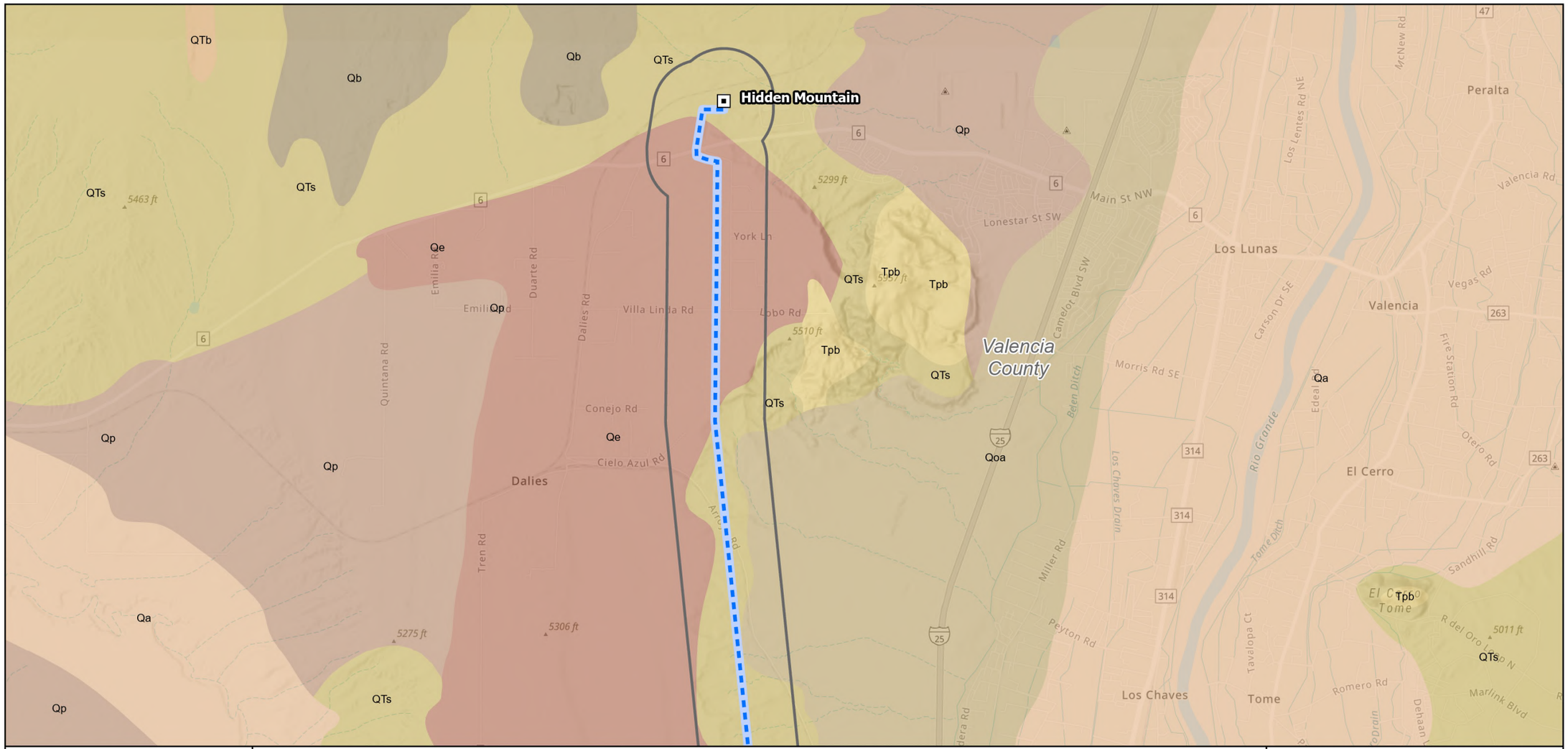
Surface Management
- Bureau of Land Management
- Forest Service
- Fish & Wildlife Service
- National Park Service
- Tribal Land
- State
- State Game & Fish
- State Park
- Private

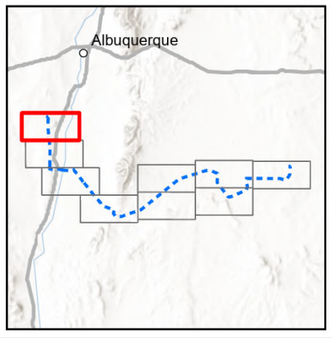
Reference Features
- Existing Substation
- 115kV Transmission Line
- 230kV Transmission Line
- 345kV Transmission Line
- Natural Gas Pipeline
- Railroad
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 1
Project Overview Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

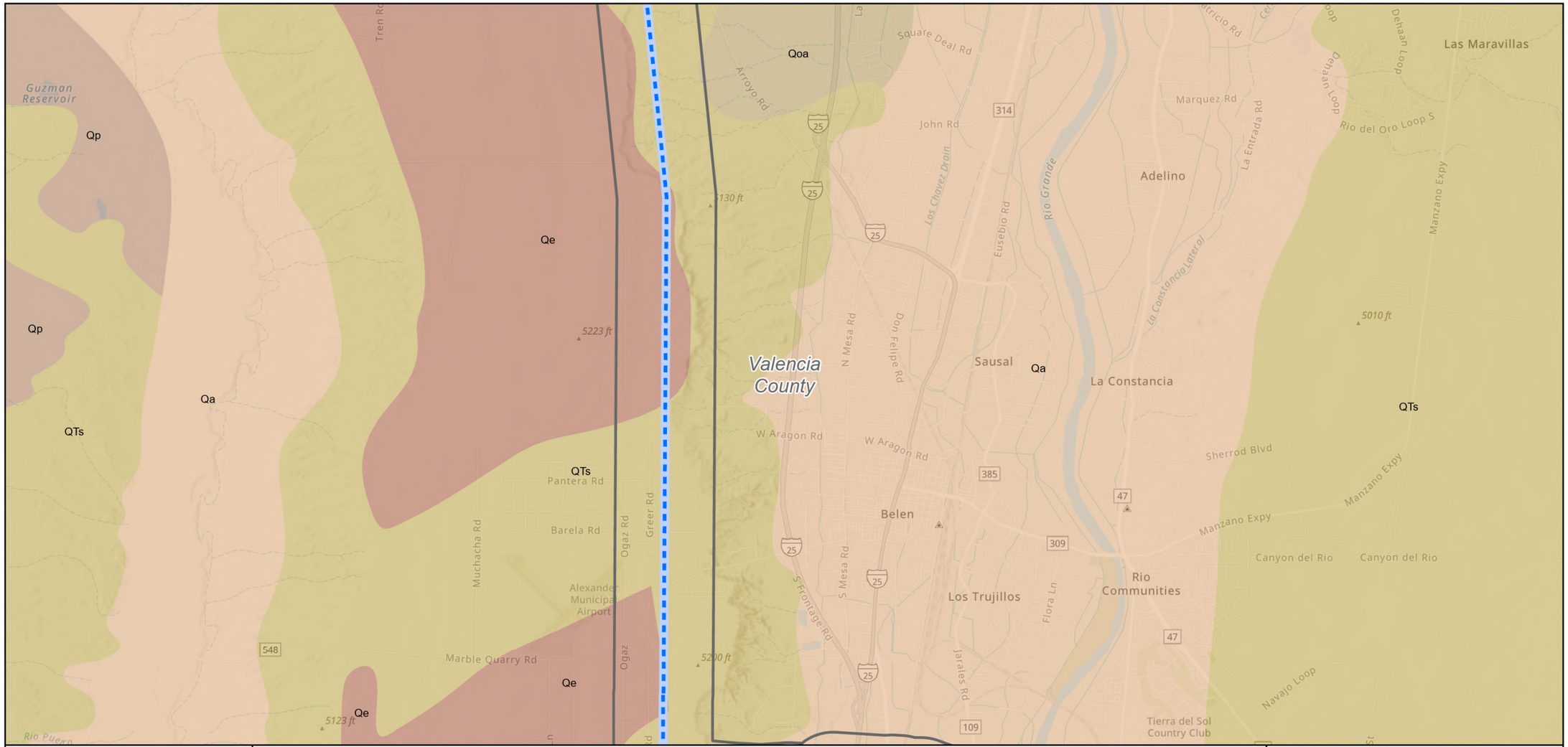
Geology Unit - Description
- Qa - Alluvium
- Qb - Basaltic to andesitic lava flows
- Qe - Eolian deposits
- Qoa - Older alluvial deposits of upland plains and piedmont areas
- Qp - Piedmont alluvial deposits
- QTb - Basaltic to andesitic lava flows
- QTs - Upper Santa Fe Group
- Tpb - Basaltic to andesitic lava flows

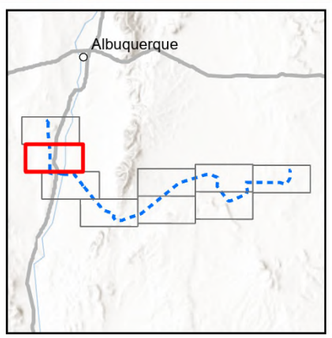
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 1 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

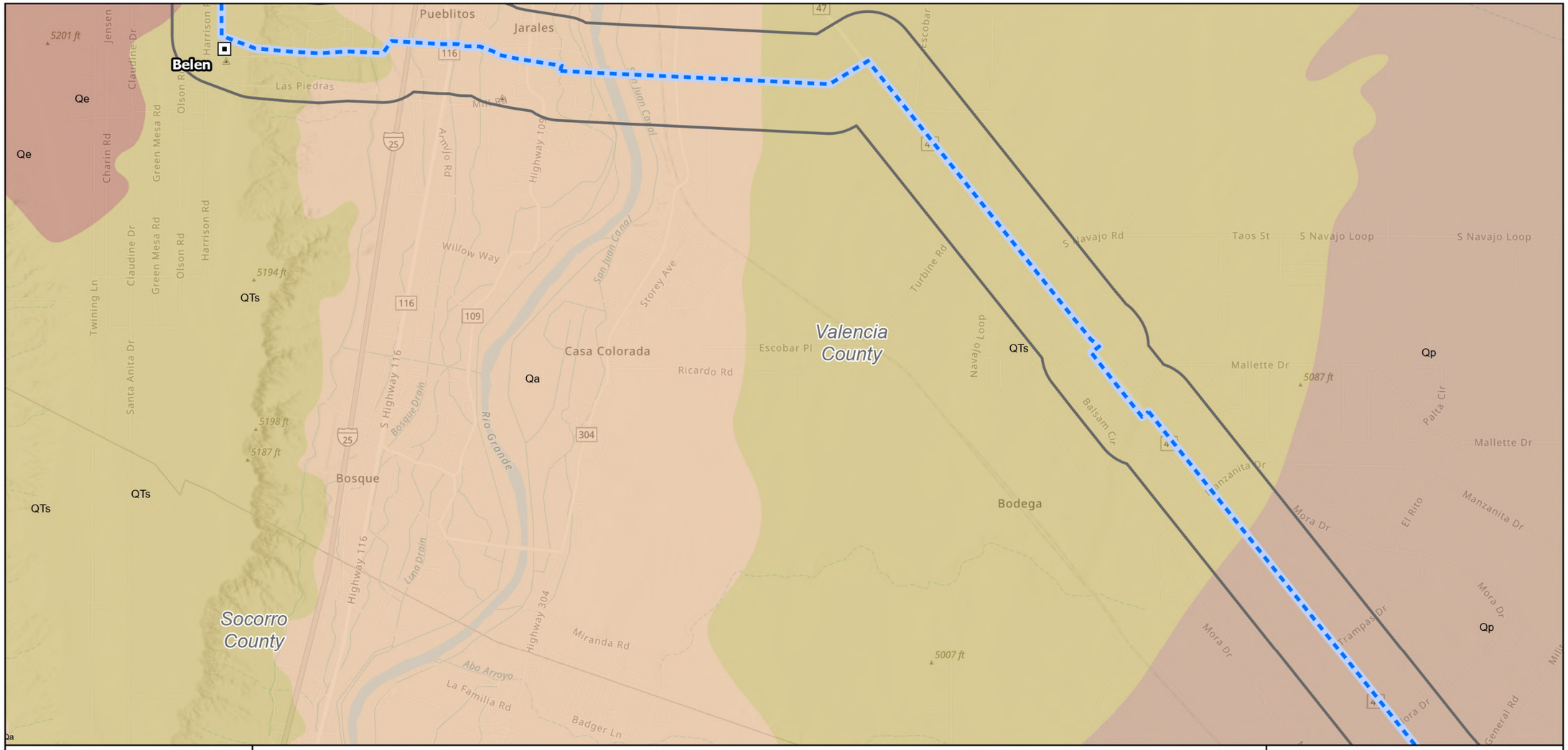
Geology Unit - Description
- Qa - Alluvium
- Qe - Eolian deposits
- Qoa - Older alluvial deposits of upland plains and piedmont areas
- Qp - Piedmont alluvial deposits
- QTs - Upper Santa Fe Group

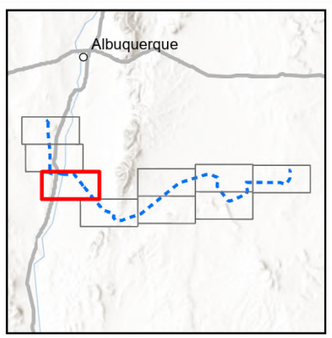
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 2 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

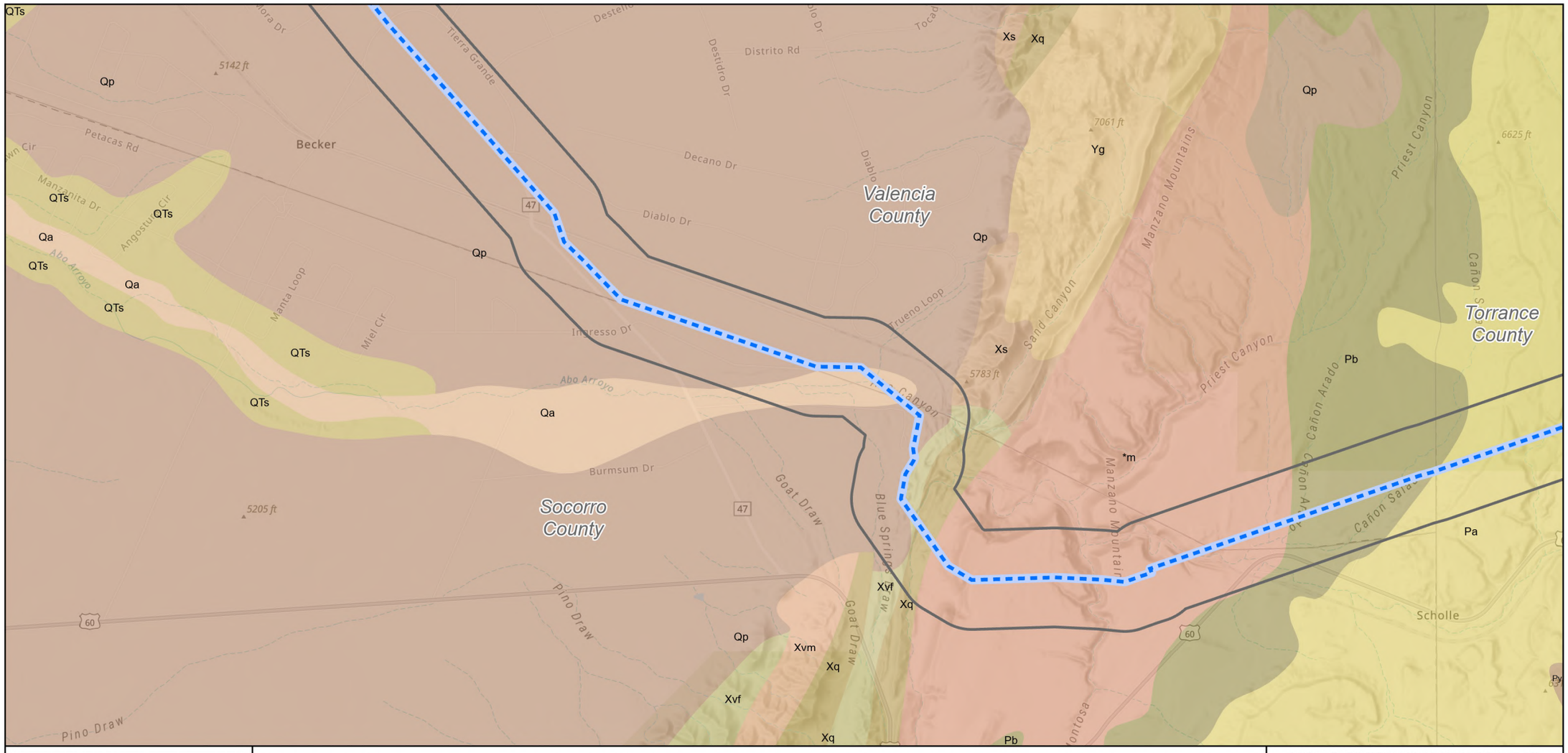
Geology Unit - Description
- Qa - Alluvium
- Qe - Eolian deposits
- Qp - Piedmont alluvial deposits
- QTs - Upper Santa Fe Group

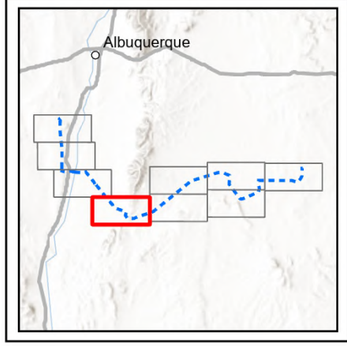
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 3 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

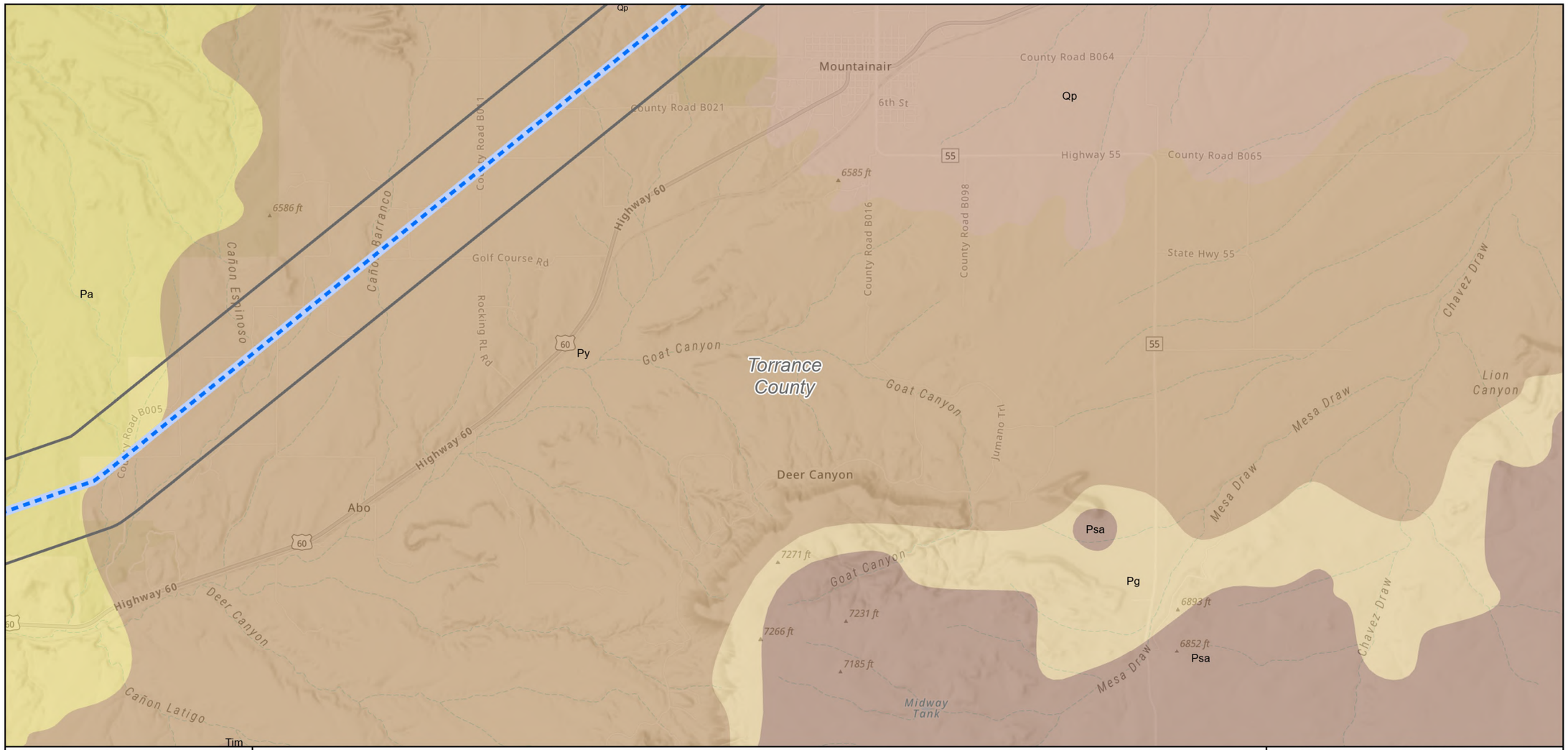
Geology Unit - Description
- IPm - Madera Formation
- Pa - Abo Formation
- Pb - Bursum Formation
- Py - Yeso Formation
- Qa - Alluvium
- Qp - Piedmont alluvial deposits
- QTs - Upper Santa Fe Group
- Xq - Paleoproterozoic quartzite
- Xs - Paleoproterozoic metasedimentary rocks
- Xvf - Paleoproterozoic rhyolite and felsic volcanic schist
- Xvm - Paleoproterozoic mafic metavolcanic rocks
- Yg - Mesoproterozoic granitic plutonic rocks

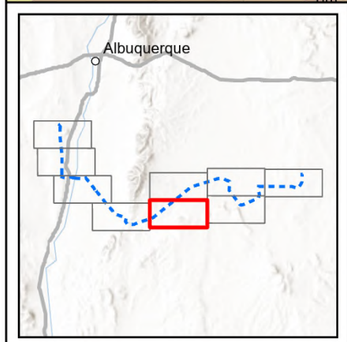
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 4 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

Geology Unit - Description
- Pa - Abo Formation
- Pg - Glorieta Sandstone
- Psa - San Andres Formation
- Py - Yeso Formation
- Qp - Piedmont alluvial deposits
- Tim - Tertiary mafic intrusive rocks

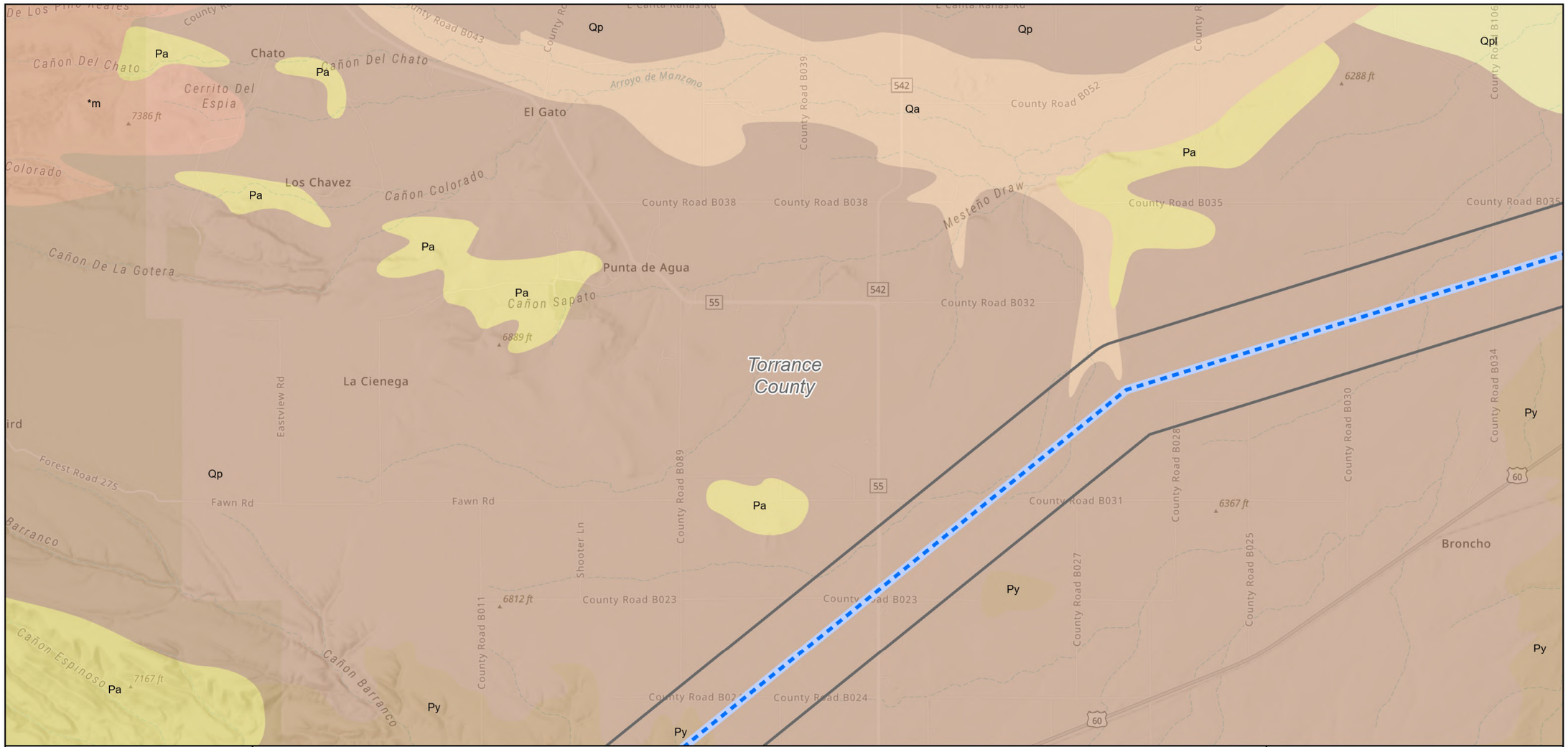
Reference Features
- County Boundary

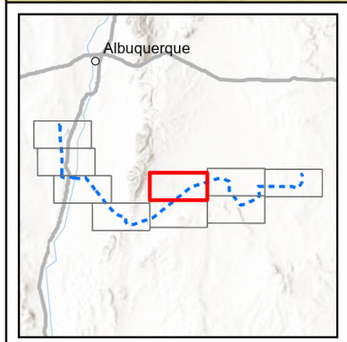
MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 5 of 9

0 1 2 Miles

wsp





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

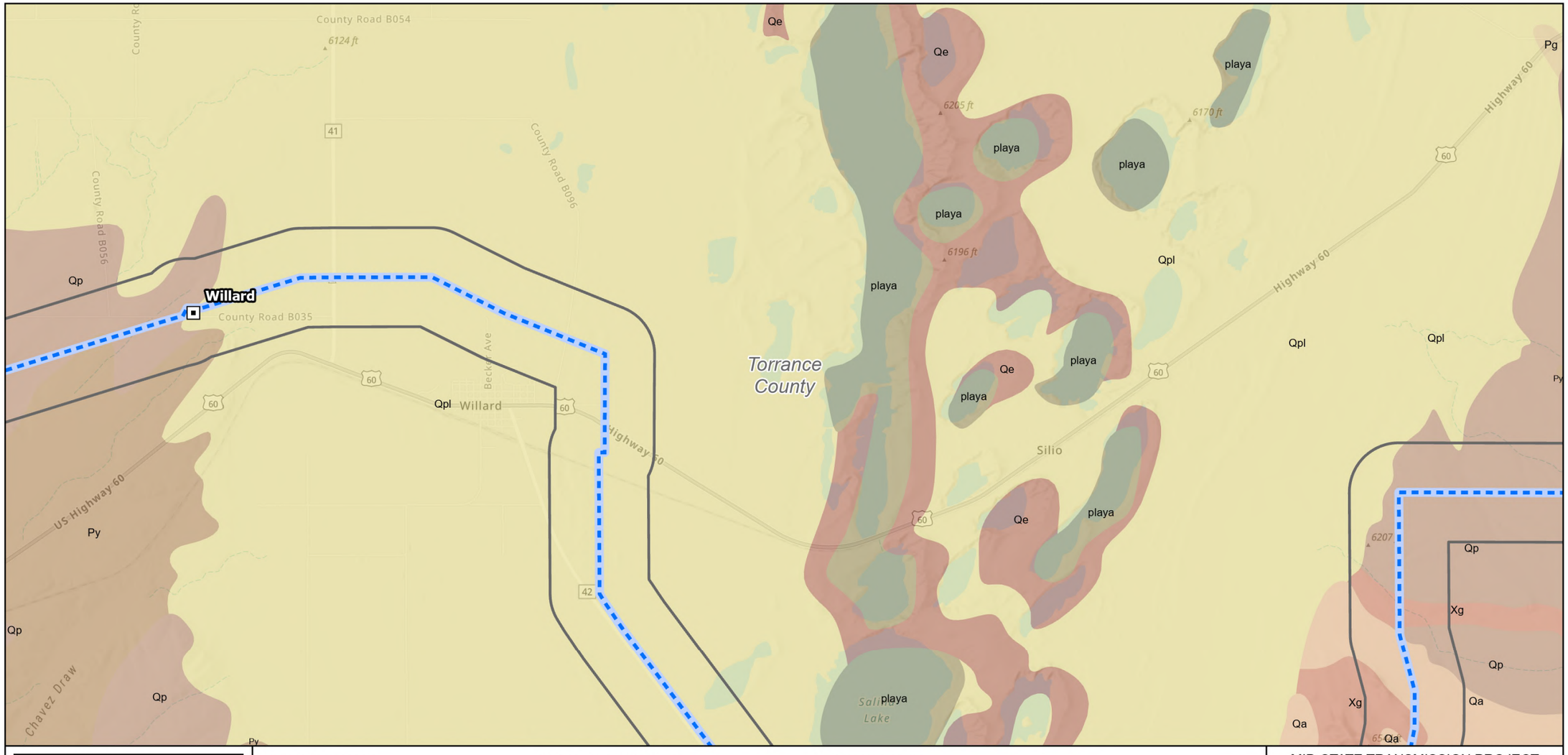
Geology Unit - Description
- IPm - Madera Formation
- Pa - Abo Formation
- Py - Yeso Formation
- Qa - Alluvium
- Qp - Piedmont alluvial deposits
- Qpl - Lacustrine and playa deposits

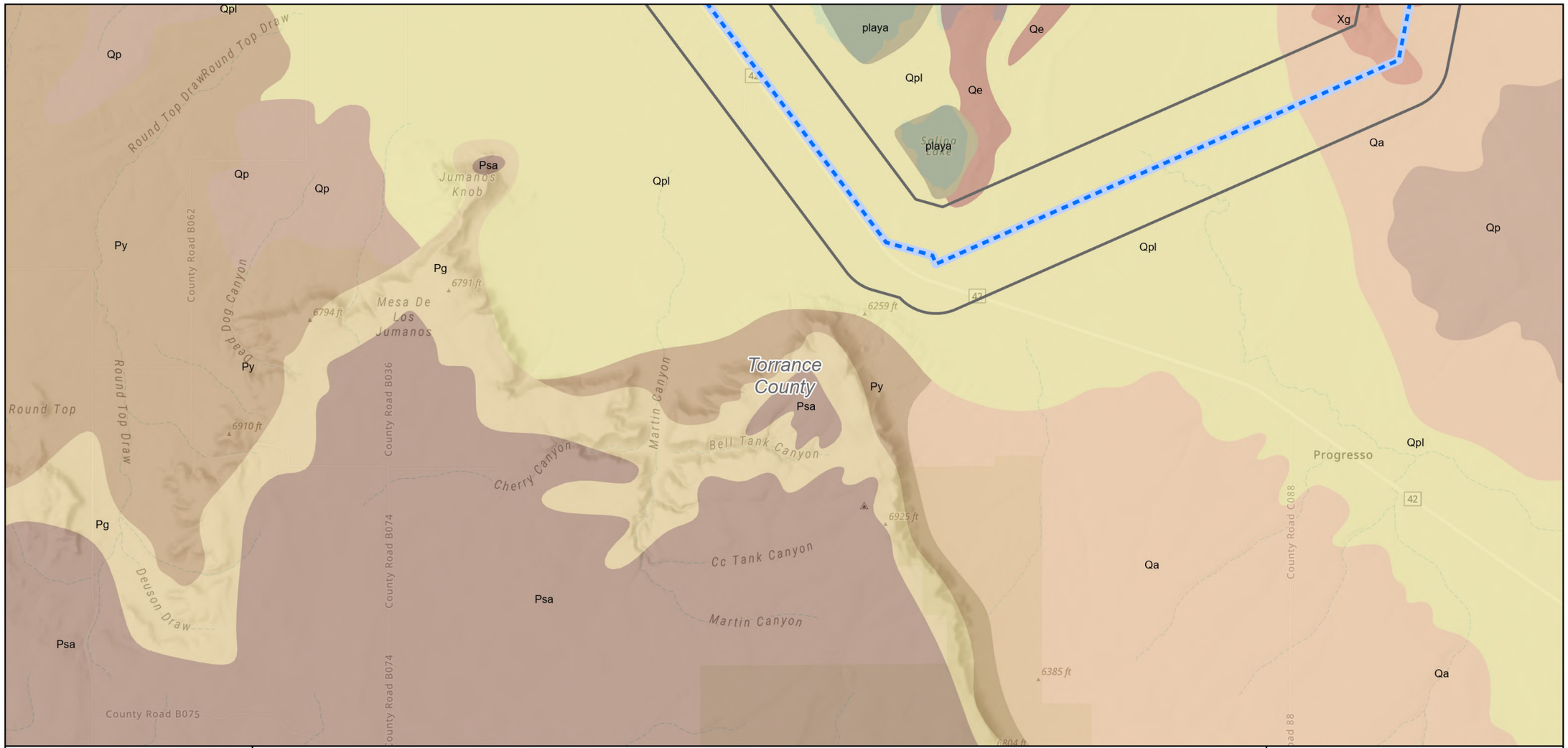
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 6 of 9

0 1 2 Miles


County Road B054
6124 ft
41
County Road B056
County Road B096
Qp
Willard
County Road B035
60
Becker Ave
Qpl
Willard
Highway 60
US Highway 60
Py
Qp
Chavez Draw
Qp
Py
Qe
Qe
6205 ft
playa
playa
playa
6196 ft
playa
Torrance County
Qe
playa
playa
6170 ft
Qpl
Highway 60
Qpl
Qpl
Silio
Qe
playa
42
playa
Salinas Lake
Pg
Highway 60
Py
6207
Qp
Xg
Qp
Xg
Qa
Qa
Qa
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Geology Unit - Description
Pg - Glorieta Sandstone
Playa
Py - Yeso Formation
Qa - Alluvium
Qe - Eolian deposits
Qp - Piedmont alluvial deposits
Qpl - Lacustrine and playa deposits
Xg - Paleoproterozoic granitic plutonic
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 2
Geologic Resources Map
Page 7 of 9
0
1
2
Miles
wsp



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

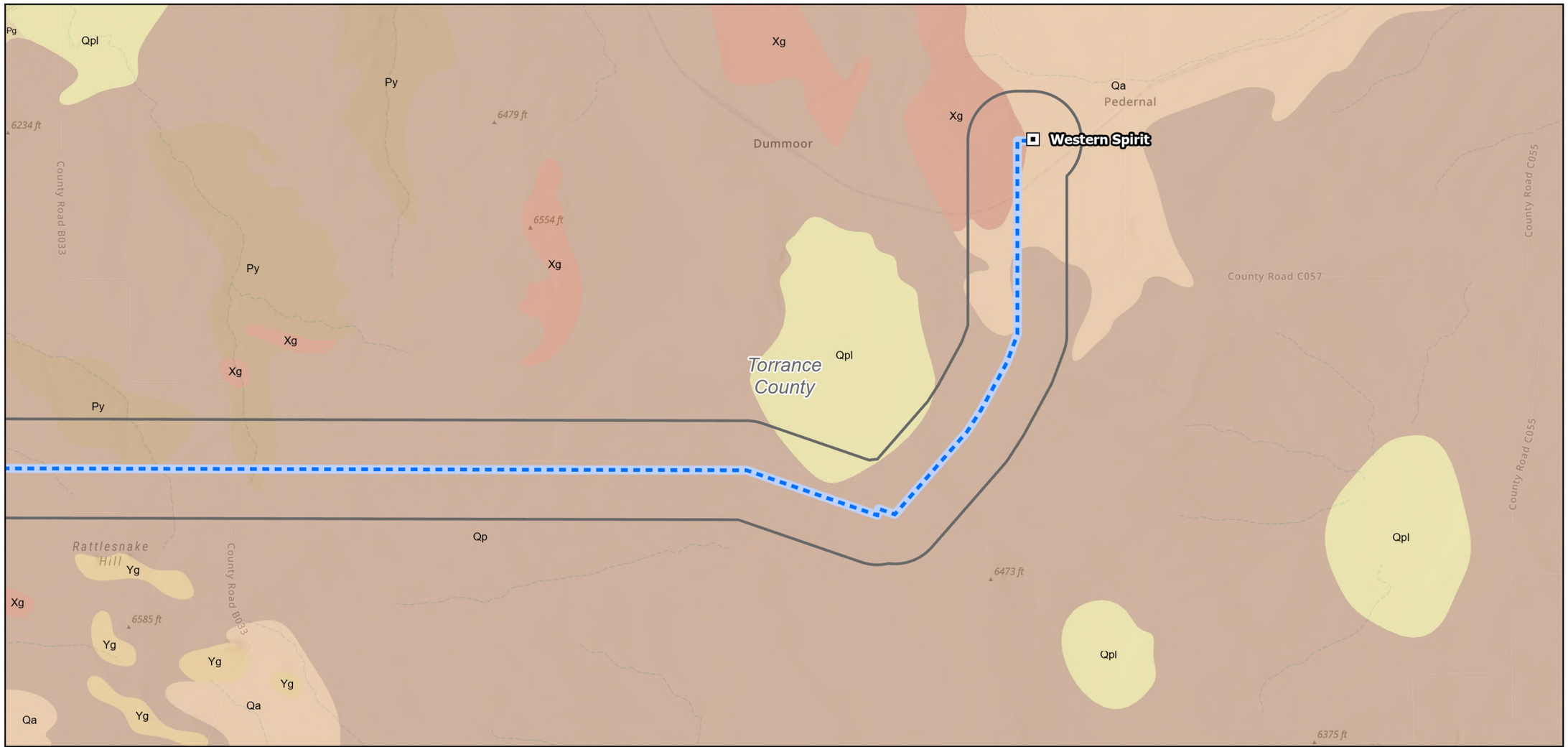
Geology Unit - Description
- Pg - Glorieta Sandstone
- Playa
- Psa - San Andres Formation
- Py - Yeso Formation
- Qa - Alluvium
- Qe - Eolian deposits
- Qp - Piedmont alluvial deposits
- Qpl - Lacustrine and playa deposits
- Xg - Paleoproterozoic granitic plutonic

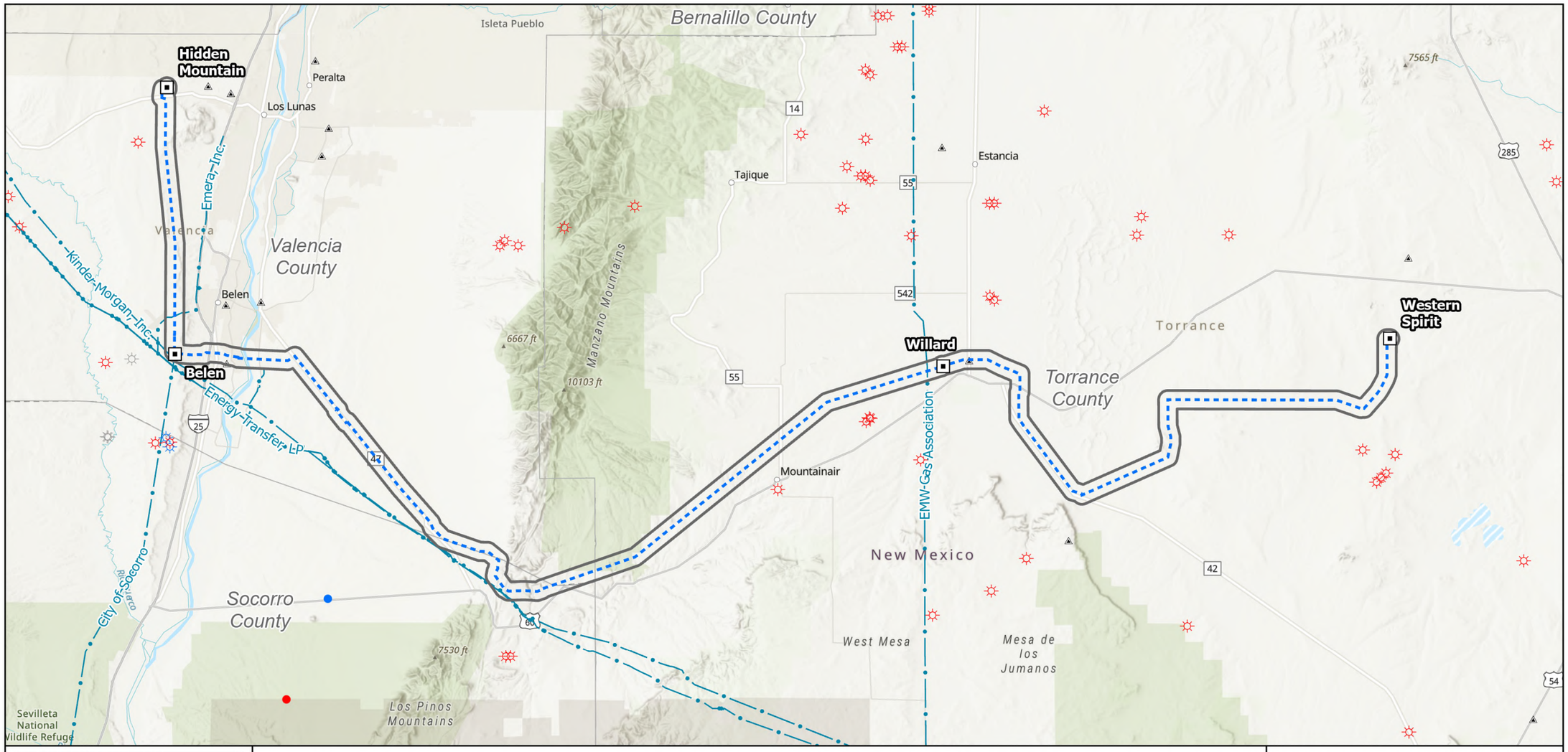
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 2
Geologic Resources Map
Page 8 of 9

0 1 2 Miles


Pg
Qpl
Py
Xg
Qa
Pedernal
6234 ft
6479 ft
Dummoor
Western Spirit
County Road B033
6554 ft
County Road C055
County Road C057
Torrance
County
Qp
Rattlesnake
Hill
Yg
6585 ft
6473 ft
6375 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Geology Unit - Description
Pg - Glorieta Sandstone
Py - Yeso Formation
Qa - Alluvium
Qp - Piedmont alluvial deposits
Qpl - Lacustrine and playa deposits
Xg - Paleoproterozoic granitic plutonic
Yg - Mesoproterozoic granitic plutonic rocks
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 2
Geologic Resources Map
Page 9 of 9
N
0
1
2
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

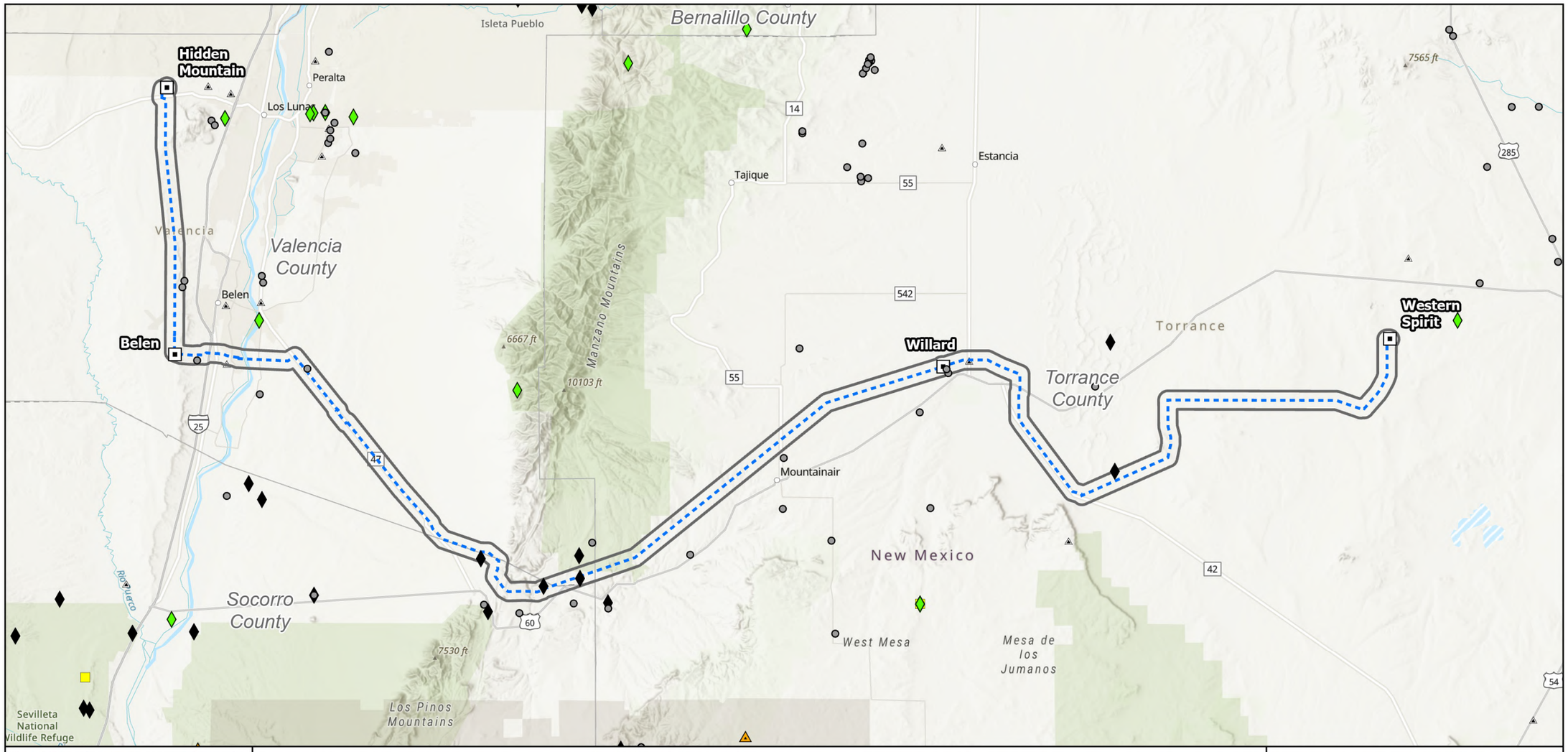
Oil and Gas Facilities
- Cancelled Gas Well
- New Gas Well
- New Oil Well
- Plugged Gas Well
- Plugged Oil Well
- Natural Gas Pipeline

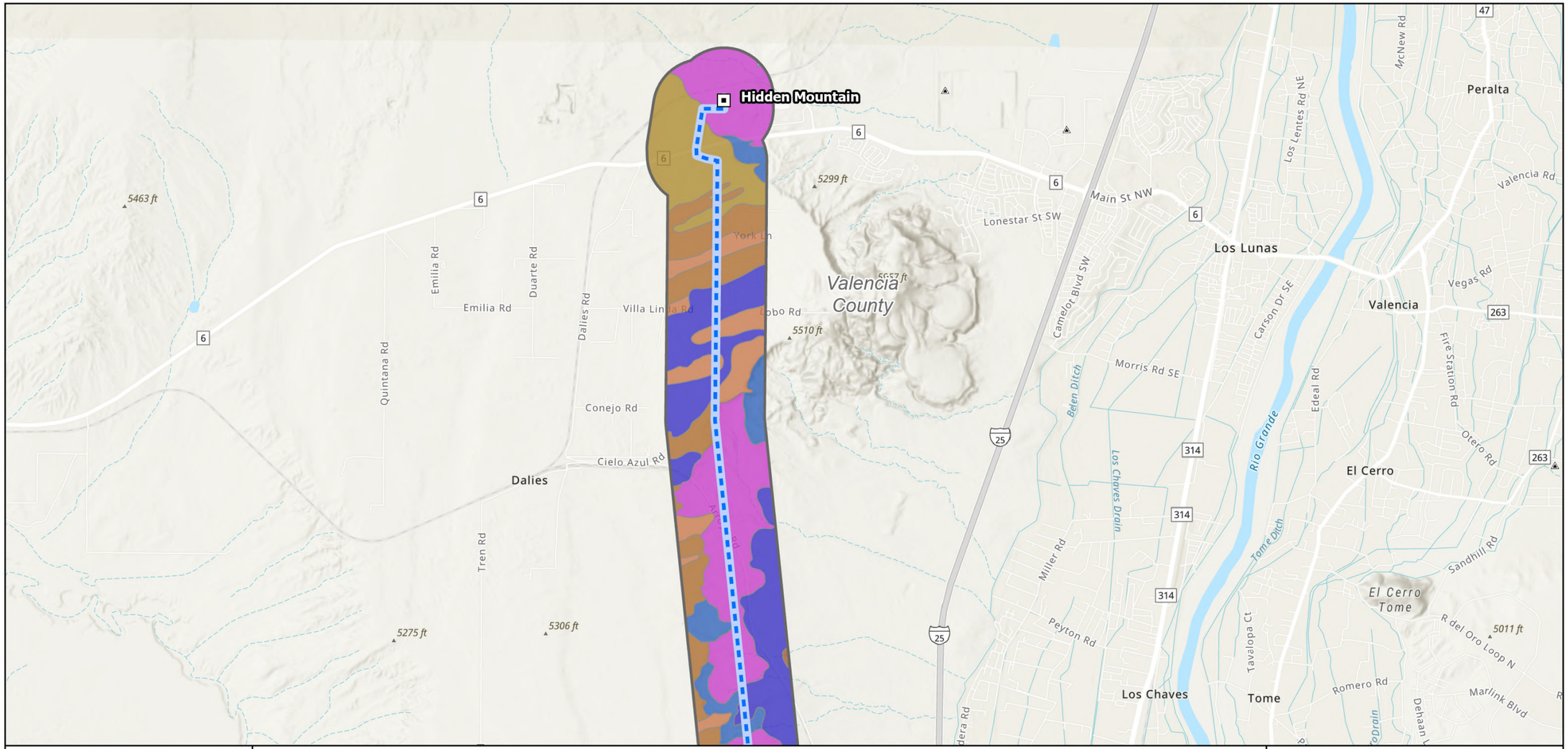
Reference Features
- Existing Substation
- County Boundary

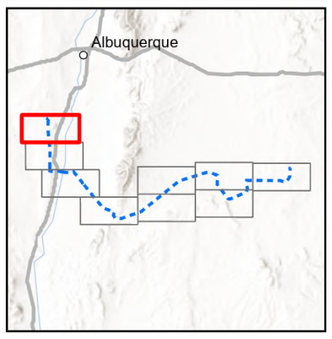
MID-STATE TRANSMISSION PROJECT

Exhibit 3
Oil and Gas Resources Map

0 5 10 Miles


Bernalillo County
Isleta Pueblo
Hidden Mountain
Peralta
Los Lunas
Valencia
Valencia County
Belen
Belen
Tajique
Estancia
7565 ft
285
14
55
542
Manzano Mountains
6667 ft
10103 ft
Willard
Torrance
Torrance County
Western Spirit
Mountainair
New Mexico
42
25
47
60
Socorro County
West Mesa
Mesa de los Jumanos
7530 ft
Los Pinos Mountains
54
Sevilleta National Wildlife Refuge
Project Area
NEW MEXICO
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Mineral Resource
Mineral Resource Occurrence
Past Producer
Producer
Prospect
Unknown
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 4
Mineral Resources Map
0
5
10
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

Mapunit Name
- Badland
- Bluepoint loamy fine sand, 1 to 9 percent slopes
- Bluepoint loamy fine sand, hummocky
- Bluepoint loamy sand, hilly
- Caliza-Bluepoint complex, 1 to 25 percent slopes
- Madurez-Bluepoint association, hummocky
- Madurez-Wink association, undulating
- Wink-Madurez association, gently sloping

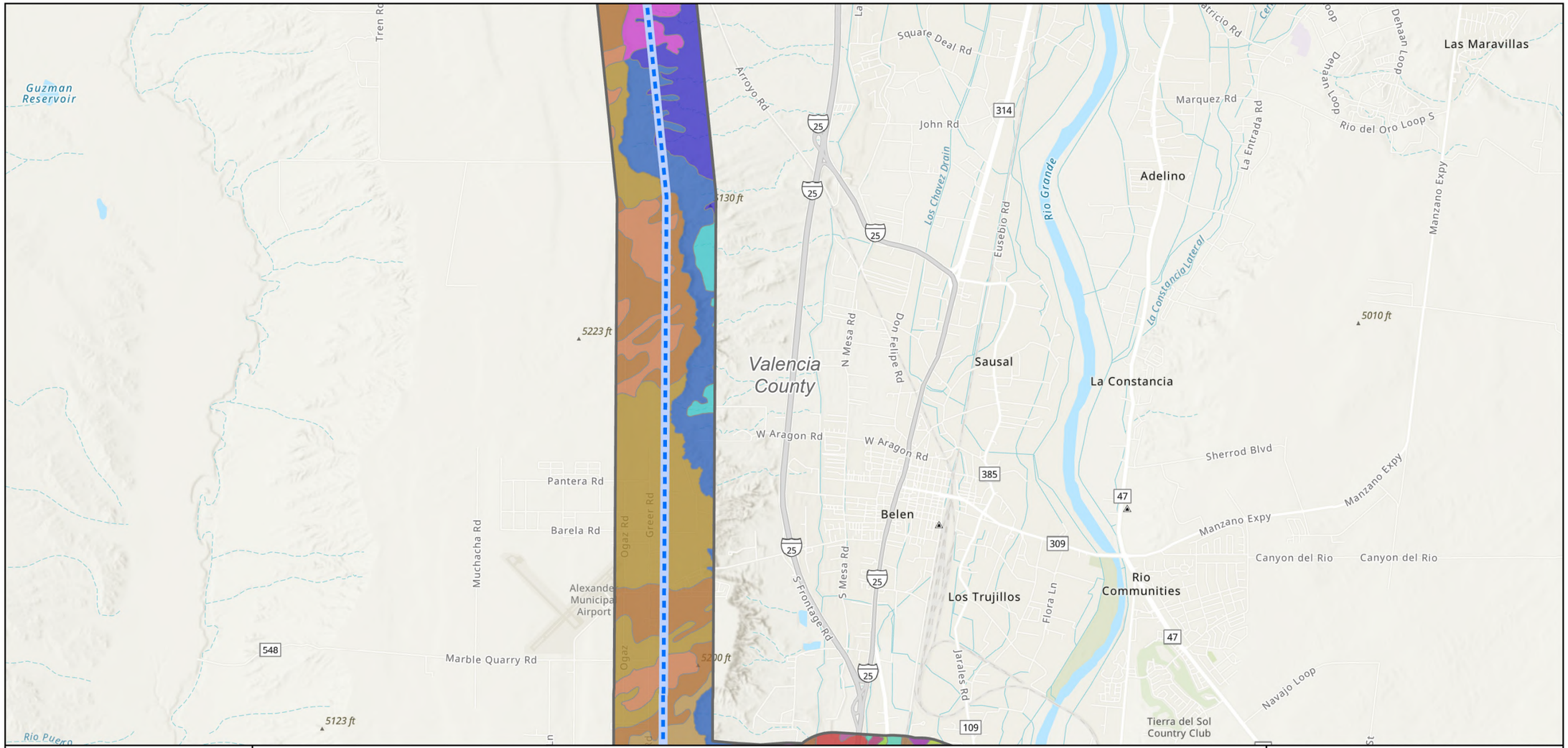
Reference Features
- Existing Substation
- County Boundary

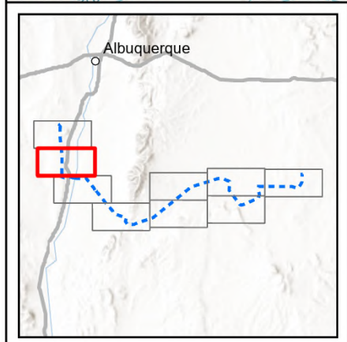
MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 1 of 9

0 1 2 Miles

wsp





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

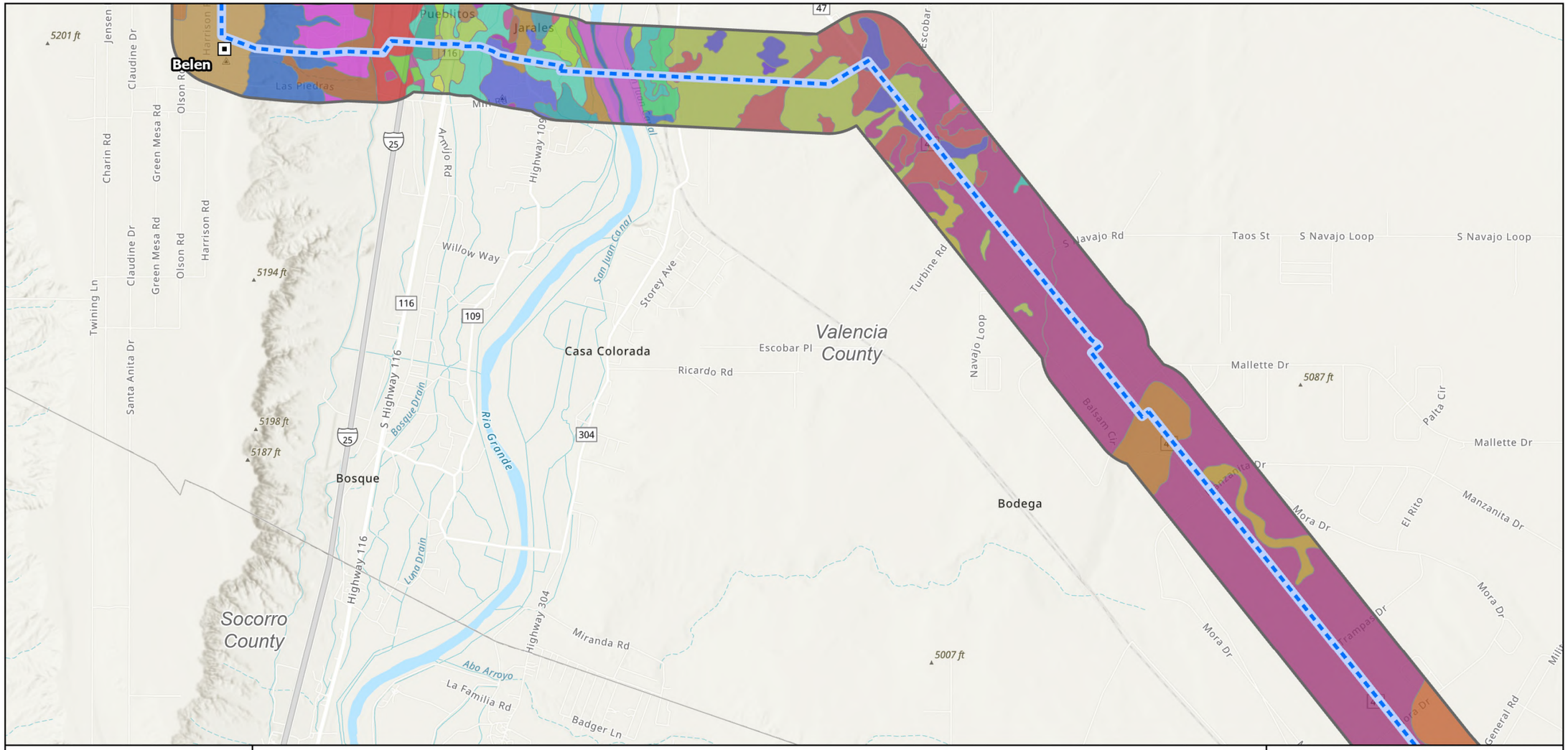
Mapunit Name
- Armijo clay
- Armijo loam, moderately alkali
- Badland
- Bluepoint loamy fine sand, 1 to 3 percent slopes
- Bluepoint loamy fine sand, 1 to 9 percent slopes
- Bluepoint loamy fine sand, hummocky
- Bluepoint loamy sand, hilly
- Caliza-Bluepoint complex, 1 to 25 percent slopes
- Gila clay loam
- Gila loam, 0 to 1 percent slopes mlra 42-1
- Gila loam, moderately alkali
- Madurez-Bluepoint association, hummocky
- Madurez-Wink association, undulating
- Vinton loam
- Vinton loam, loamy subsoil variant MLRA 42
- Vinton loamy fine sand, moderately alkali
- Wink fine sandy loam
- Wink-Madurez association, gently sloping

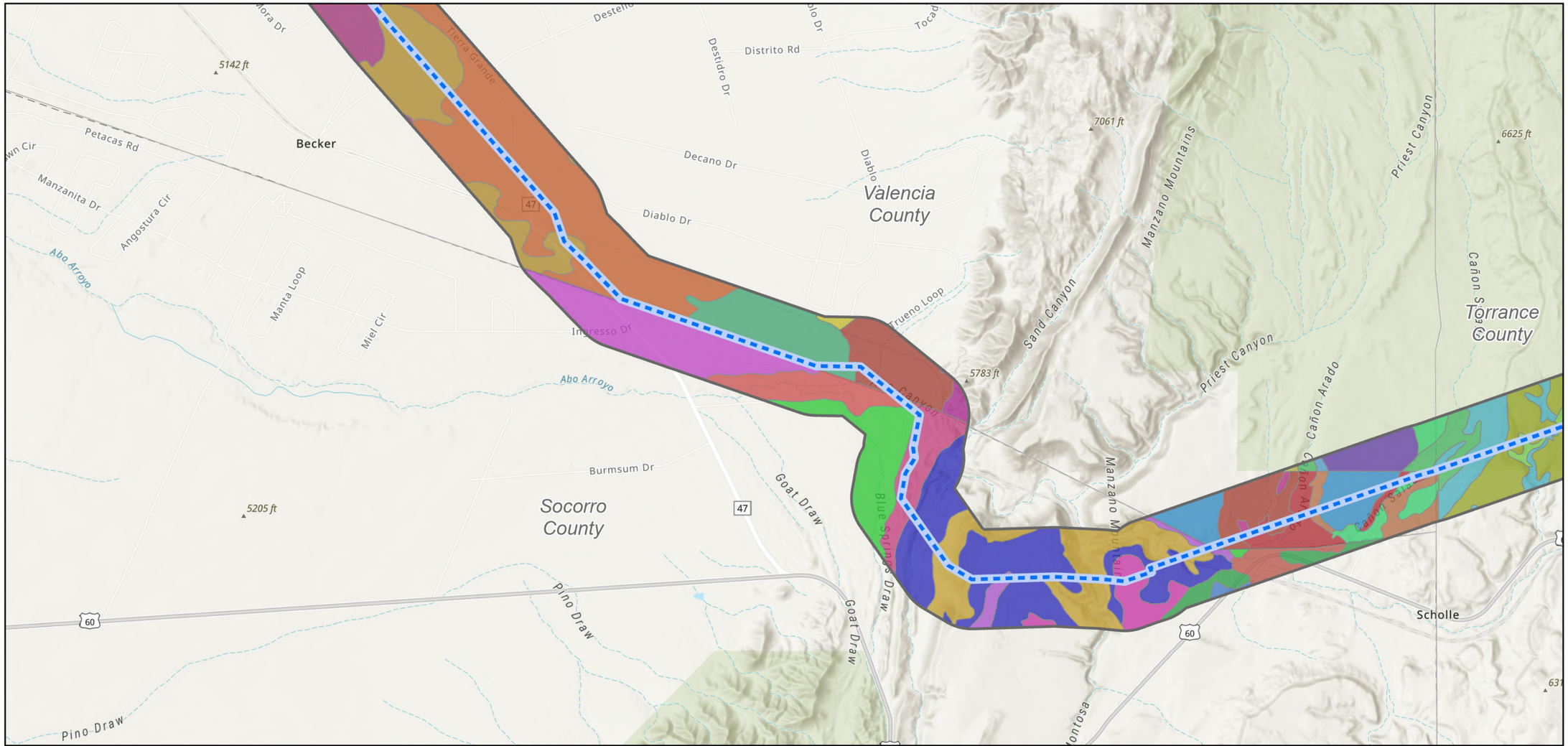
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 2 of 9

0 1 2 Miles


Belen
Pueblitos
Jarales
Las Piedras
Valencia County
Casa Colorada
Bosque
Socorro County
Bodega
Mallette Dr
Taos St
S Navajo Loop
Willow Way
Ricardo Rd
Escobar Pl
Miranda Rd
La Familia Rd
Badger Ln
Abo Arroyo
Mora Dr
Manzanita Dr
Turbine Rd
Navajo Loop
Storey Ave
Arroyo Rd
Highway 116
Highway 304
Highway 109
S Highway 116
Rio Grande
San Juan Canal
Luna Drain
Bosque Drain
Charin Rd
Claudine Dr
Green Mesa Rd
Olson Rd
Harrison Rd
Jensen
Twining Ln
Santa Anita Dr
Palta Cir
El Rito
General Rd
5201 ft
5194 ft
5198 ft
5187 ft
5087 ft
5007 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Mapunit Name
Agua loam, slightly saline
Armijo clay
Armijo loam, moderately alkali
Badland
Belen clay loam, moderately alkali
Belen loam
Bluepoint loamy fine sand, 1 to 3 percent slopes
Bluepoint loamy fine sand, 1 to 9 percent slopes
Bluepoint loamy sand, hilly
Bluepoint sandy clay loam, 1 to 3 percent slopes
Bluepoint-Wink complex, hummocky
Brazito loamy fine sand
Brazito sandy clay loam, thick surface
Gila clay loam
Gila clay loam, slightly saline
Gila loam, 0 to 1 percent slopes mlra 42-1
Gila loam, moderately alkali
Gila loam, slightly saline
Gila loam, strongly alkali
Gila loam, strongly saline and alkali
Gila loamy fine sand
Glendale clay loam, 0 to 1 percent slopes MLRA 42.1
Gravel and caliche pits
Latene loam
Madurez loamy fine sand
Madurez loamy sand, hummocky
Madurez-Wink association, undulating
Mixed alluvial land
Pajarito loamy fine sand
Riverwash
Vinton loam
Vinton loam, loamy subsoil variant MLRA 42
Vinton loam, slightly saline
Vinton loamy fine sand
Vinton loamy fine sand, moderately alkali
Wink complex, 1 to 9 percent slopes, eroded
Wink fine sandy loam
Wink loamy sand
Wink loamy sand, clayey substratum
Wink loamy sand, hummocky
Wink-Caliza complex, 1 to 15 percent slopes
Wink-Madurez association, gently sloping
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 5
Soil Resources Map
Page 3 of 9
0
1
2
Miles



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

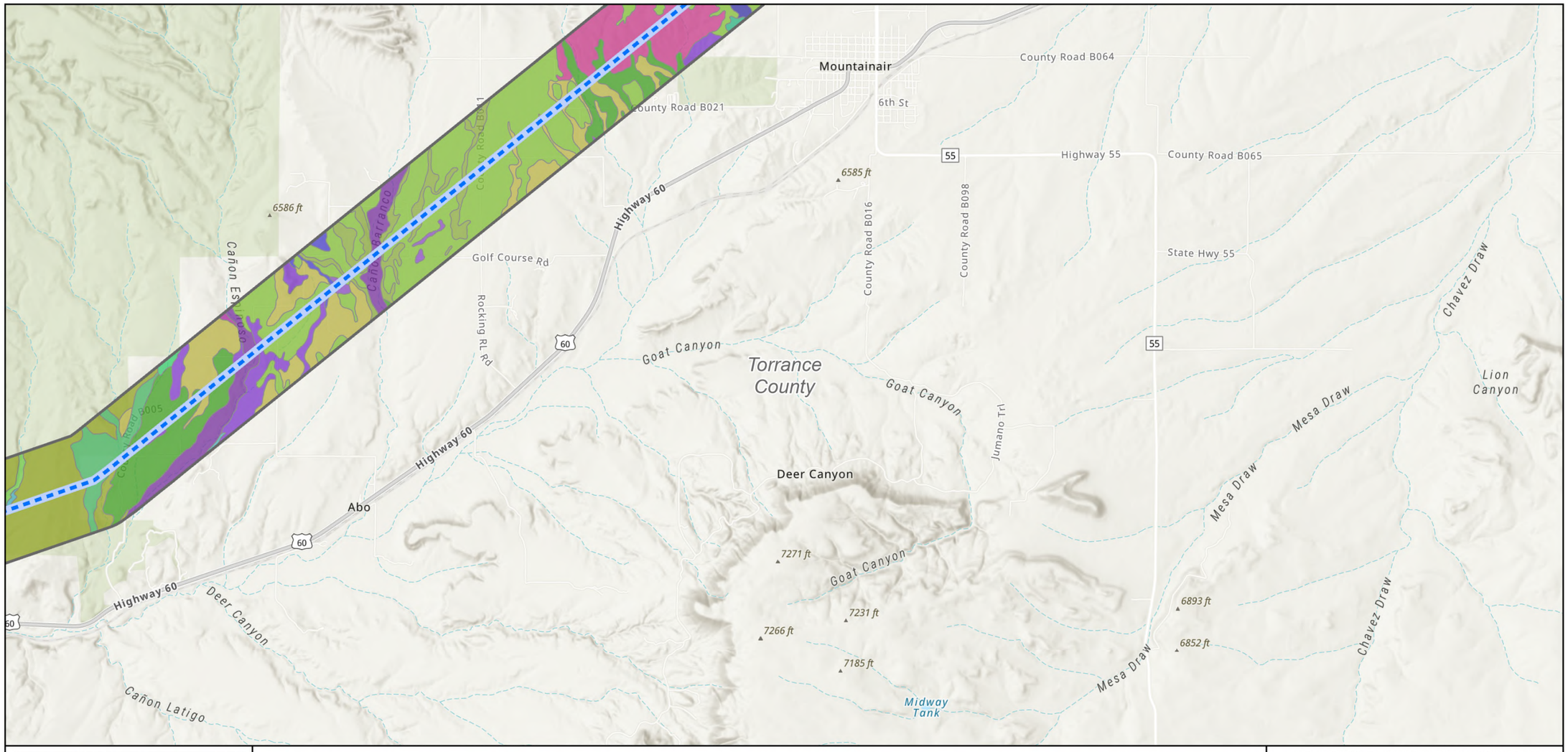
Mapunit Name
- Creel-Musofare-Clovis complex, 1 to 15 percent slopes
- Deama-Rock outcrop complex, 3 to 40 percent slopes
- Dean-Pinon association, gently sloping
- Encierro channery loam, 1 to 9 percent slopes
- Gravel and caliche pits
- Harvey-Dean association, 1 to 9 percent slopes
- Harvey-Ildecarb-Pinon complex, 2 to 10 percent slopes
- Harvey-La Fonda association, 1 to 9 percent slopes
- Hassell loam, 2 to 5 percent slopes
- La Fonda loam, gravelly substratum, 2 to 8 percent slopes
- Largo loam
- Largo loam, 0 to 3 percent slopes
- Latene loam
- Madurez loamy fine sand
- Millett-Tesajo associatin, sloping
- Moriarty clay loam, 2 to 6 percent slopes
- Ponciano very bouldery clay loam, 15 to 60 percent slopes
- Prewitt and Manzano soils
- Puertecito, moist-Rock outcrop complex, 15 to 60 percent slopes
- Rock land
- Rock outcrops and Slides
- Salas very stony loam, 30 to 70 percent slopes
- San Mateo-Glenberg complex, 0 to 2 percent slopes
- Scholle gravelly loam, 1 to 9 percent slopes
- Sedillo very gravelly loam, 3 to 9 percent slopes
- Sedillo-Clovis association, 1 to 6 percent slopes
- Steep rock land
- Tapia loam, 0 to 5 percent slopes
- Tres Hermanos-Madurez association, gently sloping
- Wink-Dona Ana loamy sands, 1 to 3 percent slopes
- Wink-Madurez association, gently sloping
- Winona-Rock outcrop complex, 5 to 45 percent slopes

Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 4 of 9

0 1 2 Miles



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

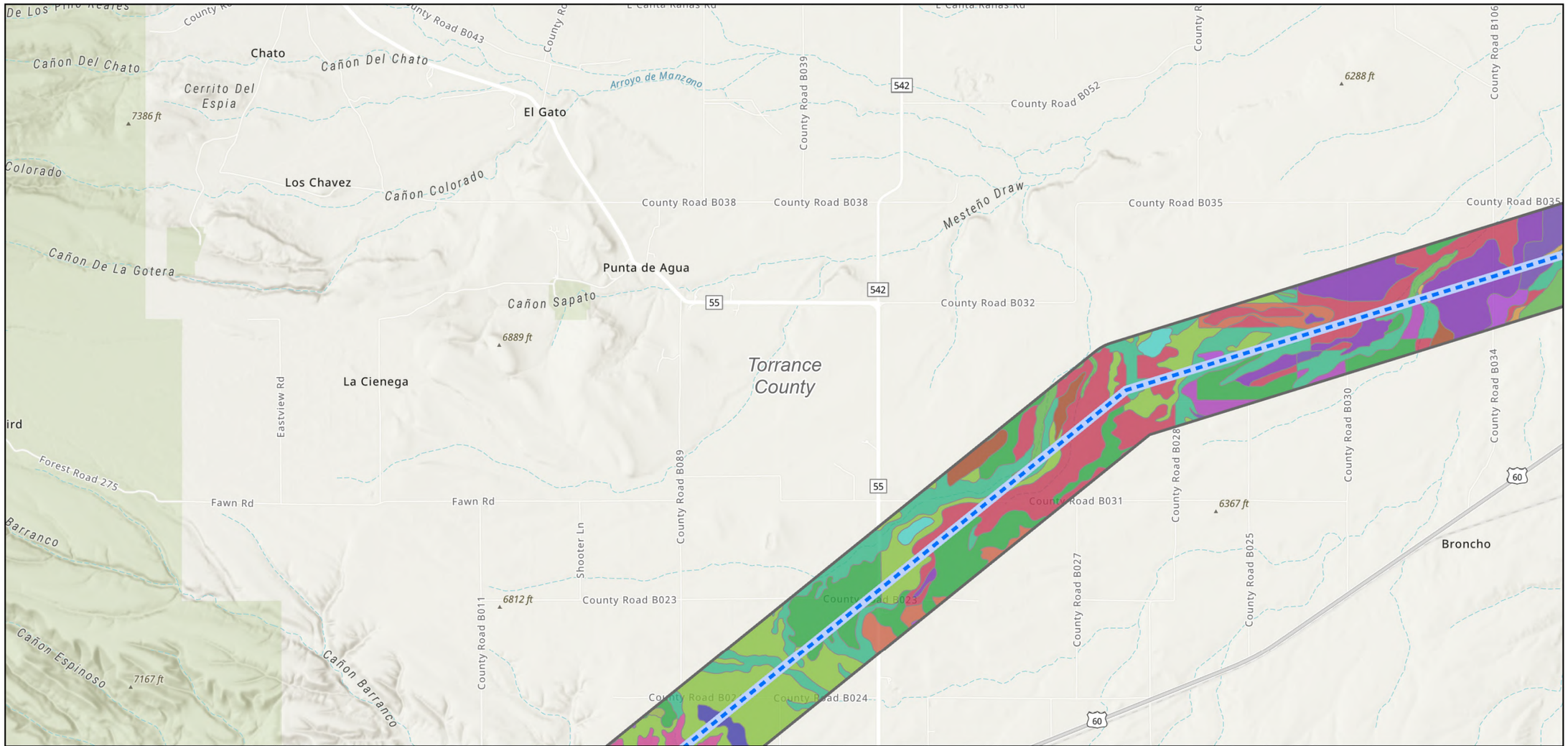
Mapunit Name
- Alicia loam, 1 to 6 percent slopes
- Chilton gravelly loam
- Clovis loam, 0 to 5 percent slopes
- Encierro channery loam, 1 to 9 percent slopes
- Harvey loam, 1 to 9 percent slopes
- Hassell loam, 2 to 5 percent slopes
- La Fonda loam, 1 to 9 percent slopes
- La Fonda loam, gravelly substratum, 2 to 8 percent slopes
- Laporte-Rock outcrop complex
- Moriarty clay loam, 2 to 6 percent slopes
- Pinon channery loam, 3 to 20 percent slopes
- Scholle gravelly loam, 1 to 9 percent slopes
- Steep rock land
- Stony steep land
- Washoe cobbly loam, 9 to 25 percent slopes
- Washoe gravelly loam, 1 to 9 percent slopes
- Witt loam, 1 to 6 percent slopes

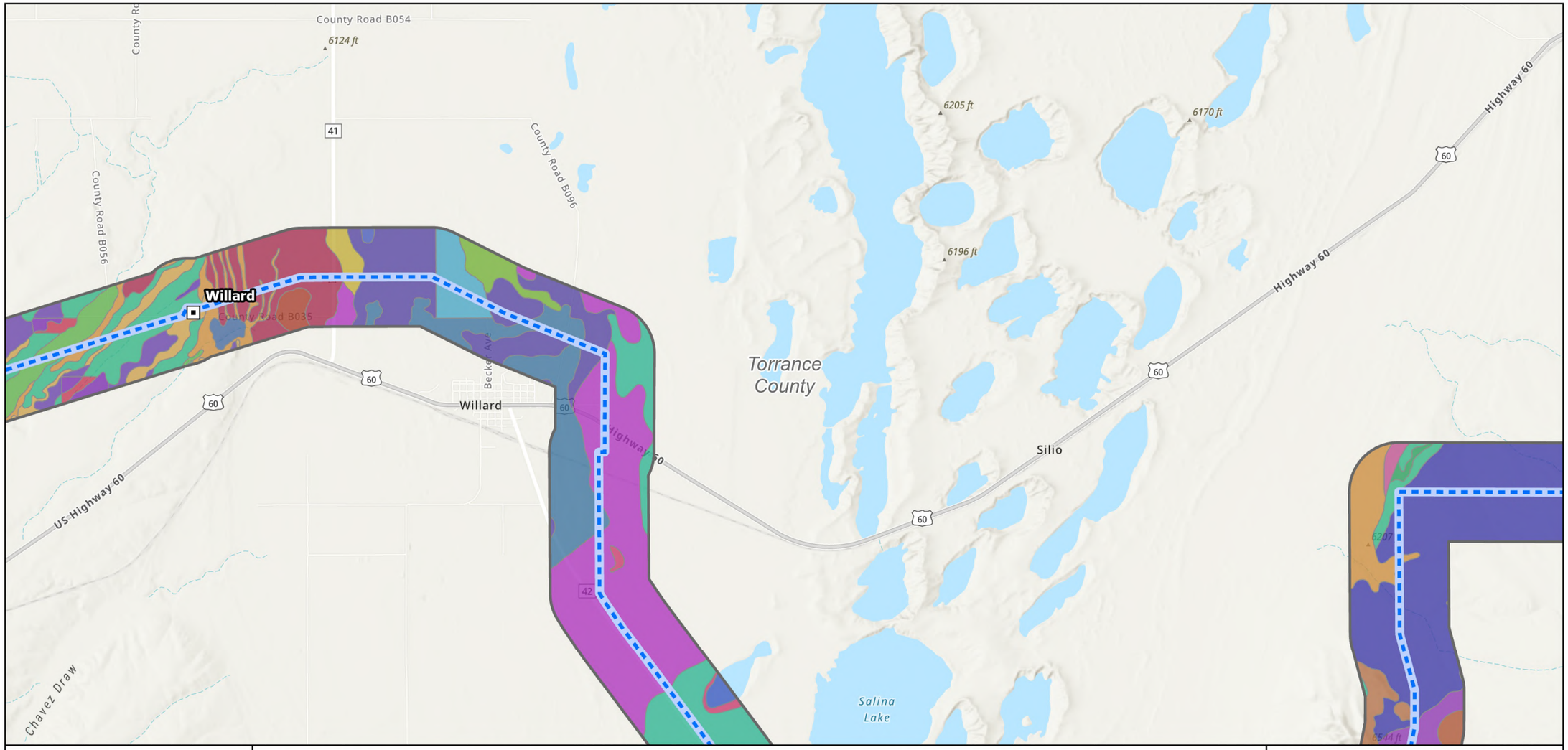
Reference Features
- County Boundary

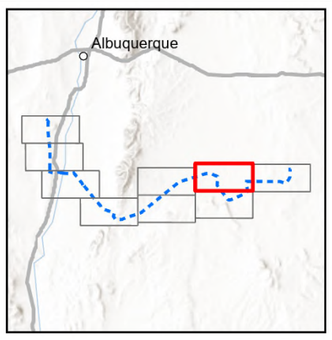
MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 5 of 9

0 1 2 Miles


Chato
Cañon Del Chato
Cerrito Del Espia
7386 ft
El Gato
Arroyo de Manzano
County Road B039
542
County Road B052
6288 ft
County Road B106
Colorado
Los Chavez
Cañon Colorado
County Road B038
County Road B038
Mesteño Draw
County Road B035
County Road B035
Cañon De La Gotera
Punta de Agua
Cañon Sapato
55
542
County Road B032
6889 ft
Torrance County
La Cienega
Eastview Rd
Forest Road 275
Fawn Rd
Fawn Rd
County Road B089
55
County Road B031
County Road B028
6367 ft
County Road B030
County Road B034
60
Barranco
Shooter Ln
Broncho
6812 ft
County Road B023
County Road B023
County Road B011
County Road B027
County Road B025
Cañon Espinoso
7167 ft
Cañon Barranco
County Road B024
60
Albuquerque
Project Components
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Mapunit Name
Clovis loam, 0 to 5 percent slopes
Clovis soils, 0 to 5 percent slopes, eroded
Harvey and Dean soils, eroded
Harvey loam, 1 to 9 percent slopes
Harvey-Dean loams, 1 to 9 percent slopes
Ildefonso fine sandy loam, 0 to 5 percent slopes
Manzano loam, 0 to 1 percent slopes
Pastura loam, 1 to 9 percent slopes
Pinon channery loam, 3 to 20 percent slopes
Tapia and Dean soils, eroded
Tapia loam, 0 to 5 percent slopes
Washoe cobbly loam, 9 to 25 percent slopes
Washoe gravelly loam, 1 to 9 percent slopes
Witt clay loam, 0 to 1 percent slopes, eroded
Witt clay loam, 1 to 6 percent slopes, eroded
Witt loam, 0 to 1 percent slopes
Witt loam, 1 to 6 percent slopes
Witt-Harvey loams, 0 to 3 percent slopes
Reference Features
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 5
Soil Resources Map
Page 6 of 9
0
1
2
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

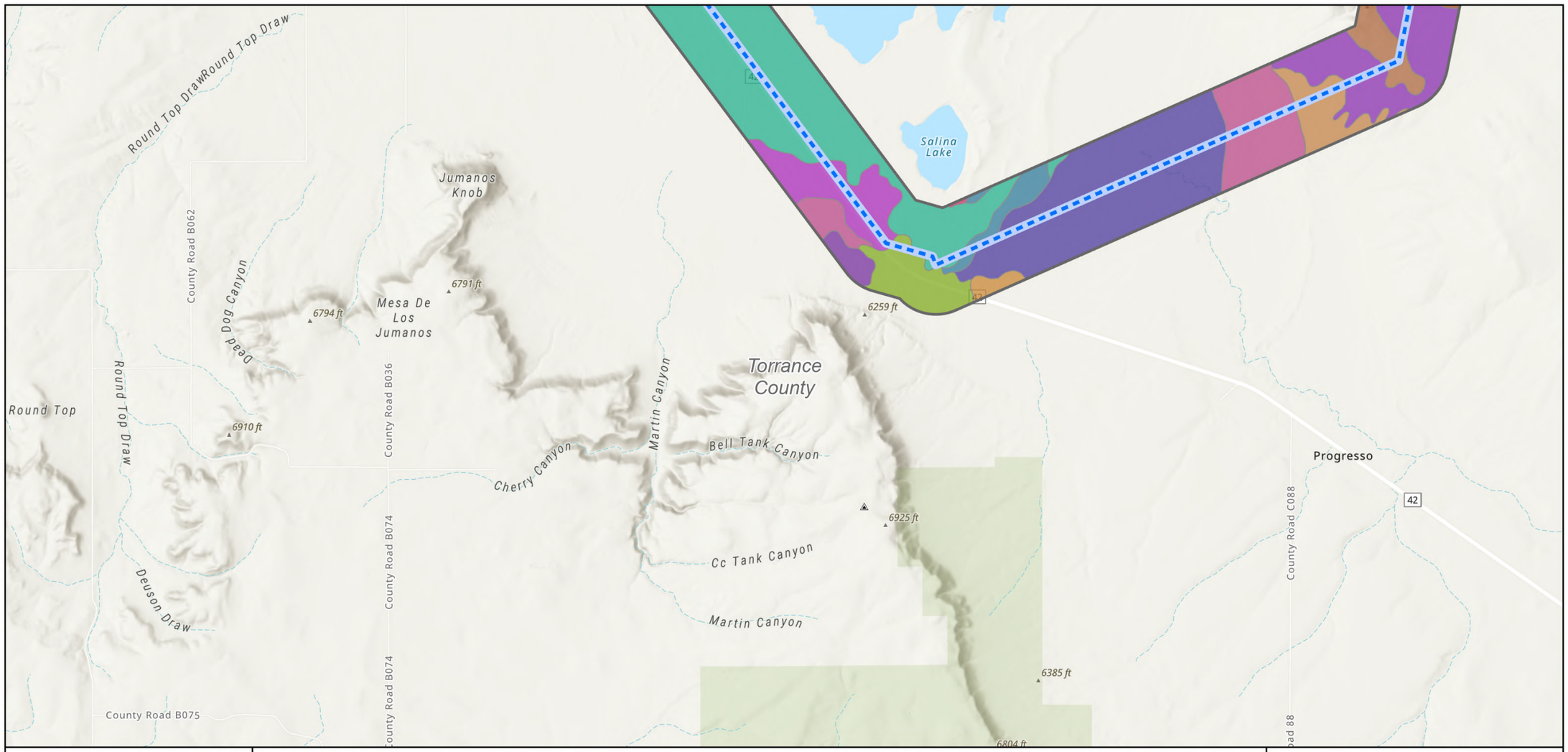
Mapunit Name
- Blown-out land
- Caliche pit
- Clovis loam, 0 to 5 percent slopes
- Harvey and Dean soils, eroded
- Harvey loam, 1 to 9 percent slopes
- Harvey loam, alkali
- Ildefonso fine sandy loam, 0 to 2 percent slopes
- Ildefonso fine sandy loam, 0 to 5 percent slopes
- Ildefonso loamy fine sand, 0 to 5 percent slopes
- Karde loam, saline
- Manzano loam, 0 to 1 percent slopes
- Manzano loam, saline substratum, 0 to 1 percent slopes
- Moriarty clay loam, 0 to 1 percent slopes
- Otero and Palma soils
- Otero and Palma soils, hummocky
- Pastura loam, 1 to 9 percent slopes
- Pastura loam, 9 to 25 percent slopes
- Pedrick loamy fine sand
- Pedrick loamy fine sand, hummocky
- Playas
- Rock land
- Tapia and Dean soils, eroded
- Tapia loam, 0 to 5 percent slopes
- Willard fine sandy loam
- Willard loam
- Willard loam, strongly saline

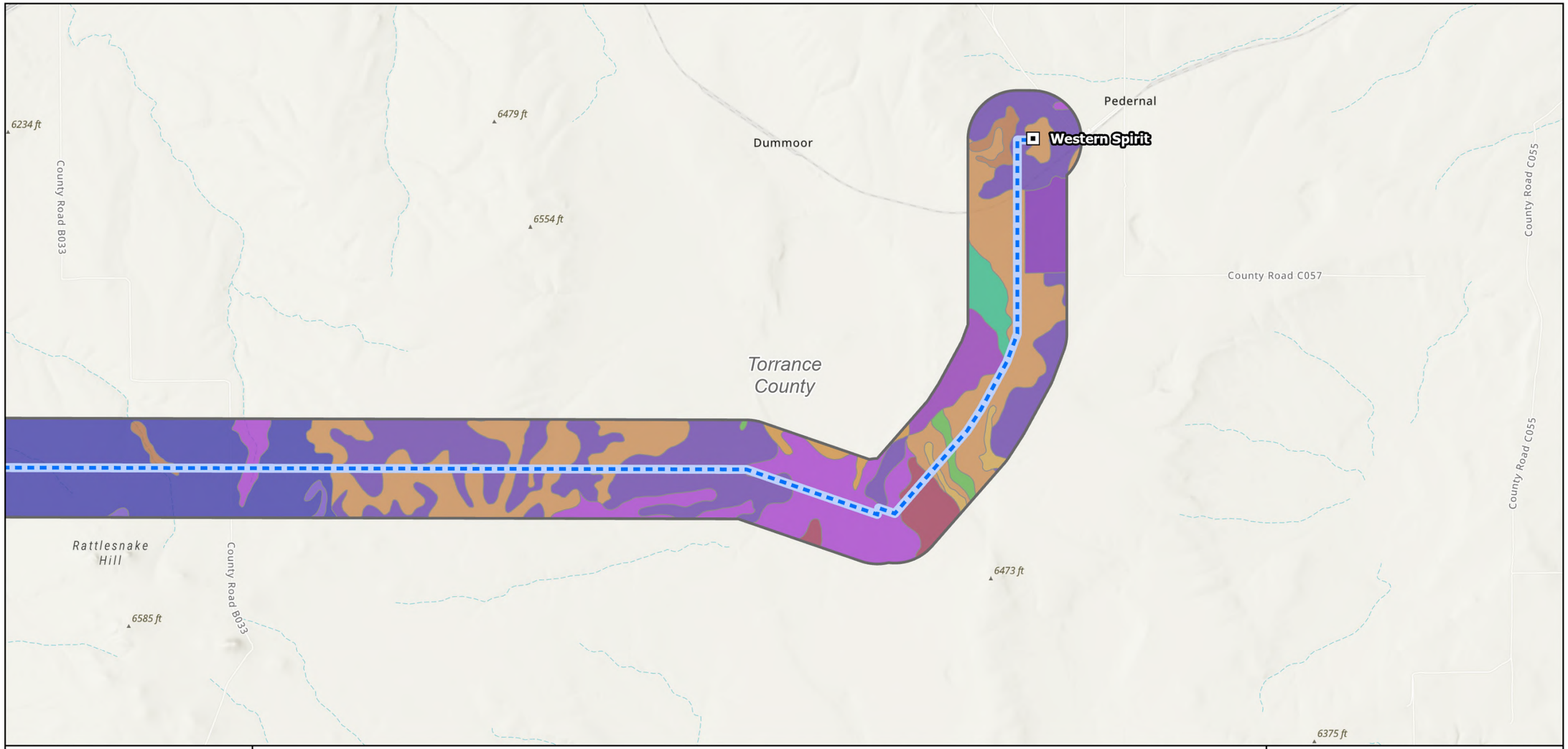
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 7 of 9

0 1 2 Miles


Round Top Draw
Round Top Draw
Jumanos Knob
Salina Lake
County Road B062
Dead Dog Canyon
6791 ft
6794 ft
Mesa De Los Jumanos
6259 ft
Torrance County
Martin Canyon
Round Top
Round Top Draw
6910 ft
County Road B036
Cherry Canyon
Bell Tank Canyon
Progresso
42
6925 ft
County Road B074
Cc Tank Canyon
Martin Canyon
County Road C088
Deuson Draw
6385 ft
County Road B075
County Road B074
6804 ft
Albuquerque
Project Components
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Mapunit Name
Alicia loam, 1 to 6 percent slopes
Dean loam, 1 to 9 percent slopes
Ildefonso fine sandy loam, 0 to 5 percent slopes
Ildefonso loamy fine sand, 0 to 5 percent slopes
Karde loam, saline
Karde-Willard loams, saline
Otero and Palma soils
Otero and Palma soils, hummocky
Pedrick loamy fine sand
Penistaja fine sandy loam, 1 to 6 percent slopes
Rock land
Willard loam
Willard loam, strongly saline
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 5
Soil Resources Map
Page 8 of 9
0
1
2
Miles
wsp



Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

Mapunit Name
- Clovis loam, 0 to 5 percent slopes
- Dean loam, 1 to 9 percent slopes
- Harvey loam, 1 to 9 percent slopes
- Harvey-Dean loams, 1 to 9 percent slopes
- Ildefonso fine sandy loam, 0 to 5 percent slopes
- Kech gravelly loam, 1 to 9 percent slopes
- Manzano loam, 0 to 1 percent slopes
- Otero and Palma soils
- Pastura loam, 1 to 9 percent slopes
- Rock land
- Tapia and Dean soils, eroded
- Tapia loam, 0 to 5 percent slopes
- Tapia-Dean loams, 0 to 5 percent slopes

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 5
Soil Resources Map
Page 9 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

Geological Unit Name
- Cenozoic: Neogene
- Cenozoic: Paleogene
- Cenozoic: Quaternary
- Mesozoic: Cretaceous
- Mesozoic: Triassic
- Neoproterozoic
- Paleoproterozoic
- Paleozoic: Carboniferous
- Paleozoic: Permian

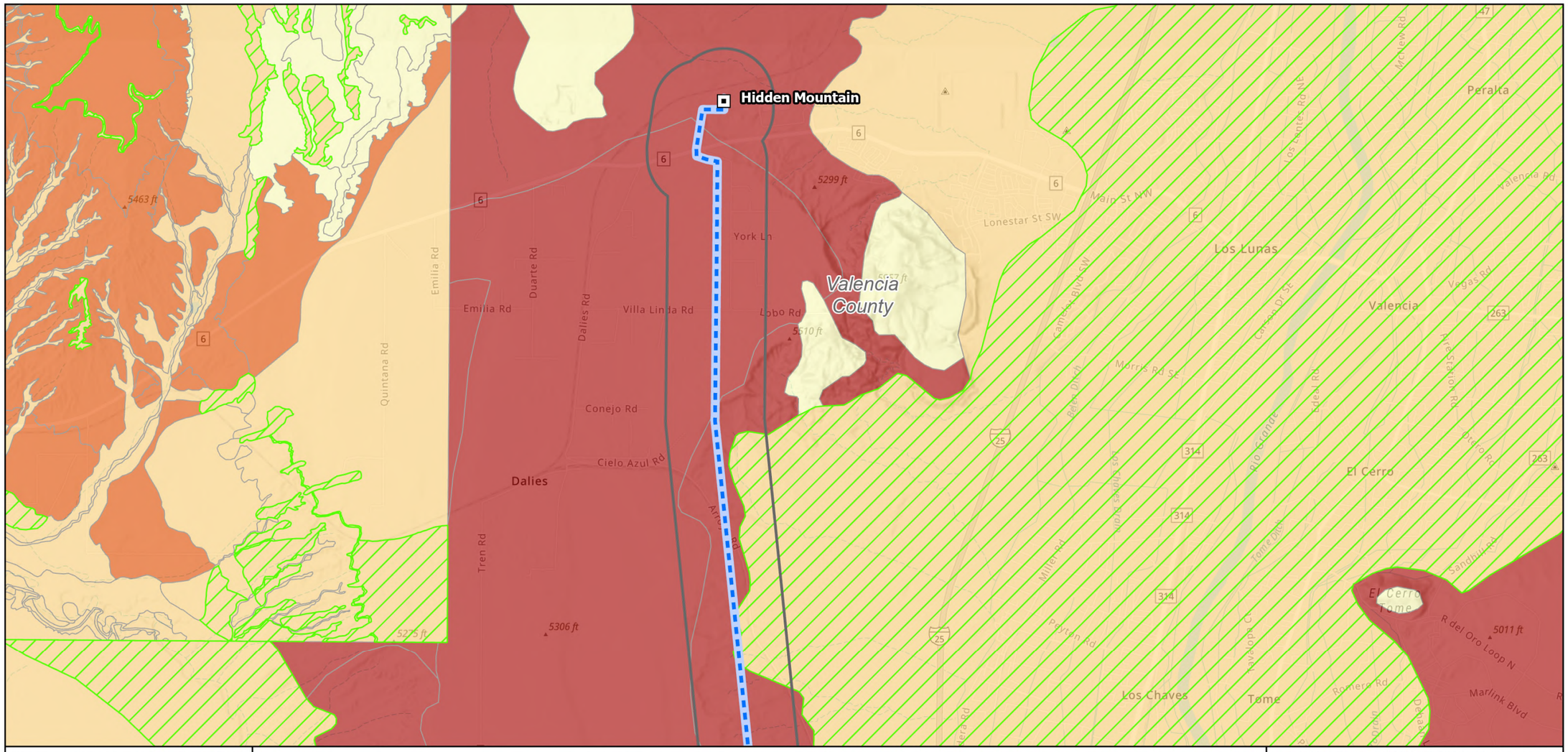
Reference Features
- Existing Substation
- County Boundary

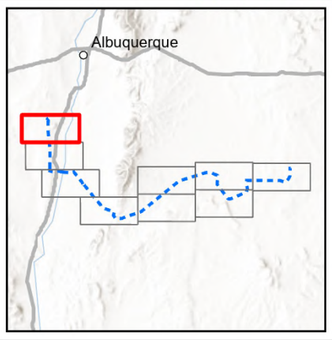
MID-STATE TRANSMISSION PROJECT

Exhibit 6
Paleontological Resources Map

0 5 10 Miles

wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

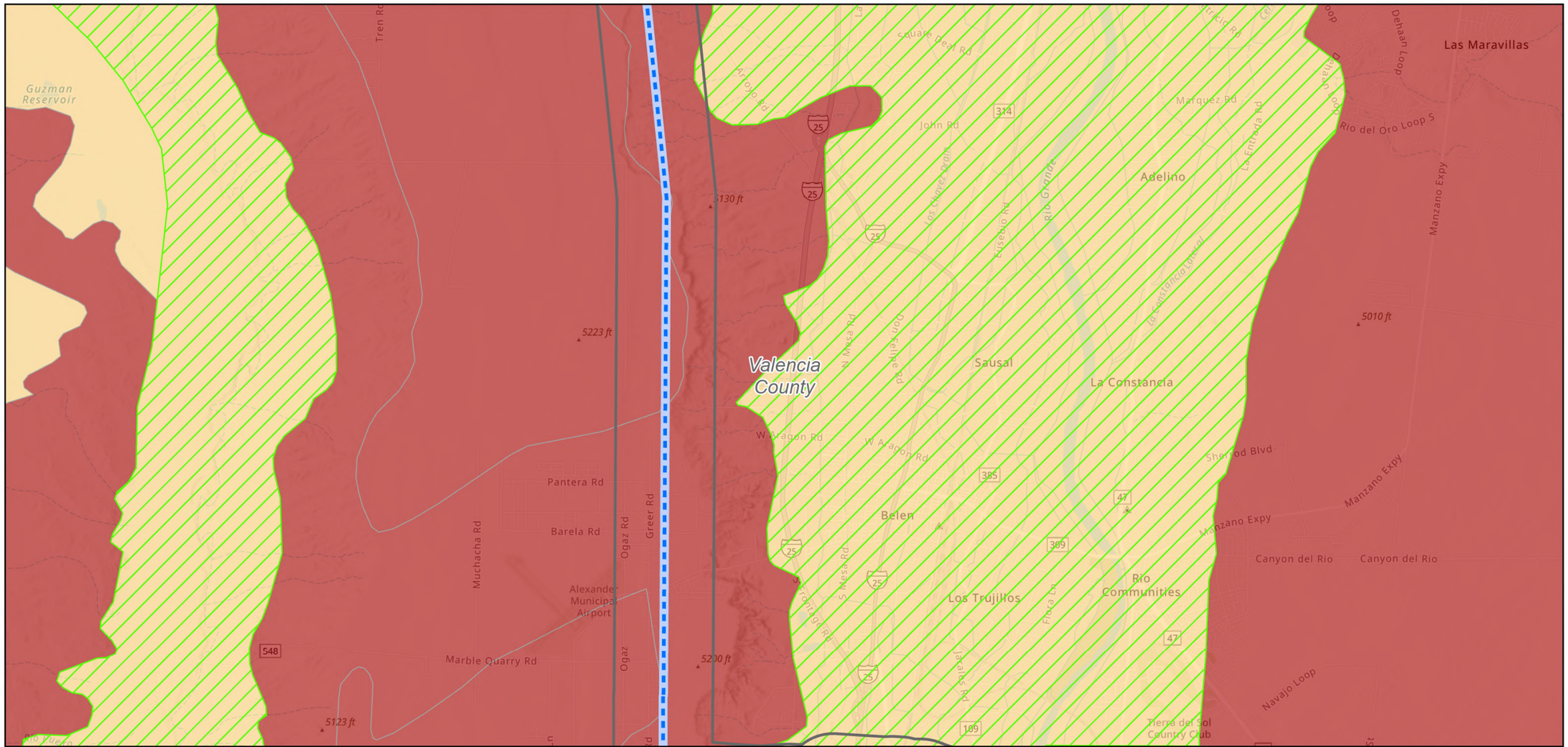
PFYC Class
- Provisional Class
- Class 1
- Class 2
- Class 4
- Class 5

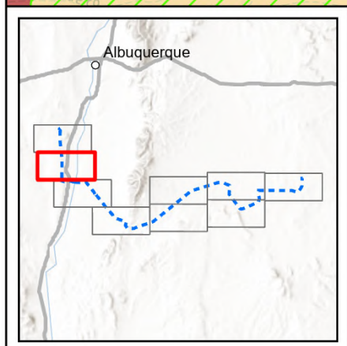
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 1 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

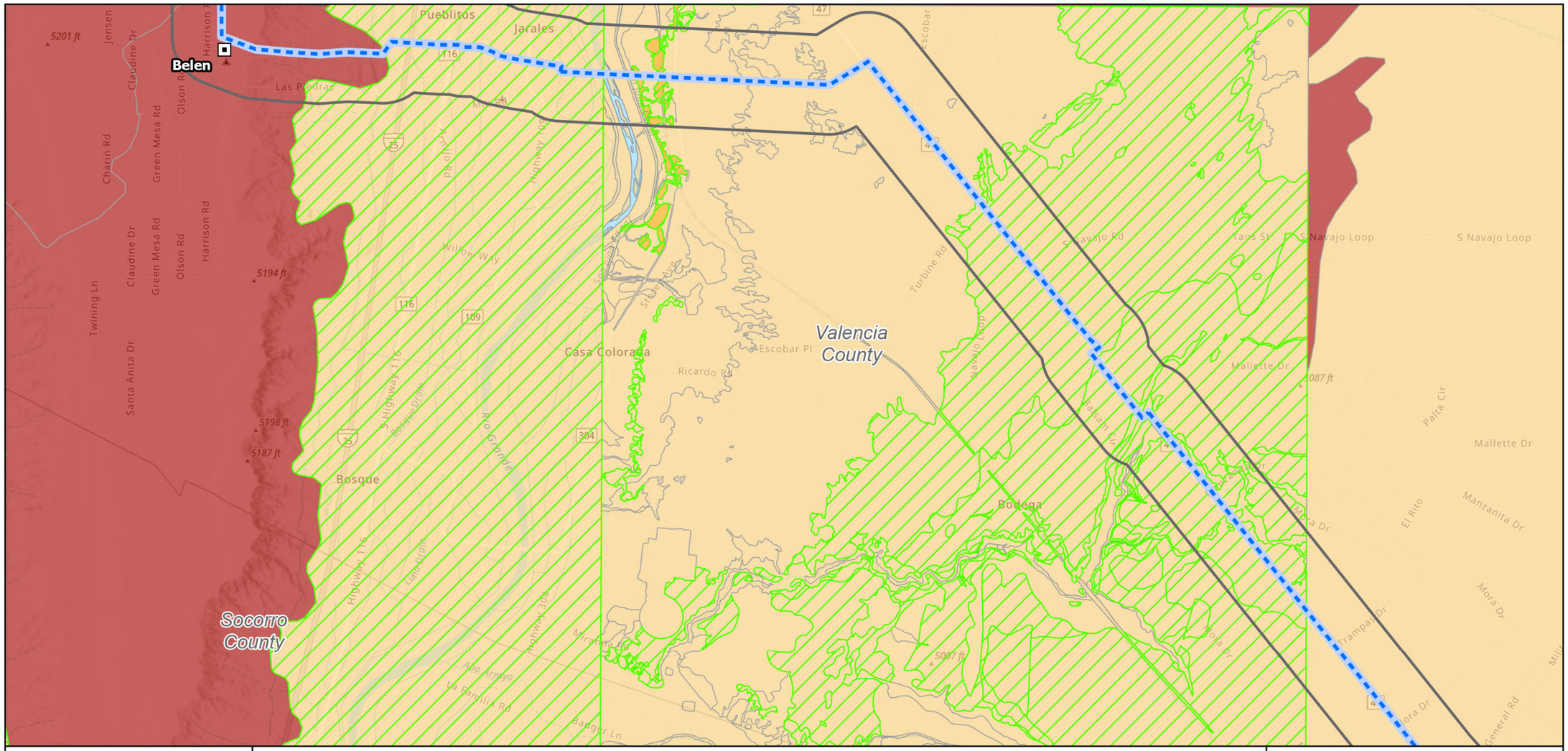
PFYC Class
- Provisional Class
- Class 2
- Class 3
- Class 5

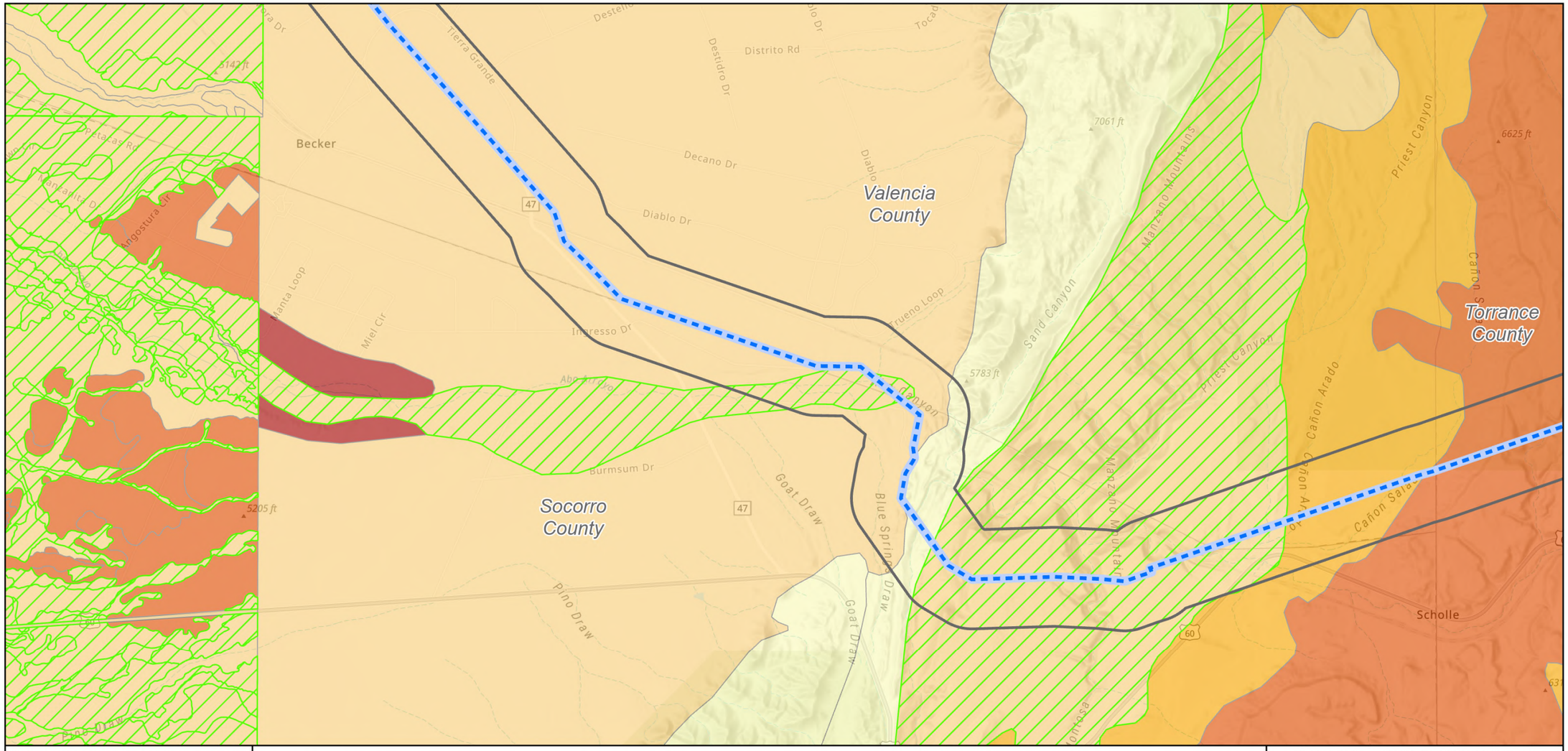
Reference Features
- Existing Substation
- County Boundary

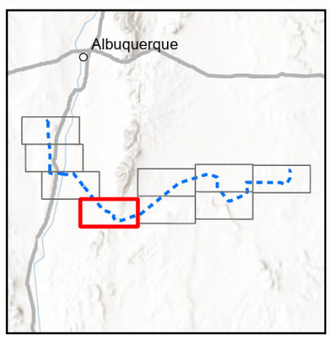
MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 2 of 9

0 1 2 Miles


Belen
Pueblitos
Jarales
Las Piedras
Valencia County
Casa Colorada
Bosque
Socorro County
Bodega
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
PFYC Class
Provisional Class
Class 2
Class 3
Class 5
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 3 of 9
0
1
2
Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

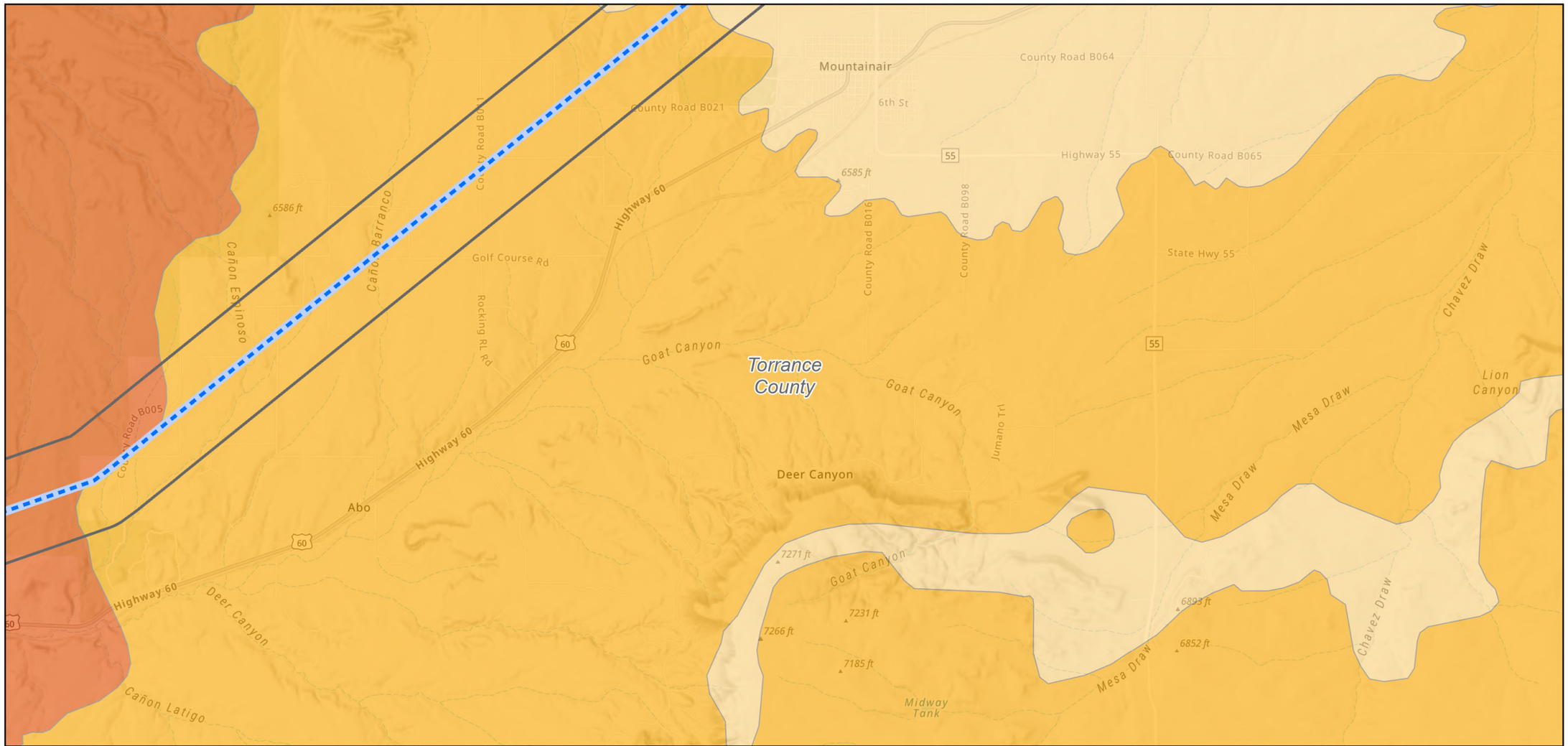
PFYC Class
- Provisional Class
- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

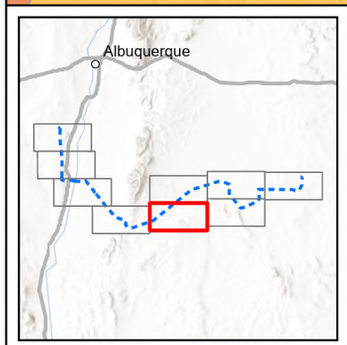
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 4 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

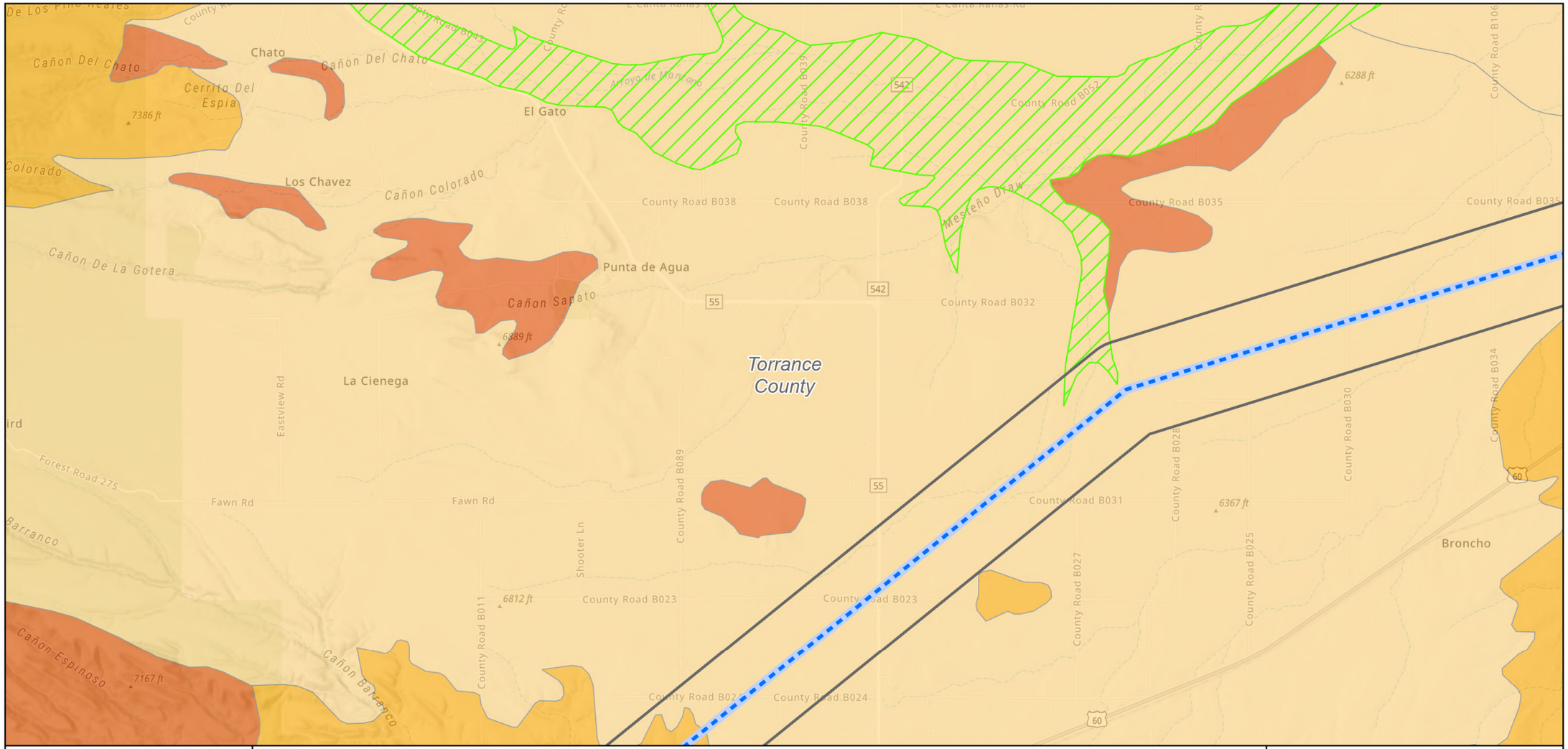
PFYC Class
- Class 1
- Class 2
- Class 3
- Class 4

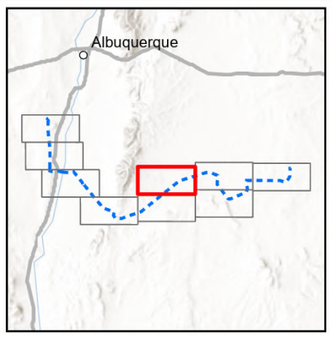
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 5 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

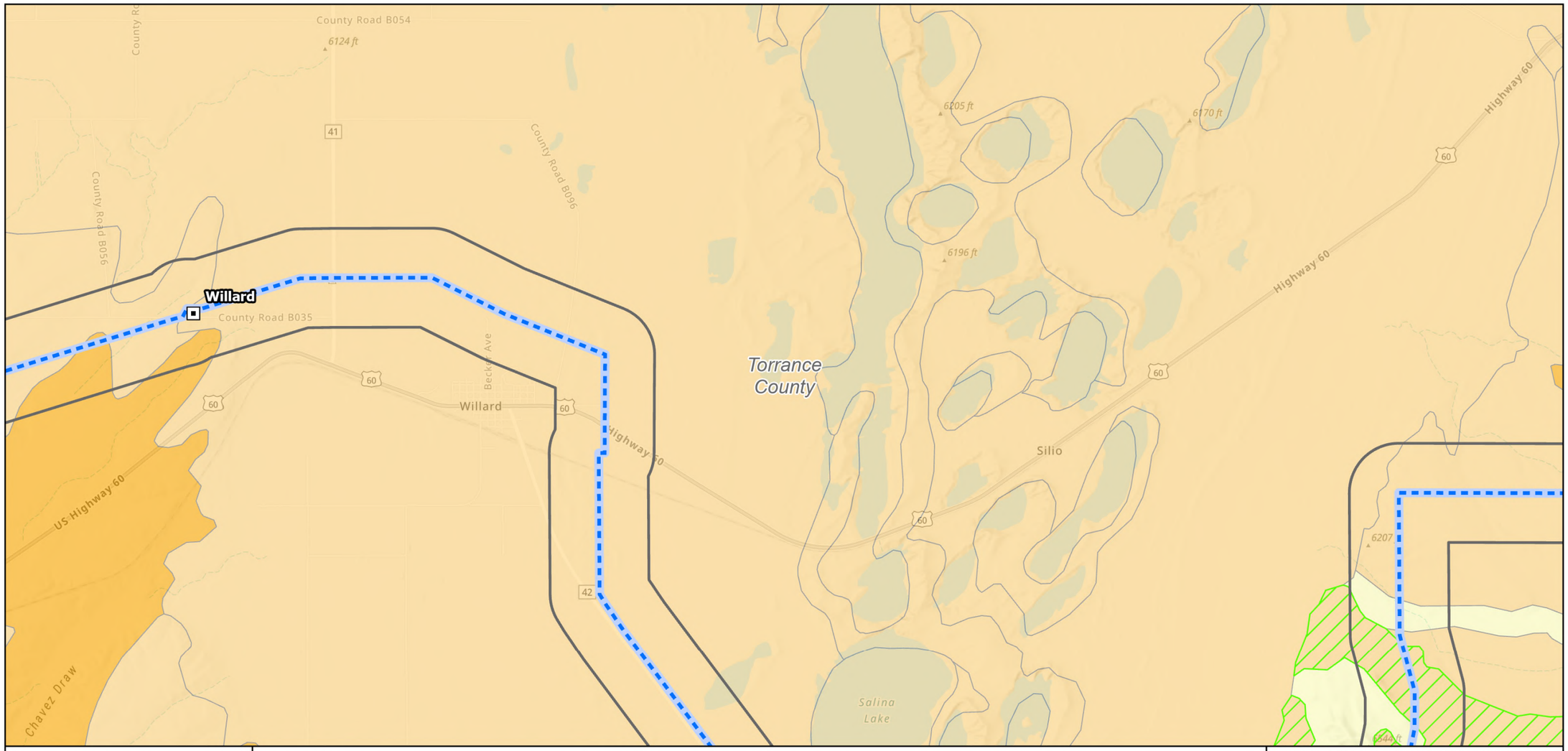
PFYC Class
- Provisional Class
- Class 2
- Class 3
- Class 4

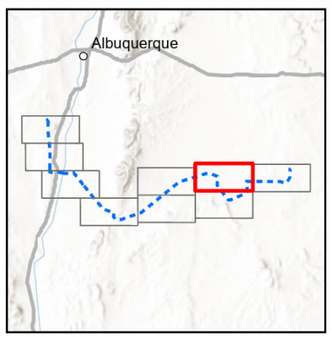
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 6 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

PFYC Class
- Provisional Class
- Class 1
- Class 2
- Class 3

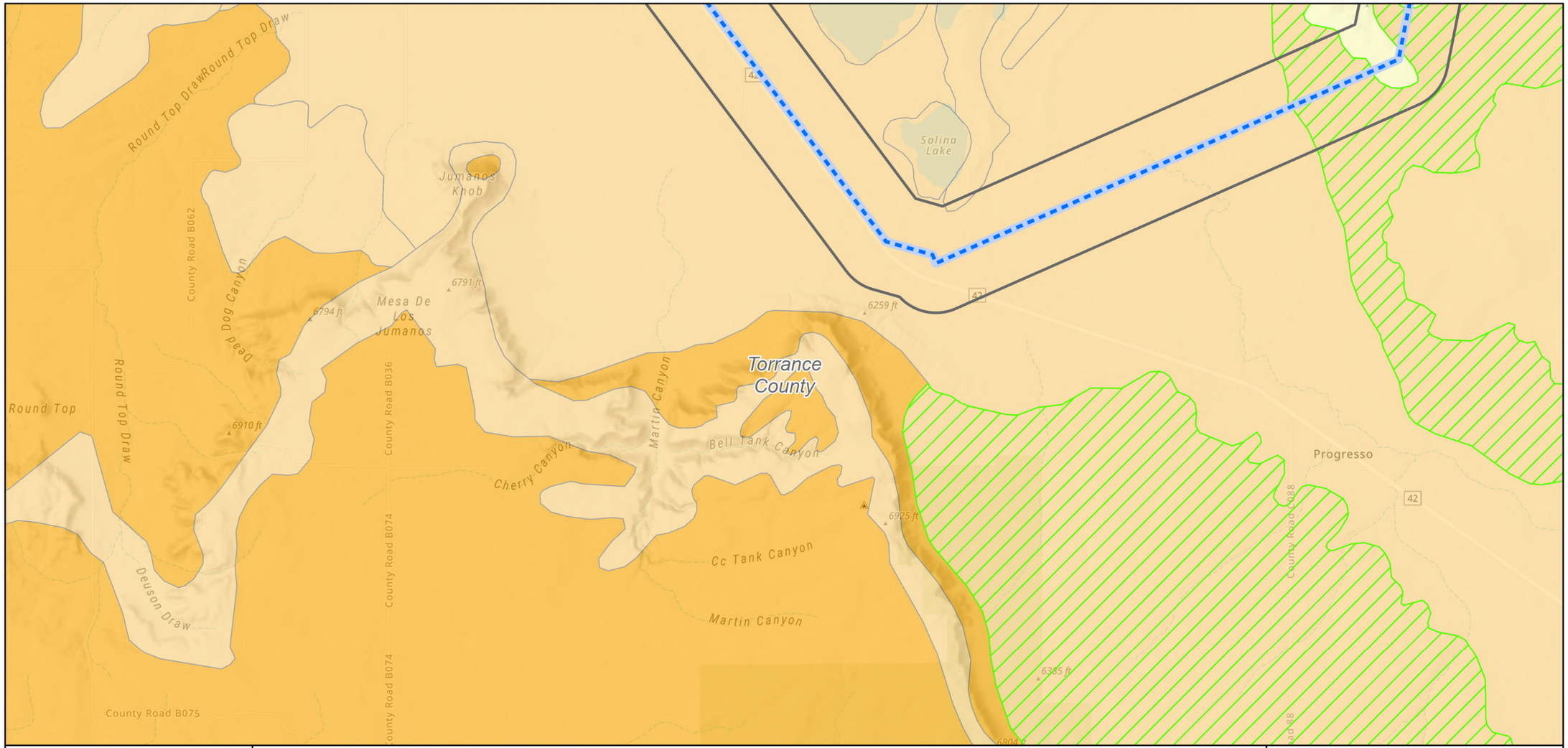
Reference Features
- Existing Substation
- County Boundary

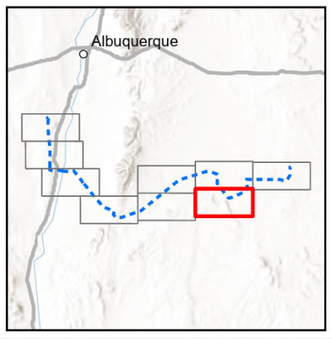
MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 7 of 9

0 1 2 Miles

wsp





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

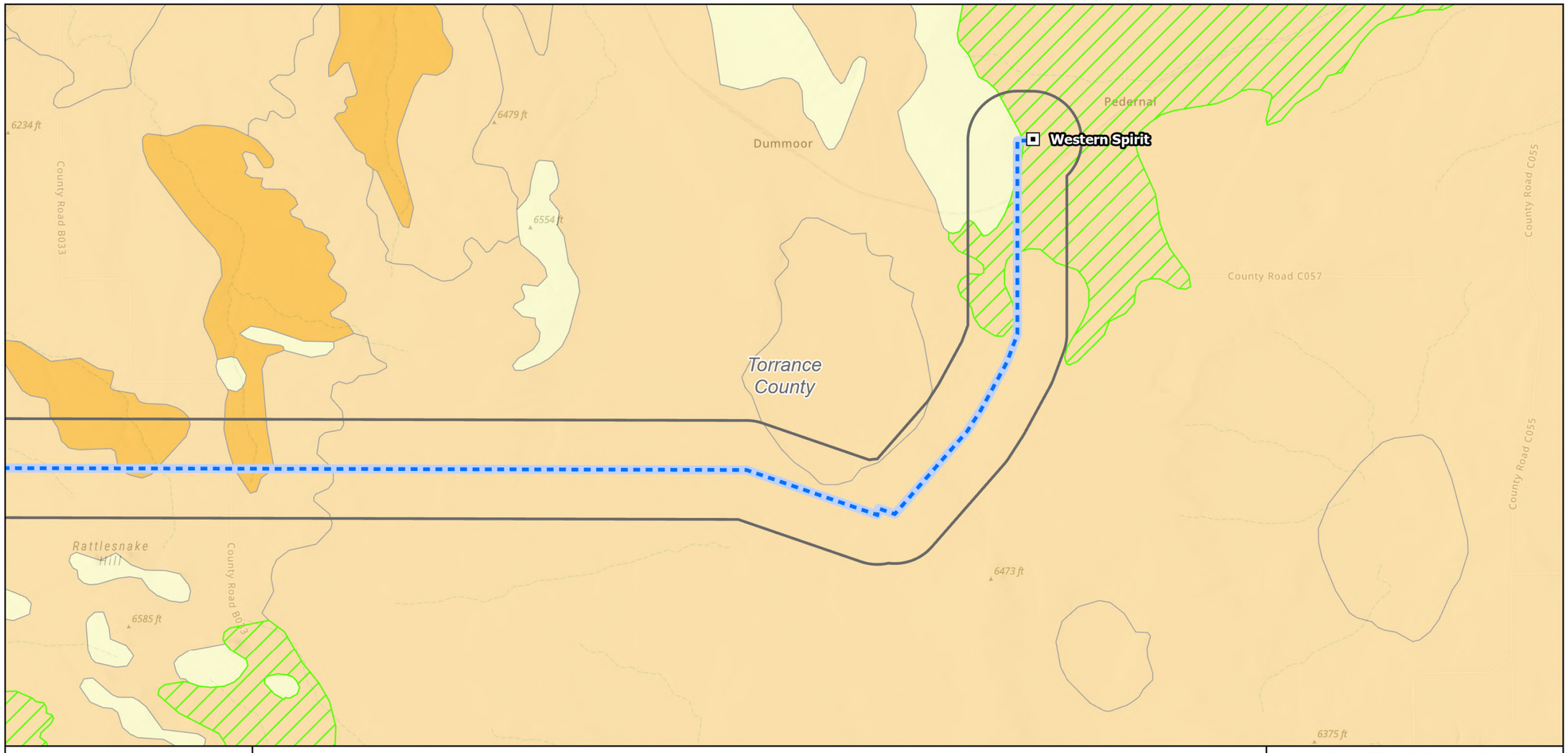
PFYC Class
- Provisional Class
- Class 1
- Class 2
- Class 3

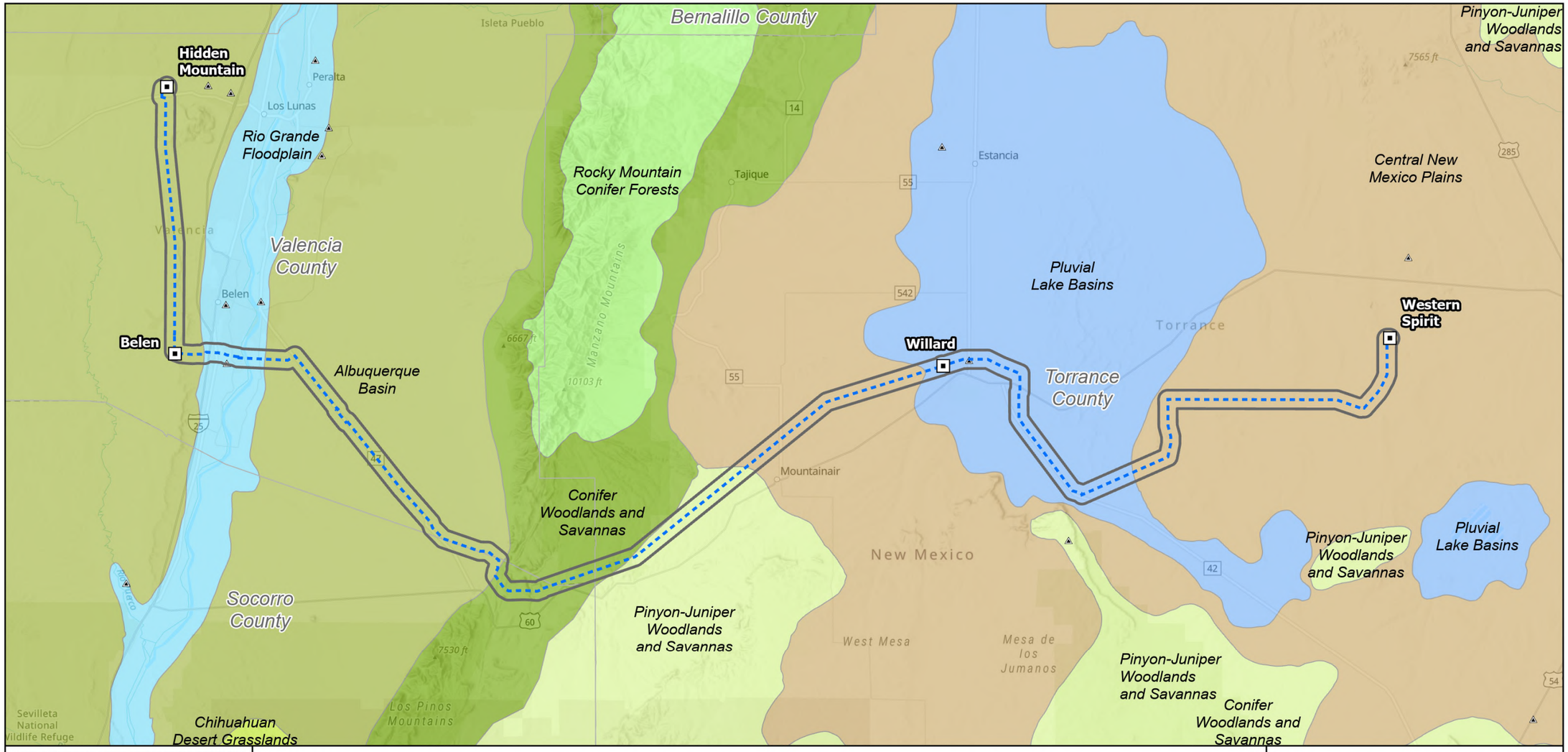
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 8 of 9

0 1 2 Miles


6234 ft
County Road B033
6479 ft
6554 ft
Dummoor
Pedernal
Western Spirit
County Road C057
County Road C055
Torrance
County
Rattlesnake
Hill
County Road B033
6585 ft
6473 ft
6375 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
PFYC Class
Provisional Class
Class 1
Class 2
Class 3
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 7
Paleontological Fossil
Yield Classification Map
Page 9 of 9
0
1
2
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

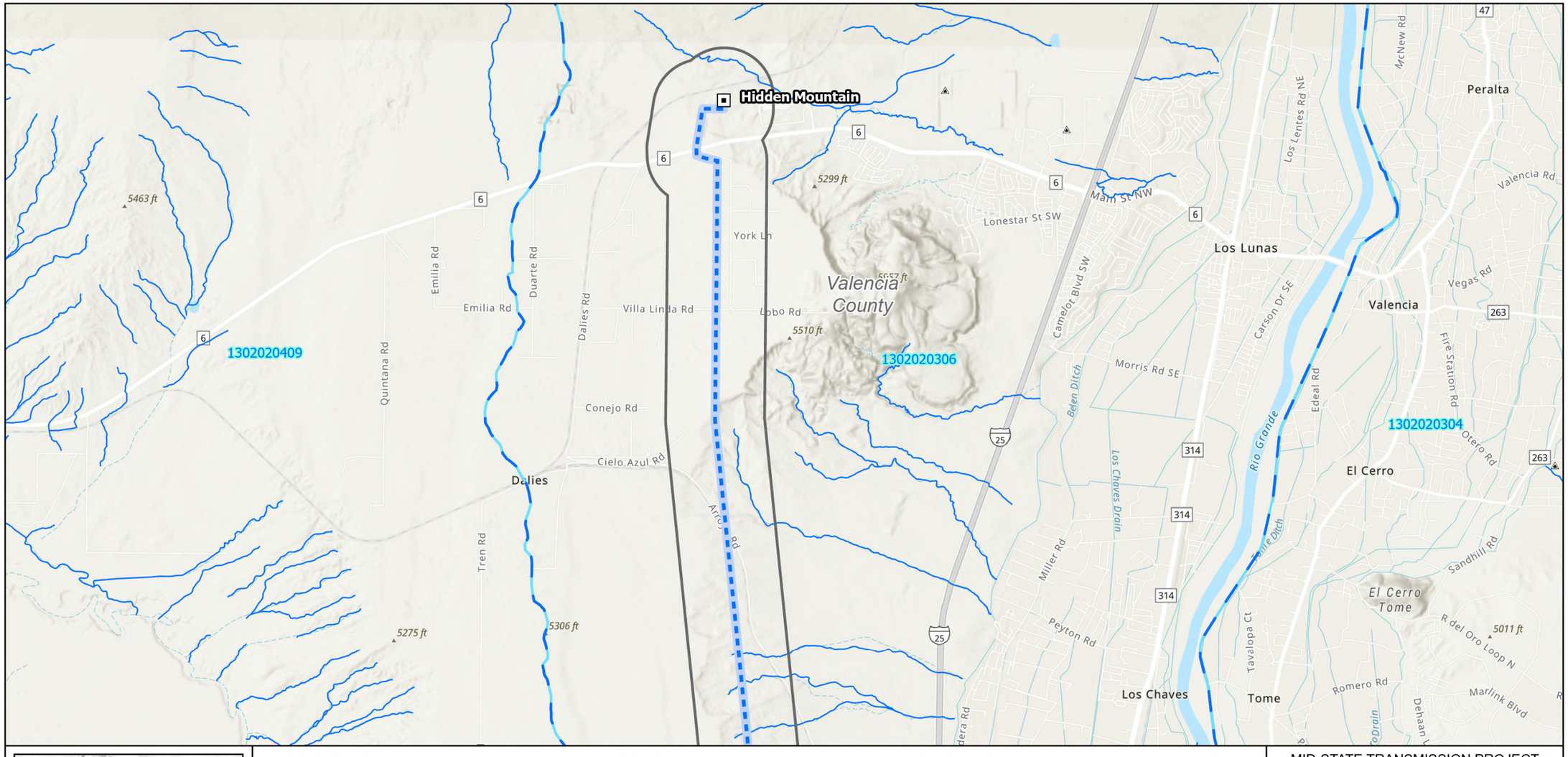
Level IV Ecoregions
- Albuquerque Basin
- Central New Mexico Plains
- Chihuahuan Desert Grasslands
- Conifer Woodlands and Savannas
- Pinyon-Juniper Woodlands and Savannas
- Pluvial Lake Basins
- Rio Grande Floodplain
- Rocky Mountain Conifer Forests

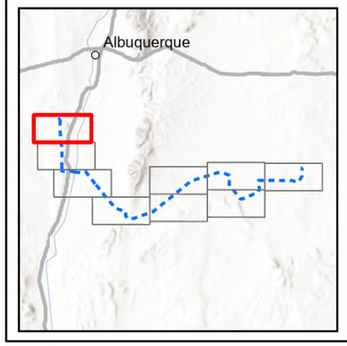
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 8
Ecoregions Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

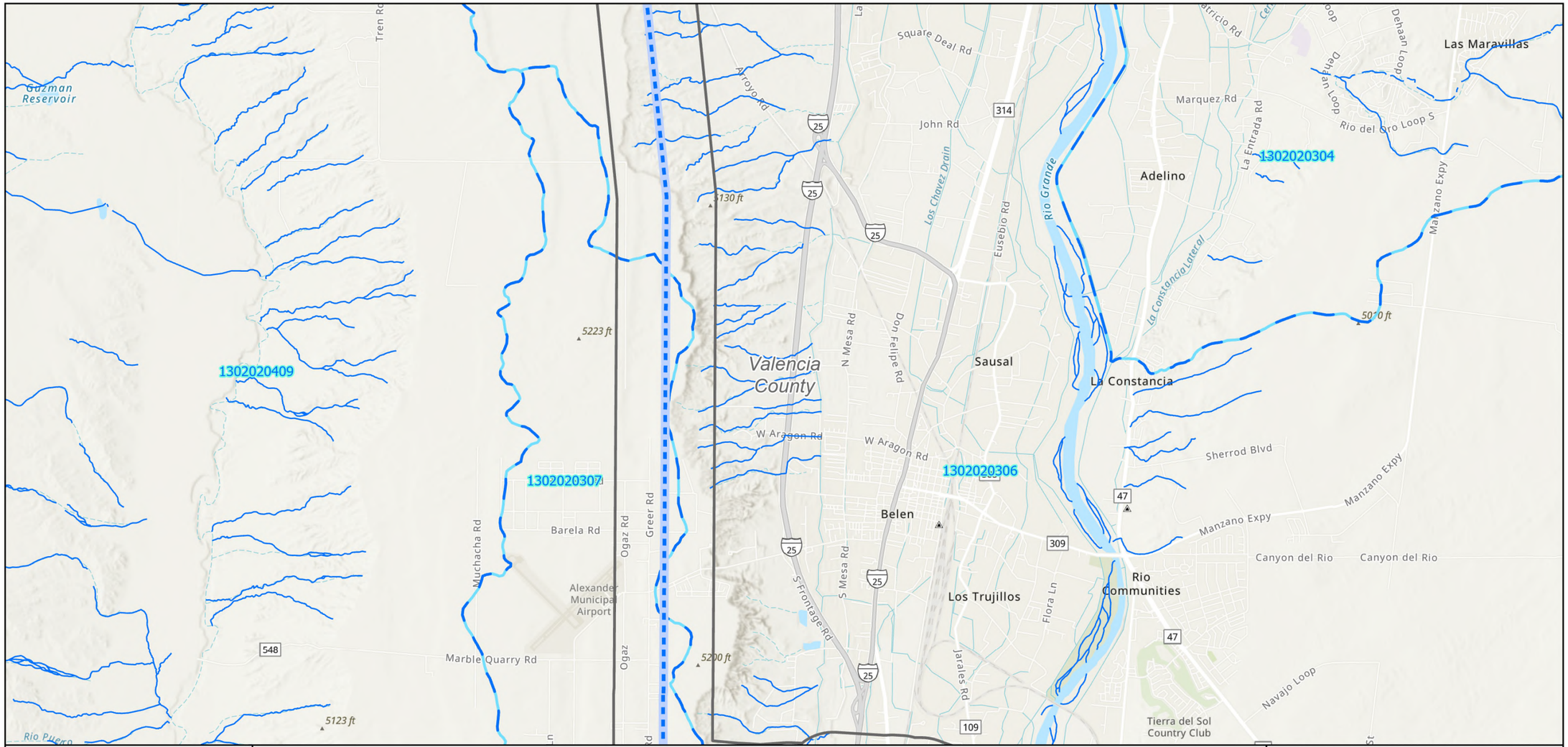
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 9
Surface Waters Map
Page 1 of 9

0 1 2 Miles

wsp



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

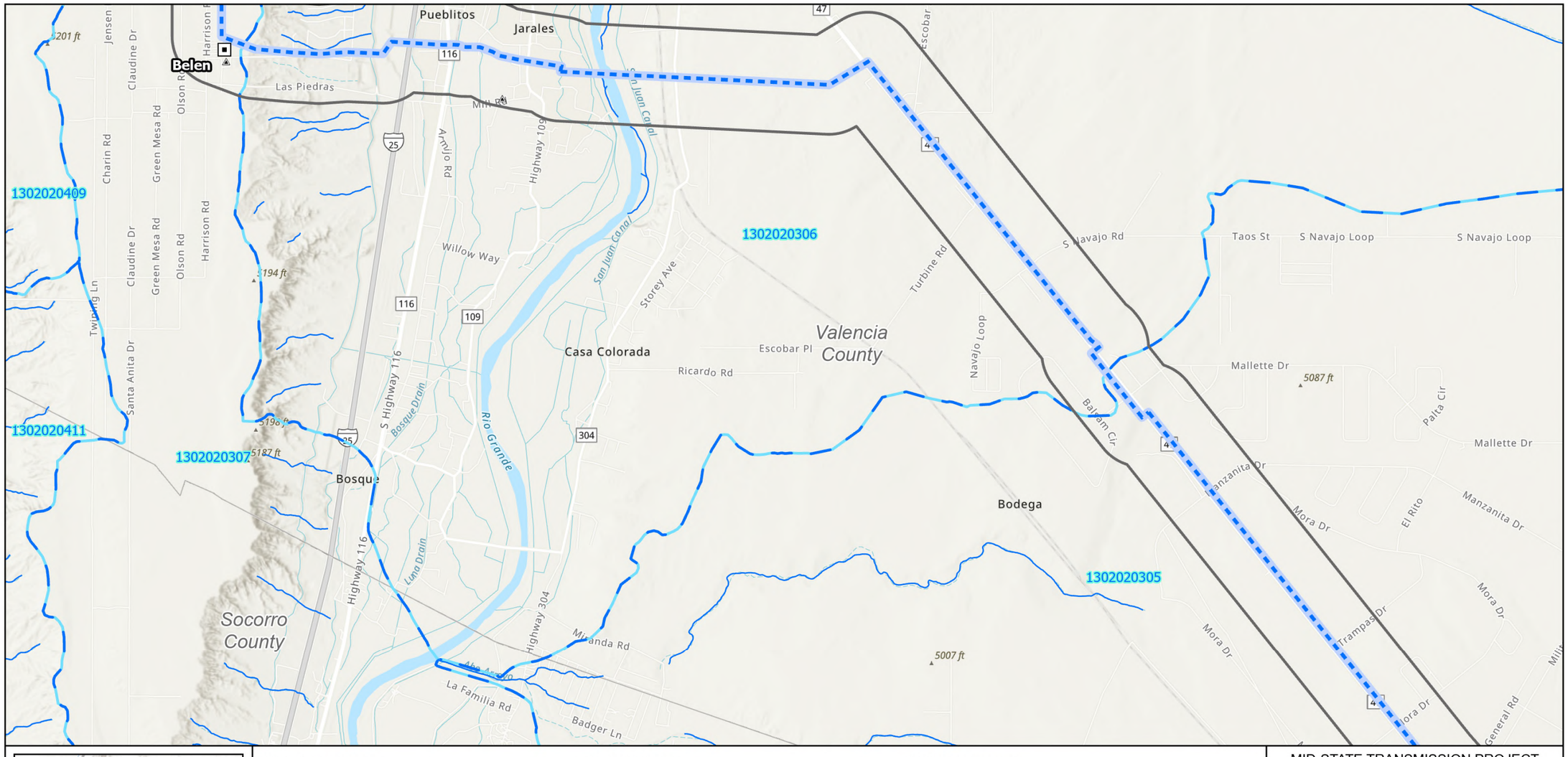
Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

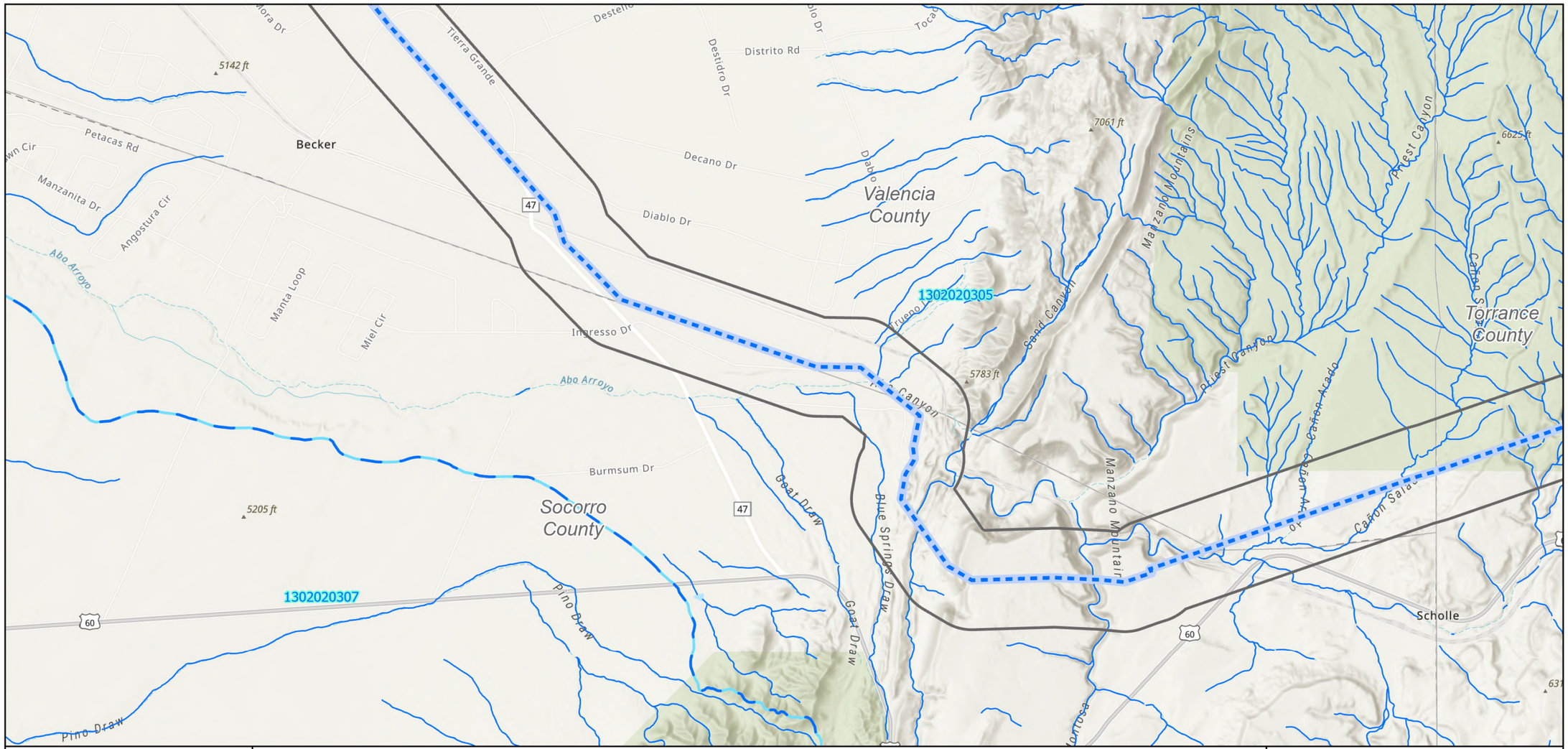
Reference Features
- Existing Substation
- County Boundary

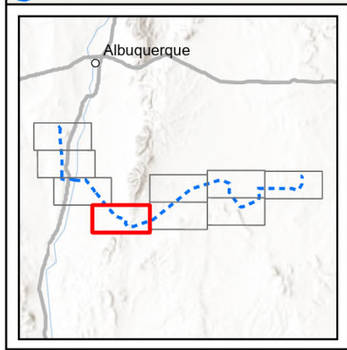
MID-STATE TRANSMISSION PROJECT

Exhibit 9
Surface Waters Map
Page 2 of 9

0 1 2 Miles


Pueblitos
Jarales
Belen
Las Piedras
Mill Rd
Arroyo Rd
Highway 109
San Juan Canal
Jensen
Claudine Dr
Charin Rd
Green Mesa Rd
Olson Rd
Harrison Rd
1302020409
Twining Ln
Santa Anita Dr
Willow Way
Storey Ave
1302020306
Turbine Rd
S Navajo Rd
Taos St
S Navajo Loop
Valencia County
Casa Colorado
Escobar Pl
Ricardo Rd
Navajo Loop
Mallette Dr
5087 ft
Palta Cir
Balsam Cir
1302020411
1302020307
5187 ft
Bosque
S Highway 116
Bosque Drain
Rio Grande
Bodega
Manzanita Dr
Mora Dr
El Rito
1302020305
Socorro County
Highway 116
Luna Drain
Highway 304
Miranda Rd
5007 ft
La Familia Rd
Badger Ln
Trampas Dr
General Rd
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Surface Waters
NHD Flowline Stream/River
HUC 10 Boundary
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 9
Surface Waters Map
Page 3 of 9
0
1
2
Miles
wsp





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

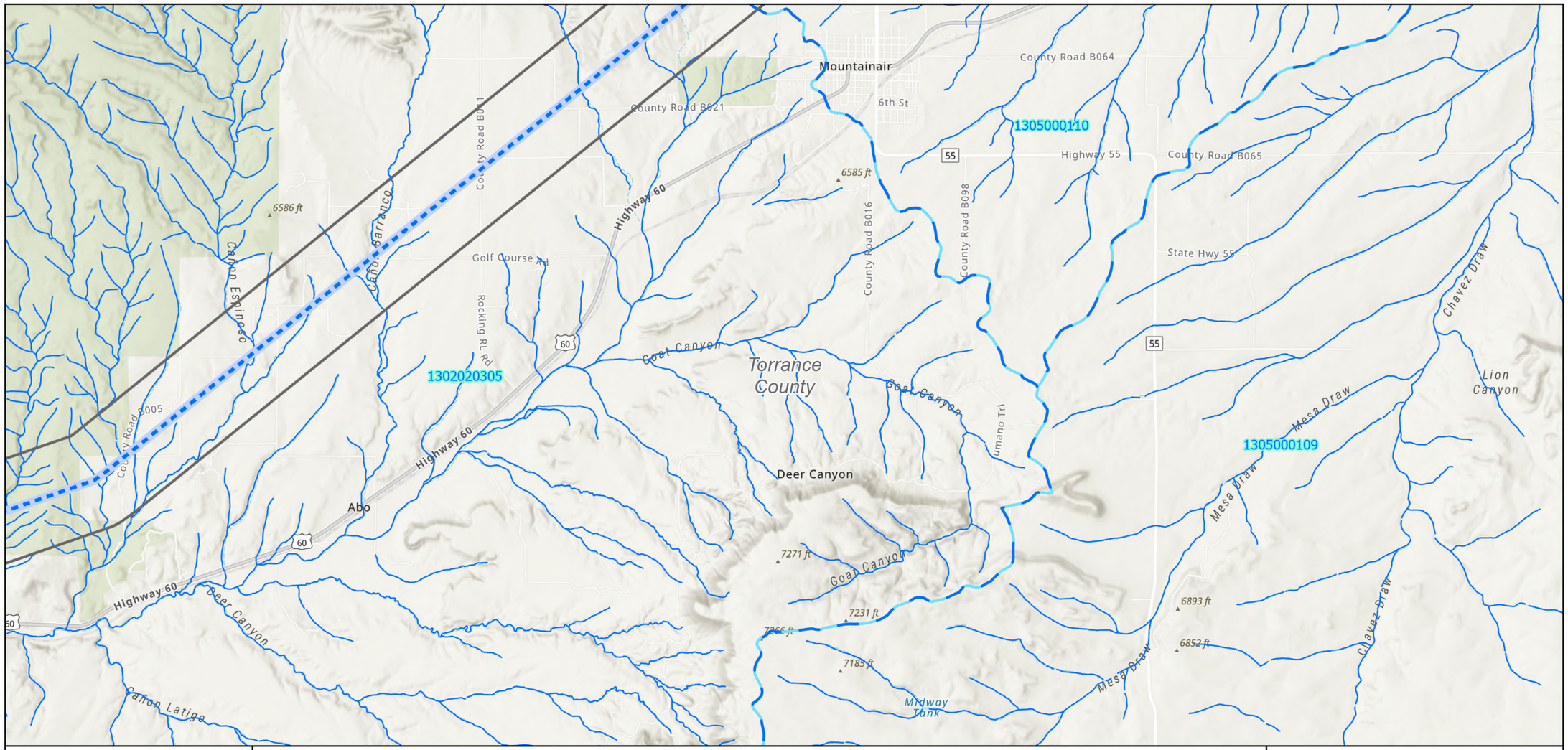
Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

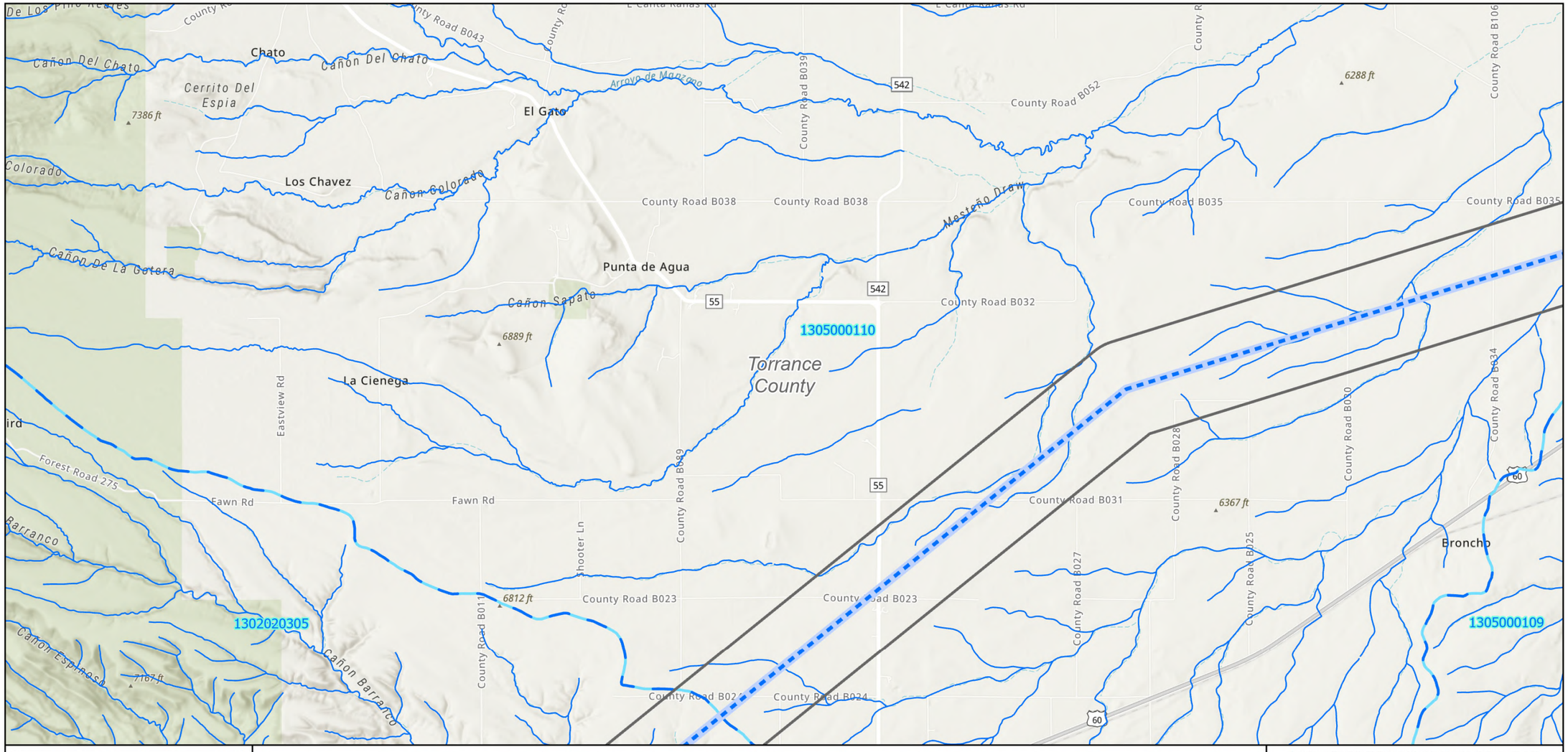
Reference Features
- County Boundary

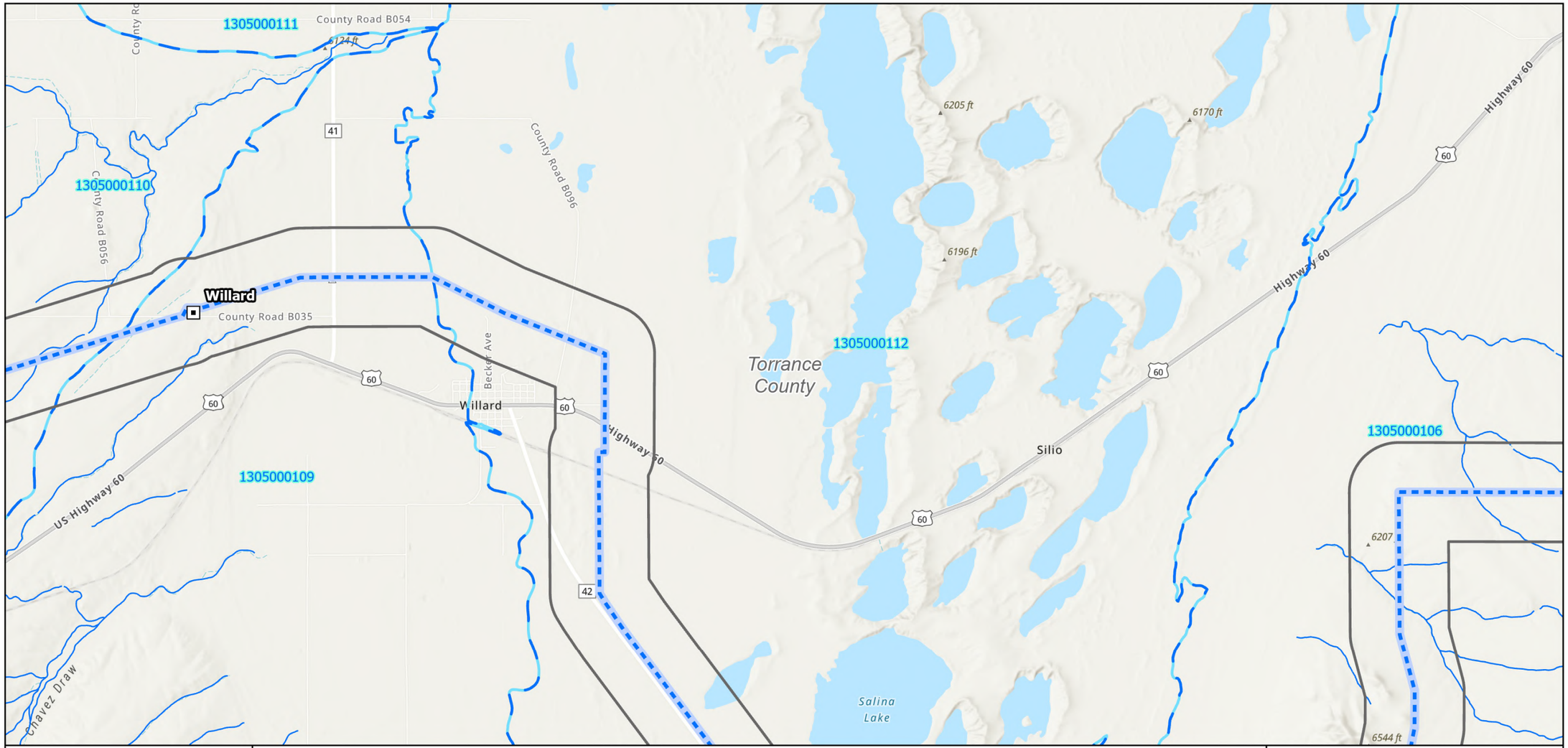
MID-STATE TRANSMISSION PROJECT

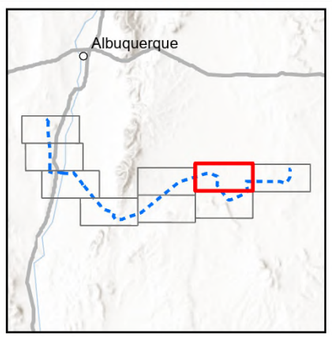
Exhibit 9
Surface Waters Map
Page 4 of 9

0 1 2 Miles


Mountainair
County Road B064
6th St
County Road B021
County Road B011
1305000110
Highway 55
County Road B065
6585 ft
55
Highway 60
6586 ft
Canon Carrizo
Canon Estripado
Golf Course Rd
County Road B016
County Road B098
State Hwy 55
Chavez Draw
Rocking RL Rd
60
Goat Canyon
1302020305
Torrance County
Goat Canyon
Lion Canyon
Mesa Draw
1305000109
County Road B005
Deer Canyon
Abo
Highway 60
Deer Canyon
7271 ft
Goat Canyon
7231 ft
7266 ft
6893 ft
6852 ft
7185 ft
Mesa Draw
Chavez Draw
Midway Tank
Canon Latigo
Albuquerque
Project Components
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Surface Waters
NHD Flowline Stream/River
HUC 10 Boundary
Reference Features
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 9
Surface Waters Map
Page 5 of 9
0
1
2
Miles


Chato
Cañon Del Chato
Cerrito Del Espia
7386 ft
El Gato
Arroyo de Manzano
County Road B039
542
County Road B052
6288 ft
County Road B106
Los Chavez
Cañon Colorado
County Road B038
County Road B038
Mesteño Draw
County Road B035
County Road B035
Cañon De La Gotera
Punta de Agua
55
542
Cañon Sapato
County Road B032
6889 ft
1305000110
Torrance County
La Cienega
Eastview Rd
Forest Road 275
Fawn Rd
Fawn Rd
Shooter Ln
County Road B039
County Road B031
6367 ft
County Road B028
County Road B030
County Road B034
60
Broncho
Barranco
County Road B011
6812 ft
County Road B023
County Road B023
County Road B027
County Road B025
1305000109
1302020305
Cañon Espinoso
7167 ft
Cañon Barranco
County Road B022
County Road B024
60
Albuquerque
Project Components
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
Surface Waters
NHD Flowline Stream/River
HUC 10 Boundary
Reference Features
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 9
Surface Waters Map
Page 6 of 9
0
1
2
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

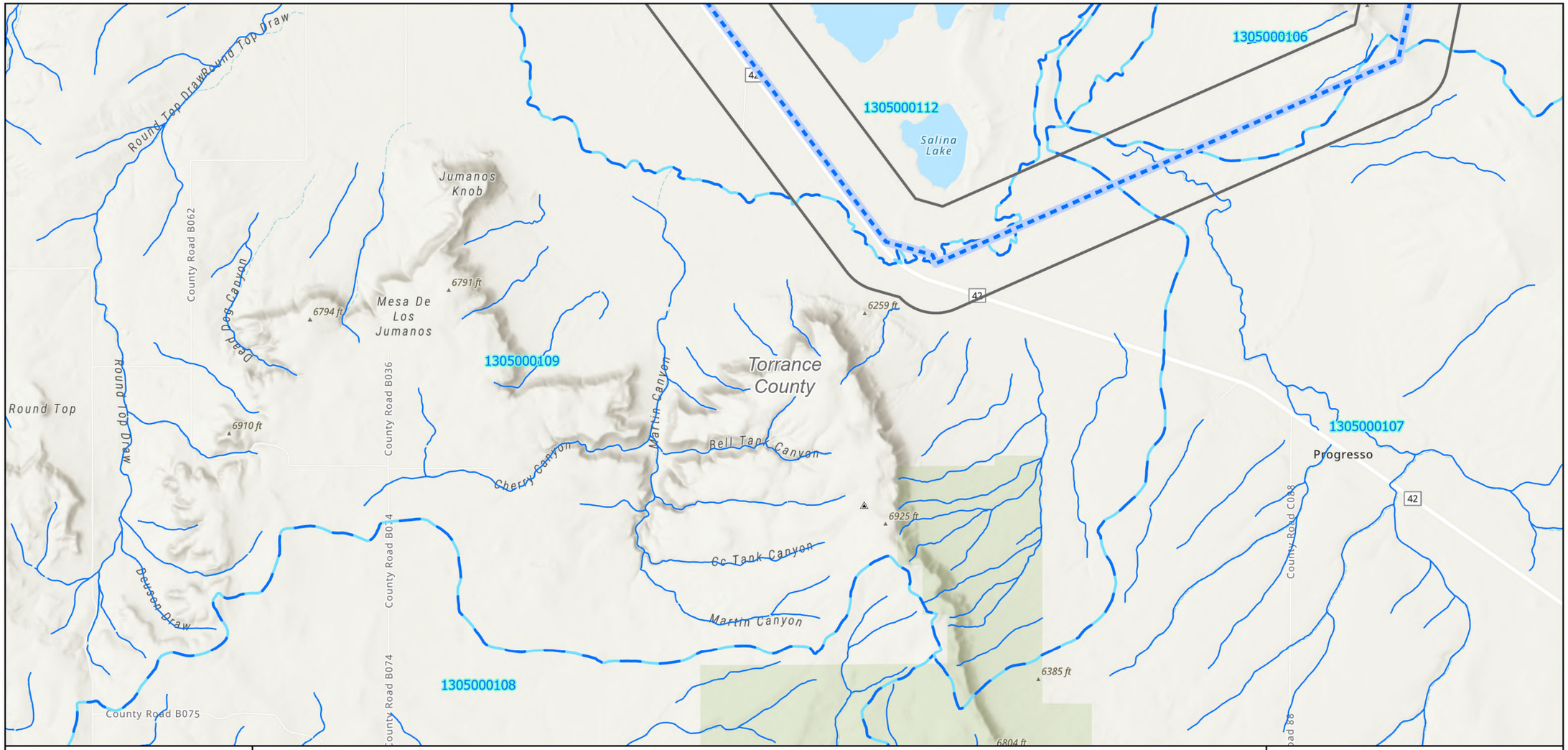
Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

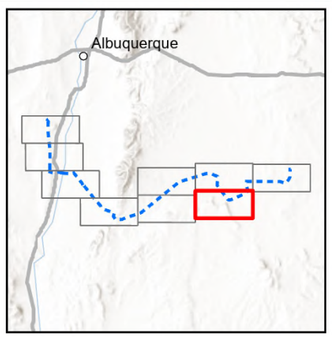
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 9
Surface Waters Map
Page 7 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

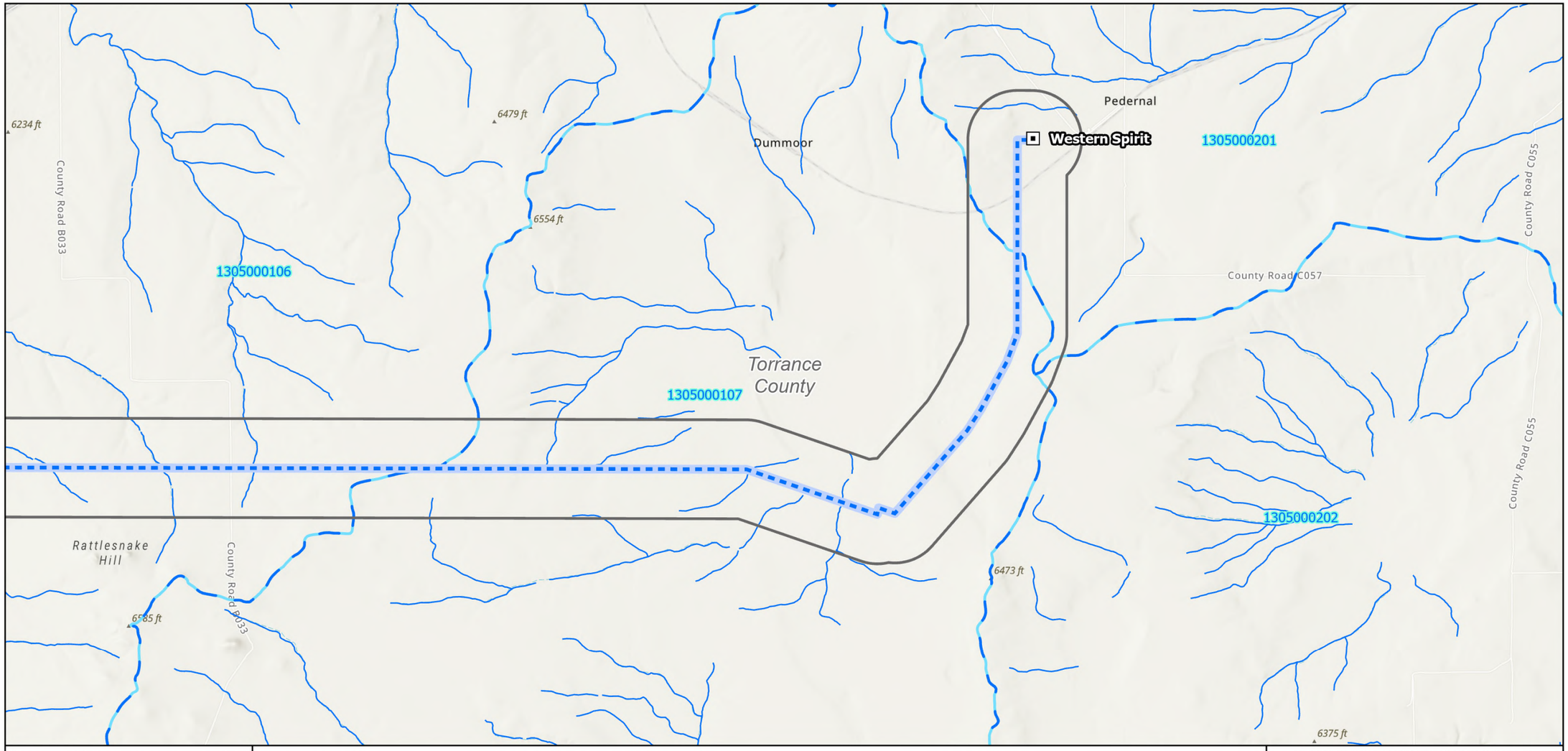
Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

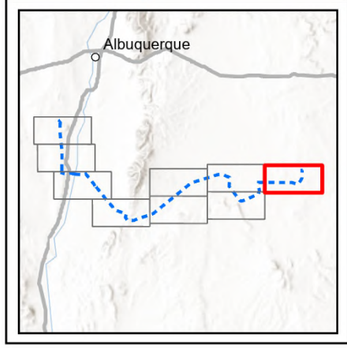
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 9
Surface Waters Map
Page 8 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

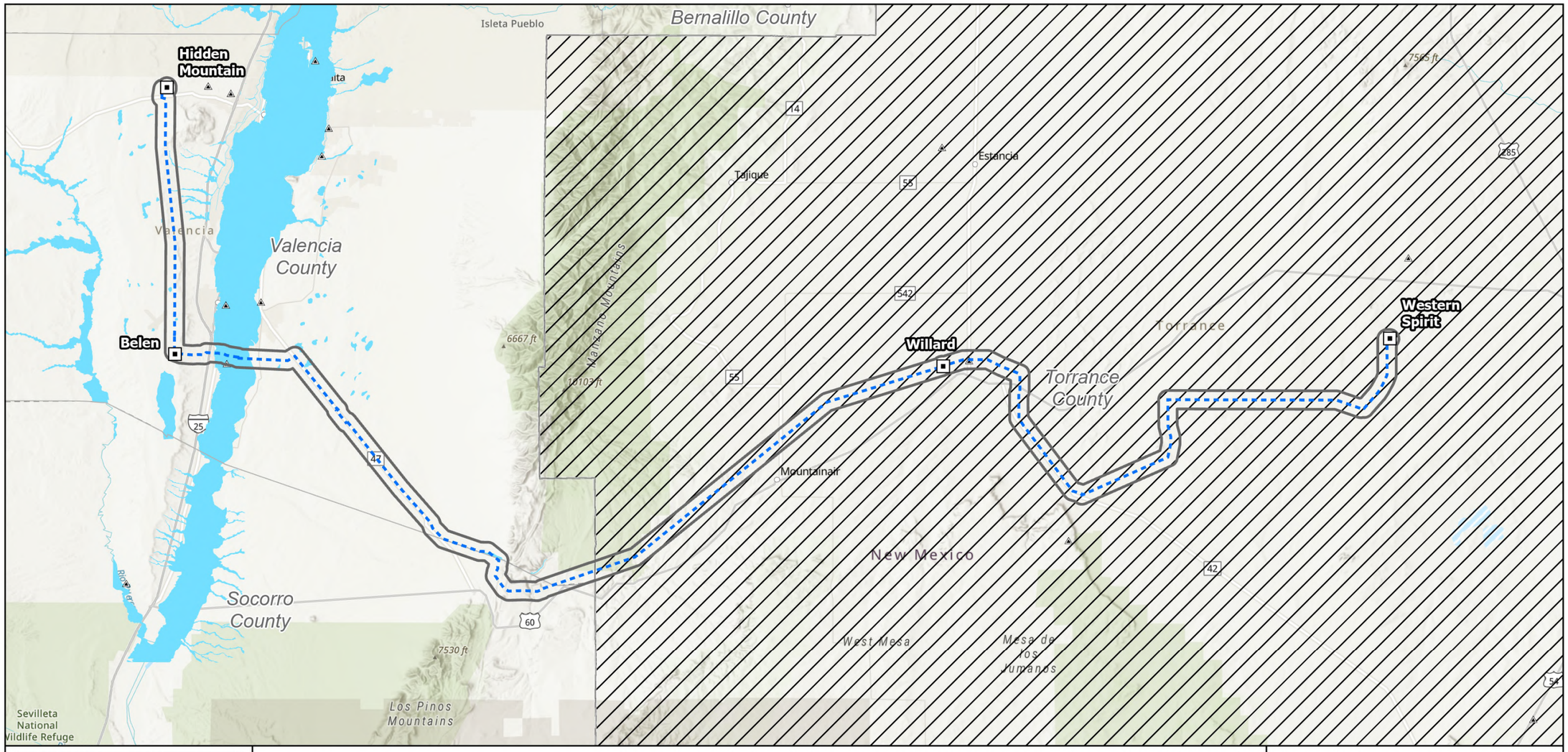
Surface Waters
- NHD Flowline Stream/River
- HUC 10 Boundary

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 9
Surface Waters Map
Page 9 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

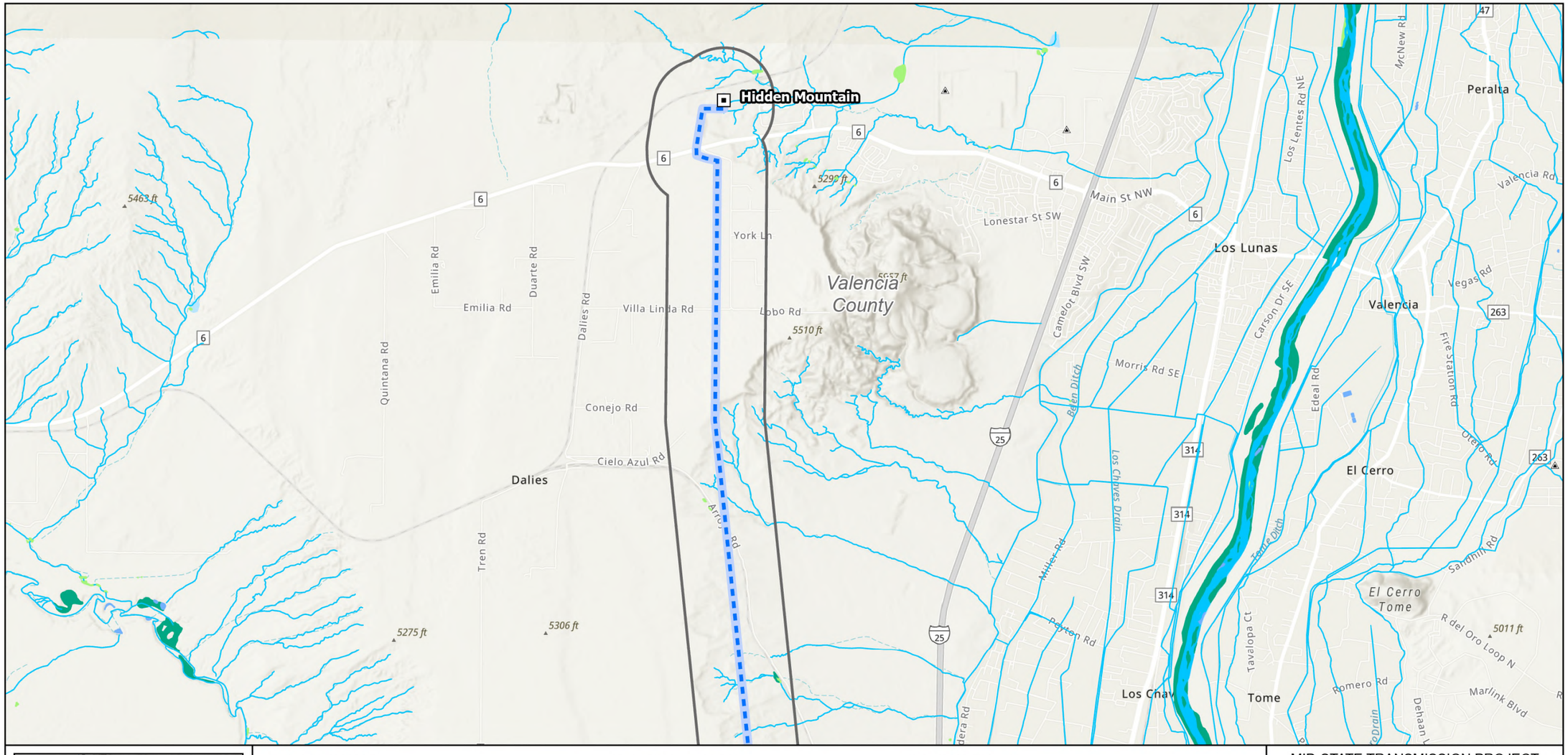
Flood Zones
- FEMA - Zone A
- Not Mapped

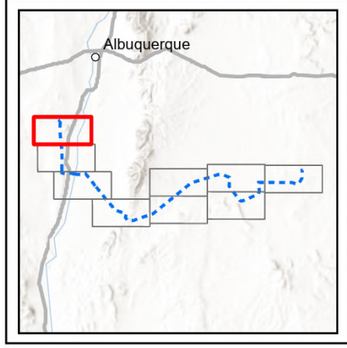
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 10
Flood Zone Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

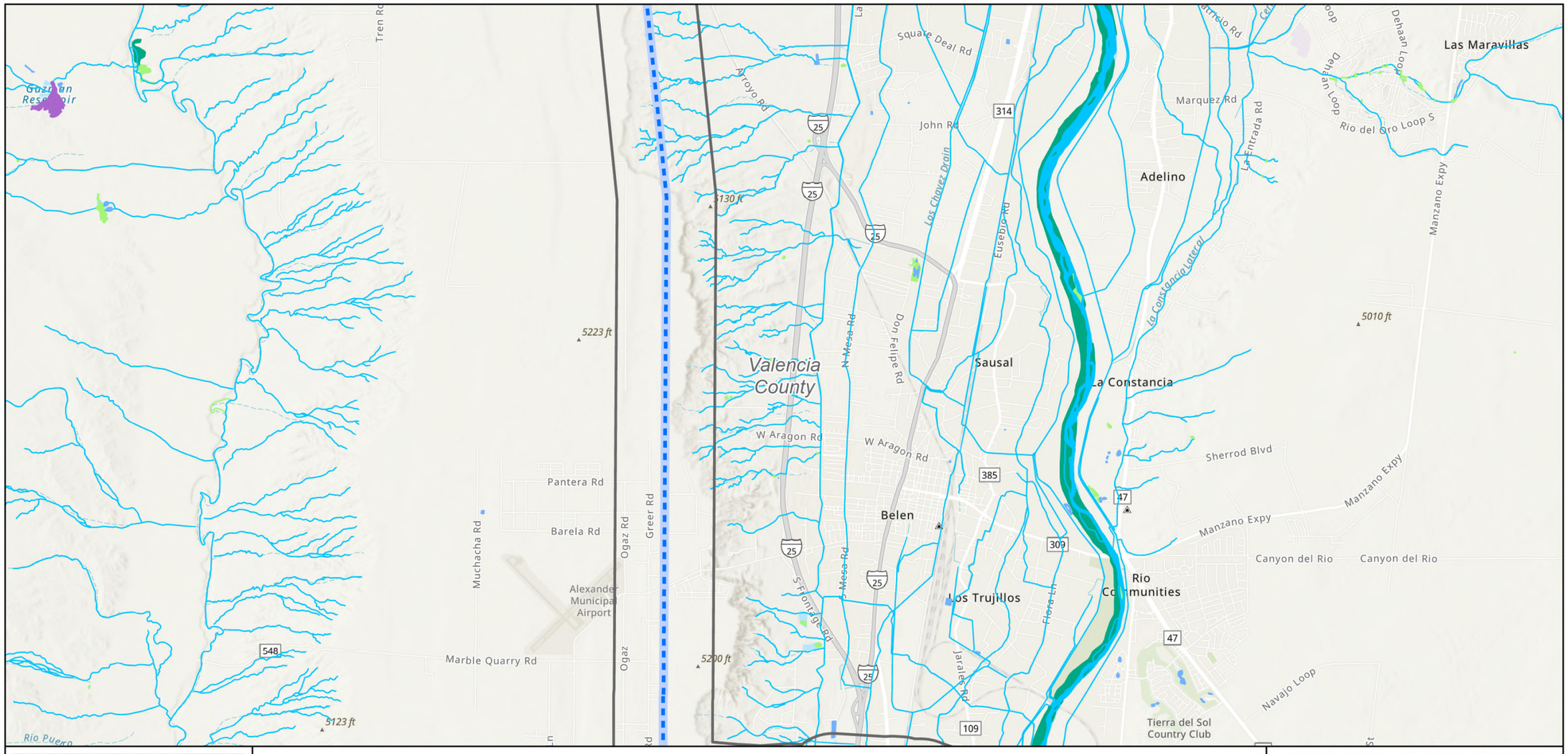
Reference Features
- Existing Substation
- County Boundary

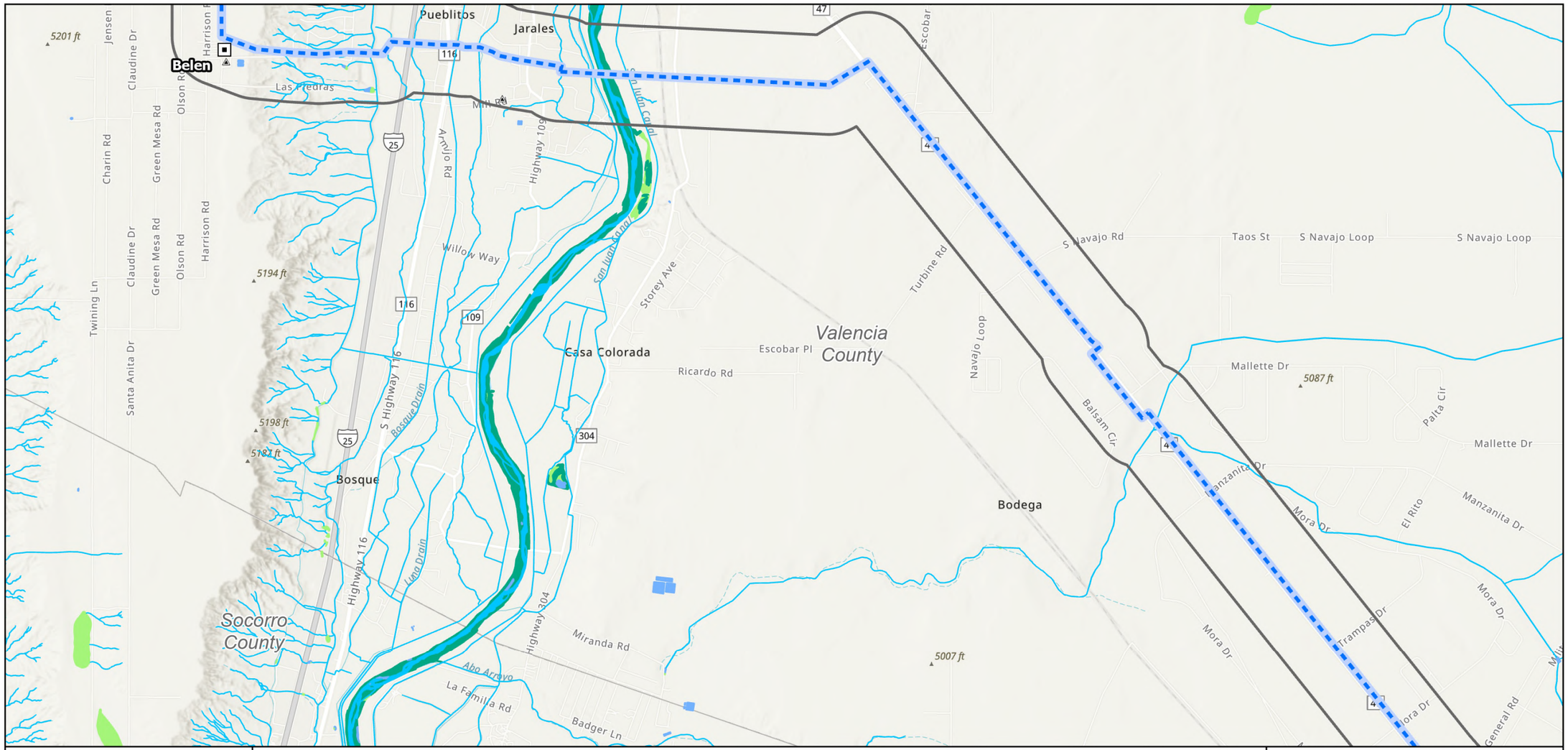
MID-STATE TRANSMISSION PROJECT

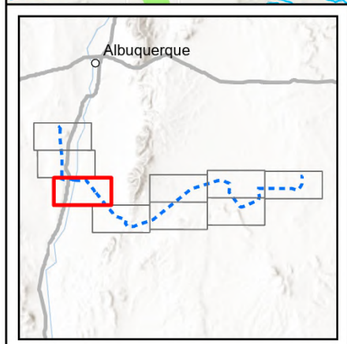
Exhibit 11
National Wetland
Inventory Map
Page 1 of 9

0 1 2 Miles

wsp


Guzman Reservoir
Tren Rd
Arroyo Rd
Square Deal Rd
John Rd
314
Marquez Rd
La Entrada Rd
Dehaan Loop
Las Maravillas
Rio del Oro Loop S
Manzano Expy
Adelino
Los Chavez Drain
Eusebio Rd
La Constancia Lateral
5130 ft
5223 ft
5010 ft
Valencia County
N Mesa Rd
Don Felipe Rd
Sausal
La Constancia
W Aragon Rd
Sherrod Blvd
385
47
Pantera Rd
Barela Rd
Muchacha Rd
Ogaz Rd
Greer Rd
Belen
309
Manzano Expy
Canyon del Rio
Alexander Municipal Airport
S Mesa Rd
S Frontage Rd
Los Trujillos
Horse Ln
Rio Communities
548
Marble Quarry Rd
5200 ft
Jarales Rd
Navajo Loop
Tierra del Sol Country Club
109
5123 ft
Rio Puerco
Albuquerque
Project Components
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
National Wetland Inventory
Freshwater Emergent Wetland
Freshwater Forested/Shrub Wetland
Freshwater Pond
Lake
Riverine
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 11
National Wetland Inventory Map
Page 2 of 9
0
1
2
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

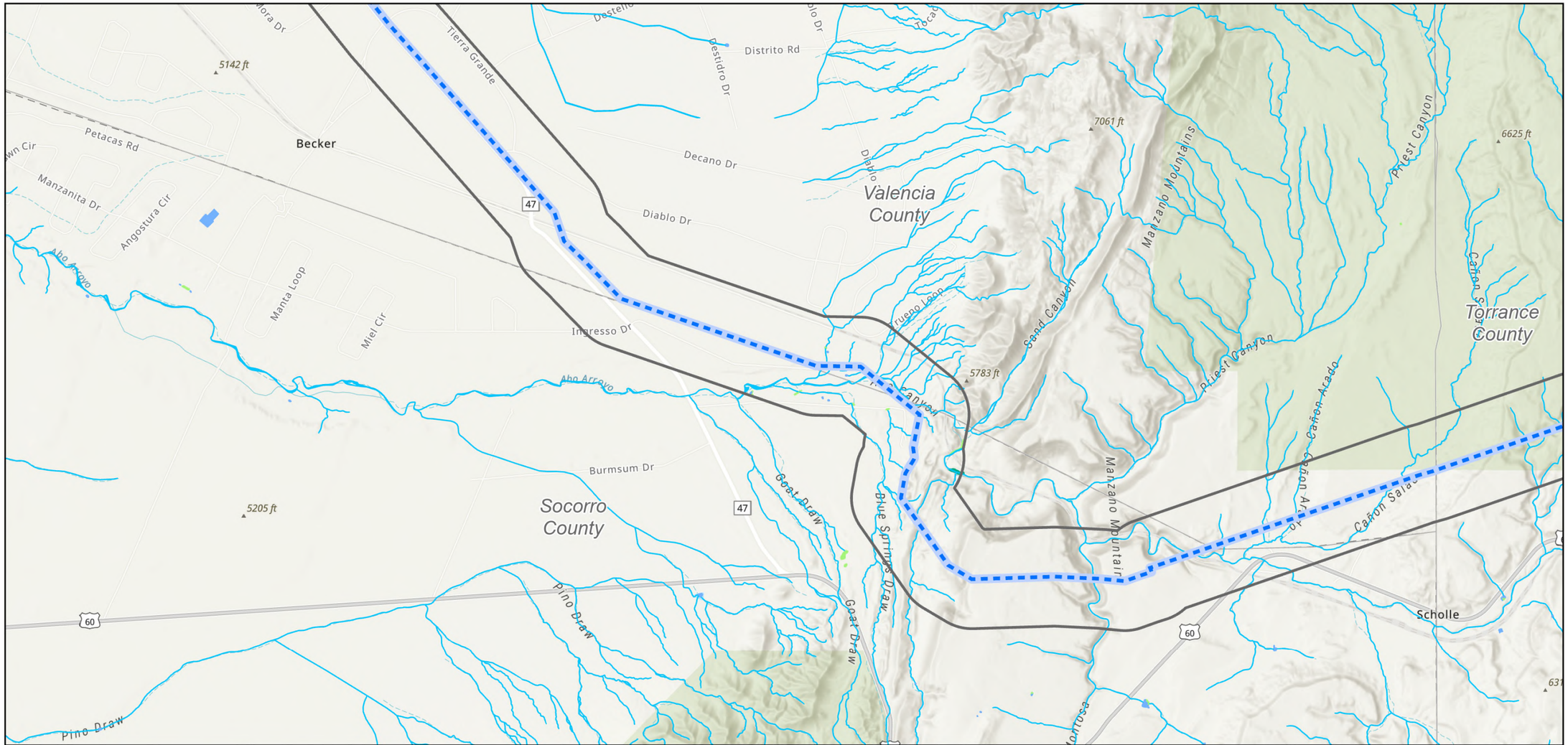
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland
Inventory Map
Page 3 of 9

0 1 2 Miles

wsp



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

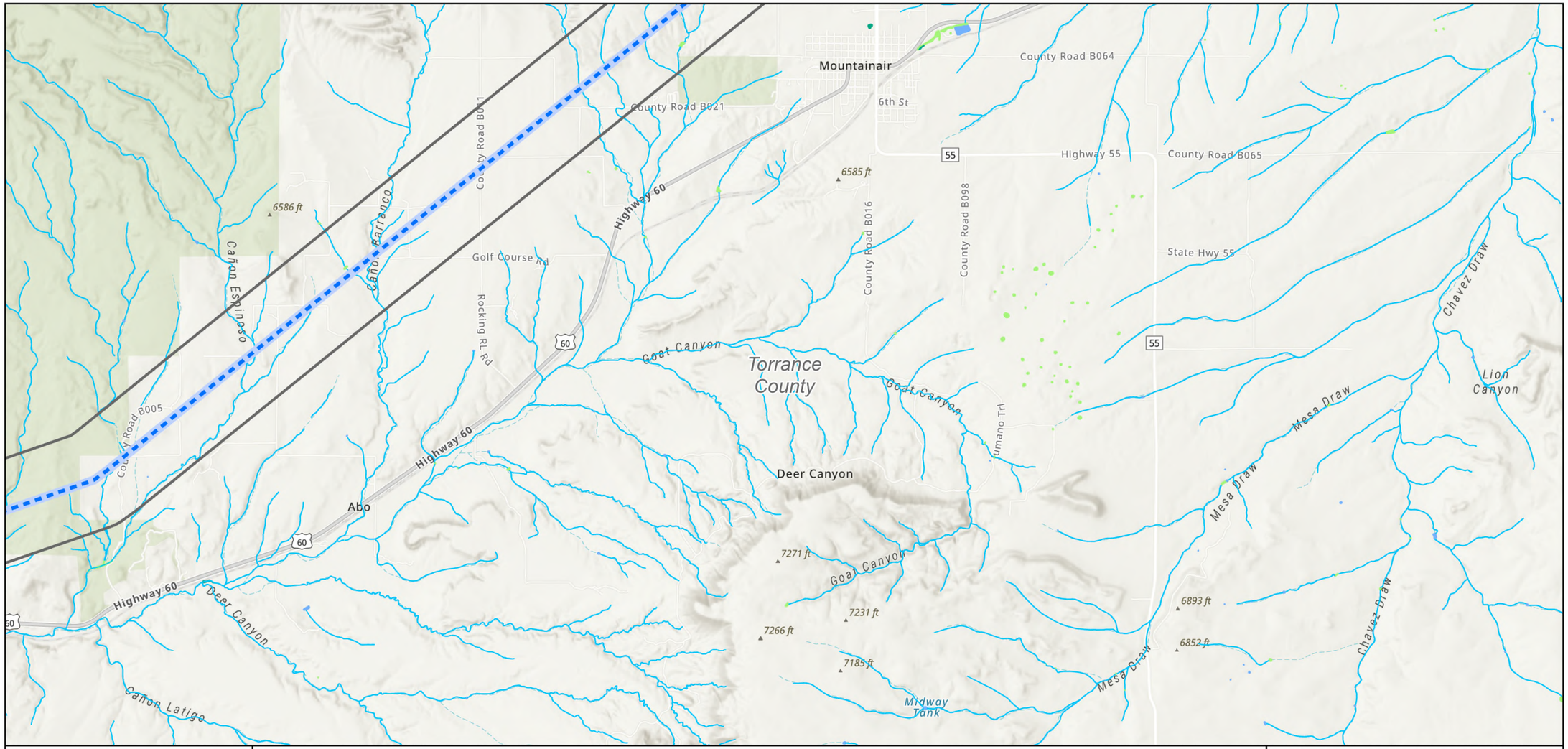
National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

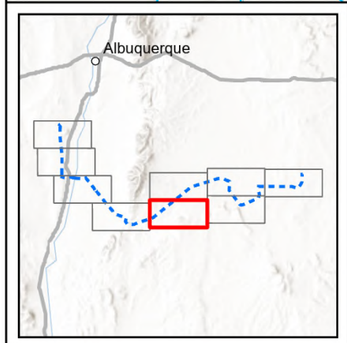
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland
Inventory Map
Page 4 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

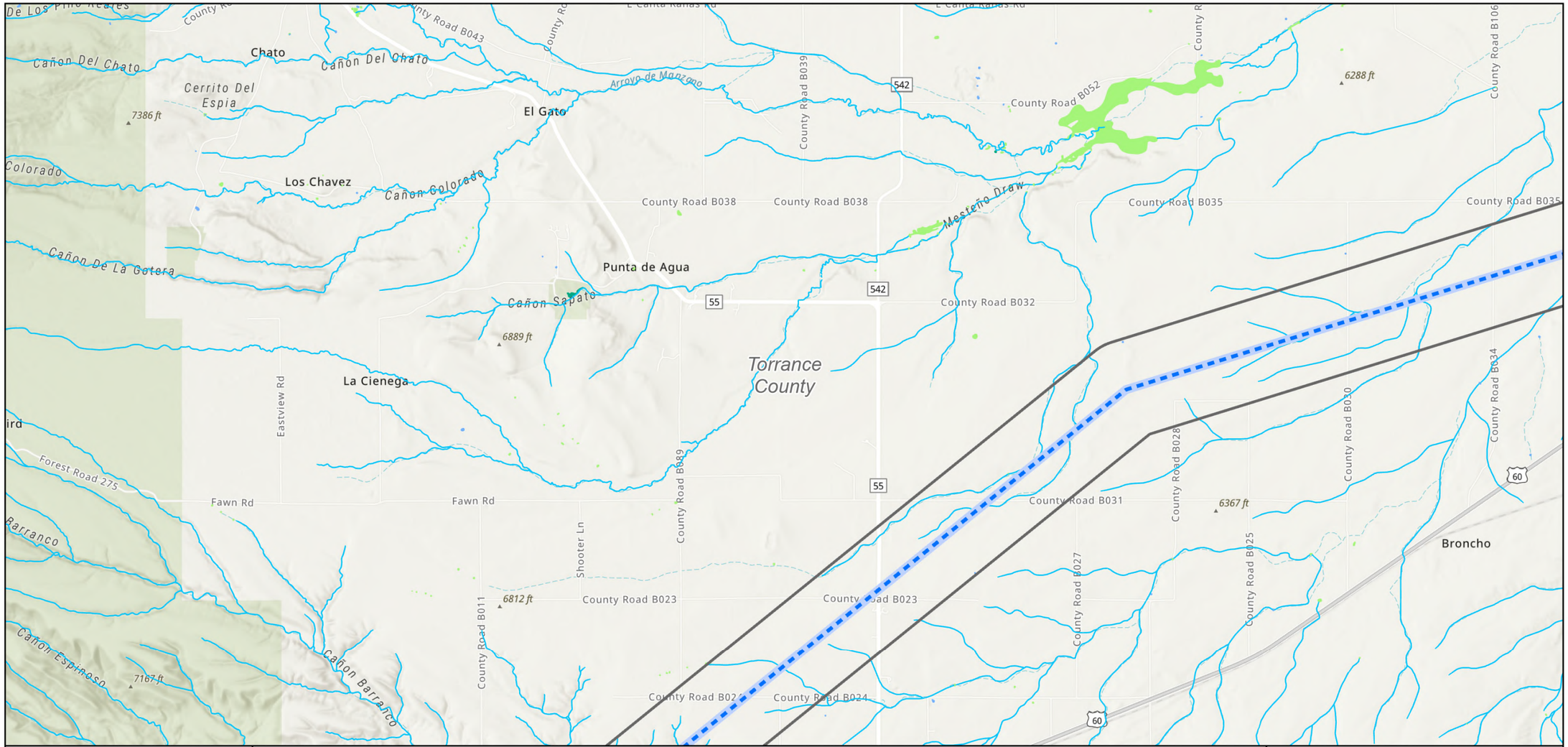
National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

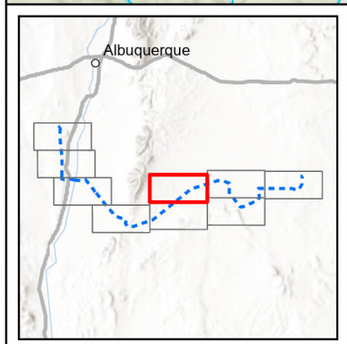
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland
Inventory Map
Page 5 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

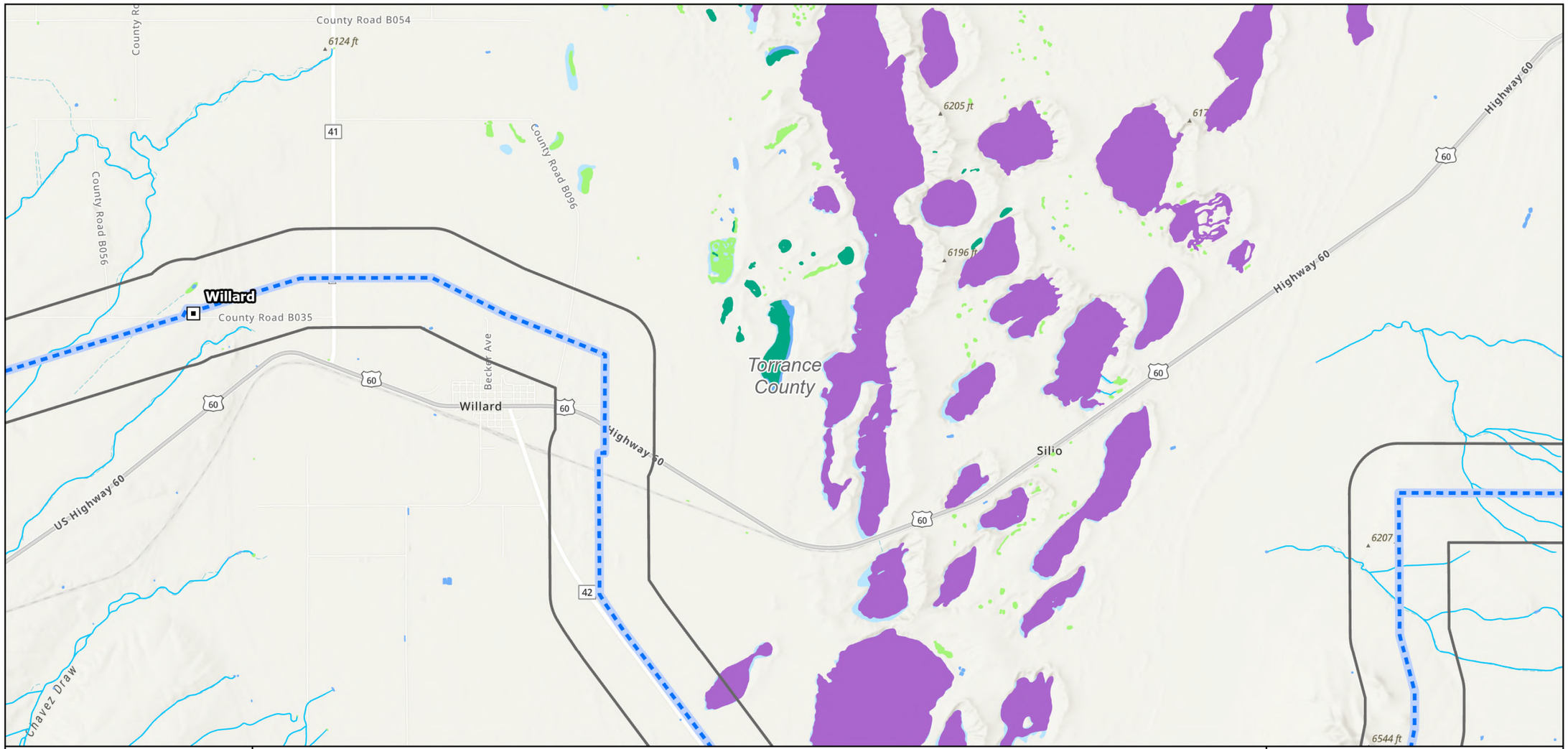
Reference Features
- County Boundary

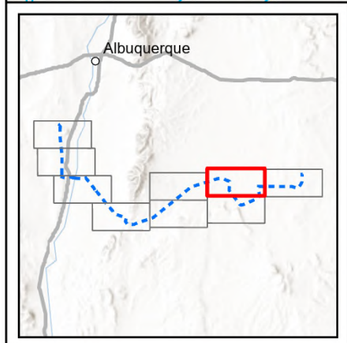
MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland
Inventory Map
Page 6 of 9

0 1 2 Miles

wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

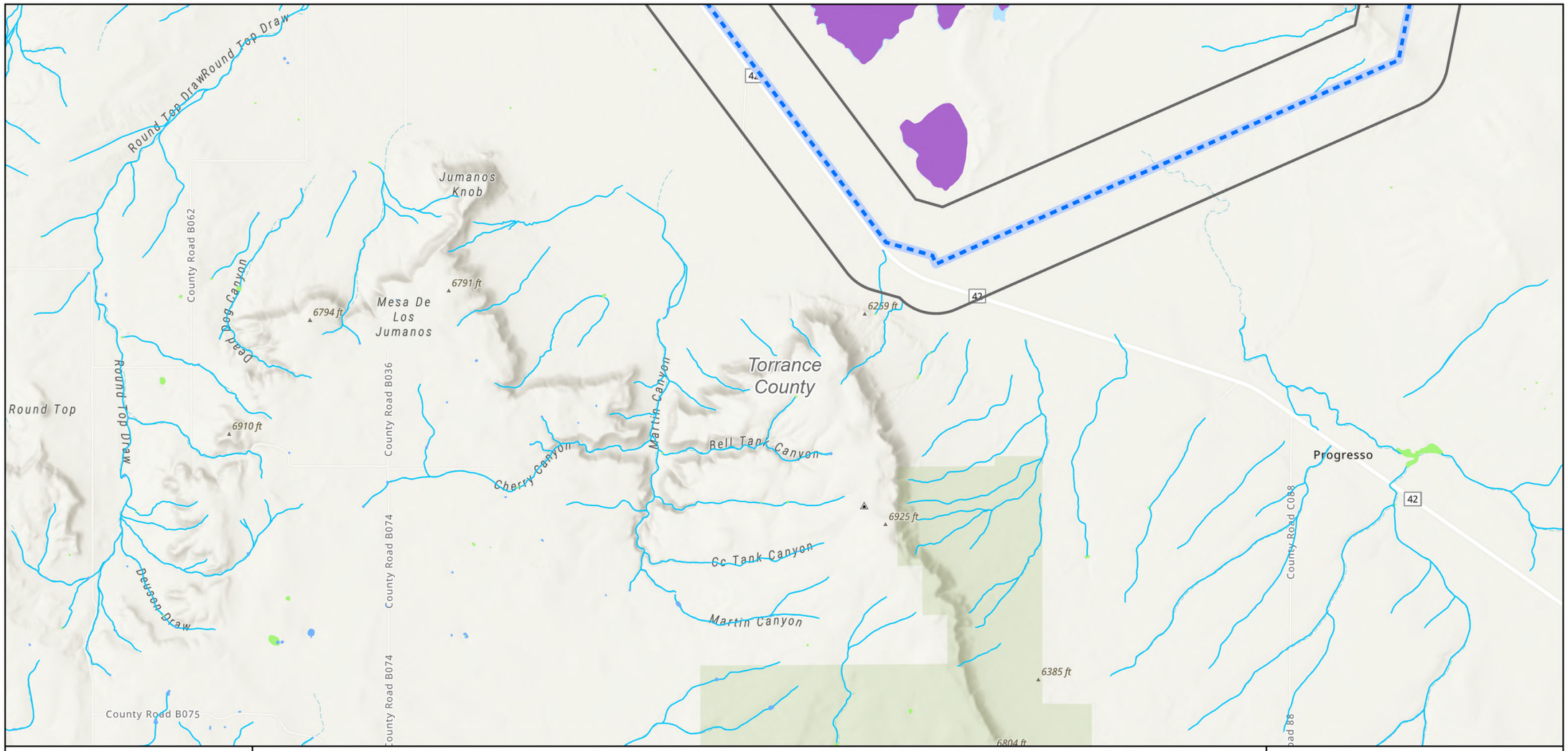
National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

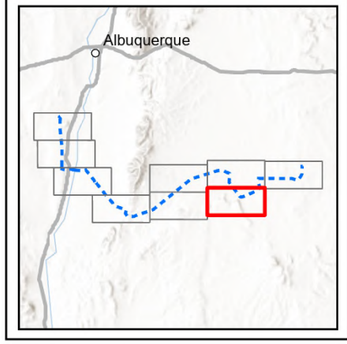
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland
Inventory Map
Page 7 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

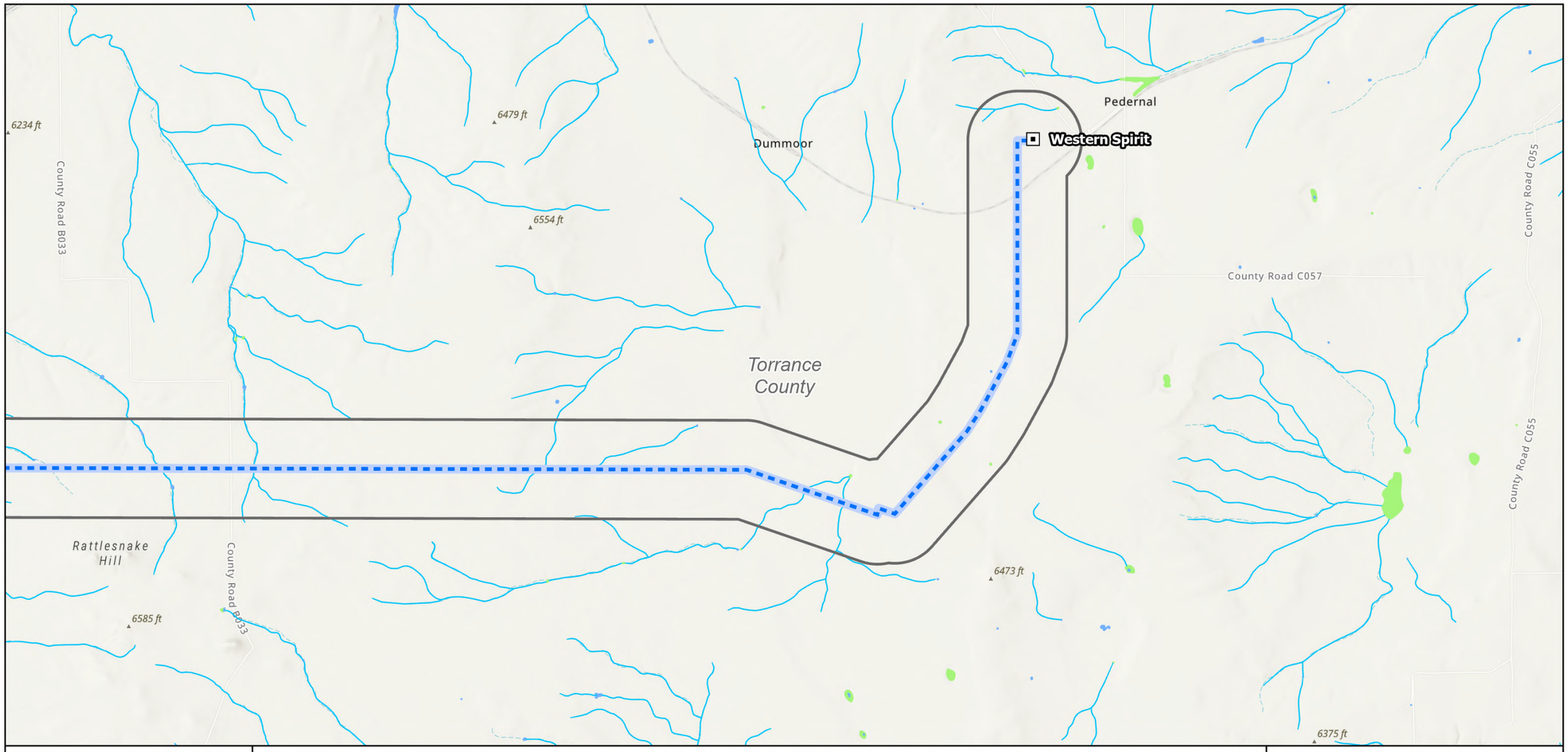
National Wetland Inventory
- Freshwater Emergent Wetland
- Freshwater Pond
- Lake
- Riverine

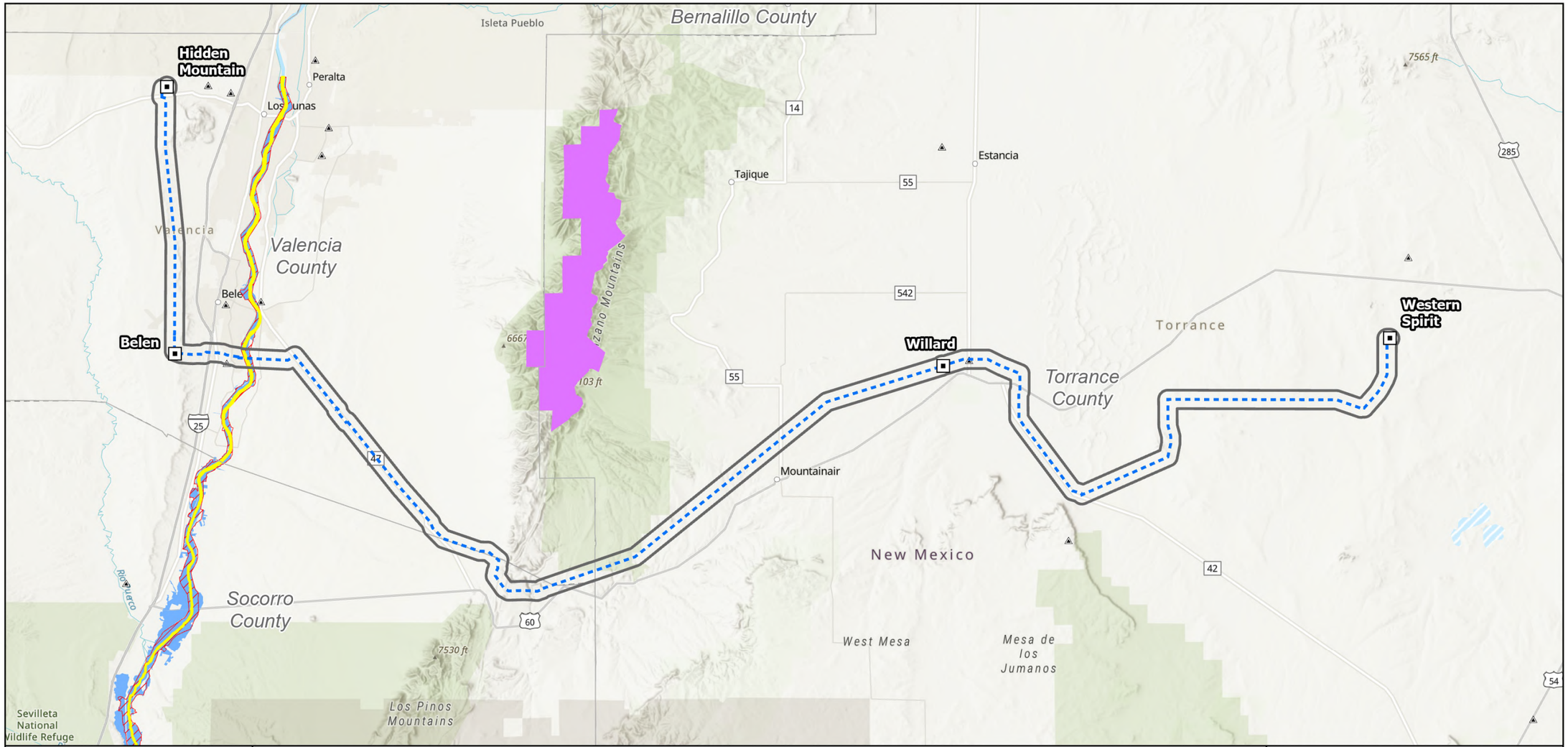
Reference Features
- Existing Substation
- County Boundary

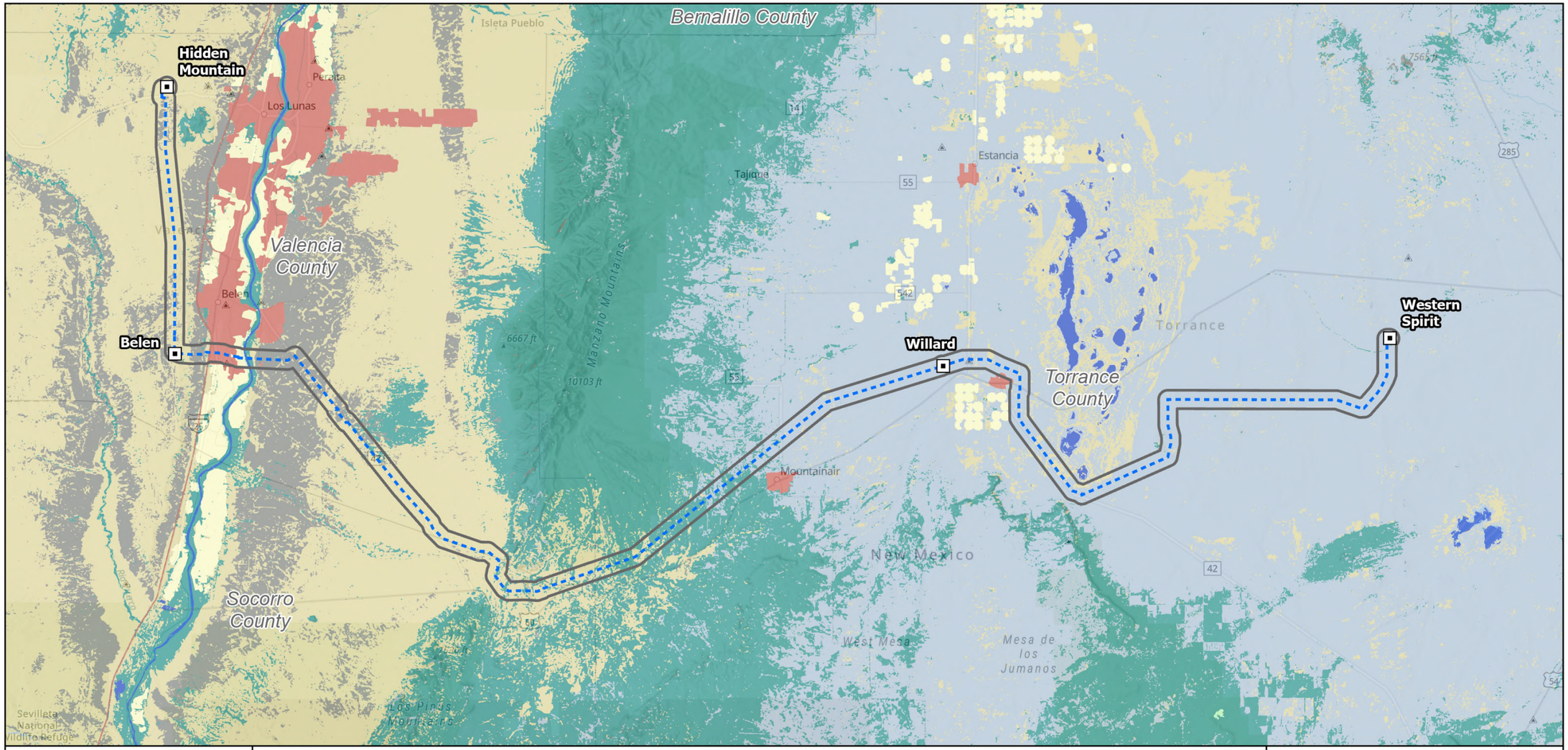
MID-STATE TRANSMISSION PROJECT

Exhibit 11
National Wetland Inventory Map
Page 8 of 9

0 1 2 Miles


6234 ft
County Road B033
6479 ft
6554 ft
Dummoor
Pedernal
Western Spirit
County Road C055
County Road C057
Torrance
County
Rattlesnake
Hill
County Road B033
6585 ft
6473 ft
6375 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
National Wetland Inventory
Freshwater Emergent Wetland
Freshwater Pond
Riverine
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 11
National Wetland
Inventory Map
Page 9 of 9
0
1
2
Miles


Hidden Mountain
Peralta
Los Lunas
Isleta Pueblo
Bernalillo County
7565 ft
14
Estancia
Tajique
55
285
Valencia
Valencia County
Belen
542
Western Spirit
Torrance
Willard
Torrance County
Mountainair
New Mexico
42
25
60
Socorro County
7530 ft
West Mesa
Mesa de los Jumanos
54
Los Pinos Mountains
Sevilleta National Wildlife Refuge
Project Area
NEW MEXICO
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Sensitive Species Habitat
Mexican spotted owl
Rio Grande Silvery Minnow
Yellow-billed Cuckoo
Southwestern willow flycatcher
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 12
Sensitive Habitat Map
0
5
10
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

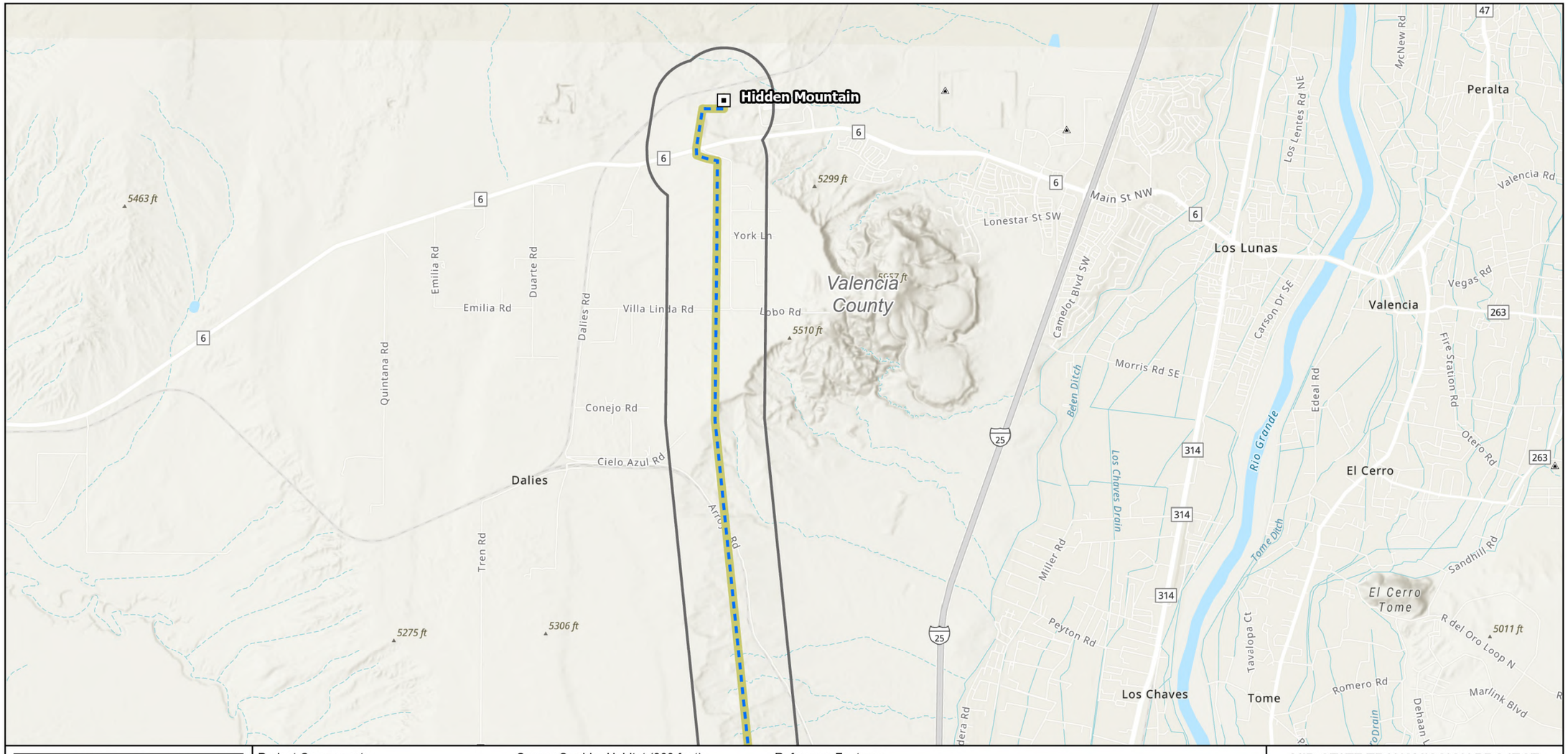
GAP Vegetation
- Agricultural Vegetation
- Developed & Other Human Use
- Forest & Woodland
- Nonvascular & Sparse Vascular Rock Vegetation
- Open Water
- Recently Disturbed or Modified
- Semi-Desert
- Shrubland & Grassland

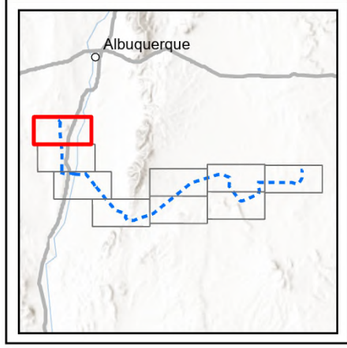
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 13
GAP Analysis Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

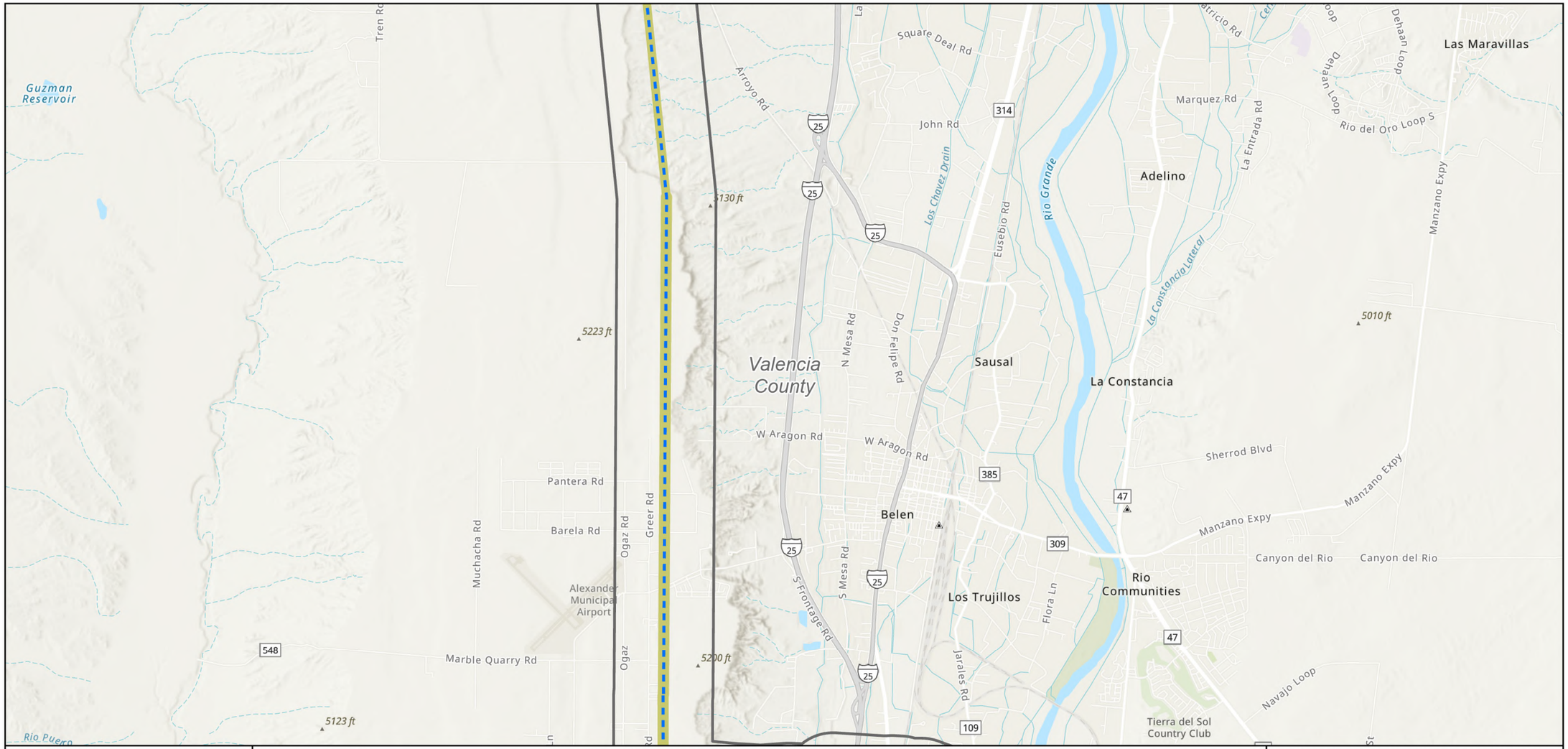
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

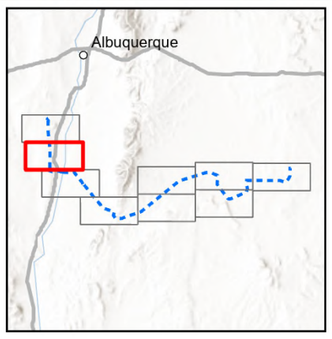
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 1 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

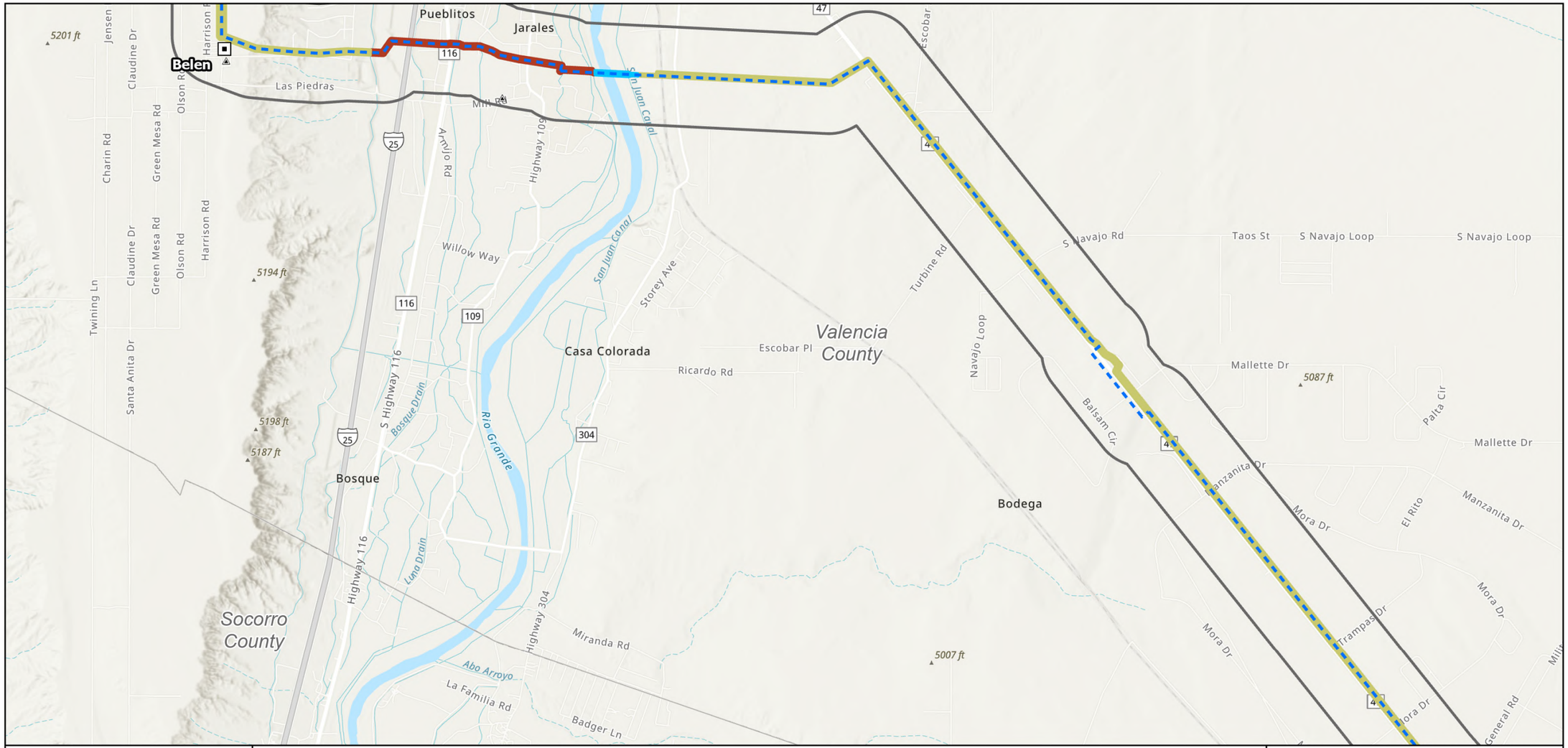
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

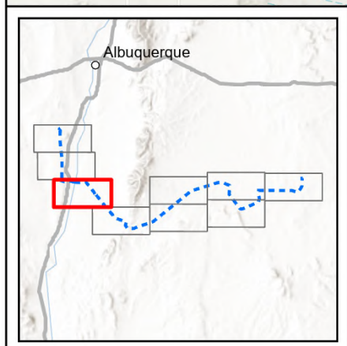
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 2 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

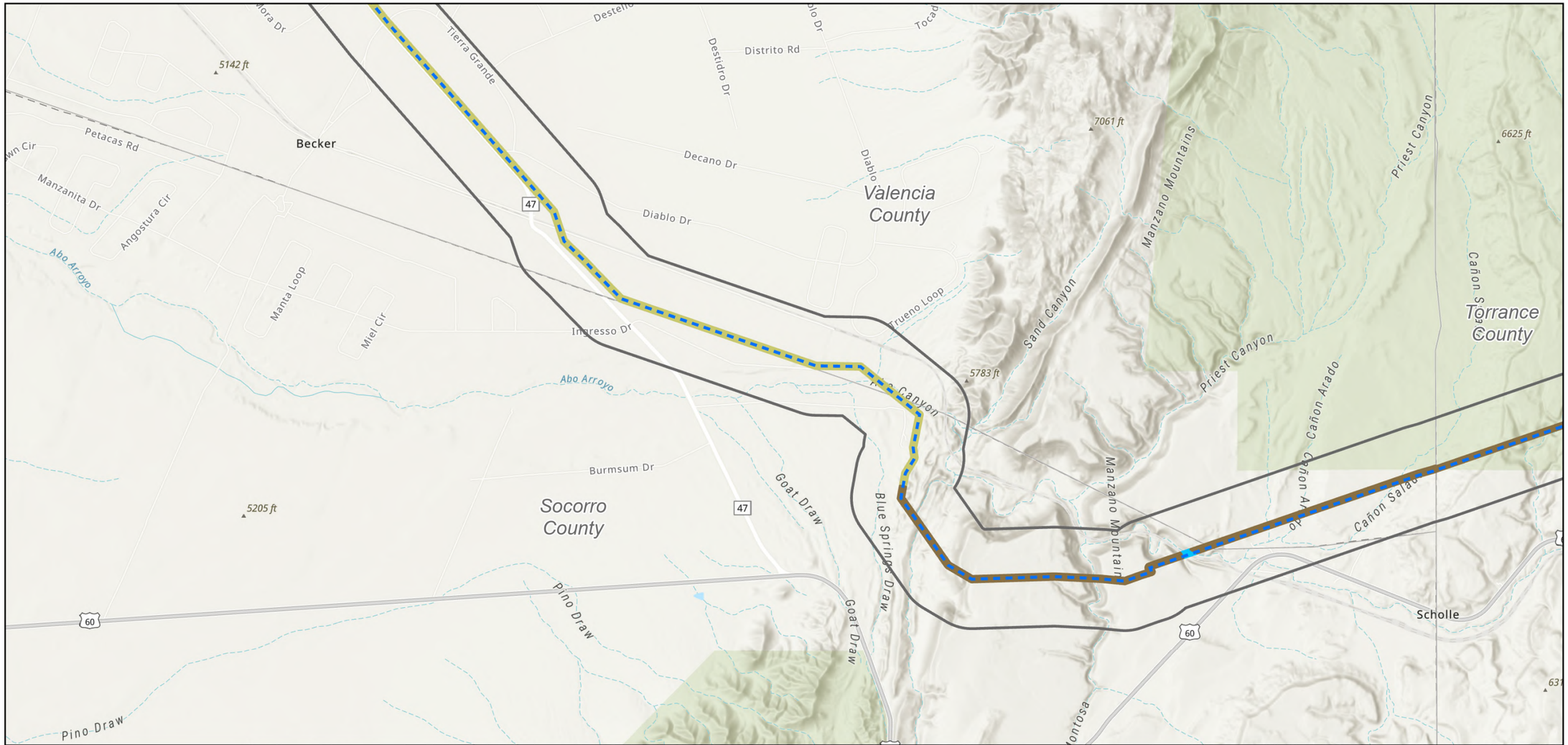
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

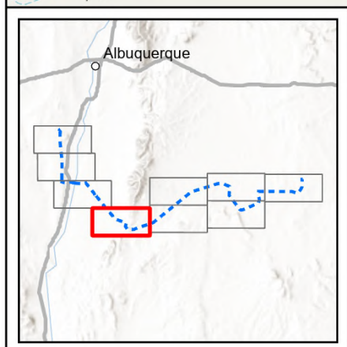
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 3 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

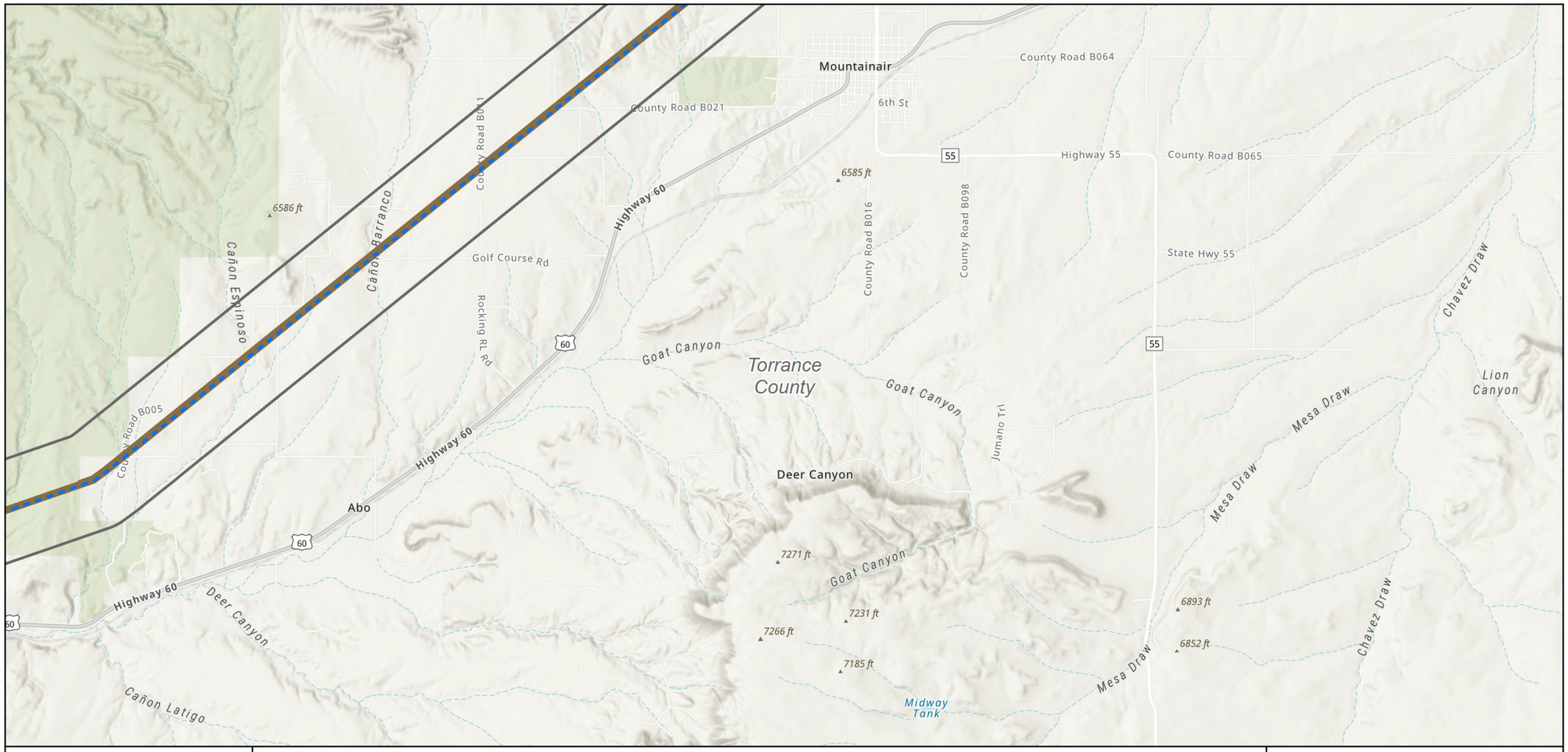
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 4 of 9

0 1 2 Miles



Project Components
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

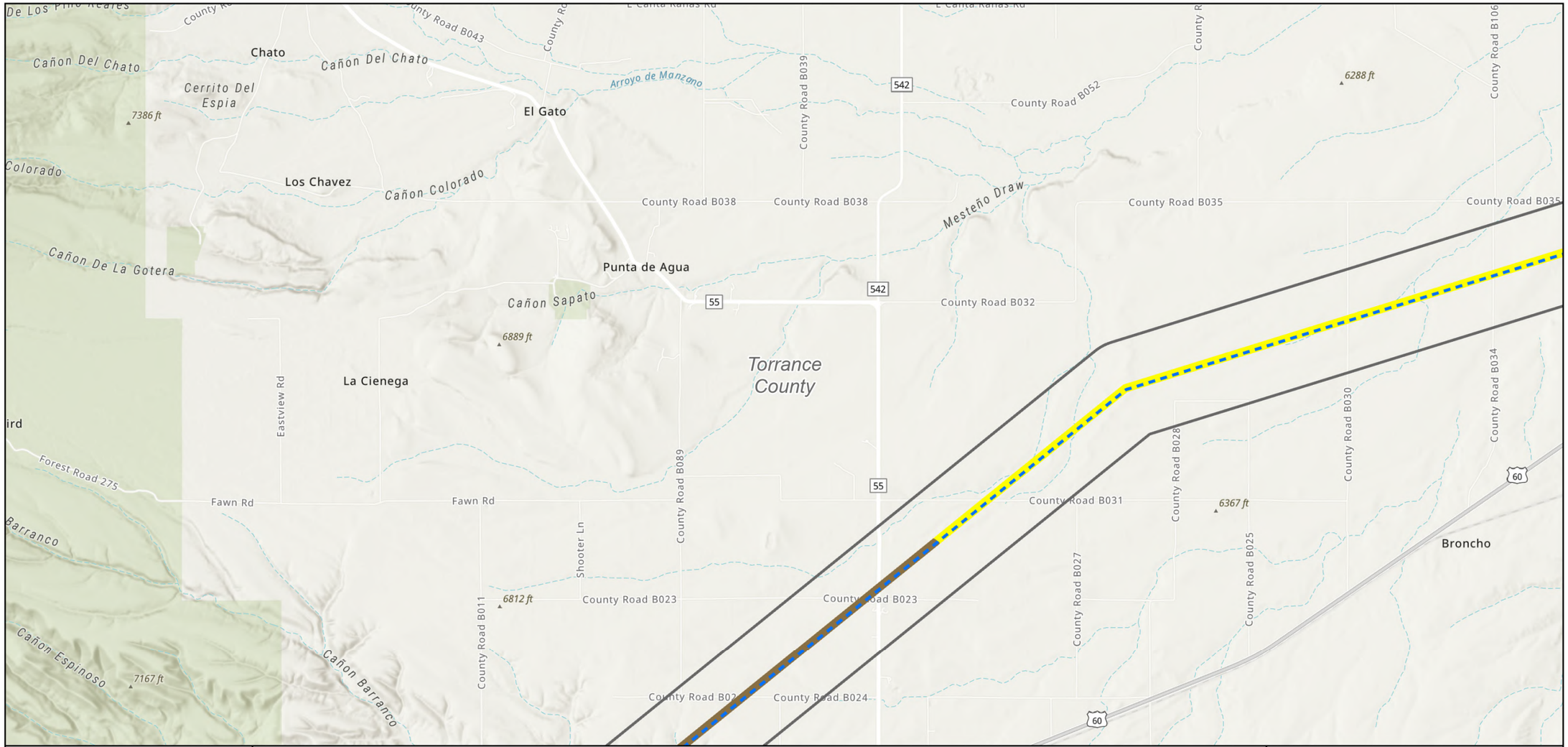
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

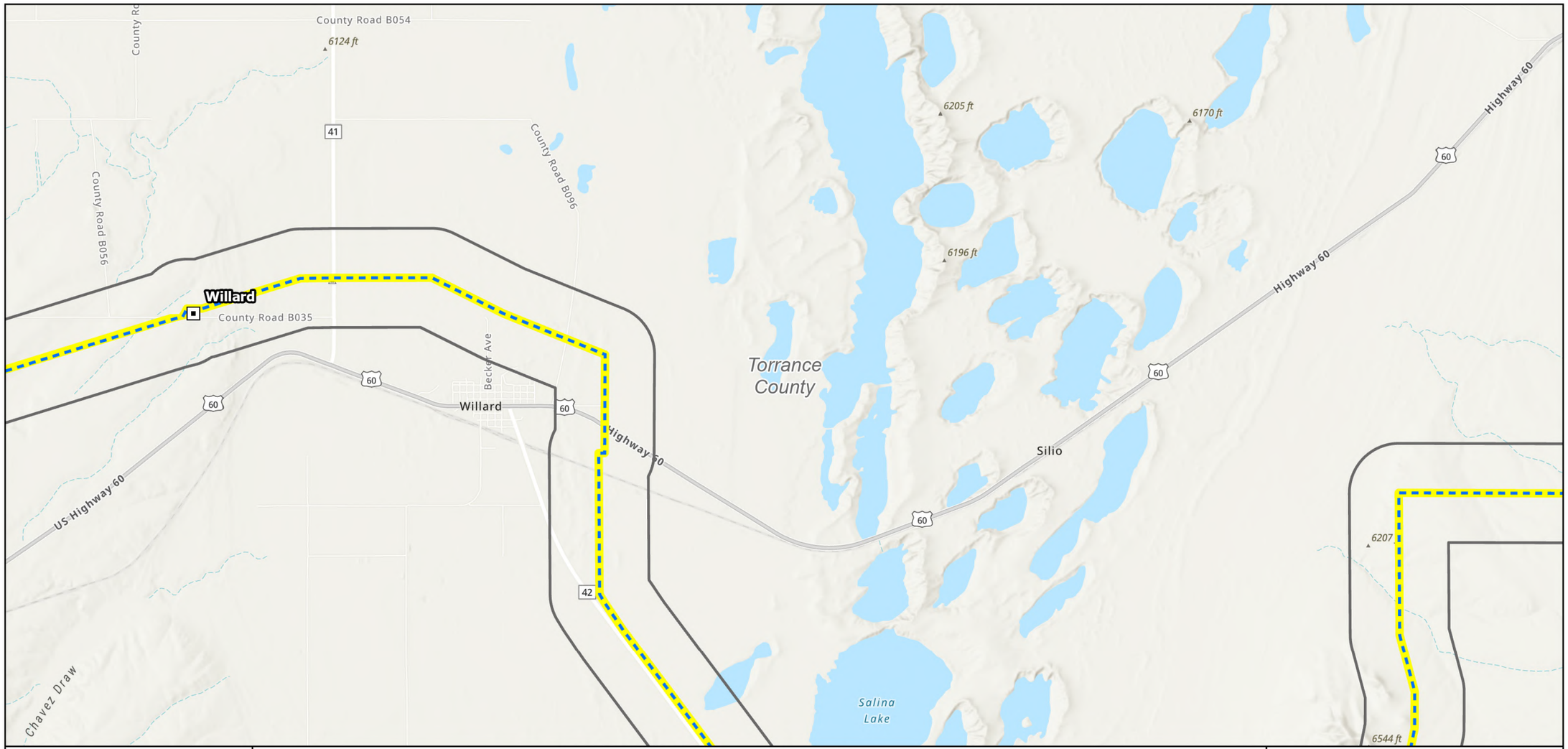
Reference Features
- County Boundary

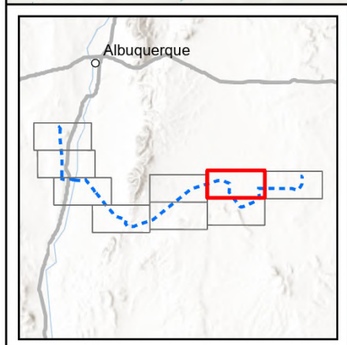
MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 5 of 9

0 1 2 Miles


Chato
Cañon Del Chato
Cerrito Del Espia
7386 ft
El Gato
Arroyo de Manzano
County Road B039
542
County Road B052
6288 ft
County Road B106
Colorado
Los Chavez
Cañon Colorado
County Road B038
County Road B038
Mesteño Draw
County Road B035
County Road B035
Cañon De La Gotera
Punta de Agua
Cañon Sapato
55
542
County Road B032
6889 ft
Torrance County
La Cienega
Eastview Rd
ird
Forest Road 275
Fawn Rd
Fawn Rd
Shooter Ln
County Road B089
55
County Road B031
6367 ft
County Road B028
County Road B030
County Road B034
60
Broncho
Barranco
6812 ft
County Road B023
County Road B023
County Road B011
County Road B027
County Road B025
Cañon Espinoso
7167 ft
Cañon Barranco
County Road B024
60
Albuquerque
Project Components
Transmission Centerline
Transmission Study Corridor (1 Mile)
Survey Corridor Habitat (300 feet)
Agriculture/Developed
Desert Scrub
Grassland
Riparian
Woodland
Reference Features
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 14
Field Verified Vegetation Map
Page 6 of 9
0
1
2
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

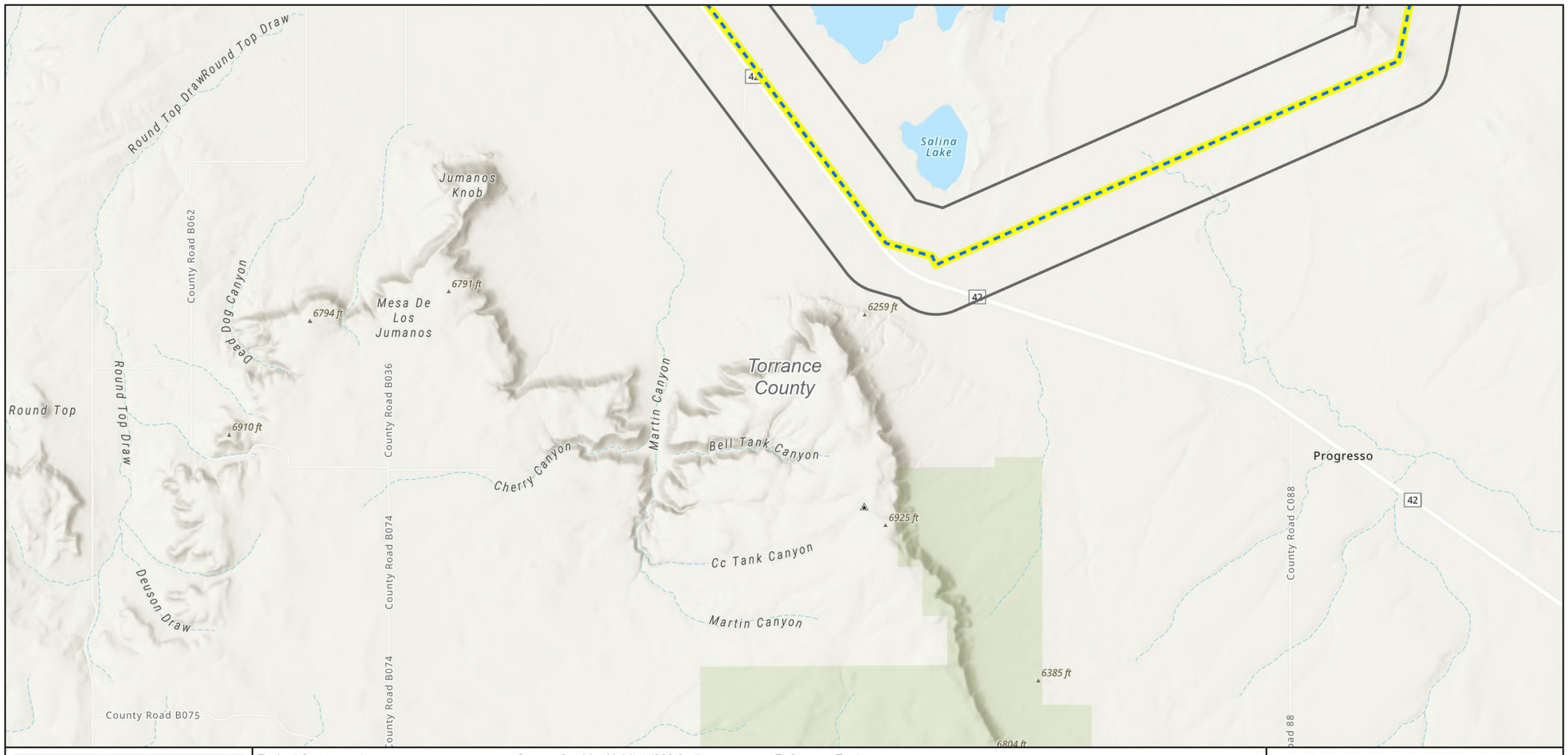
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

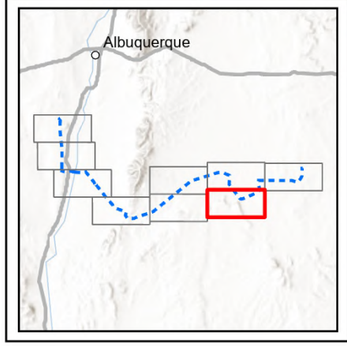
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 7 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

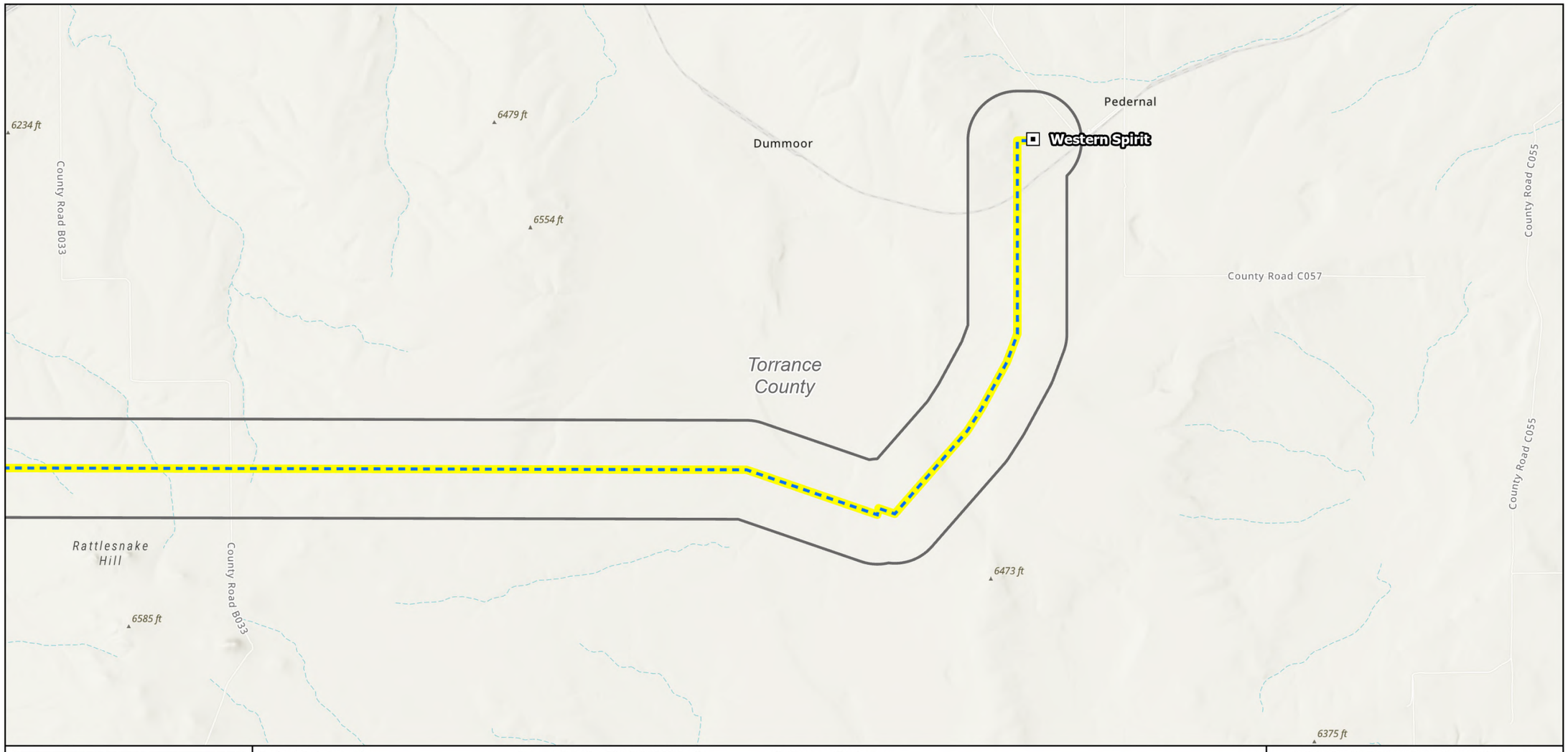
Survey Corridor Habitat (300 feet)
- Agriculture/Developed
- Desert Scrub
- Grassland
- Riparian
- Woodland

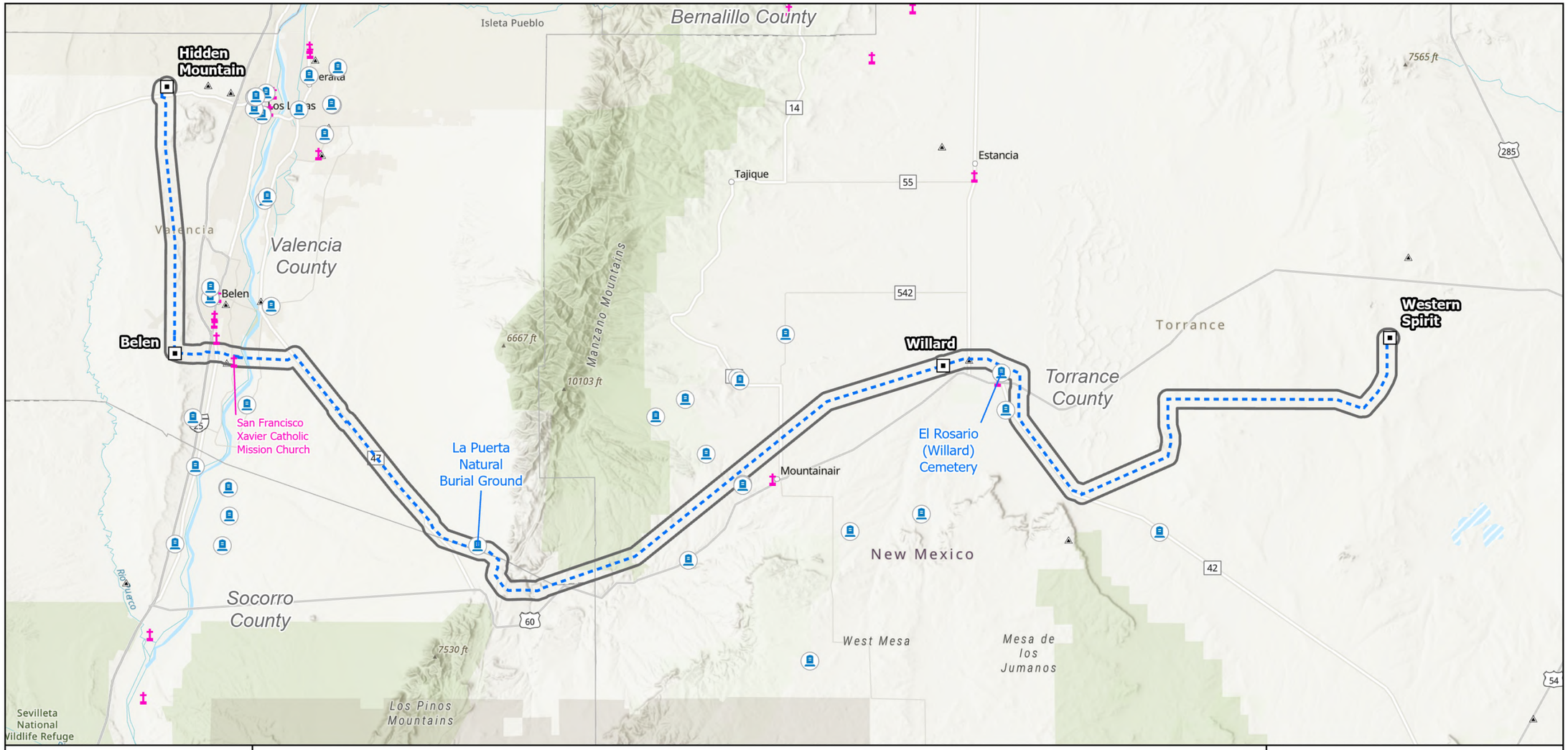
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 14
Field Verified Vegetation Map
Page 8 of 9

0 1 2 Miles


6234 ft
County Road B033
6479 ft
6554 ft
Dummoor
Pedernal
Western Spirit
County Road C055
County Road C057
Torrance
County
Rattlesnake
Hill
County Road B033
6585 ft
6473 ft
6375 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Survey Corridor Habitat (300 feet)
Agriculture/Developed
Desert Scrub
Grassland
Riparian
Woodland
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 14
Field Verified Vegetation Map
Page 9 of 9
0
1
2
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

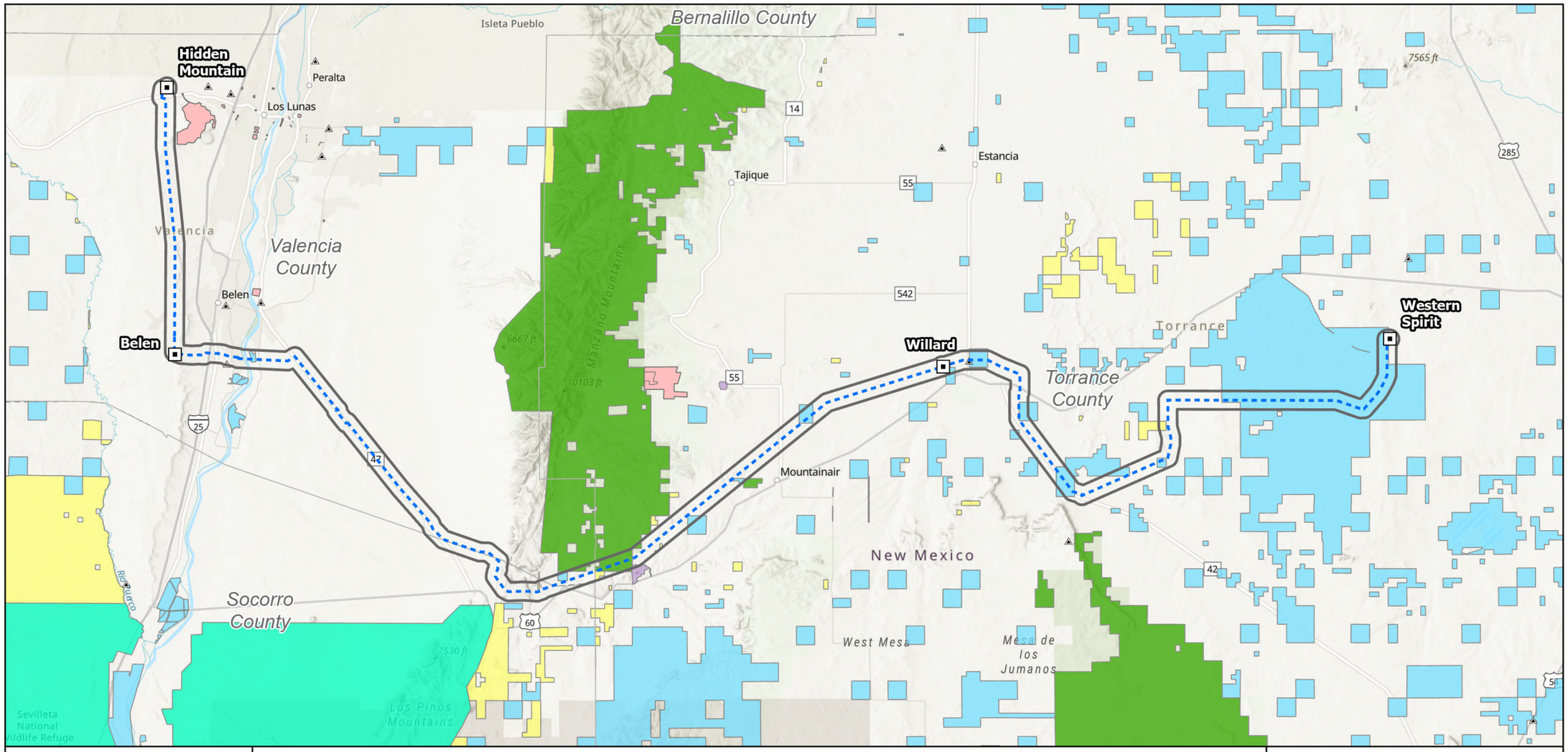
Religious Sites and Cemeteries
- Church
- Cemetery

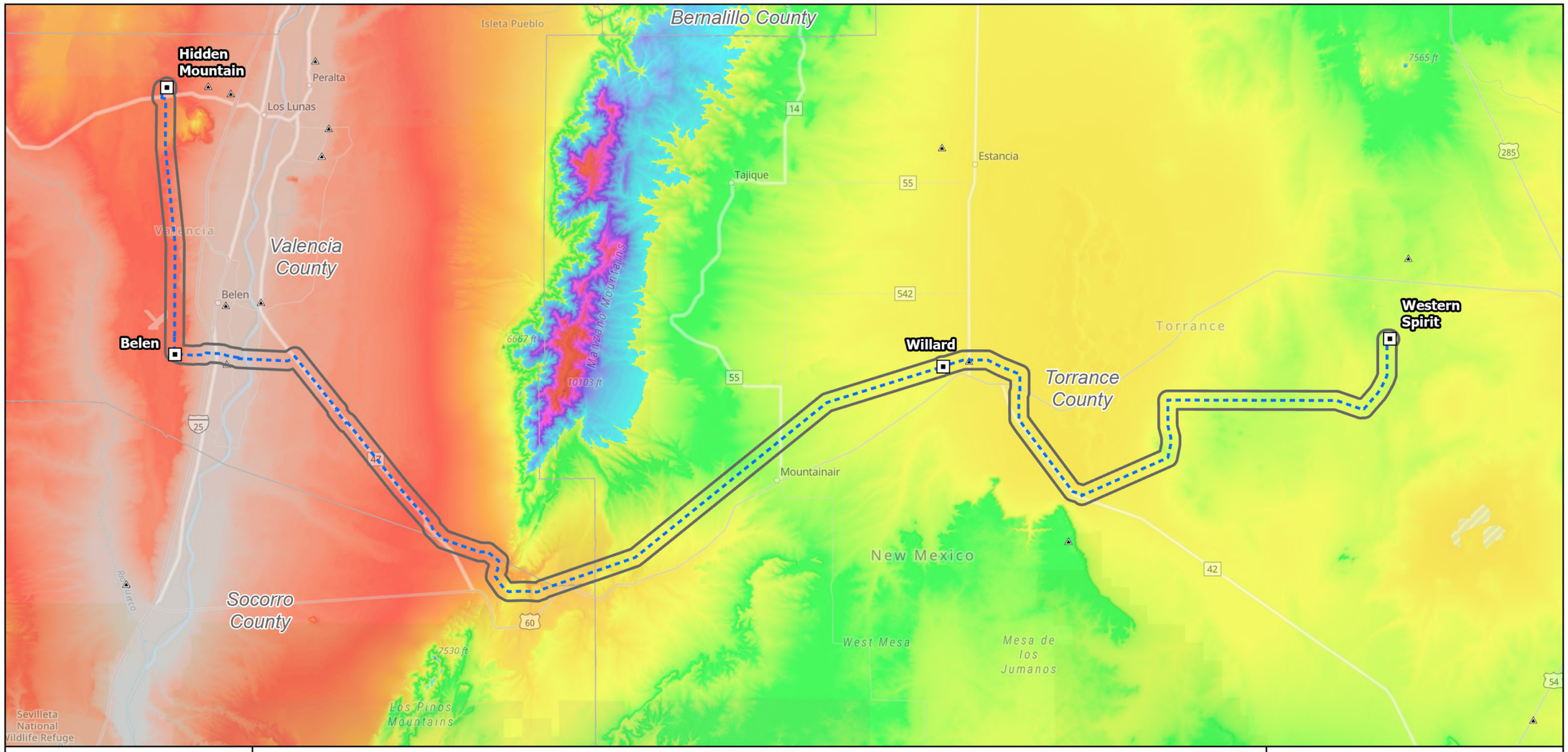
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 15
Religious Sites and Cemeteries Map

0 5 10 Miles


Hidden Mountain
Peralta
Los Lunas
Isleta Pueblo
Bernalillo County
Tajique
Estancia
7565 ft
285
14
55
542
Valencia
Valencia County
Belen
Belen
25
47
6667 ft
10103 ft
Manzano Mountains
Willard
Torrance
Torrance County
Western Spirit
Mountainair
New Mexico
42
Socorro County
60
7530 ft
West Mesa
Mesa de los Jumanos
Los Pinos Mountains
Sevilleta National Wildlife Refuge
Rio Puerco
NEW MEXICO
Project Area
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Public Lands and Easements
Bureau of Land Management
Fish & Wildlife Service
Forest Service
National Park Service
State
Other Easement
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 16
Public Lands and Easements Map
0
5
10
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

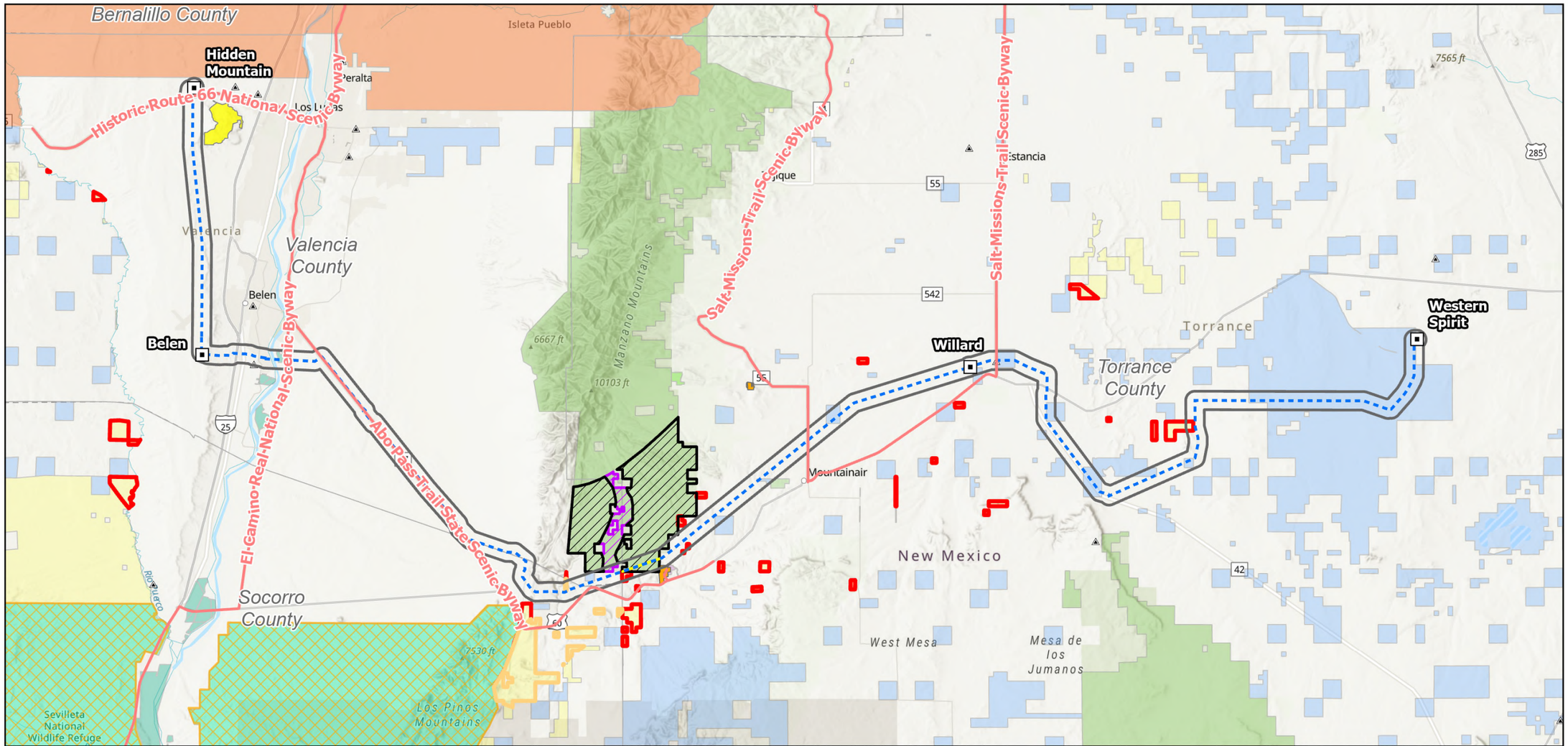
Elevation (Feet)
- High: 11,243
- Low: 1393

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 17
Elevation Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

Surface Management
- Bureau of Land Management
- Forest Service
- Fish & Wildlife Service
- National Park Service
- Tribal Land
- State
- State Game & Fish
- State Park
- Private

Visual Resources
- Salinas Pueblo Missions National Monument
- El Cerro de Los Lunas Preserve
- Sevilleta National Wildlife Preserve
- Scenic Byway
- BLM VRM Class III
- BLM VRM Class IV
- High SIO
- Moderate SIO
- Low SIO

Reference Features
- Existing Substation
- County Boundary

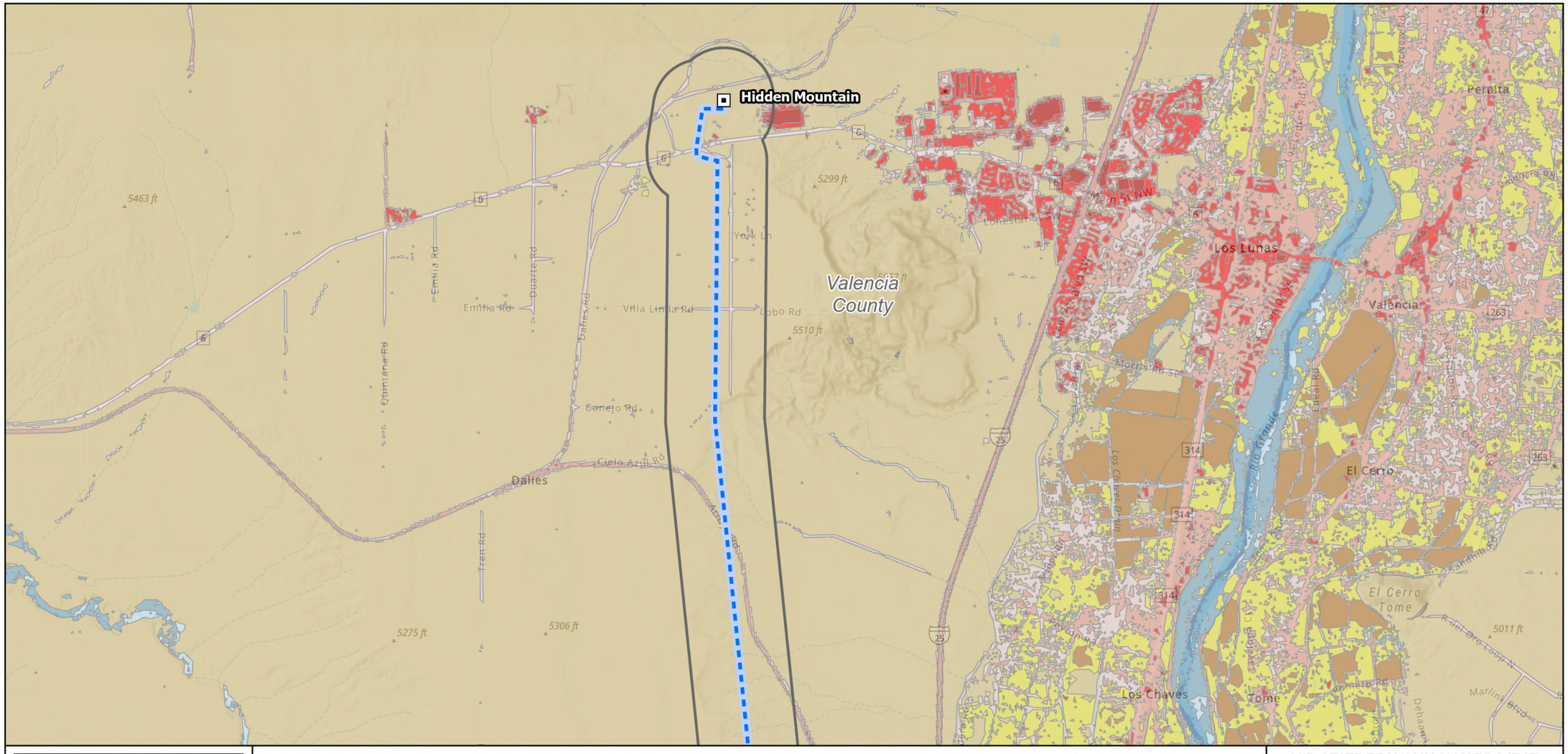
MID-STATE TRANSMISSION PROJECT

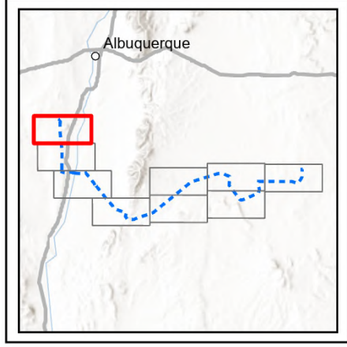
Exhibit 18
Visual Resources Map

N

0 5 10 Miles

wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

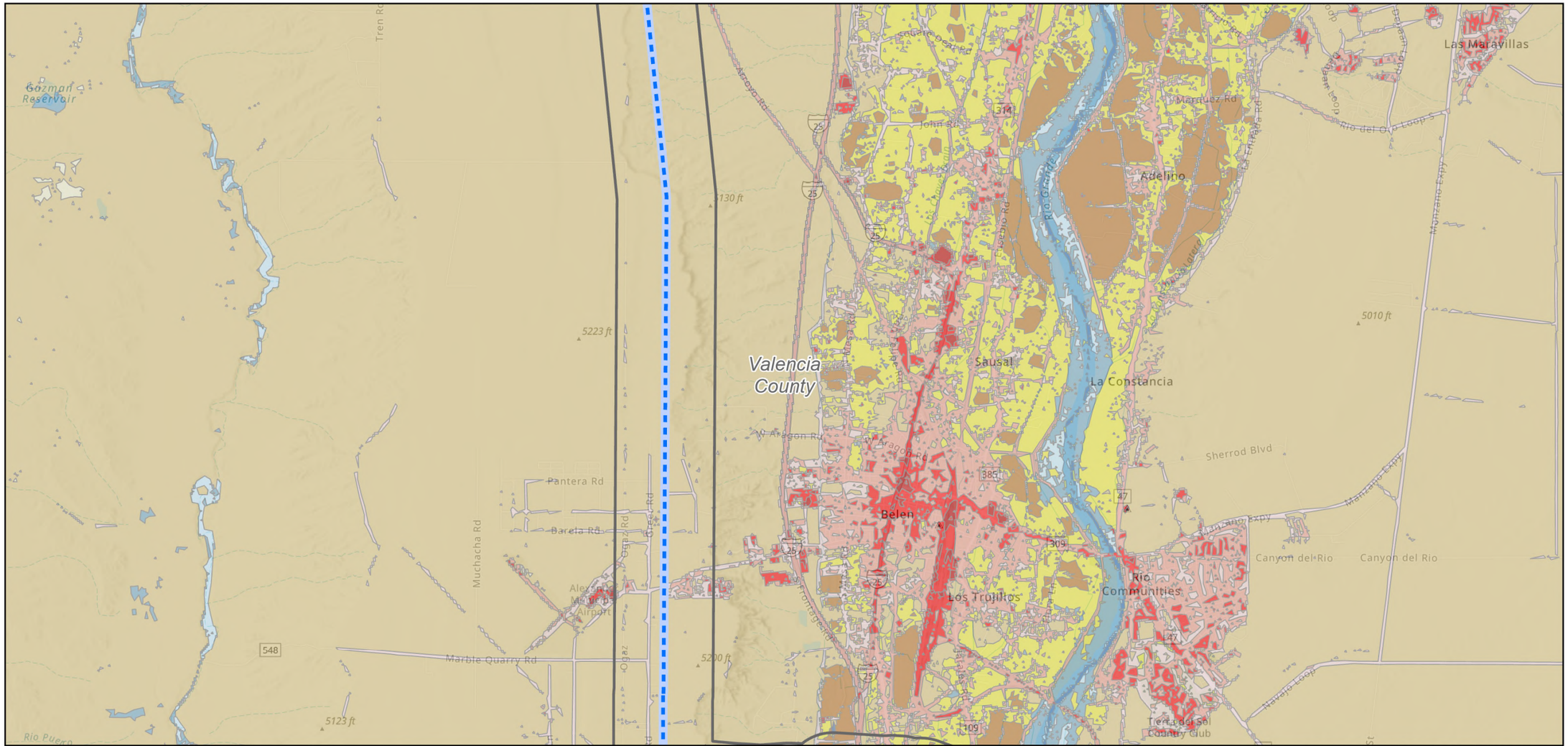
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed,High Intensity
- Barren Land (Rock/Sand/Clay)
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

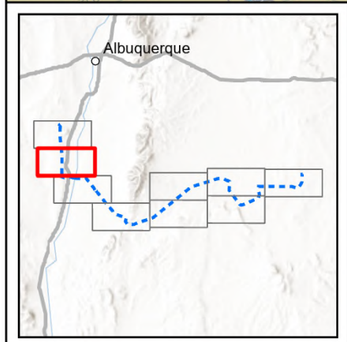
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 1 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

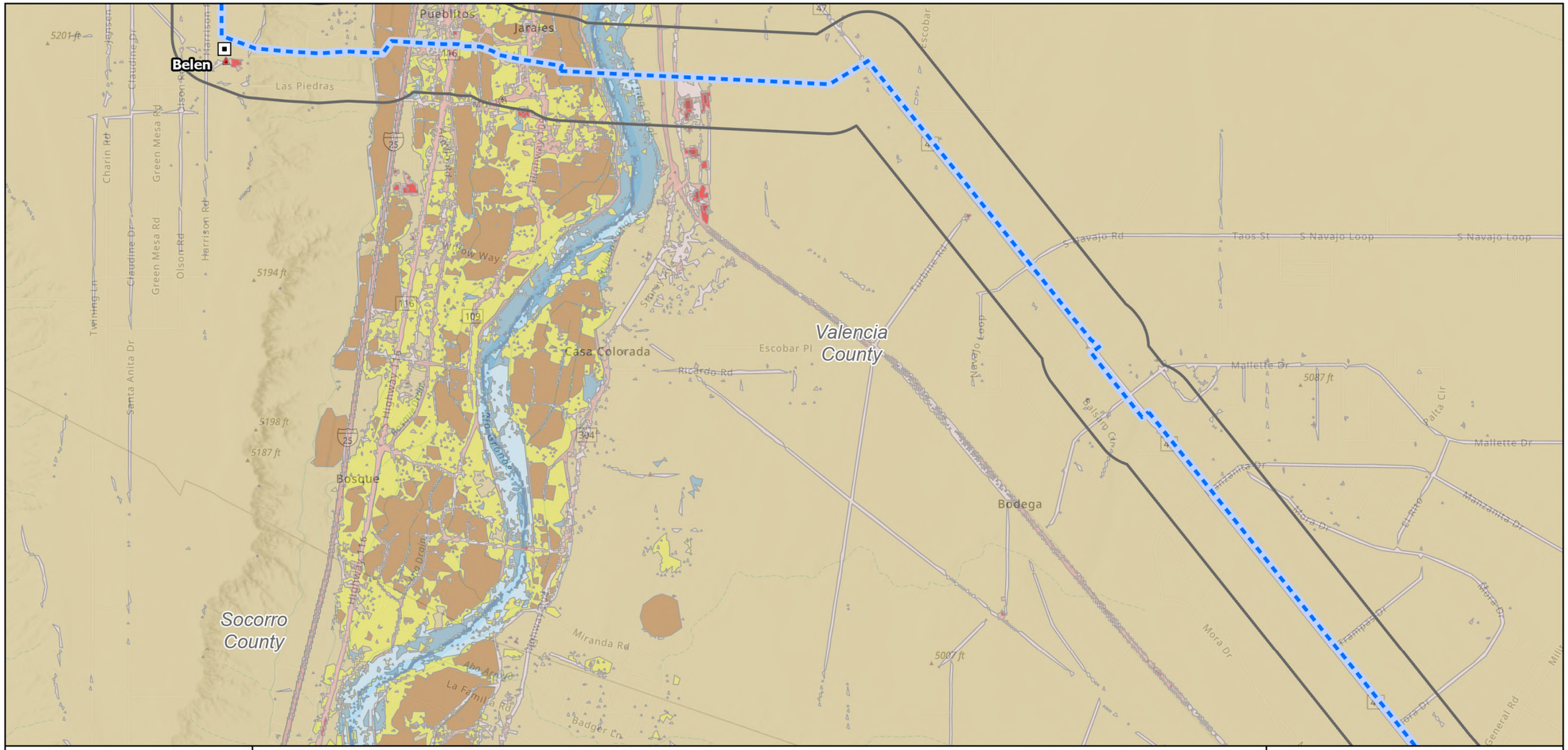
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed,High Intensity
- Barren Land (Rock/Sand/Clay)
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 2 of 9

0 1 2 Miles



Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

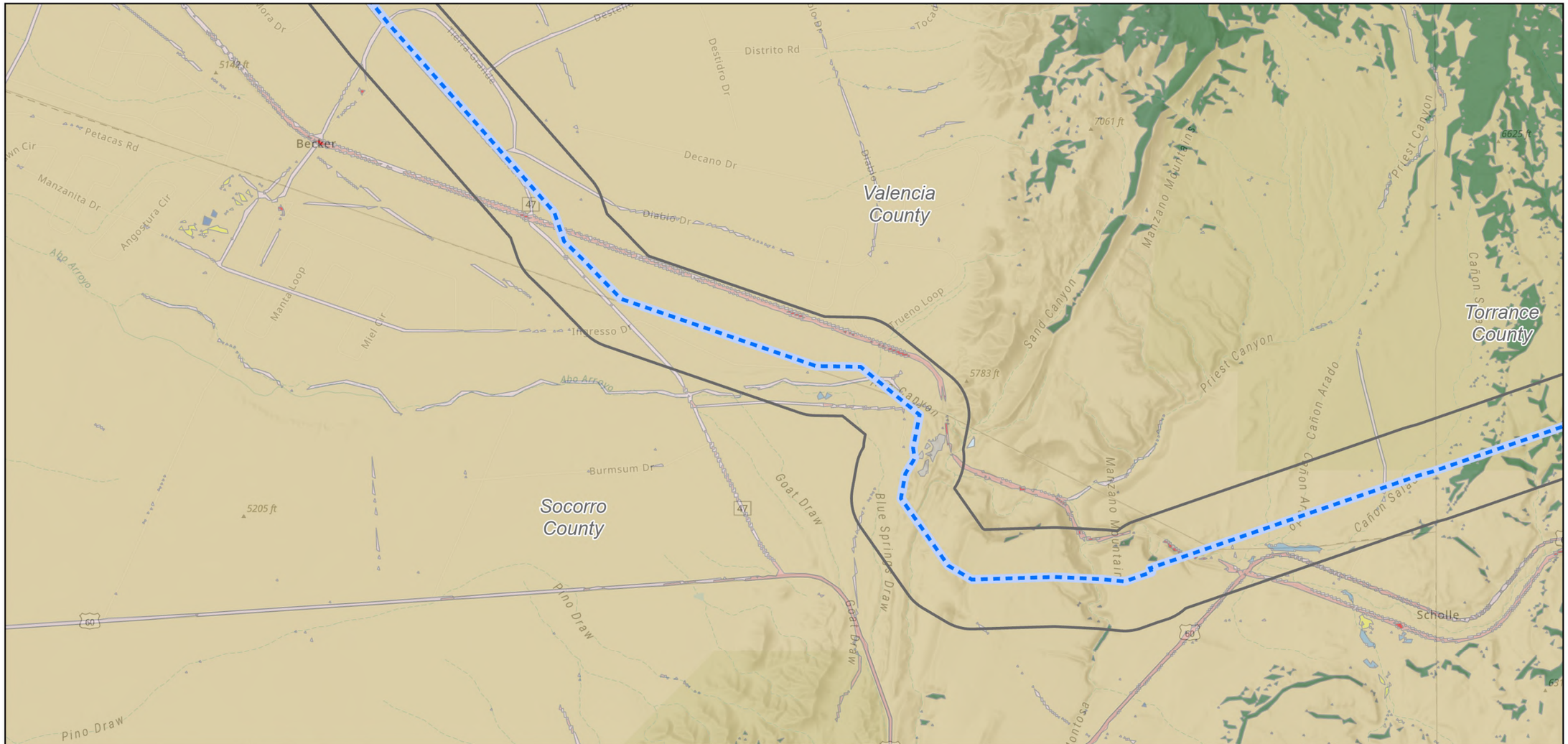
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed,High Intensity
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

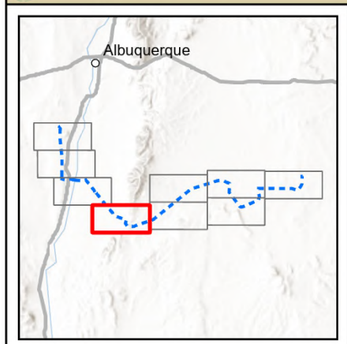
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 3 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Barren Land (Rock/Sand/Clay)
- Evergreen Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Woody Wetlands
- Emergent Herbaceous Wetlands

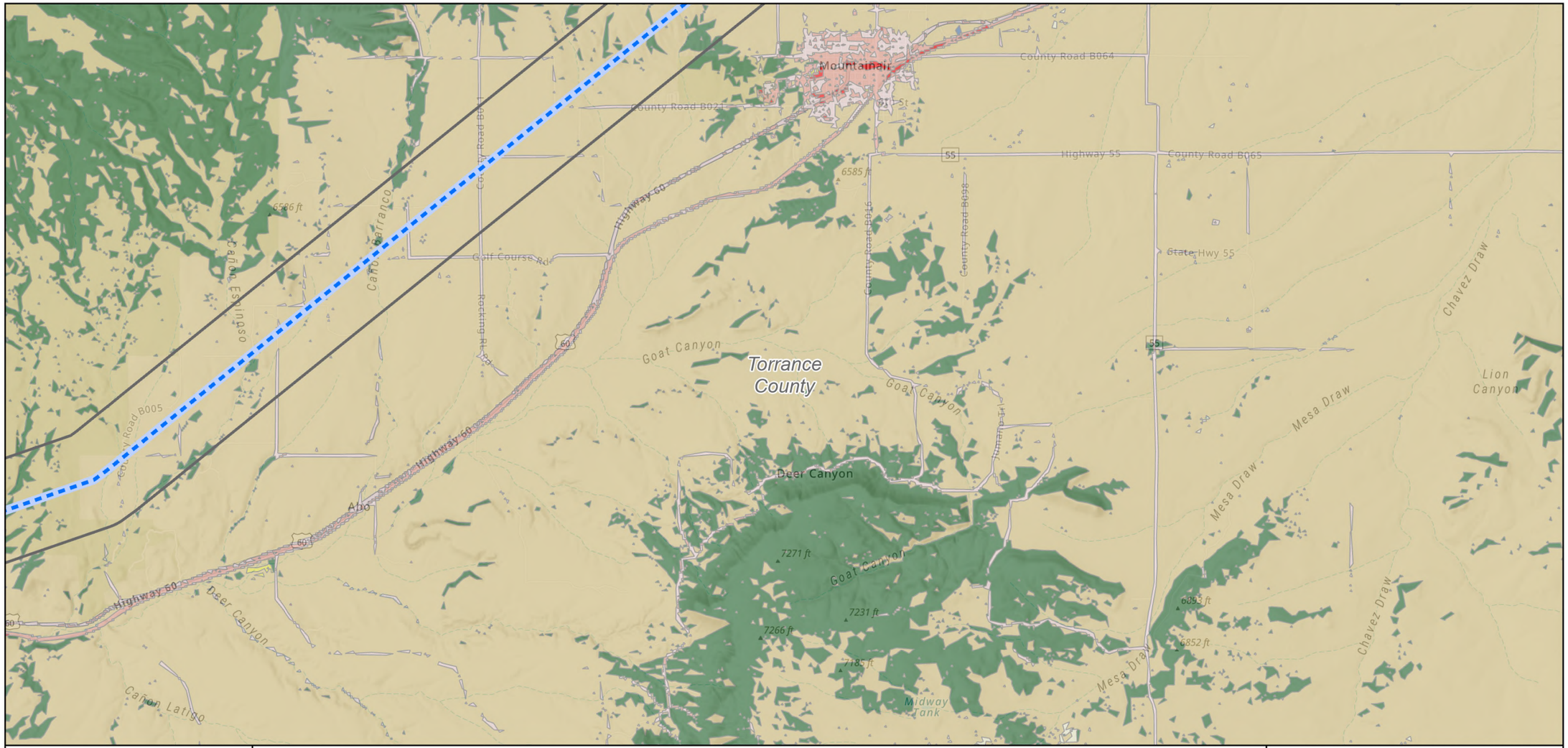
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 4 of 9

0 1 2 Miles

wsp



Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

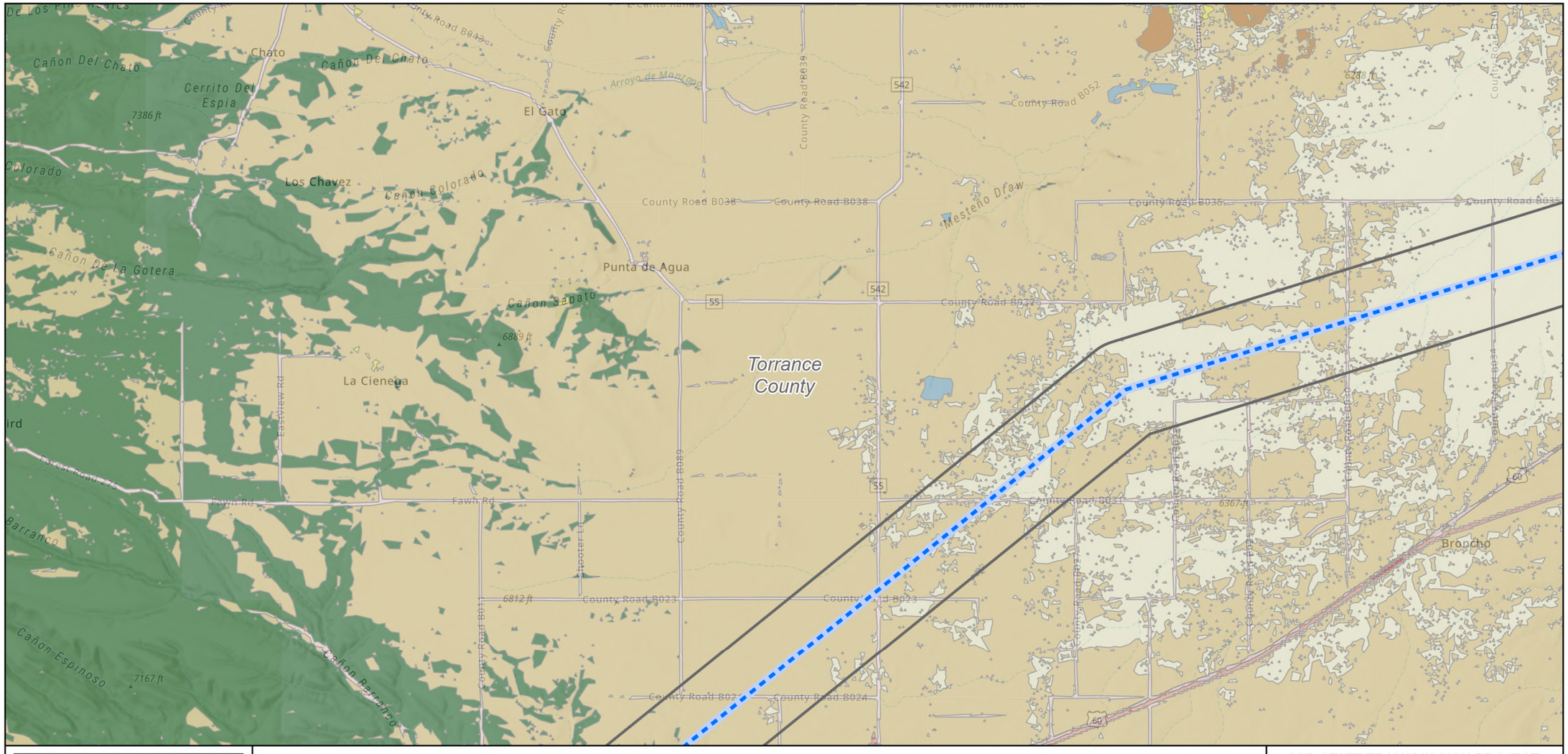
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed,High Intensity
- Barren Land (Rock/Sand/Clay)
- Evergreen Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay

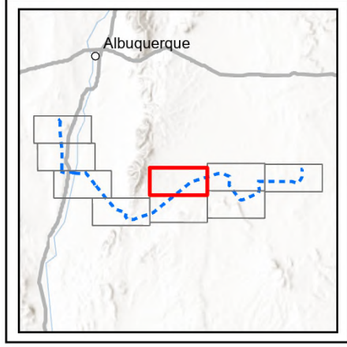
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 5 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

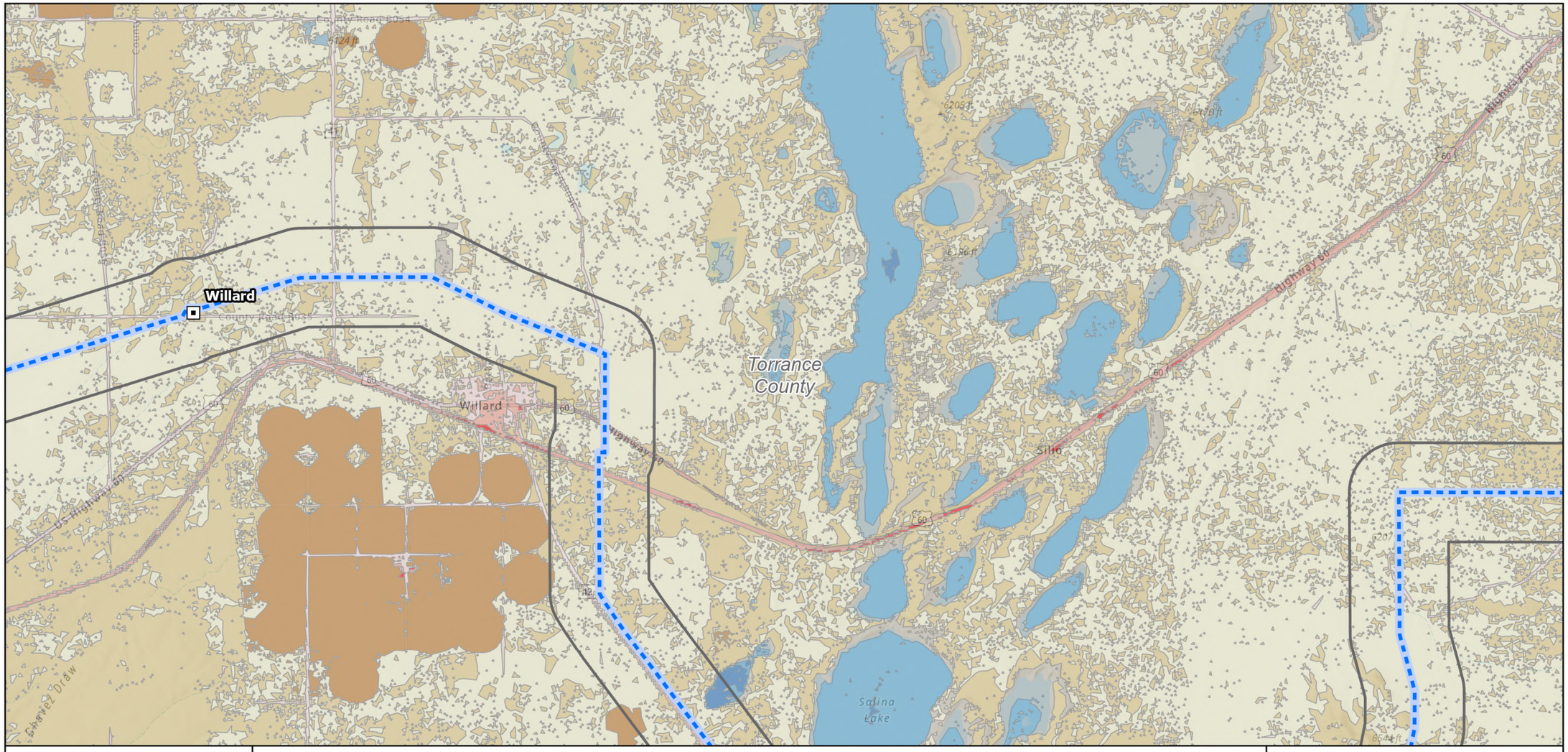
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Barren Land (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Emergent Herbaceous Wetlands

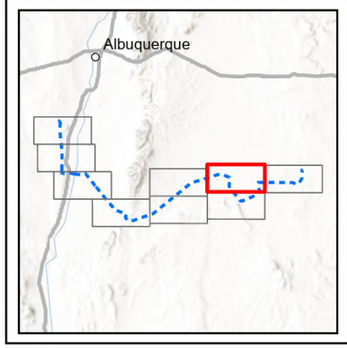
Reference Features
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 6 of 9

0 1 2 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

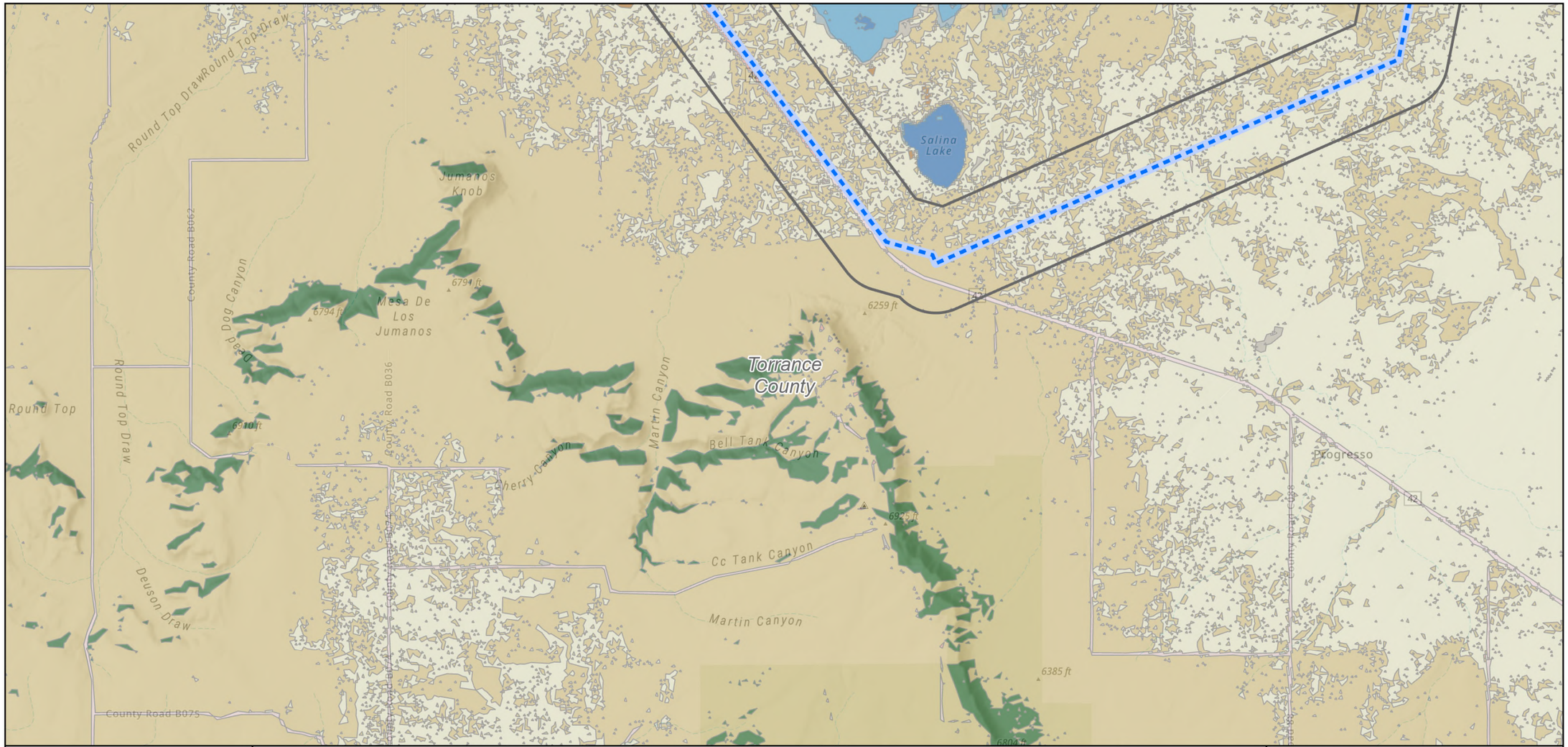
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Barren Land (Rock/Sand/Clay)
- Evergreen Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Emergent Herbaceous Wetlands

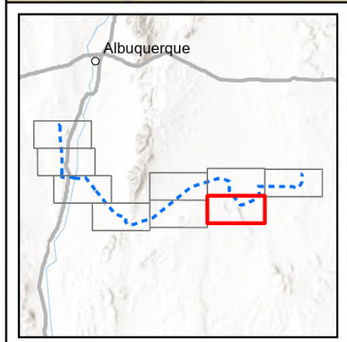
Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 7 of 9

0 1 2 Miles





Project Components
- Transmission Centerline
- Transmission ROW (200 ft)
- Transmission Study Corridor (1 Mile)

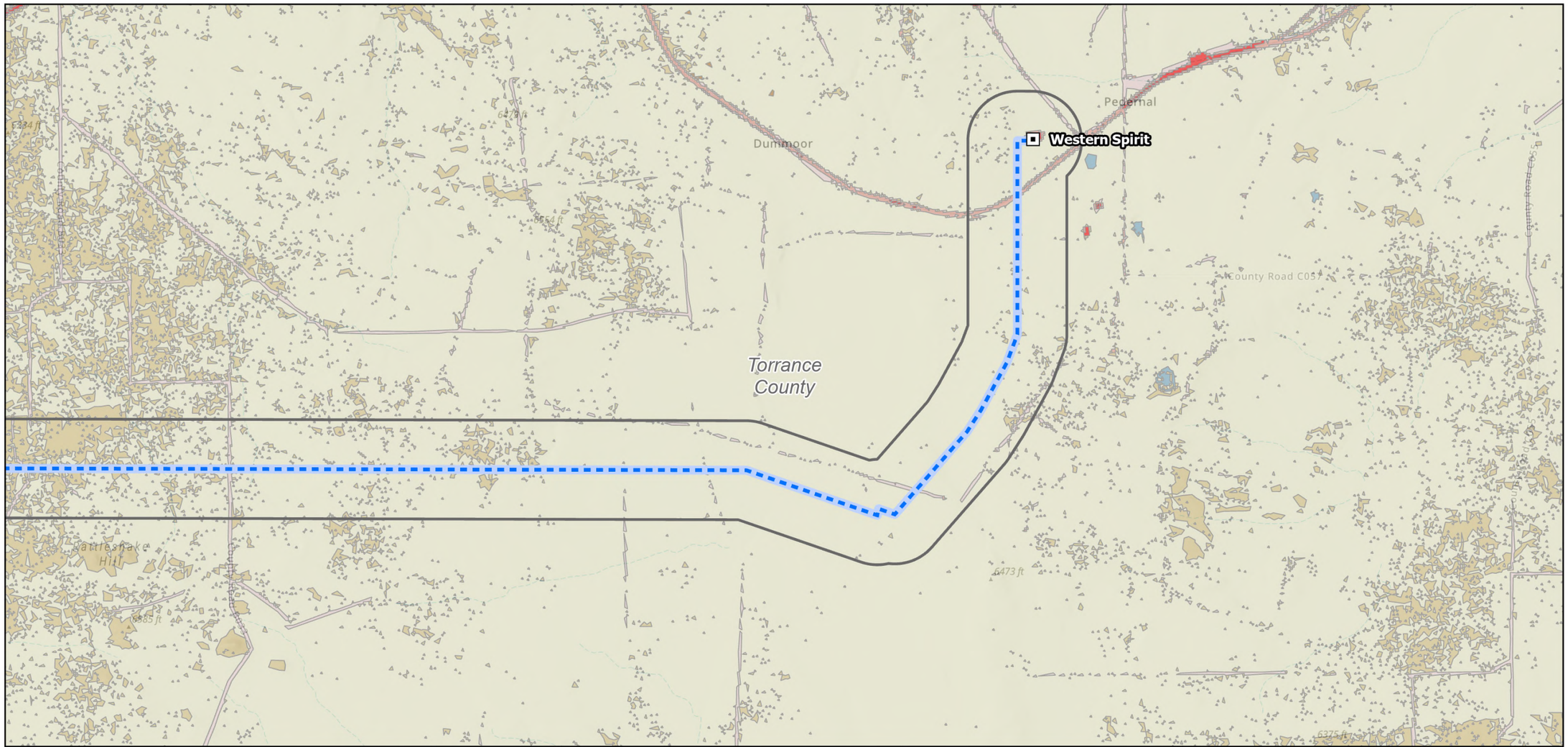
NLCD
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Barren Land (Rock/Sand/Clay)
- Evergreen Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Emergent Herbaceous Wetlands

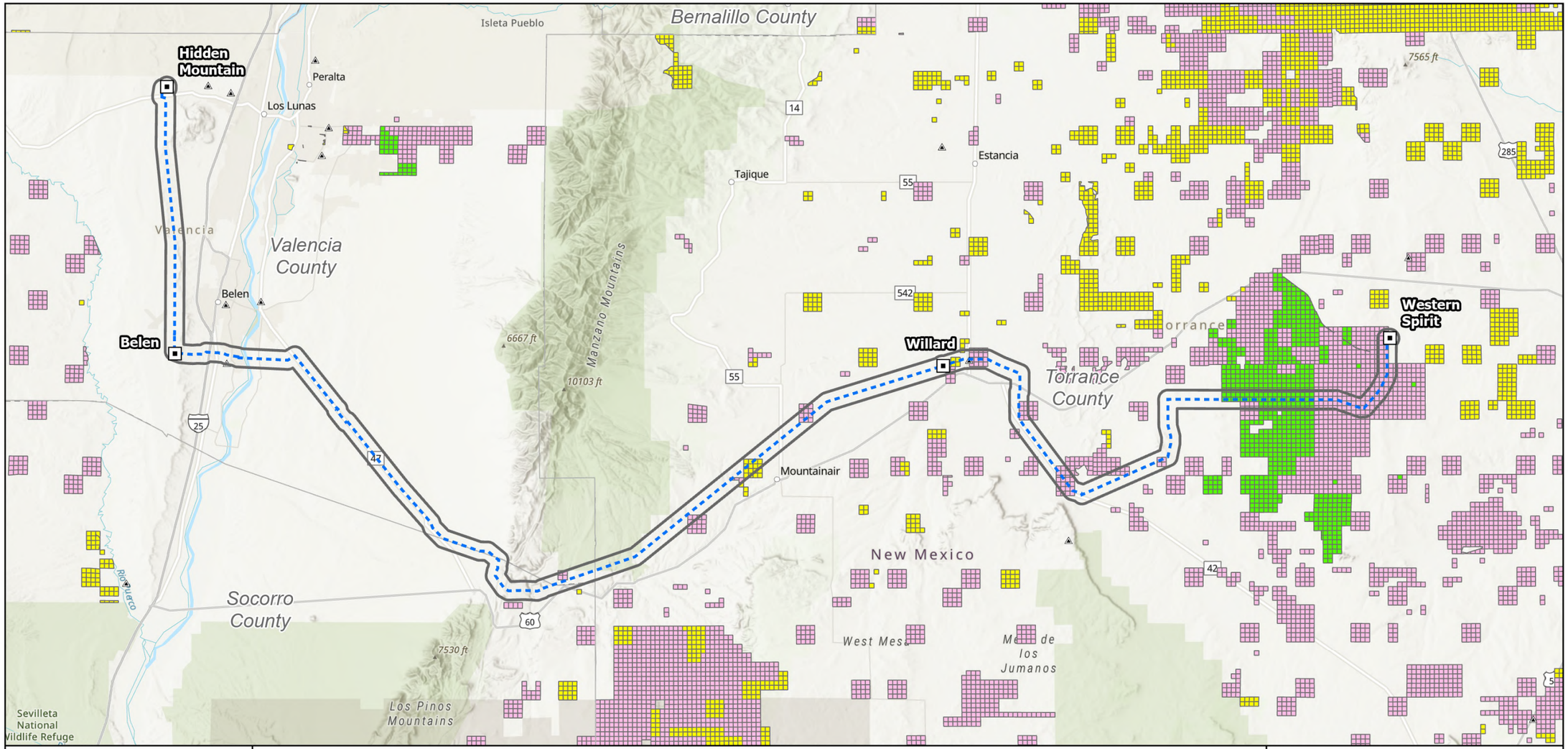
Reference Features
- Existing Substation
- County Boundary

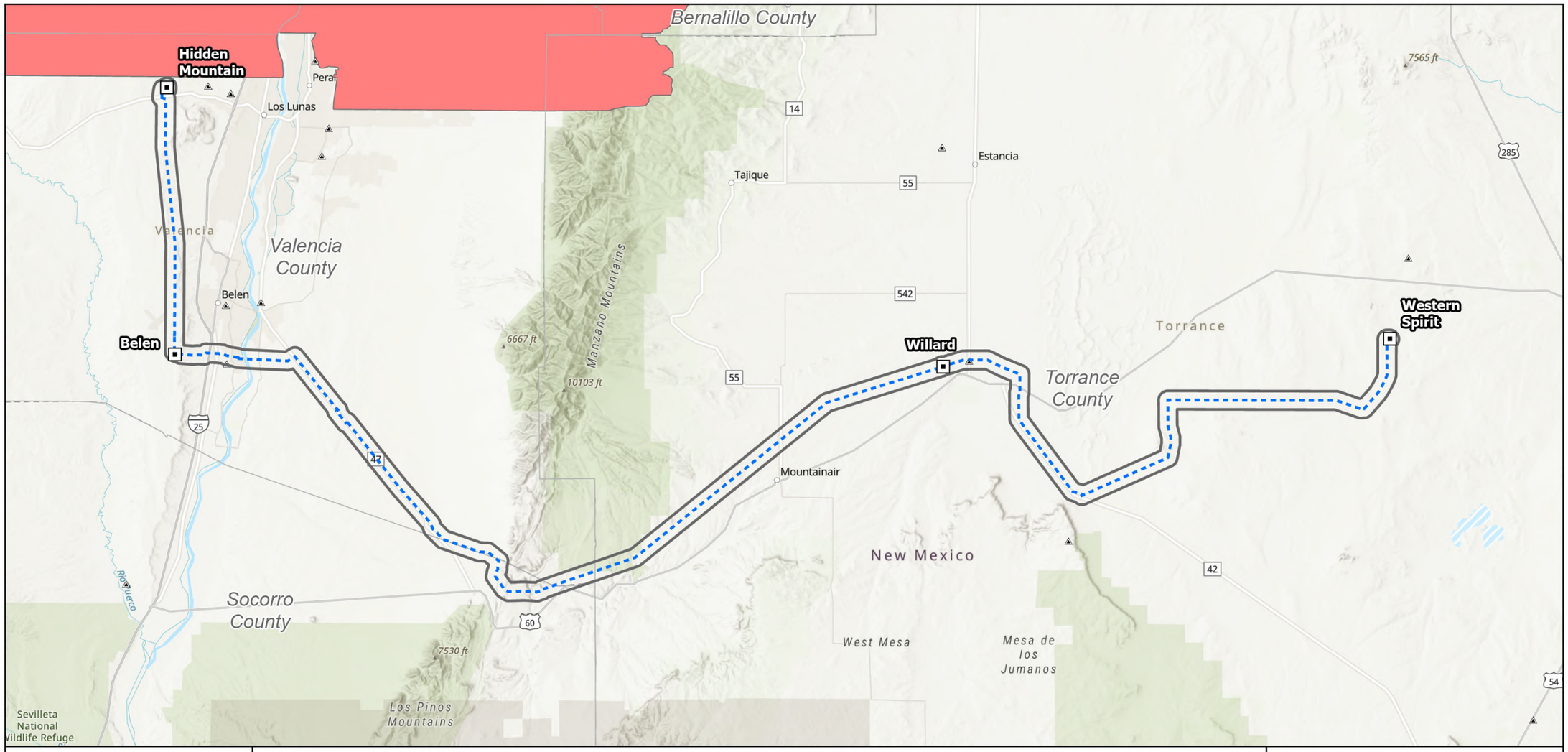
MID-STATE TRANSMISSION PROJECT

Exhibit 18
Land Cover Map
Page 8 of 9

0 1 2 Miles


Western Spirit
Pedernal
Dunmoor
Torrance
County
County Road C057
Rattlesnake
Hill
6473 ft
6885 ft
6374 ft
5234 ft
Albuquerque
Project Components
Project Substation
Transmission Centerline
Transmission ROW (200 ft)
Transmission Study Corridor (1 Mile)
NLCD
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed,High Intensity
Barren Land (Rock/Sand/Clay)
Shrub/Scrub
Grassland/Herbaceous
Cultivated Crops
Emergent Herbaceous Wetlands
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 18
Land Cover Map
Page 9 of 9
N
0
1
2
Miles
wsp


Bernalillo County
Isleta Pueblo
Hidden Mountain
Peralta
Los Lunas
Valencia
Valencia County
Belen
Belen
Tajique
Estancia
7565 ft
285
14
55
542
Manzano Mountains
6667 ft
10103 ft
Willard
Torrance
Torrance County
Western Spirit
Mountainair
New Mexico
42
25
60
Socorro County
Rio Puerco
7530 ft
West Mesa
Mesa de los Jumanos
Los Pinos Mountains
Sevilleta National Wildlife Refuge
Project Area
NEW MEXICO
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
State Trust Land Owner Status
Trust Land Surface Ownership
Trust Land Subsurface Ownership
Trust Land Surface & Subsurface Ownership
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 20
State Owned Lands Map
0
5
10
Miles
wsp





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

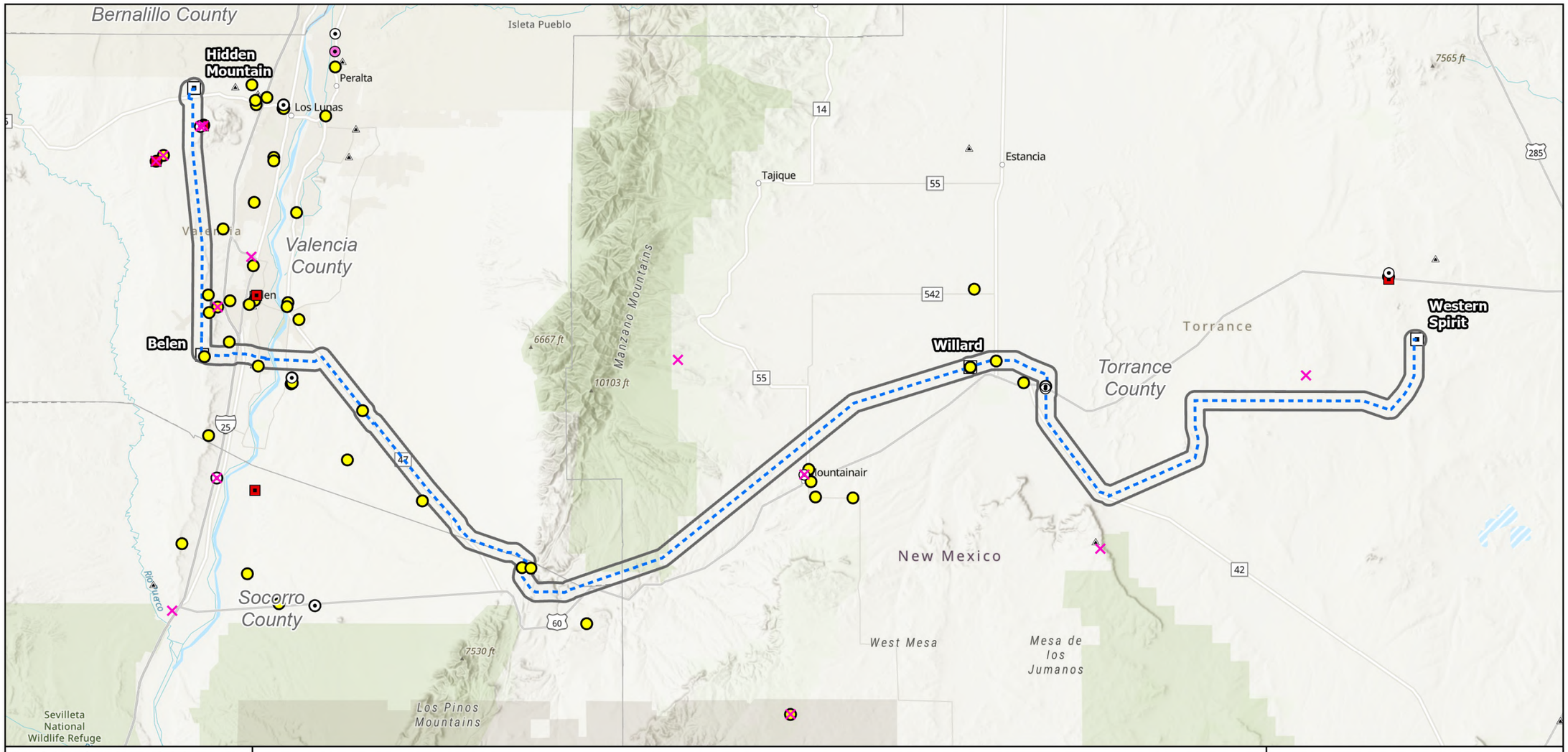
Tribal Boundaries
- Pueblo of Isleta

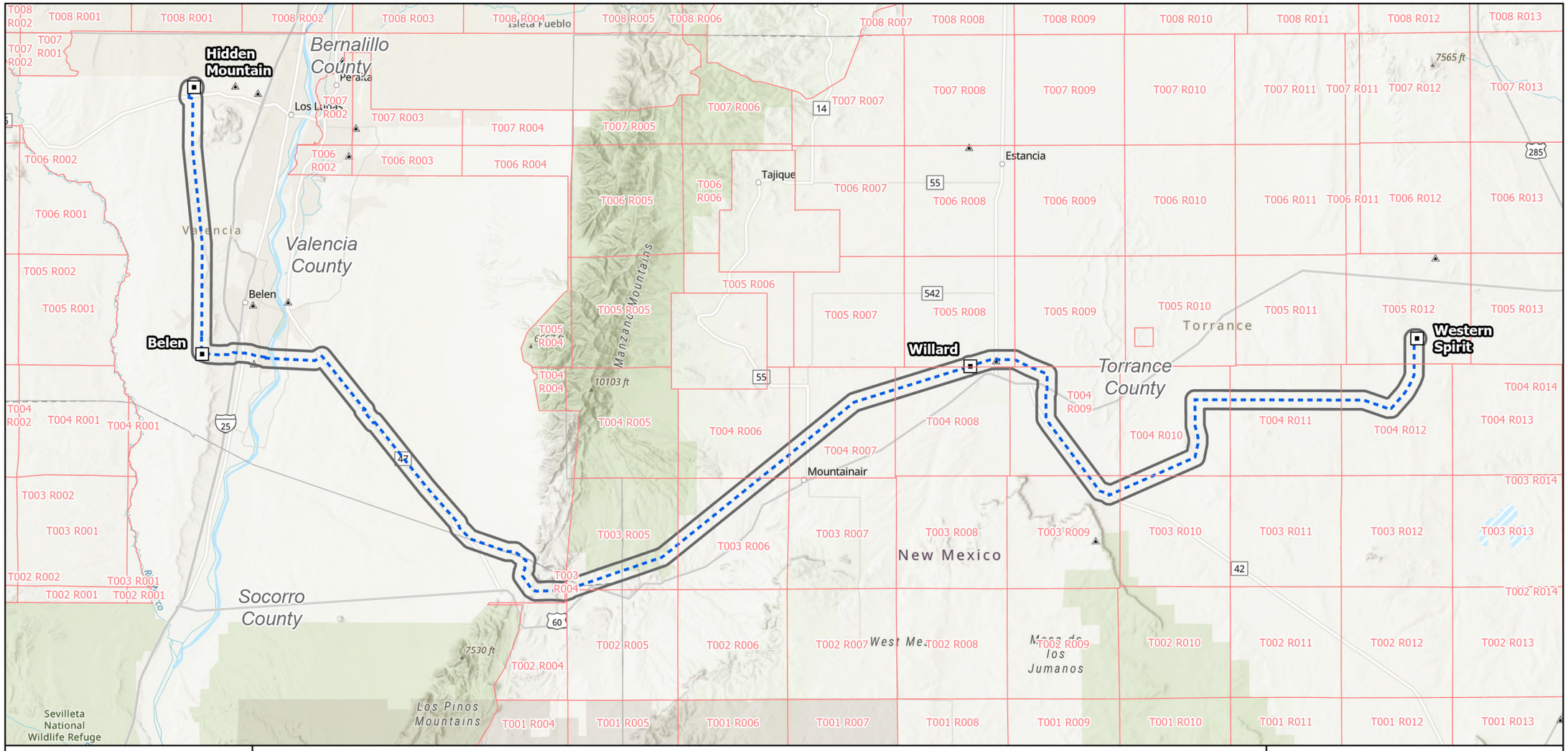
Reference Features
- Existing Substation
- County Boundary

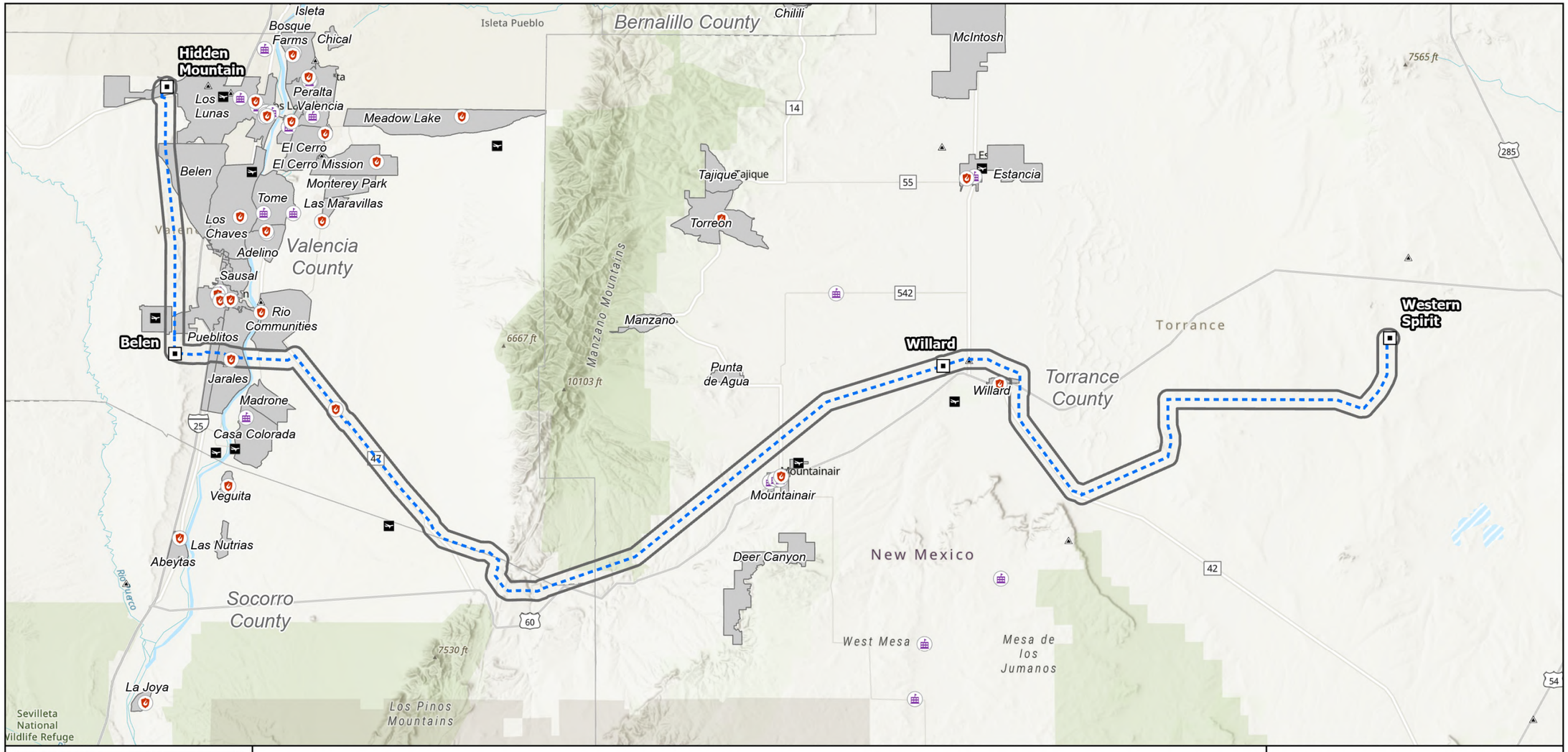
MID-STATE TRANSMISSION PROJECT

Exhibit 21
American Indian Areas Map

0 5 10 Miles


Bernalillo County
Isleta Pueblo
Hidden Mountain
Peralta
Los Lunas
Valencia County
Belen
Tajique
Estancia
14
55
542
6667 ft
Manzano Mountains
10103 ft
Willard
Torrance
Torrance County
Western Spirit
Mountainair
New Mexico
42
285
7565 ft
25
27
60
Socorro County
7530 ft
West Mesa
Mesa de los Jumanos
Los Pinos Mountains
Sevilleta National Wildlife Refuge
Project Area
NEW MEXICO
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Communication Towers
AM Tower
ASR Tower
Cellular Tower
FM Tower
Microwave Tower
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 22
Communications Map
0
5
10
Miles
wsp


Hidden Mountain
Bernalillo County
Valencia County
Belen
Willard
Western Spirit
Torrance County
Tajique
Estancia
Mountainair
Manzano Mountains
Socorro County
Los Pinos Mountains
Sevilleta National Wildlife Refuge
New Mexico
Torrance
10103 ft
7565 ft
7530 ft
Project Area
NEW MEXICO
Albuquerque
Las Cruces
El Paso
Project Components
Project Substation
Transmission Centerline
Transmission Study Corridor (1 Mile)
Pubic Land Survey System
Township Boundary
Reference Features
Existing Substation
County Boundary
MID-STATE TRANSMISSION PROJECT
Exhibit 23
Public Land Survey System (PLSS) Map
0
5
10
Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

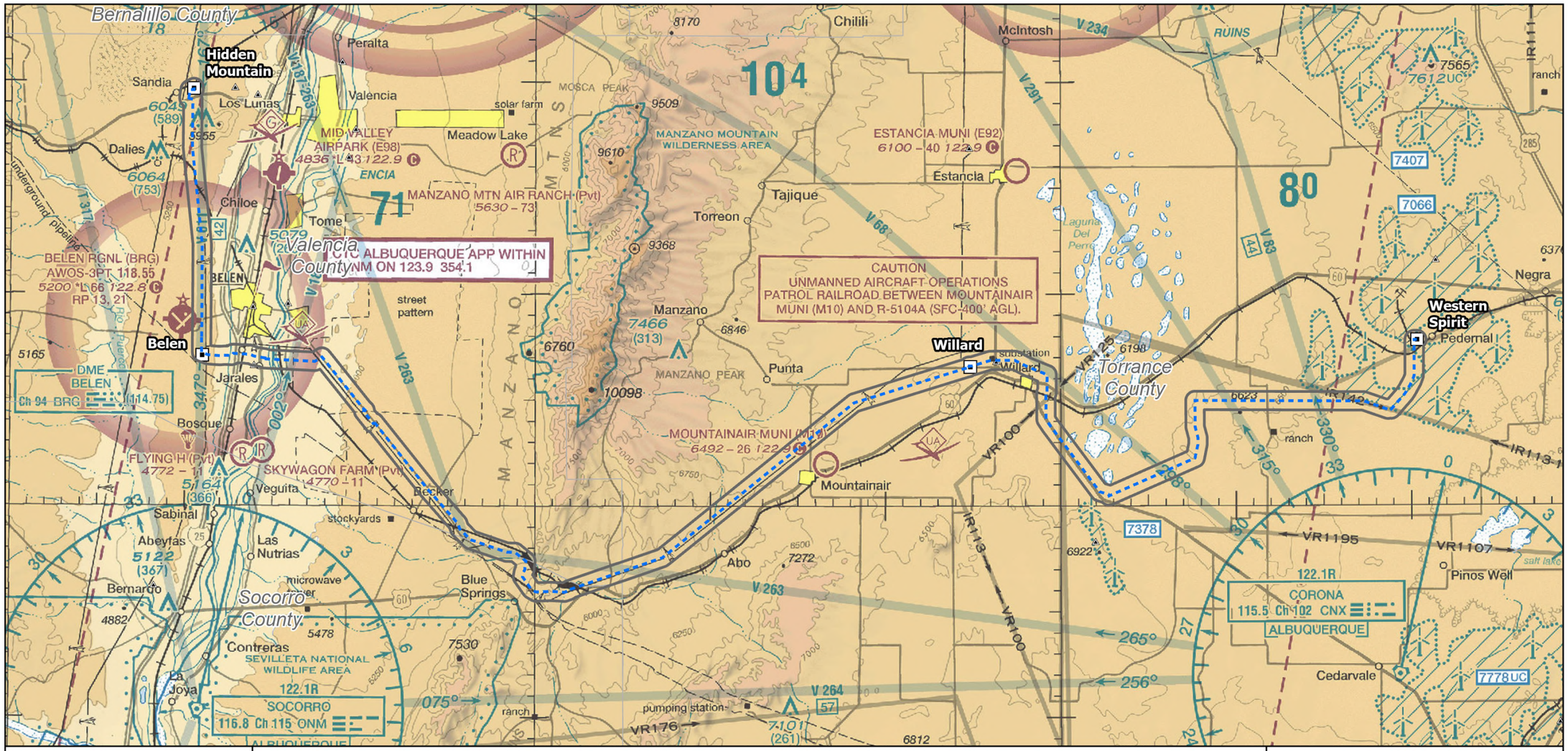
Public Facilities
- Airport
- Hospital
- School
- Fire/EMS
- Municipal Boundary

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 24
Public Facilities Map

0 5 10 Miles





Project Components
- Project Substation
- Transmission Centerline
- Transmission Study Corridor (1 Mile)

Reference Features
- Existing Substation
- County Boundary

MID-STATE TRANSMISSION PROJECT

Exhibit 25
Visual Flight Rules Map

0 5 10 Miles

Appendix B - Oversized Tables

Table 3-4 **Soil Coverage Types within the Transmission Study Corridor**

Table 3-13 **USFS-Listed Sensitive Species with the Potential to Occur within the Transmission Study Corridor**

Table 3-14 **BLM-listed Sensitive Species with the Potential to Occur within the Transmission Study Corridor**

Table 3-16 **Archaeological Resources within Transmission Study Corridor**

Table 3-4 Soil Coverage Types within the Transmission Study Corridor

Map Unit Symbol	Soil Map Unit Name	Farmland Class	Estimated Acreage	Percent of Transmission Study Corridor
603	Wink-Dona Ana loamy sands, 1 to 3 percent slopes	Not Prime Farmland	790.5	1.2%
606	Largo loam, 0 to 3 percent slopes	Not Prime Farmland	435.2	0.6%
650	Typic Camborthids-Nolam association, 2 to 50 percent slopes	Not Prime Farmland	3.0	0%
651	Barana loam, 0 to 2 percent slopes	Not Prime Farmland	51.3	0.1%
716	Creel-Musofare-Clovis complex, 1 to 15 percent slopes	Not Prime Farmland	131.6	0.2%
737	Harvey-La Fonda association, 1 to 9 percent slopes	Not Prime Farmland	18.3	0%
738	Harvey-Dean association, 1 to 9 percent slopes	Not Prime Farmland	225.4	0.3%
760	Sedillo-Clovis association, 1 to 6 percent slopes	Not Prime Farmland	874.9	1.3%
765	Puertecito, moist-Rock outcrop complex, 15 to 60 percent slopes	Not Prime Farmland	295.9	0.4%
783	Ponciano very bouldery clay loam, 15 to 60 percent slopes	Not Prime Farmland	0.3	0%
826	Harvey-Ildecarb-Pinon complex, 2 to 10 percent slopes	Not Prime Farmland	102.0	0.2%
834	San Mateo-Glenberg complex, 0 to 2 percent slopes	Not Prime Farmland	115.6	0.2%
840	Deama-Rock outcrop complex, 3 to 40 percent slopes	Not Prime Farmland	669.9	1.0%
845	Winona-Rock outcrop complex, 5 to 45 percent slopes	Not Prime Farmland	1,218.4	1.8%
Al	Alicia loam, 1 to 6 percent slopes	Not Prime Farmland	432.2	0.6%
Bu	Blown-out land	Not Prime Farmland	193.1	0.3%
Cg	Chilton gravelly loam	Not Prime Farmland	269.6	0.4%
Cn	Clovis loam, 0 to 5 percent slopes	Prime Farmland	3,893.1	5.8%
Co	Clovis soils, 0 to 5 percent slopes, eroded	Not Prime Farmland	210.0	0.3%
CP	Caliche pit	Not Prime Farmland	48.6	0.1%
De	Dean loam, 1 to 9 percent slopes	Not Prime Farmland	2,424.1	3.6%
Ec	Encierro channery loam, 1 to 9 percent slopes	Not Prime Farmland	992.6	1.5%

Map Unit Symbol	Soil Map Unit Name	Farmland Class	Estimated Acreage	Percent of Transmission Study Corridor
Hf	Harvey loam, 1 to 9 percent slopes	Farmland of Statewide Importance	1,977.5	2.9%
Hg	Harvey loam, alkali	Farmland of Statewide Importance	99.5	0.1%
Hh	Harvey-Dean loams, 1 to 9 percent slopes	Not Prime Farmland	1,170.6	1.7%
Hm	Harvey and Dean soils, eroded	Not Prime Farmland	1,390.9	2.1%
Hs	Hassell loam, 2 to 5 percent slopes	Not Prime Farmland	63.0	0.1%
Ih	Ildefonso fine sandy loam, 0 to 2 percent slopes	Farmland of Statewide Importance	578.7	0.9%
Ik	Ildefonso fine sandy loam, 0 to 5 percent slopes	Farmland of Statewide Importance	679.2	1.0%
Im	Ildefonso loamy fine sand, 0 to 5 percent slopes	Not Prime Farmland	648.1	1.0%
Ka	Karde loam, saline	Not Prime Farmland	41.4	0.1%
Kd	Karde-Willard loams, saline	Not Prime Farmland	151.7	0.2%
Kg	Kech gravelly loam, 1 to 9 percent slopes	Not Prime Farmland	33.4	0.0%
La	La Fonda loam, 1 to 9 percent slopes	Not Prime Farmland	719.6	1.1%
Lg	La Fonda loam, gravelly substratum, 2 to 8 percent slopes	Not Prime Farmland	54.3	0.1%
Lp	Laporte-Rock outcrop complex	Not Prime Farmland	31.8	0%
Ma	Manzano loam, 0 to 1 percent slopes	Prime Farmland	441.0	0.7%
Mc	Manzano loam, saline substratum, 0 to 1 percent slopes	Prime Farmland	122.9	0.2%
Mm	Moriarty clay loam, 0 to 1 percent slopes	Not Prime Farmland	9.0	0%
Mo	Moriarty clay loam, 2 to 6 percent slopes	Not Prime Farmland	390.8	0.6%
Op	Otero and Palma soils	Not Prime Farmland	1,035.2	1.5%
Or	Otero and Palma soils, hummocky	Not Prime Farmland	50.8	0.1%
Pa	Pastura loam, 1 to 9 percent slopes	Not Prime Farmland	291.7	0.4%
Pb	Pastura loam, 9 to 25 percent slopes	Not Prime Farmland	24.5	0%
Pd	Pedrick loamy fine sand	Farmland of Statewide Importance	2,402.6	3.6%
Pe	Pedrick loamy fine sand, hummocky	Farmland of Statewide Importance	794.2	1.2%

Map Unit Symbol	Soil Map Unit Name	Farmland Class	Estimated Acreage	Percent of Transmission Study Corridor
Pg	Penistaja fine sandy loam, 1 to 6 percent slopes	Not Prime Farmland	316.9	0.5%
Px	Pinon channery loam, 3 to 20 percent slopes	Not Prime Farmland	26.0	0%
PY	Playas	Not Prime Farmland	39.5	0.1%
Rk	Rock land	Not Prime Farmland	412.4	0.6%
Rs	Rock outcrops and Slides	Not Prime Farmland	8.4	0%
Sc	Scholle gravelly loam, 1 to 9 percent slopes	Not Prime Farmland	703.9	1.0%
Sm	Steep rock land	Not Prime Farmland	316.0	0.5%
So	Stony steep land	Not Prime Farmland	5.1	0%
Tc	Tapia loam, 0 to 5 percent slopes	Not Prime Farmland	2,823.2	4.2%
Td	Tapia-Dean loams, 0 to 5 percent slopes	Farmland of Statewide Importance	228.1	0.3%
Te	Tapia and Dean soils, eroded	Not Prime Farmland	1,036.2	1.5%
Wa	Washoe cobbly loam, 9 to 25 percent slopes	Not Prime Farmland	539.0	0.8%
Wb	Washoe gravelly loam, 1 to 9 percent slopes	Not Prime Farmland	279.9	0.4%
Wh	Willard fine sandy loam	Prime Farmland	59.2	0.1%
Wk	Willard loam	Farmland of Statewide Importance	2,250.9	3.4%
Wm	Willard loam, strongly saline	Not Prime Farmland	2,238.7	3.3%
Wn	Witt loam, 0 to 1 percent slopes	Prime Farmland	69.7	0.1%
Wo	Witt clay loam, 0 to 1 percent slopes, eroded	Prime Farmland	136.2	0.2%
Wp	Witt loam, 1 to 6 percent slopes	Farmland of Statewide Importance	3,004.0	4.5%
Wr	Witt clay loam, 1 to 6 percent slopes, eroded	Prime Farmland	1,076.0	1.6%
Ws	Witt-Harvey loams, 0 to 3 percent slopes	Prime Farmland	111.8	0.2%
Ah	Agua loam, slightly saline	Farmland of Statewide Importance	14.6	0%
Au	Armijo loam, moderately alkali	Farmland of Statewide Importance	7.3	0%
Aw	Armijo clay	Farmland of Statewide Importance	59.9	0.1%
BD	Badland	Not Prime Farmland	1,684.2	2.5%
Be	Belen loam	Farmland of Statewide Importance	8.8	0%
Bg	Belen clay loam, moderately alkali	Farmland of Statewide Importance	16.6	0.0%
BK	Bluepoint loamy sand, hilly	Not Prime Farmland	1,012.7	1.5%

Map Unit Symbol	Soil Map Unit Name	Farmland Class	Estimated Acreage	Percent of Transmission Study Corridor
Bm	Bluepoint loamy fine sand, 1 to 3 percent slopes	Farmland of Statewide Importance	247.1	0.4%
BO	Bluepoint loamy fine sand, 1 to 9 percent slopes	Not Prime Farmland	1,377.9	2.1%
BP	Bluepoint loamy fine sand, hummocky	Not Prime Farmland	3,109.1	4.6%
Br	Bluepoint sandy clay loam, 1 to 3 percent slopes	Farmland of Statewide Importance	7.7	0%
Bs	Bluepoint-Wink complex, hummocky	Not Prime Farmland	602.8	0.9%
Bu	Brazito loamy fine sand	Farmland of Statewide Importance	2.4	0%
Bw	Brazito sandy clay loam, thick surface	Farmland of Statewide Importance	0.6	0%
CE	Caliza-Bluepoint complex, 1 to 25 percent slopes	Not Prime Farmland	111.4	0.2%
DP	Dean-Pinon association, gently sloping	Not Prime Farmland	352.7	0.5%
Ga	Gila loamy fine sand	Farmland of Statewide Importance	13.7	0%
Gd	Gila loam, 0 to 1 percent slopes mlra 42-1	Farmland of Statewide Importance	340.8	0.5%
Ge	Gila loam, slightly saline	Farmland of Statewide Importance	120.4	0.2%
Gf	Gila loam, moderately alkali	Farmland of Statewide Importance	25.3	0%
Gg	Gila loam, strongly alkali	Not Prime Farmland	134.1	0.2%
Gh	Gila loam, strongly saline and alkali	Not Prime Farmland	214.7	0.3%
Gk	Gila clay loam	Farmland of Statewide Importance	96.9	0.1%
Gm	Gila clay loam, slightly saline	Farmland of Statewide Importance	67.1	0.1%
Gs	Glendale clay loam, 0 to 1 percent slopes MLRA 42.1	Farmland of Statewide Importance	3.6	0%
HA	Hassell loam, 2 to 5 percent slopes	Not Prime Farmland	117.1	0.2%
LG	Largo loam	Not Prime Farmland	224.0	0.3%
LV	Latene loam	Not Prime Farmland	1,654.4	2.5%
Ma	Madurez loamy sand, hummocky	Not Prime Farmland	73.4	0.1%
Md	Madurez loamy fine sand	Not Prime Farmland	1,094.2	1.6%
ME	Madurez loamy fine sand	Not Prime Farmland	3,373.7	5.0%
MH	Madurez-Bluepoint association, hummocky	Not Prime Farmland	761.8	1.1%

Map Unit Symbol	Soil Map Unit Name	Farmland Class	Estimated Acreage	Percent of Transmission Study Corridor
MK	Madurez-Wink association, undulating	Not Prime Farmland	1,591.1	2.4%
Mn	Mixed alluvial land	Not Prime Farmland	249.7	0.4%
Pa	Pajarito loamy fine sand	Not Prime Farmland	80.9	0.1%
PITS	Gravel and caliche pits	Not Prime Farmland	28.3	0%
Rv	Riverwash	Not Prime Farmland	24.5	0%
RW	Rock land	Not Prime Farmland	149.5	0.2%
RX	Rock outcrop-Akela complex, 10 to 50 percent slopes	Not Prime Farmland	266.5	0.4%
SA	Salas very stony loam, 30 to 70 percent slopes	Not Prime Farmland	60.0	0.1%
SG	Sedillo very gravelly loam, 3 to 9 percent slopes	Not Prime Farmland	538.7	0.8%
TU	Tres Hermanos-Madurez association, gently sloping	Not Prime Farmland	152.3	0.2%
Vd	Vinton loamy fine sand	Farmland of Statewide Importance	30.1	0%
Vf	Vinton loamy fine sand, moderately alkali	Farmland of Statewide Importance	22.3	0%
Vg	Vinton loam	Farmland of Statewide Importance	26.5	0%
Vh	Vinton loam, slightly saline	Farmland of Statewide Importance	27.7	0%
Vo	Vinton loam, loamy subsoil variant MLRA 42	Farmland of Statewide Importance	4.0	0%
Wk	Wink loamy sand	Not Prime Farmland	1,105.0	1.6%
Wm	Wink loamy sand, clayey substratum	Not Prime Farmland	5.7	0%
Wn	Wink loamy sand, hummocky	Not Prime Farmland	193.1	0.3%
WO	Wink fine sandy loam	Not Prime Farmland	588.3	0.9%
Wr	Wink-Caliza complex, 1 to 15 percent slopes	Not Prime Farmland	118.2	0.2%
Ws	Wink complex, 1 to 9 percent slopes, eroded	Not Prime Farmland	6.9	0%
WU	Wink-Madurez association, gently sloping	Not Prime Farmland	2,641.2	3.9%
		Total	**67,128.7***	**99.3%***

* Sum of components may not add up to the actual total due to the overlap of some geographic integration systems (GIS) data received.

Source: USDA NRCS 2026

Prime Farmland = Land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses; governed under the Farmland Protection Policy Act (7 U.S.C. § 4201–4209).

Farmland of Statewide Importance = Land that is not classified as Prime Farmland but is nonetheless important for the production of food, feed, fiber, forage, or oilseed crops within a particular state; governed under the Farmland Protection Policy Act (7 U.S.C. § 4201–4209).

Table 3-13 USFS-listed Sensitive Species with the Potential to Occur within the Transmission Study Corridor

Common Name	Scientific Name	USFS Status*	IUCN Status**	Likelihood of Occurrence
Amphibians				
Northern leopard frog	*Lithobates pipiens*	SEN	LC	**None;** USFS lands within the Transmission Study Corridor do not include permanent ponds or streams.
Birds				
Northern goshawk	*Accipiter gentilis*	SEN	LC	**Possible;** USFS lands within the Transmission Study Corridor include suitable forested habitat.
Western burrowing owl	*Athene cunicularia hypugaea*	SEN	LC	**Possible;** prairie dog colonies, which are utilized by burrowing owls for nesting, were observed within the Transmission Study Corridor during field surveys. However, no colonies were observed on USFS lands, and no burrowing owls were observed anywhere within the Transmission Study Corridor.
Mountain plover	*Charadrius montanus*	SEN	NT	**Possible;** the Transmission Study Corridor contains suitable shortgrass prairie habitat.
Yellow-billed Cuckoo	*Coccyzus americanus*	SEN	LC	**Not likely;** USFS lands within the Transmission Study Corridor do not support riparian woodlands dominated by cottonwood, willows, and dense mesquite.
American peregrine falcon	*Falco peregrinus anatum*	SEN	LC	**Possible;** USFS lands within the Transmission Study Corridor supports suitable forested habitat for foraging, but no cliff habitat required for nesting.
Lesser prairie chicken	*Tympanuchus pallidicinctus*	SEN	VU	**None;** the Transmission Study Corridor is outside of the species' known range.

Common Name	Scientific Name	USFS Status*	IUCN Status**	Likelihood of Occurrence
Gray vireo	*Vireo vicinior*	SEN	LC	**Likely;** USFS lands within the Transmission Study Corridor supports shrubland and mid-elevation pinyon-juniper woodlands.
Crustaceans				
Dumont's fairy shrimp	*Streptocephalus henridumontis*	SEN	N/A	**None;** the Transmission Study Corridor is outside the species' known range.
Fish				
Zuni bluehead sucker	*Catostomus discobolus jarrovii*	SEN	LC	**None;** USFS lands within the Transmission Study Corridor do not support permanent ponds or streams; Transmission Study Corridor is outside the species' known range.
Rio Grande sucker	*Catostomus plebeius*	SEN	DD	**None;** USFS lands within the Transmission Study Corridor do not support permanent ponds or streams.
Rio Grande chub	*Gila pandora*	SEN	LC	**None;** USFS lands within the Transmission Study Corridor do not support permanent ponds or streams.
Suckermouth minnow	*Phenacobius mirabilis*	SEN	LC	**None;** the Transmission Study Corridor does not cross the Canadian River, Cimarron, or Vermejo tributaries.
Mammals				
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	SEN	LC	**Not likely;** potentially suitable foraging habitat occurs within shrubland and mixed woodlands on USFS lands within the Transmission Study Corridor, however caves suitable for roosting are not present.
Gunnison's prairie dog	*Cynomys gunnisoni*	SEN	LC	**Possible;** active prairie dog colonies were observed on private lands in the eastern portion of the Transmission Study Corridor, however habitat on USFS lands for the species is marginal, and

Common Name	Scientific Name	USFS Status*	IUCN Status**	Likelihood of Occurrence
				no active nor inactive colonies were observed during field surveys.
Black-tailed prairie dog	*Cynomys ludovicianus*	SEN	LC	**Possible;** active prairie dog colonies were observed on private lands in the eastern portion of the Transmission Study Corridor, however habitat on USFS lands for the species is marginal, and no active nor inactive colonies were observed.
Spotted bat	*Euderma maculatum*	SEN	LC	**Not likely;** potentially suitable foraging habitat occurs within pinyon-juniper woodland on USFS lands within the Transmission Study Corridor, however steep cliffs suitable for roosting are not present.
Allen's lappet-browned bat	*Idionycteris phyllotis*	SEN	LC	**None;** the Transmission Study Corridor is outside of the species' known range.
Cebolleta southern pocket gopher	*Thomomys bottae paguatae*	SEN	LC	**None;** the Transmission Study Corridor is outside of the species' known range.
Swift fox	*Vulpes velox*	SEN	LC	**Not likely;** USFS lands within the Transmission Study Corridor do not support open shortgrass prairie habitat.
Plants				
Greene milkweed	*Asclepias uncialis ssp. uncialis*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Zuni milkvetch	*Astragalus accumbens*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Villous groundcover milkvetch	*Astragalus humistratus var. crispulus*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Chaco milkvetch	*Astragalus micromerius*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
One-flowered milkvetch	*Astragalus wittmannii*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.

Common Name	Scientific Name	USFS Status*	IUCN Status**	Likelihood of Occurrence
Sivinski's fleabane	*Erigeron sivinskii*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Sandia alum root	*Heuchera pulchella*	SEN	N/A	**None;** the Transmission Study Corridor does not contain limestone cliffs at 8,000 – 10,000 ft elevation.
Tall bitterweed	*Hymenoxys brachyactis*	SEN	N/A	**Likely;** USFS lands within the Transmission Study Corridor supports suitable pinyon-juniper woodlands in the southern Manzano Mountains.
Spellenberg's groundsel	*Packera spellenbergii*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
San Mateo penstemon	*Penstemon pseudoparvus*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Reptiles				
Arid land ribbon snake	*Thamnophis proximus diabolicus*	SEN	LC	**None;** USFS lands within the Transmission Study Corridor do not contain riparian habitat or suitable bodies of water.

*SEN = Sensitive
**LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered; DD = Data Deficient

Table 3-14 BLM-listed Sensitive Species with the Potential to Occur within the Transmission Study Corridor

Common Name	Scientific Name	BLM Status*	IUCN Status**	Likelihood of Occurrence
Amphibians				
Northern leopard frog	*Lithobates pipiens*	SEN	LC	**None;** BLM lands within the Transmission Study Corridor do not include permanent ponds or streams.
Birds				
Mexican whip-poor-will	*Antrostomus arizonae*	SEN	LC	**Likely;** the Transmission Study Corridor contains suitable mid-elevational pine-oak woodland habitat.
Mountain plover	*Charadrius montanus*	SEN	NT	**Possible;** the Transmission Study Corridor contains suitable shortgrass prairie habitat, however, the species is most common in the northeastern part of the state.
Pinyon jay	*Gymnorhinus cyanocephalus*	SEN	VU	**Likely;** the Transmission Study Corridor contains suitable pinyon-juniper woodland habitat.
Loggerhead shrike	*Lanius ludovicianus*	SEN	NT	**Possible;** the Transmission Study Corridor contains suitable open woodland habitat, however, it is outside of the species' usual distribution.
Virginia's warbler	*Leiothylpis virginiae*	SEN	LC	**Not likely;** the Transmission Study Corridor does not contain the ravines and steep, rocky slopes the species prefers.
Black-chinned sparrow	*Spizella atrogularis evura*	SEN	LC	**Possible;** the Transmission Study Corridor contains suitable areas of sparse shrubs and trees with a grassland component, however, there are not recorded observations of the species in Torrance County.

Common Name	Scientific Name	BLM Status*	IUCN Status**	Likelihood of Occurrence
Bendire's thrasher	*Toxostoma bendirei*	SEN	VU	**Not likely;** the Transmission Study Corridor does not contain yucca grassland or Sonoran desert habitat; the species is most common in the southeastern portion of New Mexico.
Fish				
Rio Grande sucker	*Catostomus plebeius*	SEN	DD	**None;** BLM lands within the Transmission Study Corridor do not support permanent ponds or streams.
Rio Grande chub	*Gila pandora*	SEN	LC	**None;** BLM lands within the Transmission Study Corridor do not support permanent ponds or streams.
Roundtail chub	*Gila robusta*	SEN	VU	**None;** BLM lands within the Transmission Study Corridor do not support permanent ponds or streams.
Insects				
Western bumble bee	*Bombus occidentalis*	SEN	VU	**Not likely;** the Transmission Study Corridor does not intersect high elevation, montane meadows.
American bumble bee	*Bombus pensylvanicus*	SEN	VU	**Possible;** the Transmission Study Corridor supports flowering plants utilized by the species.
Monarch butterfly	*Danaus plexippus*	SEN	VU	**Possible;** milkweed (*Asclepias* sp.) individuals, the host plant for monarch butterflies, were observed throughout the Transmission Study Corridor during field surveys.

Common Name	Scientific Name	BLM Status*	IUCN Status**	Likelihood of Occurrence
Mammals				
Townsend's big-eared bat	*Corynorhinus townsendii*	SEN	LC	**Not likely;** marginal foraging habitat occurs on BLM lands within the Transmission Study Corridor, however there are no caves necessary for roosting.
Gunnison's prairie dog	*Cynomys gunnisoni*	SEN	LC	**Possible;** active prairie dog colonies were observed on private lands in the eastern portion of the Transmission Study Corridor, however habitat on USFS lands for the species is marginal, and no active nor inactive colonies were observed.
Black-tailed prairie dog	*Cynomys ludovicianus*	SEN	LC	**Possible;** active prairie dog colonies were observed on private lands in the eastern portion of the Transmission Study Corridor, however habitat on USFS lands for the species is marginal, and no active nor inactive colonies were observed.
Spotted bat	*Euderma maculatum*	SEN	LC	**Not likely;** marginal foraging habitat occurs on BLM lands within the Transmission Study Corridor, however there are no caves necessary for roosting.
Hoary bat	*Lasiurus cinereus*	SEN	LC	**Not likely;** BLM lands within the Transmission Study Corridor do not support open water or riparian corridors necessary for foraging, nor large conifer species for roosting.

Common Name	Scientific Name	BLM Status*	IUCN Status**	Likelihood of Occurrence
Plants				
Galisteo sand verbena	*Abronia bigelovii*	SEN	N/A	**None;** no gypsum outcrops are present on BLM land within the Transmission Study Corridor.
Knight's milkvetch	*Astragalus knightii*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Acoma fleabane	*Erigeron acomanus*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Todilto stickleaf	*Mentzelia todiltoensis*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Cinder scorpionweed	*Phacelia serrata*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Yeso twinpod	*Physaria newberryi var. yesicola*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Mancos saltbush	*Proatriplex pleiantha*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Parish's alkaligrass	*Puccinellia parishii*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.
Gypsum townsend's daisy	*Townsendia gypsophila*	SEN	N/A	**None;** the Transmission Study Corridor is outside of the species' known range.

*SEN = Sensitive

**LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered; DD = Data Deficient

Table 3-16 Archaeological Resources within Transmission Study Corridor

LA Number	Site Type	NRHP Evaluation
97	Both Historic and Prehistoric	Eligible
323	Prehistoric	Unevaluated
956	Unknown	Unevaluated
4974	Prehistoric	Unevaluated
6556	Unknown	Unevaluated
6820	Unknown	Unevaluated
10734	Both Historic and Prehistoric	Eligible
10736	Prehistoric	Unevaluated
13717	Unknown	Unevaluated
27576	Prehistoric	Unevaluated
33127	Both Historic and Prehistoric	Eligible
37482	Prehistoric	Unevaluated
38360	Unknown	Unevaluated
38364	Unknown	Unevaluated
38365	Both Historic and Prehistoric	Unevaluated
38366	Both Historic and Prehistoric	Unevaluated
38368	Prehistoric	Unevaluated
38369	Prehistoric	Unevaluated
38370	Unknown	Unevaluated
38371	Unknown	Unevaluated
38372	Prehistoric	Unevaluated
38373	Unknown	Unevaluated
38374	Prehistoric	Unevaluated
38375	Prehistoric	Unevaluated
38376	Prehistoric	Unevaluated
38377	Prehistoric	Unevaluated
38378	Prehistoric	Unevaluated
38379	Unknown	Unevaluated
38380	Prehistoric	Unevaluated
44066	Prehistoric	Unevaluated
44067	Prehistoric	Unevaluated
44069	Prehistoric	Unevaluated
44070	Prehistoric	Unevaluated
44071	Unknown	Unevaluated
45857	Prehistoric	Unevaluated
50252	Prehistoric	Unevaluated
50253	Prehistoric	Eligible
50254	Prehistoric	Eligible
52003	Prehistoric	Unevaluated
52004	Prehistoric	Unevaluated

LA Number	Site Type	NRHP Evaluation
60960	Prehistoric	Unevaluated
60961	Unknown	Unevaluated
60966	Unknown	Unevaluated
60970	Unknown	Unevaluated
61129	Unknown	Unevaluated
69565	Prehistoric	Unevaluated
69566	Prehistoric	Unevaluated
69567	Prehistoric	Unevaluated
69568	Prehistoric	Unevaluated
69569	Prehistoric	Unevaluated
69570	Unknown	Unevaluated
69571	Prehistoric	Not Eligible
69881	Historic	Not Eligible
69882	Historic	Unevaluated
69883	Prehistoric	Eligible
70128	Unknown	Unevaluated
70605	Historic	Unevaluated
86701	Both Historic and Prehistoric	Not Eligible
88310	Prehistoric	Unevaluated
88311	Prehistoric	Unevaluated
88312	Prehistoric	Unevaluated
88330	Prehistoric	Unevaluated
99188	Prehistoric	Unevaluated
99189	Both Historic and Prehistoric	Eligible
99190	Both Historic and Prehistoric	Eligible
99191	Both Historic and Prehistoric	Unevaluated
99192	Unknown	Eligible
99193	Prehistoric	Unevaluated
99194	Unknown	Unevaluated
99210	Unknown	Unevaluated
99211	Prehistoric	Unevaluated
99212	Prehistoric	Unevaluated
100339	Historic	Unevaluated
100340	Historic	Unevaluated
105019	Unknown	Unevaluated
105020	Prehistoric	Unevaluated
105021	Prehistoric	Unevaluated
105022	Prehistoric	Unevaluated
105023	Prehistoric	Unevaluated
106768	Prehistoric	Unevaluated
116046	Historic	Unevaluated
116047	Historic	Unevaluated

LA Number	Site Type	NRHP Evaluation
128086	Historic	Unevaluated
129131	Prehistoric	Unevaluated
129132	Prehistoric	Unevaluated
129133	Prehistoric	Eligible
129134	Prehistoric	Eligible
129135	Prehistoric	Eligible
129136	Prehistoric	Eligible
130451	Historic	Unevaluated
131422	Historic	Not Eligible
138157	Prehistoric	Eligible
138158	Prehistoric	Not Eligible
141133	Historic	Unevaluated
142520	Both Historic and Prehistoric	Not Eligible
146930	Historic	Unevaluated
146931	Historic	Unevaluated
146932	Prehistoric	Unevaluated
146933	Both Historic and Prehistoric	Unevaluated
146934	Historic	Unevaluated
146935	Historic	Unevaluated
146937	Prehistoric	Unevaluated
146938	Historic	Unevaluated
146939	Historic	Unevaluated
146940	Both Historic and Prehistoric	Unevaluated
146941	Both Historic and Prehistoric	Unevaluated
146942	Historic	Unevaluated
146943	Historic	Unevaluated
146944	Both Historic and Prehistoric	Unevaluated
146945	Prehistoric	Unevaluated
146946	Both Historic and Prehistoric	Unevaluated
146947	Historic	Unevaluated
146948	Historic	Unevaluated
146949	Historic	Unevaluated
146950	Historic	Unevaluated
146951	Historic	Unevaluated
146952	Historic	Unevaluated
146953	Historic	Unevaluated
146954	Historic	Unevaluated
146955	Historic	Unevaluated
146956	Historic	Unevaluated
146957	Historic	Unevaluated
146958	Historic	Unevaluated
146959	Prehistoric	Unevaluated

LA Number	Site Type	NRHP Evaluation
146960	Historic	Unevaluated
146961	Unknown	Unevaluated
146962	Prehistoric	Unevaluated
146963	Both Historic and Prehistoric	Unevaluated
146964	Historic	Unevaluated
146965	Historic	Unevaluated
146966	Historic	Unevaluated
147804	Historic	Not Eligible
148455	Historic	Unevaluated
148456	Historic	Unevaluated
148457	Historic	Unevaluated
148458	Historic	Unevaluated
148459	Prehistoric	Unevaluated
148474	Historic	Unevaluated
148475	Historic	Unevaluated
148480	Historic	Not Eligible
152178	Prehistoric	Unevaluated
152179	Prehistoric	Unevaluated
152180	Both Historic and Prehistoric	Unevaluated
152181	Prehistoric	Unevaluated
152182	Unknown	Unevaluated
152183	Historic	Unevaluated
152184	Historic	Unevaluated
152190	Prehistoric	Unevaluated
152582	Prehistoric	Unevaluated
152583	Unknown	Unevaluated
152584	Prehistoric	Unevaluated
152585	Unknown	Unevaluated
152586	Both Historic and Prehistoric	Unevaluated
152587	Prehistoric	Unevaluated
152588	Prehistoric	Unevaluated
152589	Prehistoric	Unevaluated
152590	Prehistoric	Unevaluated
152591	Unknown	Unevaluated
152592	Both Historic and Prehistoric	Not Eligible
152594	Prehistoric	Eligible
152596	Prehistoric	Unevaluated
153004	Historic	Unevaluated
153406	Historic	Not Eligible
155986	Historic	Unevaluated
156828	Prehistoric	Unevaluated
160288	Historic	Not Eligible

LA Number	Site Type	NRHP Evaluation
160955	Prehistoric	Not Eligible
160956	Historic	Unevaluated
161041	Historic	Not Eligible
161042	Prehistoric	Not Eligible
162678	Prehistoric	Eligible
162679	Prehistoric	Unevaluated
162684	Prehistoric	Unevaluated
162685	Prehistoric	Unevaluated
162686	Prehistoric	Unevaluated
162687	Historic	Unevaluated
162688	Prehistoric	Unevaluated
162689	Prehistoric	Unevaluated
162690	Prehistoric	Unevaluated
162691	Prehistoric	Unevaluated
162692	Both Historic and Prehistoric	Unevaluated
163076	Prehistoric	Unevaluated
163077	Prehistoric	Unevaluated
163697	Historic	Unevaluated
164803	Prehistoric	Eligible
178207	Historic	Unevaluated
178208	Prehistoric	Unevaluated
178209	Historic	Unevaluated
178210	Historic	Unevaluated
184017	Prehistoric	Unevaluated
186893	Historic	Unevaluated
186894	Unknown	Not Eligible
186895	Both Historic and Prehistoric	Unevaluated
186896	Historic	Unevaluated
186905	Historic	Unevaluated
186906	Historic	Unevaluated
186908	Historic	Not Eligible
187523	Historic	Not Eligible
187524	Historic	Not Eligible
187528	Historic	Not Eligible
187529	Historic	Unevaluated
187534	Historic	Eligible
187541	Historic	Unevaluated
187542	Historic	Not Eligible
187548	Historic	Not Eligible
189501	Both Historic and Prehistoric	Unevaluated
191153	Unknown	Not Eligible
193469	Prehistoric	Eligible

LA Number	Site Type	NRHP Evaluation
193470	Historic	Unevaluated
193471	Historic	Unevaluated
195895	Historic	Not Eligible
197316	Prehistoric	Not Eligible
197317	Historic	Unevaluated
198901	Historic	Unevaluated
198903	Prehistoric	Unevaluated
198904	Prehistoric	Unevaluated
198905	Prehistoric	Unevaluated
198906	Prehistoric	Unevaluated
198907	Prehistoric	Unevaluated
198908	Historic	Unevaluated
198909	Prehistoric	Unevaluated
199046	Prehistoric	Unevaluated
199337	Prehistoric	Unevaluated
199469	Prehistoric	Unevaluated
200707	Historic	Unevaluated
201848	Prehistoric	Unevaluated
201849	Prehistoric	Unevaluated
201850	Historic	Unevaluated
201851	Prehistoric	Unevaluated
201852	Prehistoric	Unevaluated
201853	Prehistoric	Unevaluated
201854	Historic	Unevaluated
202404	Both Historic and Prehistoric	Unevaluated
203462	Prehistoric	Unevaluated
203463	Prehistoric	Unevaluated
203464	Both Historic and Prehistoric	Unevaluated
203465	Both Historic and Prehistoric	Unevaluated
203466	Both Historic and Prehistoric	Unevaluated
203467	Prehistoric	Unevaluated
203468	Prehistoric	Unevaluated
203469	Prehistoric	Unevaluated
203470	Prehistoric	Unevaluated
203471	Both Historic and Prehistoric	Unevaluated
203472	Historic	Unevaluated
203474	Prehistoric	Unevaluated
203476	Prehistoric	Unevaluated
203477	Historic	Unevaluated
203478	Prehistoric	Unevaluated
203479	Prehistoric	Unevaluated
203481	Prehistoric	Unevaluated

LA Number	Site Type	NRHP Evaluation
203483	Both Historic and Prehistoric	Unevaluated
203484	Both Historic and Prehistoric	Unevaluated
203485	Prehistoric	Unevaluated
203486	Prehistoric	Unevaluated
203487	Prehistoric	Unevaluated
203488	Both Historic and Prehistoric	Unevaluated
203489	Prehistoric	Unevaluated
203490	Historic	Unevaluated
203491	Both Historic and Prehistoric	Unevaluated
203492	Prehistoric	Not Eligible
203493	Prehistoric	Unevaluated
205930	Historic	Unevaluated
205931	Historic	Unevaluated
205932	Historic	Unevaluated
207623	Prehistoric	Unevaluated
207697	Prehistoric	Not Eligible
207960	Prehistoric	Unevaluated
207961	Both Historic and Prehistoric	Unevaluated

Appendix C - Permit Matrix

Agency	Proposal Requiring Action	Land Use Statute, Administrative Regulation or Environmental Authorization	Relevant Laws and Regulations
Federal			
Bureau of Land Management (BLM)	Pre-construction surveys; construction, operation, and abandonment of transmission line on BLM land	Right-of-way grant	Federal Land Policy and Management Act (FLPMA) (43 U.S.C. § 1761-1771); 43 CFR Part 2800
United States Forest Service (USFS)	Pre-construction surveys; construction, operation, and abandonment of transmission line on National Forest System land	Special Use Permit	FLPMA (43 U.S.C. § 1761-1771)
United States Fish and Wildlife Service (USFWS)	Manage effects on species listed or critical habitat designated under the Endangered Species Act (ESA)	Compliance with Section 7 or Section 10 the ESA	ESA, as amended (16 U.S.C. §1531 et seq.); BLM Manual H-6840 (Special-Status Species)
State Historic Preservation Officer, Advisory Council on Historic Preservation, tribes, other federal, state, and local agencies, and consulting parties	Identification of, and potential disturbance to, historic properties in Project area	Compliance with Section 106 of NHPA	National Historic Preservation Act (16 U.S.C. § 470); 36 CFR Part 800)
United States Environmental Protection Agency (USEPA)	Construction sites with greater than 1 acre of land disturbed	Section 402 National Pollutant Discharge Elimination System General Permit for Stormwater Discharges from Construction Activities	Clean Water Act (33 U.S.C. § 1342)
U.S. Army Corps of Engineers (USACE)	Construction across water resources	Section 10 and/or Section 404 permits (see below)	33 U.S.C. § 403, 1344(a); 33 CFR Parts 320, 322, 323, 325
	Potential discharge into waters of the U.S. (including wetlands and washes)	Section 404 permit for discharge of dredged or fill material to waters of the U.S.	Clean Water Act (33 U.S.C. § 1344)

Agency	Proposal Requiring Action	Land Use Statute, Administrative Regulation or Environmental Authorization	Relevant Laws and Regulations
Federal Highway Administration (also New Mexico Department of Transportation [NMDOT])	Construction, operation, and abandonment of transmission line across or within highway rights-of-way	Permits to cross Federal Aid Highway; 4(f) compliance	Federal-Aid Highway Act (23 U.S.C. § 101 et seq.); 23 CFR Parts 1.23 and 1.27; 23 CFR Part 645; 23 CFR Part 771
State of New Mexico			
New Mexico Public Regulation Commission	Construction of a transmission line with a voltage of 230 kV or greater	Transmission line location approval/ROW width determination	New Mexico Statute Annotated (NMSA) 1978 § 62-9-3 and 62-9-3.2
NMDOT	Upgrading gravel access roads and any additional highway entry/exit points	Access Permit, including stipulations for any safety enhancements necessary to the highway	18.31.6 NMAC
	Installation of transmission line within the ROW of state-managed roadways	New Mexico Public Highway Utility Accommodation Permit	17.4.2 NMAC
New Mexico Environment Department (NMED), Water Quality Bureau	Protect water quality standards during construction and operation activities	National Pollutant Discharge Elimination System Construction Stormwater Permit and Stormwater Pollution Prevention Plan	NMSA 74-6; 20.6 NMAC
NMED/Hazardous Waste Bureau	Management of hazardous waste on-site during construction /operation	Hazardous Waste Permit	NMSA 74-4; 20.4 NMAC
	Storage and use of hazardous chemicals on-site during construction/operation	USEPA Waste Activity USEPA ID Number	NMSA 4-4E-1
New Mexico State Lands Office	Construction of a transmission line on New Mexico State Lands	Right-of-way or easement on state land	NMSA 19-7-57
New Mexico State Historic Preservation Division	Identification of, and potential disturbance to, cultural resources in Project area	Cultural survey permit; coordination with State Historic Preservation Officer	NMSA 18-6; 4.108, 4.10.15 NMAC

Agency	Proposal Requiring Action	Land Use Statute, Administrative Regulation or Environmental Authorization	Relevant Laws and Regulations
Local			
Middle Rio Grande Conservancy District, Department of the Interior	Rio Grande crossing permit	Middle Rio Grande Conservancy District License Agreement	NMSA 1978 § 73-14-1
Socorro County	Encroachment of county right-of-way	Infrastructure Placement Permit	Socorro County Ordinance 2010-003
Torrance County	Work, excavating, boring, crosscuts or other cuts on county roads	Excavation Permit	Torrance County Road Department
Valencia County	Facilities within 100-year floodplain	Floodplain Development Permit and Elevation Certificate	Valencia County Code §154.150 Floodplain Overlay District
	Utilization of county right-of-way	Right-of-way Use Permit	Valencia County Code §94.027 Road Cut and Infrastructure Placement

Appendix D - Sandhill Crane Collision Risk Assessment

TECHNICAL MEMORANDUM

DATE: October 9, 2026

TO: Mid-State Transmission LLC

CC: Ian Evans, Environmental Senior Manager, Pattern Energy
Morgan Martin, Natural Resources Environmental Associate, Pattern Energy

FROM: Quentin Hays, Senior Wildlife Ecologist, GeoSystems Analysis, Inc.
Rachel Vanausdall, Senior Wildlife Ecologist, GeoSystems Analysis, Inc.

RE: Sandhill crane collision risk assessment for the Mid-State Transmission Project

Introduction and Executive Summary

The Mid-State Transmission Project (MST; Project) is an approximately 103-mile (mi; 166-kilometer [km]) electrical transmission line being developed by Mid-State Transmission LLC in Torrance, Socorro, and Valencia counties, New Mexico on behalf of the Public Service Company of New Mexico (PNM). The Project will be constructed in two configurations, including primarily rebuilding an existing 115-kilovolt (kV) PNM transmission line (i.e., the WL 115-kV transmission line that connects the existing Willard and Los Morros substations) to support a new, 345-kV transmission line, and where not practicable, constructing a new, standalone 345-kV transmission line (Figure 1). This memorandum provides the results of an assessment of the exposure rate, used as a proxy for collision risk, of sandhill cranes (Antigone.canadensis; SACR), focusing on the Project's crossing of the Rio Grande in Valencia County, where the existing WL 115-kV transmission line will be rebuilt to support a new, 345-kV transmission line.

Using empirical flight data, the individual passage rate of SACR crossing the existing WL 115-kV transmission at the Rio Grande was estimated to be 0.53 crossings per SACR per day, translating to approximately 24,065 crossings per day, conservatively assuming a wintering SACR population size of 45,000 in the Middle Rio Grande Valley (MRGV; Hays et al. 2021) and a scenario where all wintering SACR would regularly traverse the area. Using the same assumptions, the population exposure rate at the existing WL 115-kV transmission line was predicted to be to 1,131 exposed crossings per day, and the addition of the Project resulted in a predicted exposure rate of 2,856 exposed crossings per day. Assuming a collision rate of 0.00023 collisions per exposed crossing (Brown and Drewien 1995), 0.66 collisions per day, or 53 collisions for an entire season, were predicted at the Project. Utilizing bird flight diverters (BFD) on the Project would reduce the exposure rate and thus potential collisions materially. Brown and Drewien (1995) demonstrated a 91.3% reduction in SACR collisions with power lines with BFD, which would reduce estimated SACR collisions for the Project to 4 per season.

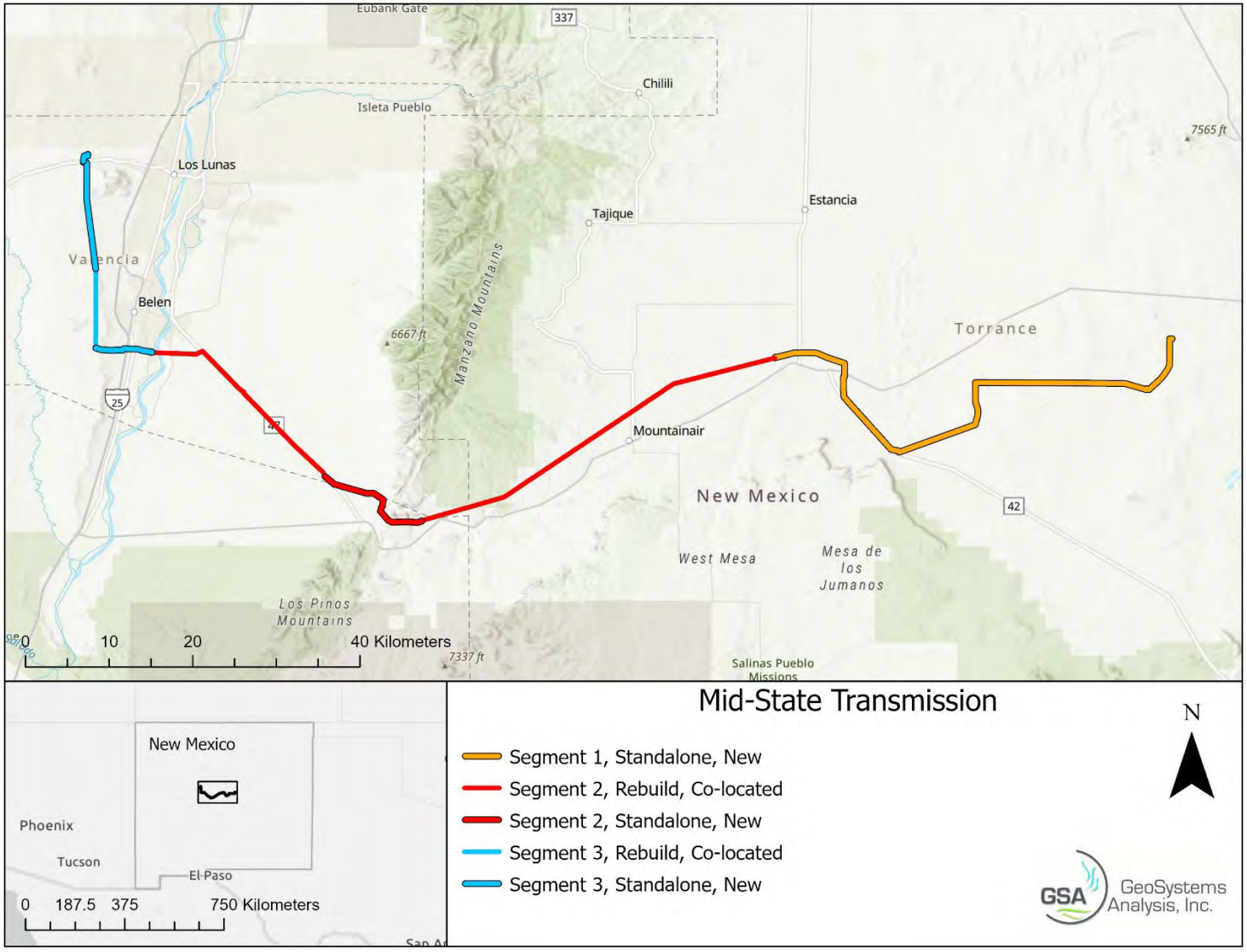


Figure 1. The Mid-State Transmission Project in Torrance, Socorro, and Valencia counties, New Mexico.

Background

Construction of the Project is planned to occur in an area considered to be important for wintering SACR and waterfowl. Each year approximately 80% of the estimated 25,000 Rocky Mountain Population (RMP) greater SACR (A¡.c¡.tabida; Seamans 2026) and thousands of lesser SACR (A¡.c¡. canadensis) from the Midcontinent Population (MCP) overwinter along the Rio Grande in the MRGV (Boggie et al. 2018; Drewien and Bizeau 1974; Seamans 2026). Sandhill cranes roost along the Rio Grande and on public lands managed for waterbirds, and forage in surrounding agricultural lands, including on supplemental cereal grain crops (e.g., corn) grown and provisioned by a multiagency program.

The MRGV is also an important wintering area for various species of waterfowl, including geese and several dabbling duck species. Light geese (i.e., lesser snow geese [Anser.caerulescens] and Ross's geese [A¡.rossii]) overwinter in the thousands and use similar roosting and foraging habitat as sandhill cranes (Boggie et al. 2023). Over 30,000 northern pintail (Anas.acuta) and several thousand mallards (A¡.platyrhynchos) may use the MRGV during fall migration and the wintering period (Lee et al. 2007). These species make localized movements throughout the MRGV, specifically along the Rio Grande and within the public areas managed for waterbirds.

Power lines that bisect flights paths are known to create collision risk to birds (APLIC 2012, 2026). Large-bodied birds, such as SACR and waterfowl, are particularly susceptible to collision with power lines due to longer wingspans, reduced maneuverability in flight relative to smaller-bodied birds, and tendency to flock and travel in large groups (Bevanger 1998). For example, Brown and Drewien (1995) estimated that for every 100,000 crossing events over power lines by SACR in the San Luis Valley, Colorado, up to 23 fatal collisions occurred, translating to a collision rate of up to 0.00023 collisions per crossing. Dwyer et al. (2019) estimated 37 collisions out of a total of 916 crossing events in Nebraska, translating to a collision rate of 0.04 collisions per crossing. The position of power lines relative to foraging or roosting habitat may also put birds at greater risk of collision as they move among feeding, roosting, and loafing sites. Sandhill cranes and waterfowl often move several times in a single day while wintering in the MRGV, and the frequency of movements may vary throughout the wintering season (Hays et al. 2021). Studies have found that SACR and waterfowl may be more at risk to collision with power lines in areas with wetlands adjacent to agricultural fields used for foraging (Brown et al. 1987, Faanes 1987).

In order for a collision to occur, an individual bird must first be exposed to a power line (i.e., near the line); the degree of exposure varies based on several factors, such as behavior, weather, and time of year. Data on direct mortality from power lines are unavailable in many cases, and exposure risk is often estimated in lieu of collision risk (e.g., Hays et al. 2021), with the assumption that exposure risk and collision risk and are linearly related. However, while exposure events may be frequent, collisions depend on various factors, such as morphology of the bird, weather, lighting, and overall visibility, which collectively influence collision avoidance behaviors (i.e., changing flight direction in response to detection of the line) and may result in a non-linear relationship between exposure and collision (D'Amico et al. 2019). Collision avoidance behaviors also vary widely among avian species, with large-bodied, less maneuverable waterbirds (e.g., SACR) showing less ability to avoid collisions when exposed. Exposure risk is still informative, as exposure to a power line must occur before collision occurs, and data on collision rates (i.e., the number of collisions per exposed crossings) from other studies, if available, can be used to predict the number of potential collisions.

The proposed Project is within the wintering distribution of both SACR and multiple waterfowl species. Specifically, the Project is planned to cross the Rio Grande at a point approximately 15 miles north of areas primarily managed for foraging and roosting SACR and waterfowl. An assessment of the collision risk to SACR posed by hypothetical transmission lines across the MRGV was completed previously (Hays et al. 2021). Hays et al. (2021) identified that exposure rates of SACR were highest within the MRGV at Rio Grande crossings immediately adjacent to these wildlife areas south of the proposed Project.

Sandhill cranes are also exposed to a number of anthropogenic pressures in addition to crossing and potentially colliding with power lines. For example, 1,810 RMP SACR were legally harvested by hunters in 2025-26 (Seamans 2026), and SACR are often subject to mortality from disease outbreaks on the wintering grounds within managed areas in the MRGV. Despite this, population estimates of RMP and MCP SACR have increased in recent years (Seamans 2026).

While collision with power lines bisecting flight paths is a risk to SACR and waterfowl, there are commonly employed measures that can reduce this risk. Measures employed to minimize collision risk posed by power lines typically center on improving visibility to birds in flight through the use of various marking devices, or BFD, which have been shown to reduce collision rates (Table 1; Sporer et al. 2013; Bernardino et al. 2019; Ferrer et al. 2020). These reductions in collision rates arise as the visibility of power lines is increased and the exposure zone for birds in flight shrinks, reducing exposure rates. Devices used to mark lines include aviation marker balls, different styles of spiral line markers, and modern dynamic, or "flapper" type devices. Studies have shown that collision rates may decline by 50-98% for SACR and other large-bodied birds through the use of BFD (Barrientos et al. 2011; Bernardino et al. 2019; Dwyer et al. 2019). Of particular relevance to the analysis described herein, a reduction in collision mortality of approximately 62% for SACR and waterfowl, and 91.3% for just SACR, was shown when BFD were installed on a power line in the San Luis Valley in southern Colorado (Brown and Drewien 1995).

Table 1. Efficacy of bird flight diverters commonly used on power lines to reduce avian collisions.

Device	Description	Reduction in Collisions	Species	Source
Aviation Marker Balls				
marker balls	large colored spheres	53%	waterfowl, SACR	Morkill and Anderson 1991; Savereno et al. 1996
Spiral Line Markers				
spiral vibration damper	PVC spiral device	62%	waterfowl, SACR	Brown and Drewien 1995
Bird-Flight Diverter™	PVC spiral device that increases in diameter	57-90%	cranes, waterfowl, herons, rails, storks	Koops 1987; Alonso 1994; Crowder 2000
Swan-Flight Diverter™	PVC spiral with larger diameter in the center	38-95%	cranes, waterfowl, swans, storks	Barrientos et al. 2012; Crowder 2000; Janss and Ferrer 1998; Rasmussen 2001
Suspended/Dynamic Devices (i.e., Flappers)				

Device	Description	Reduction in Collisions	Species	Source
general designs	swinging and fixed devices of various shapes	40-70.9%	waterfowl, SACR	Brown and Drewien 1995; Ferrer et al. 2020
FireFly™	rectangular plates with reflective surfaces	50-98%	SACR, passerines	Yee 2008; Murphy et al. 2009, Dwyer et al. 2019*

*Dwyer et al. (2019) demonstrated a 98% reduction in SACR collisions with power lines in Nebraska by utilizing FireFly™ BFD in conjunction with ultraviolet power line illumination technology, the Avian Collision Avoidance System.

In addition to installing BFD, co-locating power lines has been identified as a way to reduce collision risk to birds (Thompson 1978; APLIC 2012). Co-location of power lines refers to placing new power lines in existing rights-of-way (ROW) or immediately adjacent and parallel to existing power lines. Co-location of new power lines with existing lines combines two independent collision hazards into a single hazard that birds in flight must avoid, reducing the overall combined collision risk for both power lines if constructed and located independently by minimizing risk flight behaviors (Bevanger 1994). Also, additional power line configurations immediately adjacent and parallel to one another may increase overall visibility of the combined hazard, and best practice guidelines suggest that new power lines be sited along existing linear elements (e.g., roads) to help reduce exposure and minimize collisions (Williams 2003, Prinsen et al. 2012, SNH 2016).

Other evidence suggests that rebuilding and combining existing power lines with new configurations on the same towers may also reduce collision risk. Ground or shield wires located above conductors and typically the uppermost portion of a power line configuration are frequently the primary risk for bird collisions (Bevanger 1994; Thompson 1978). These wires are generally single wires, often paired, not bundled, and thinner when compared to conductors; studies suggest that birds collide with these wires as they try to maneuver over the more visible conductors (Bevanger and Brøseth 2001; Prinsen et al. 2011). Thus, rebuilding an existing power line to combine two otherwise independent power lines would reduce the total number of overhead ground wires, reducing the exposure zone and collision risk. Similarly, studies have shown that reducing the total number of horizontal obstacles on power lines lowers collision risk (Bernardino et al. 2018; Bevanger and Brøseth 2001). Further, because exposure in such instances is consolidated into a single hazard and associated collision risk declines with increased avoidance behaviors, it is likely that BFD will reduce collision risk for both existing and new power lines that are rebuilt into a single, new configuration.

Purpose

The purpose of this memorandum is to evaluate contemporary SACR passages and exposure to the existing WL 115-kV transmission line, assess whether exposure rates for SACR would change with the construction of the Project, and translate SACR exposure rates to the potential number of collisions that could occur due to the Project. Exposure rate was calculated in lieu of collision rate, as collision data are unavailable for the existing WL 115-kV transmission line or other power lines in the MRGV. However, exposure rate does not account for avoidance behaviors, and collision rates are typically magnitudes of order lower than exposure rates. Thus, because studies have demonstrated low collision rates for SACR (e.g., Brown and Drewien 1995), we assumed that collision rate relative to exposure rate would be low (i.e., 0.00023 collisions per exposed crossing [Brown and Drewien

1995]). An assessment of exposure rates provides a baseline for understanding potential collisions. Because the impact of co-located/rebuilt power lines on SACR exposure to collisions in the MRGV is not known, we examined the change in exposure rates under two scenarios: 1) if the Project increases exposure rates due to additional transmission line configurations on the landscape, and 2) if the Project decreases exposure rates. We used data collected from SACR marked with GPS devices as part of an unrelated study to measure current exposure rates and estimated changes in exposure rates under these two scenarios. The evaluation described herein also includes proposed mitigation measures intended to minimize collision risk to SACR and other birds posed by construction and operation of the Project.

Study Area

The Study Area includes the portion of the proposed Project that bisects the MRGV in Valencia County, New Mexico and surrounding lands (Figure 2). Sandhill cranes and waterfowl utilize public and private property both north and south of the Project in the MRGV. To examine exposure rates of SACR and capture flights that crossed the existing WL 115-kV transmission line and proposed Project, we defined a Study Area that accounts for movement of SACR among roosting, foraging, and loafing sites. The Study Area was informed by empirical and interpolated flight data from SACR marked with GPS devices.

For the purposes of this memorandum, a maximum ROW of 200 feet (ft; 61 meters [m]) has been assumed, but some segments of the Project may have a smaller permanent ROW depending on the surrounding vegetation/habitat, sensitive areas, land constraints, and engineering considerations.

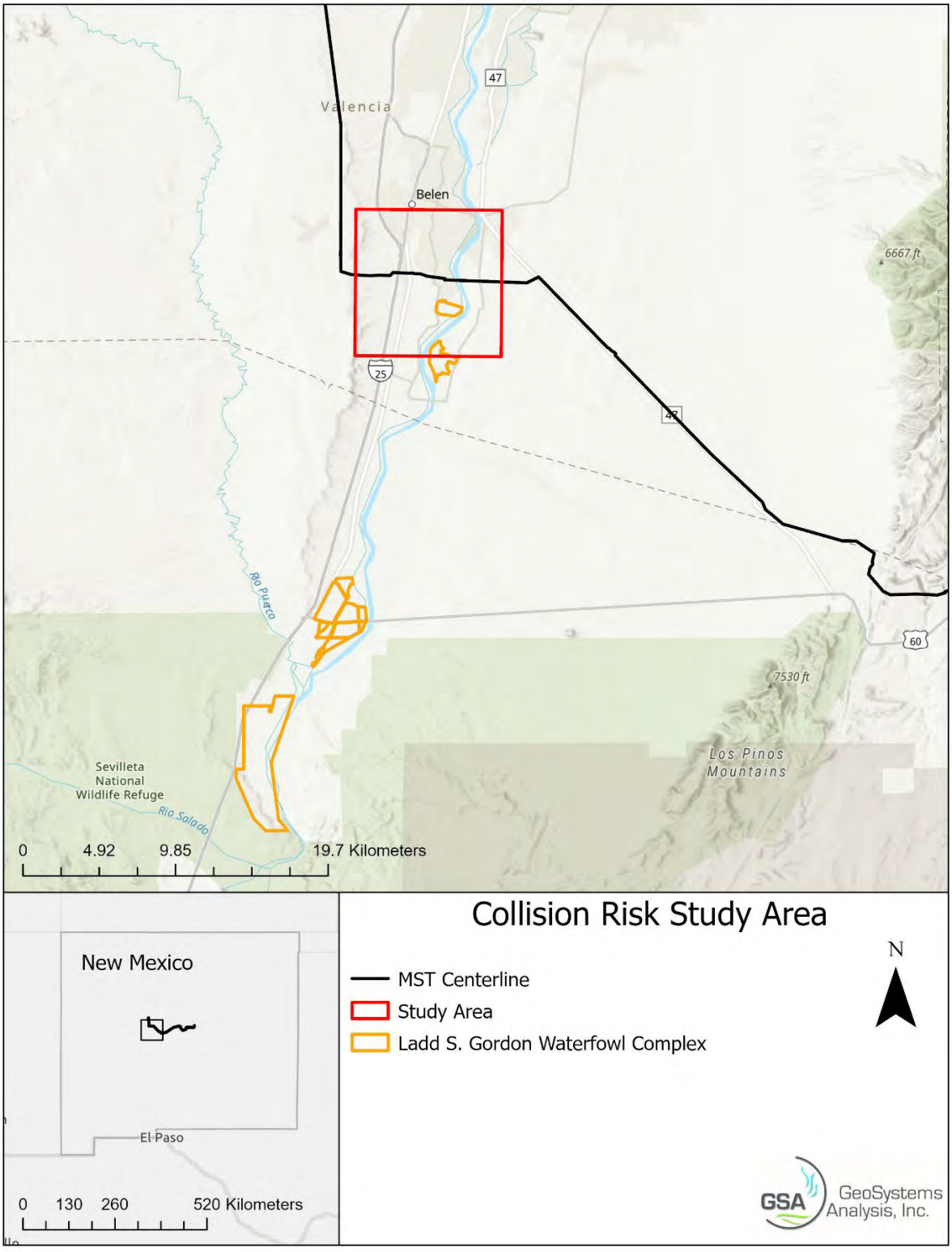


Figure 2. The sandhill crane collision risk Study Area for the Mid-State Transmission Project in Torrance, Socorro, and Valencia counties, New Mexico.

Methods

Data.Formatting

The GPS data were formatted to include only data between December 6, 2025, and February 15, 2026, within the Study Area. While many SACR may still be present in the MRGV at the end of February, some may be starting spring migration and so have longer and higher flights, which can be considered outliers compared to daily winter flights. Including such outliers would reduce estimated exposure rates for SACR wintering in the MRGV.

We assigned locations to be either "in-flight" or "stationary" based on both calculated speed (in meters [m]/second [s]) and accelerometer data. We assigned locations with a speed of >0.6 m/s as "in-flight". For the first half of the study, GPS units acquired fixes every 30 minutes. After January 8, 2026, GPS units were programmed to use flight mode, whereby accelerometer capabilities allowed the units to switch to 15-second fixes when flight was detected. These data provided a finer temporal structure from which flight characteristics could be assessed.

Passage.Rate.and.Exposure.Rate

The exposure zone is an area immediately around a transmission line where a bird could plausibly interact with the transmission line and potentially avoid or collide with the line (Figure 3). To be exposed to a transmission line, a bird must be 1) flying, 2) crossing the transmission line, and 3) near the transmission line. Thus, we determined a SACR to be exposed to a transmission line when it was crossing a transmission line and within the exposure zone.

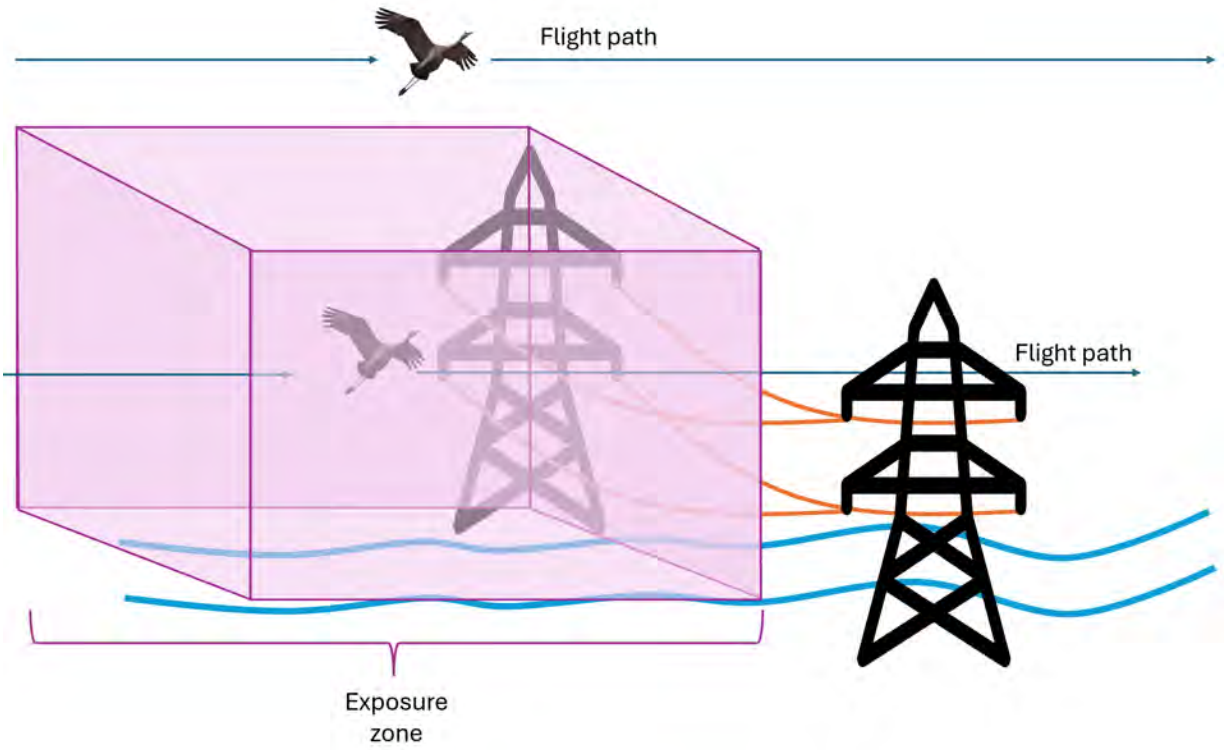


Figure 3. An example schematic of the exposure zone experienced by sandhill cranes near a transmission line.

Exposure to a transmission line is conditional on flight, so we used only flight locations to estimate exposure probability. Collisions occur as SACR approach a power line and when the line is approximately perpendicular to their flight path. Empirical data also confirm that SACR primarily fly over power lines rather than under (Brown et al. 1987, Morkill and Anderson 1991). We defined crossings as those where a marked SACR traveled between two consecutive locations and the flight route crossed the existing WL 115-kV transmission line.

The exposure zone was determined based on the maximum height of the existing WL 115-kV transmission line or the maximum height of the Project, the height of the SACR during flight, and the location of the SACR relative to the existing WL 115-kV transmission line or the Project (see.Figure 3). We assumed that exposure would differ between the existing WL 115-kV transmission line and the Project due to differing maximum heights of the existing WL 115-kV transmission line and the Project at the Rio Grande crossing. The height of the exposure zone (i.e., exposure height) was based on the height of the transmission structures and the height above ground level (AGL) of the uppermost wires on either the existing WL 115-kV transmission line or the Project. The maximum exposure height corresponded to the approximate height of the transmission towers on either side of the Rio Grande, plus an additional 4.9 m (Morkill and Anderson 1991; Hays et al. 2021). Minimum height of the exposure zone was ground level, as SACR typically fly over power lines and flight trajectories below the minimum height of power line configurations could still result in exposure as birds attempt to avoid collisions by flying over the span. For the existing WL 115-kV transmission line, the exposure height ranged between 0 and 29.9 m AGL; for the Project the exposure height ranged between 0 and 64.9 m AGL. The length of the exposure zone (i.e., exposure distance) was based on anecdotal observations and empirical evidence of SACR crossing power lines. Empirical data on the ability of SACR to perceive power lines are limited, and what information is available is primarily based on observations of behaviors of SACR flying near power lines. Morkill and Anderson (1991) observed most SACR reacting (i.e., gaining altitude, flaring, or changing direction in flight) to 345- and 69-kV transmission lines within 25 m from the lines, but 27% of observed flocks reacted at farther distances (i.e., up to 250 m). Because definitive data on the distance at which SACR respond to power lines are limited and show varying results based on location, we used a conservative distance of 250 m from the existing WL 115-kV transmission line as a precautionary measure intended to encompass the space within which SACR have been observed altering flight behavior (i.e., engaging in avoidance behavior) when encountering a power line.

Using the number of crossings and exposed crossings at the existing WL 115-kV transmission line, we calculated: 1) individual passage rate, 2) population passage rate, 3) individual exposure rate, and 4) population exposure rate. Passage rates provide a measure of how frequently SACR interact with the existing WL 115-kV transmission line and the proposed Project, while exposure rate measures how frequently those passages result in an exposure event. We calculated the individual passage rate as the number of crossings per SACR per day over the WL 115-kV transmission line, while the population passage rate was calculated as the individual passage rate multiplied by the population of SACR known to regularly winter in the MRGV from (i.e., 45,000 [Hays et al. 2021]). Similarly, we calculated the individual exposure rate as the number of exposed crossings per SACR per day, while the population exposure rate was calculated as the individual exposure rate multiplied by the population of SACR known to regularly winter in the MRGV. Additionally, exposure rates for the Project were calculated, and the resulting average exposure rate was compared to the exposure rate for the

existing WL 115-kV transmission line. Analyses were completed in Program R (R Core Team 2026). We reported measures of variability and uncertainty using 95% confidence intervals (CI).

We extrapolated passage and exposure rates to the population level assuming that 45,000 SACR use the MRGV during the wintering season (Hays et al. 2021). This number comes from a combination of the recent estimates of the RMP SACR population size (e.g., Seamans 2026) and the number of MCP SACR that also winter in the MRGV. The number 45,000 may be an overestimate of population size in the MRGV during the winter and is certainly a conservative estimate of the number of SACR that regularly interact with the existing WL 115-kV transmission line and would thus interact with the Project, so resulting exposure rates and corresponding collision estimates should be considered highly conservative.

Finally, we estimated the potential the number of SACR collisions with the Project using the exposure rate estimate and available literature on collision rates with and without BFD installed. Brown and Drewien (1995) estimated that at most 0.00023 collisions of SACR occurred per crossing for power lines without BFD. We multiplied this value by the population exposure rate to estimate the number of SACR collision that could occur with the Project without BFD. We repeated this process for the Project with BFD using the estimate of 0.00002 collisions per crossing with BFD installed from Brown and Drewien (1995).

Results

A total of 32 SACR were marked with GPS units and used to examine passage and exposure rates between December 6, 2025, and February 15, 2026.

Existing.WL.77❶_kV.Transmission.Line

The average individual passage rate for the existing WL 115-kV transmission line was 0.53 (95% CI, 0.47-0.60) crossings per SACR per day and increased throughout the season, peaking around mid-February (Figure 4). Conservatively assuming 45,000 SACR were within the Study Area, the average population passage rate was 24,065 (95% CI, 21,282-26,848) crossings per day.

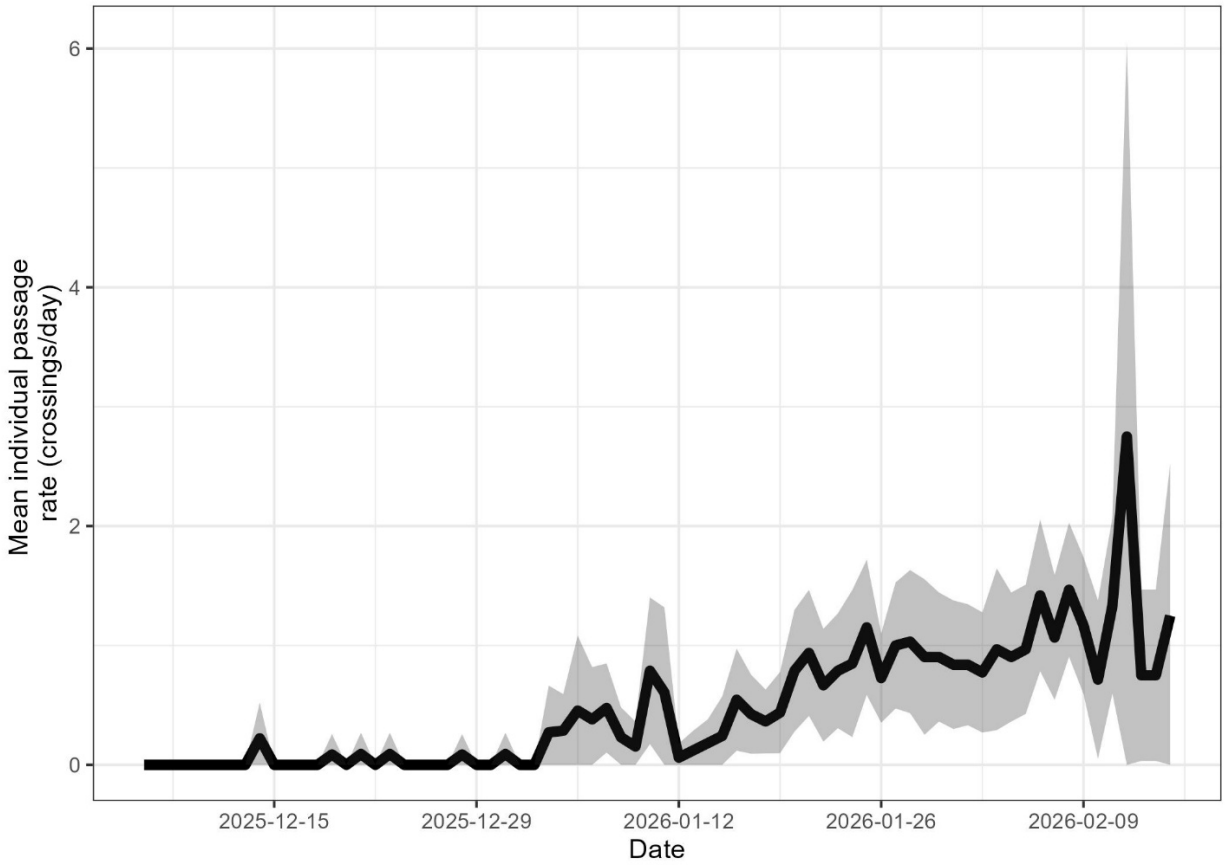


Figure 4. Mean individual passage rates of SACR crossing the existing WL 115-kV transmission line during the 2025-2026 winter season. Shaded regions represent 95% confidence intervals.

The average individual exposure rate for the existing WL 115-kV transmission line was 0.03 (95% CI, 0.002-0.03) exposed crossings per SACR per day Figure 5. Conservatively assuming 45,000 SACR were within the Study Area, the average population exposure rate was 1,131 (95% CI, 779-1,484) exposed crossings per day.

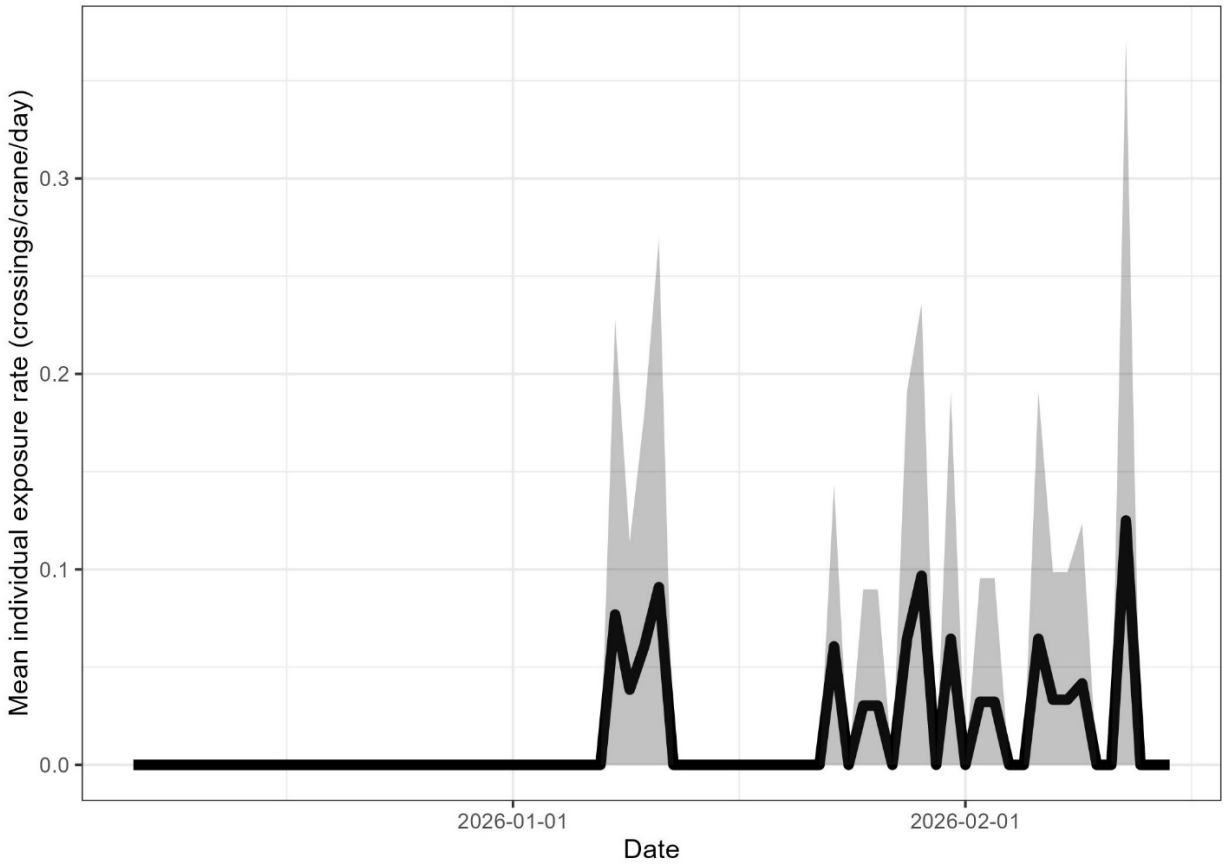


Figure 2. Mean individual exposure rates of SACR crossing the existing WL 115-kV transmission line during the 2025-2026 winter season. Shaded regions represent 95% confidence intervals.

Existing.WL.77❶_kV.Transmission.Line.Combined.with.the.Project

With the addition of the Project, the average individual exposure rate increased to 0.06 (95% CI, 0.05-0.08) exposed crossings per SACR per day (Figure 6), translating to 2,856 (95% CI, 2,140-3,571) exposed crossings per day using the conservative assumption that 45,000 SACR were within the Study Area. Using a value of 0.00023 collisions per crossing of the Project without BFD (Brown and Drewien 1995), we estimated 0.66 collisions per day, resulting in 53 collisions per season (i.e., 81 days per season [Hays et al. 2021]). Using a value of 0.00002 collisions per crossing of the Project with BFD (Brown and Drewien 1995), we estimated 0.06 collisions per day, resulting in 4 collisions per season.

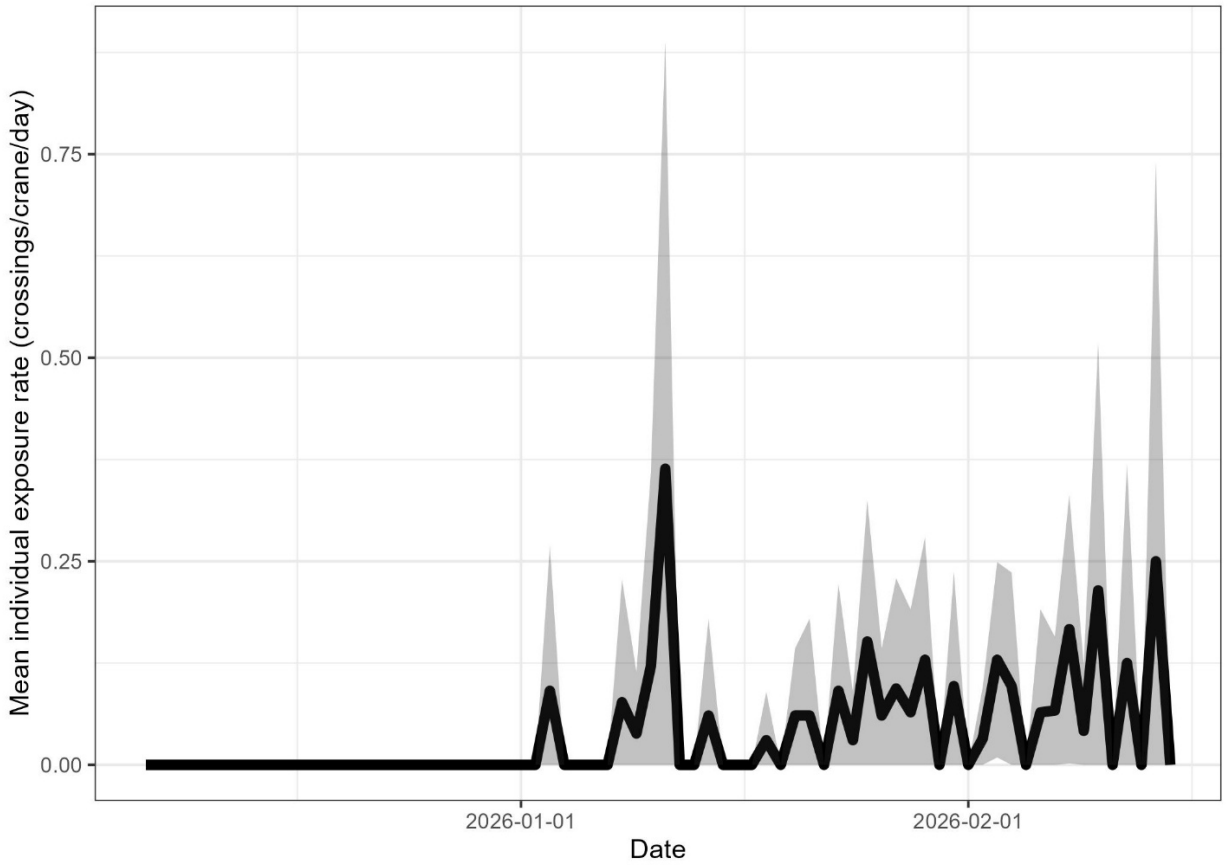


Figure 6. Mean individual exposure rates of SACR crossing the Project (pre-construction) during the 2025-2026 winter season. Shaded regions represent 95% confidence intervals.

Summary and Discussion

The population passage for the existing WL 115-kV transmission line indicated that SACR were regularly crossing this transmission line during the 2025-2026 winter season. Average individual passage rate for the existing WL 115-kV transmission line (i.e., 0.53 crossings per SACR per day) translated to a peak of 24,065 crossings per day, using the conservative assumption of 45,000 wintering SACR in the MRGV and Study Area. Changes in passage rates are likely related to changes in habitat use by SACR throughout the season (Vanausdall et al. 2025). Average individual exposure rate (i.e., 0.03) for the existing WL 115-kV transmission line was relatively low relative to passage rates

and translated to 1,131 exposed crossings per day, using the same conservative population assumptions.

Comparing the estimates described herein to those of other studies, individual exposure rates were within the realm of expectations. For example, the individual exposure rate estimate for the existing WL 115-kV transmission line (i.e., 0.03) was within range of Hays et al. (2021), who provided estimates on exposure rates for SACR along the Rio Grande in the MRGV. Hays et al. (2021) found peak exposure rates (i.e., 0.075) near the Bernardo Wildlife Management Area (WMA), which is part of the Ladd S. Gordon Waterfowl Complex approximately 15 miles south of the proposed Project. Our individual exposure rate estimate (i.e., 0.03) for the existing WL 115-kV transmission line was considerably lower than the peak estimate for a hypothetical line near Bernardo WMA 15 miles south. This difference in exposure rates is likely related to habitat availability and use. Wintering SACR spend a considerable amount of time foraging and roosting in and around Bernardo WMA, which is managed specifically for SACR and waterfowl, whereas there are no sites close to the existing WL 115-kV transmission line managed specifically for SACR.

Exposure rate increased with the addition of the Project to the existing WL 115-kV transmission line, from 0.03 exposed crossings per SACR per day to 0.06 exposed crossings per SACR per day, resulting in an estimated 2,856 exposed crossings per day, again using the conservative assumption of 45,000 SACR within the MRGV and Study Area. While the Project resulted in increased exposure, this combined exposure rate is lower than if the Project were to be built independently of the existing WL 115-kV transmission line, which would create an additional exposure zone beyond the exposure zone of the existing WL 115-kV transmission line. For example, if the Project were to be built independently of the existing 115-kV transmission line it would presumably carry the same or similar exposure rate as that estimated herein (i.e., approximately 0.06 exposed crossings per SACR per day), and the existing WL 115-kV transmission line would carry the same estimated exposure rate (i.e., 0.03 exposed crossings per SACR per day). This would result in a total exposure risk of approximately 0.09 exposed crossings per SACR per day for two independent transmission lines, which is greater than the estimate of 0.06 exposed crossings per SACR per day when the existing WL 115-kV transmission line is combined with the Project.

Finally, we predicted that 53 collisions could occur due to the Project based on our estimates of exposure rate and assumptions related to the wintering SACR population size and use of the Study Area. This is a conservative estimate, as SACR space use and distribution in the MRGV is highly variable both within and among seasons. For example, RMP SACR are known to winter in the MRGV south of the Study Area (e.g., Bosque del Apache National Wildlife Refuge, approximately 60 miles south) and utilize relatively localized wintering home ranges that do not intersect the Study Area (Hays et al 2021).

The addition of BFD to the Project showed a decrease in the number of potential collisions to 4 per season. While these predicted fatalities are still important to consider, it is also important to consider these impacts in context with other anthropogenic pressures, such as the approximately 1,800 RMP SACR that were legally harvested by hunters in 2025-26. Indeed, wintering population estimates of SACR in the MRGV have remained stable or increased in recent years despite increasing hunting pressure and impacts from other anthropogenic sources.

Mitigation Measures

The Project is committed to applying APLIC principles and completing an avian risk review to inform locations for BFD to minimize avian collision risk posed by the Project. This risk review will also utilize stakeholder input. Specific BFD designs will be selected based on site-specific criteria including relative collision risk to SACR, as well as overall efficacy and durability of BFD. Based on best available science and the analyses described herein, implementation of BFD on the Project within the vicinity of the Rio Grande will result in material reductions in SACR collisions with the Project.

References

Alonso, J. C., J. A. Alonso, and R. Munoz-Pulido. 1994. Mitigation of bird collisions with transmission lines through groundwire marking. Biological Conservation 67:129-134.

Avian Power Line Interaction Committee (APLIC). 2012. Reducing Avian Collisions with Power Lines: The State of the Art in 2012. Edison Electric Institute and APLIC. Washington, D.C.

APLIC. 2026. Suggested Practices for Avian Protection on Power Lines. Delaware.

Barrientos, R., J. C. Alonso, C. Ponce, C., and C. Palacín. 2011. Meta-analysis of the effectiveness of marked wire in reducing avian collisions with power lines. Conservation Biology 25:893-903.

Bernardino, J., K. Bevanger, R. Barrientos, J. F. Dwyer, A. T. Marques, R. C. Martins, J. M. Shaw, J. P. Silva, and F. Moreira. 2018. Bird collisions with power lines: State of the art and priority areas for research. Biological Conservation 22:1-13.

Bernardino, J., R. C. Martins, R. Bispo, and F. Moreira. 2019. Re-assessing the effectiveness of wire-marking to mitigate bird collisions with power lines: A meta-analysis and guidelines for field studies. Journal of Environmental Management 252:109651.

Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. Ibis 136:412–425.

Bevanger, K. 1998. Biological and conservation aspects of bird mortality caused by electricity power lines: a review. Biological Conservation 86:67-76.

Bevanger, K., and H. Brøseth. 2001. Bird collisions with power lines - an experiment with ptarmigan (Lagopus spp.). Biological Conservation 99:341–346.

Boggie, M. A., D. P. Collins, and S. A. Carleton, S. A. 2023. Availability of supplemental corn for sandhill cranes, light geese, and dabbling ducks wintering in New Mexico. Journal of Fish and Wildlife Management 14:51–61.

Boggie, M. A., D. P. Collins, J. Patrick Donnelly, and S. A. Carleton. 2018. Land use, anthropogenic disturbance, and riverine features drive patterns of habitat selection by a wintering waterbird in a semiarid environment. PLoS ONE, 13:1–26.

Brown, W. M., R. C. Drewien, and E. G. Bizeau. 1987. Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. Pages 128-136 inJ. C. Lewis, editor, Proceedings of the 1985 Crane Workshop, Grand Island, Nebraska.

Brown, W. M. and R. C. Drewien. 1995. Evaluation of two power line markers to reduce crane and waterfowl collision mortality. Wildlife Society Bulletin 23:217-227.

Crowder, M. R. 2000. Assessment of devices designed to lower the incidence of avian power line strikes. Master's Thesis, Purdue University.

D'Amico, M., R. C. Martins, J. M. Álvarez-Martínez, M. Porto, R. Barrientos, and F. Moreira. 2019. Bird collisions with power lines: Prioritizing species and areas by estimating potential population-level impacts. Diversity and Distributions 25:975-982.

Drewien, R. C., and E. G. Bizeau. 1974. Status and distribution of greater sandhill cranes in the Rocky Mountains. Journal of Wildlife Management 38: 720–742.

Dwyer, J.F., A.K. Pandey, L.A. McHale, and R.E. Harness. 2019. Near-ultraviolet light reduced Sandhill Crane collisions with a power line by 98%. The Condor Ornithological Applications 121(2) duz008.

Faanes, C. A. 1987. Bird behavior and mortality in relation to power lines in prairie habitat. U. S. Fish and Wildlife Service General Technical Report 7. 24 pp.

Ferrer, M., V. Morandini, R. Baumbusch, R. Muriel, M. De Lucas, and C. Calabuig. 2020. Efficacy of different types of "bird flight diverter" in reducing bird mortality due to collision with transmission power lines. Global Ecology and Conservation 23: e01130.

Garrettson, P. R. and M. E. Seamans. 2025. Status and harvest of sandhill cranes: Mid-continent, Rocky Mountain, Lower Colorado River Valley, and Eastern Populations. Administrative Report, U.S. Fish and Wildlife Service, Laurel, Maryland and Lakewood, Colorado, U.S.A. 46pp including tables and figures.

Hays, Q. R., A. T. Tredennick, J. D. Carlisle, D. P. Collins, and S. A. Carleton. 2021. Spatially explicit assessment of sandhill crane exposure to potential transmission line collision risk. Journal of Wildlife Management 85:1440-1449.

Janss, G. F. E. and M. Ferrer. 1998. Rate of bird collision with power lines: effects of conductor-marking and static wire-marking. Journal of Field Ornithology 69:8-17.

Koops, F. B. J. 1987. Collision victims of high-tension lines in the Netherlands and effects of marking. KEMA Report 01282-MOB 86-3048.

Lee, C., J. P. Taylor, D. A. Haukos, and M. C. Anderson, M. C. 2007. Winter survival of northern pintails in the Middle Rio Grande Valley, New Mexico. Western North American Naturalist 67:79-85.

Morkill, A. E. and S. H. Anderson. 1991. Effectiveness of marking power lines to reduce sandhill crane collisions. Wildlife Society Bulletin 19:442-449.

Murphy, R. K., S. M. McPherron, G. D. Wright, and K. L. Serbousek. 2009. Effectivness of avian collision averters in preventing migratory bird mortality from power line strikes in the Central Platte River, Nebraska. 2008-2009 Final Report. 30 September 2009, Dept. of Biology, University of Nebraska-Kearney, Kearney, NE. 32 pp.

Prinsen, H., G. Boere, N. Píres, and J. Smallie. 2011. Review of the conflict between migratory birds and electricity power grids in the African-Eurasian region. www.buwa.nl

Rasmussen, P. J. 2001. Problem resolutions for avian interactions at two NSP facilities. InProc. Avian Interactions with Utility and Communication Structures Workshop. 2–3 December 1999. Charleston, SC. EPRI Technical Report No. 1006907.

Savareno, A. J., L. A. Savareno, R. Boettcher, and S. M. Haig. 1996. Avian behavior and mortality at power lines in coastal South Carolina. Wildlife Society Bulletin 24:636-648.

Seamans, M. 2026. Status and Harvests of Sandhill Cranes 2026: Mid-Continent, Rocky Mountain, Lower Colorado River Valley and Eastern Populations. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Branch of Assessment and Decision Support, Lakewood, CO. September 1, 2026. Available online: https://www.fws.gov/media/status-and-harvests-sandhill-cranes-2026

Scottish Natural Heritage. 2016. Assessment and mitigation of impacts of power lines and guyed meteorological masts on birds. Guidance Version 1: July 2016. www.snh.gov.uk

Sporer, M. K., J. F. Dwyer, B. D. Gerber, R. E. Harness, and A. K. Pandey. 2013). Marking power lines to reduce avian collisions near the Audubon National Wildlife Refuge, North Dakota. Wildlife Society Bulletin 37:796-804.

Thompson, L. S. 1978. Transmission line wire strikes: mitigation through engineering design and habitat modification. In M. L. Avery (Ed.), Impacts.of.Transmission.Lines.on.Birds.in.Flight (pp. 27–52). US Fish and Wildlife Service.

Williams, J.H. 2003. International Best Practice for Assessing and Reducing the Environmental Impacts of High-Voltage Transmission Lines. Prepared for the Third Workshop on Power Grid Interconnection in Northeast Asia, Vladivostok, Russia.

Yee, M. L. 2008. Testing the effectiveness of an avian flight diverter for reducing avian collisions with distribution power lines in the Sacramento Valley, CA. California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2007-I22.

Best Management Practices

PNM Exhibit IE-5

Is contained in the following 6 pages.

	Category	No.	Pattern Energy New Mexico Environmental Best Management Practices (September 16, 2026)
New Mexico State Land Office Required Practices for Surface Users			
New Mexico State Land Office Required Practices for Surface Users	Design	1	New surface disturbance will be minimized within 200 feet of the boundary of riparian areas, wetlands, playas or other water bodies (e.g., the ordinary high water mark) to the extent practicable. Where avoidance is not practicable, impacts will be minimized and comply with the U.S. Army Corps of Engineers Nationwide Permit under Section 404 of the Clean Water Act. Boring under these water features may be utilized where practicable and designs are approved. To minimize new surface disturbance within 200 feet of the boundary of any riparian area, wetland, playa or other water body means: only temporary use will be allowed; no blading, grading, or digging; no permanent structures; no permanent roads (with the exception of the permanent maintenance road where no other route is possible, but never across playas); no introduction of outside material, (i.e. gravel, caliche, base course), no mechanical compaction, and full reclamation requirements for any temporary use: flipping or ripping compacted temporary use areas if necessary; reseeding, weed control, re-contouring to previous condition. For any permanent maintenance road crossing a riparian area, to minimize new surface disturbance means the minimum width that is absolutely necessary, and the road must be designed to allow the natural hydrology of the basin to continue functioning as if the road was not there: built to allow water to move under, through or across the road, without catchments or pooling or channeling, with erosion control structures and flow dispersal structures as necessary, and plantings as necessary to manage hydrologic functioning condition.
		2	All efforts should be made to minimize new surface disturbance: new roads and rights-of-way should make use of pre-existing disturbed areas, including existing roadbeds, pipeline or utility line rights-of-way, or in pre-existing or dedicated corridors when practicable.
		3	No new surface disturbance will be permitted within 200' feet of the centerline of ephemeral drainages, floodways, arroyos or other short duration flow channels, except when crossing these channels and drainages. Where avoidance is not practicable, impacts will be minimized and comply with the U.S. Army Corps of Engineers Nationwide Permit under Section 404 of the Clean Water Act. Drainage crossings will be perpendicular to flow, and will be built to accommodate 25-year flood events and to control erosion. Boring under these water features maybe utilized where practicable and designs are approved.
		4	Establish property boundaries.
		5	Minimize new surface disturbance and design for minimum necessary width/area of impact according to expected purpose and use.
		6	Avoid wetlands, known critical habitat, and protected areas.
		7	Avoid steep slopes (>12%) where practicable; grades from 4-10% are preferred for managing drainage; roads and rights-of-way are best placed at the toe of slopes where cross slope is between 5% and 40%.
		8	Preserve as much natural vegetation and living root structure as possible. If the material is less than three inches in diameter, lopping and scattering is permitted. If greater than three inches, the material can be chipped or masticated then spread to no thicker than four and a half inches.
		9	Provide adequate surface drainage; as grade steepens drainage features, such as water bars, must be closer together; drainage features on fine grained soils should be closer together.
		10	Account for cultural resources at least in accordance with minimum standards as set forth in NMSLO policy ADM-0106.
		11	Account for biological resources at least in accordance with minimum standards as set forth in NMSLO Policy ADM-0105.
		12	Include a spill containment and prevention plan where hazardous materials are involved.
		13	Include a reclamation plan detailing soil stabilization and revegetation process.
		14	Include an access control plan.
		15	All reclamation success criteria shall follow federal NPDES guidelines whereas a minimum of 70% density (of pre-existing conditions) of native flora shall be successfully reestablished prior to release from permit requirements for ongoing inspections and maintenance of temporary ESC BMPs.
		16	Use only native weed-free certified seed for reclamation.
		17	Include a noxious weed prevention plan.
		18	Include a dust abatement plan.
		19	Address crown, inslope, outslope and shoulder design (roads).
		20	Address trenching and boring design, including depth, casing, core sampling, valve location and access management (pipelines).
		21	Define use, location and size of temporary work space, temporary storage and turnouts.
		22	Address logistics of construction.

New Mexico State Land Office Required Practices for Surface Users	Construction Practices	23	Address all pertinent state and federal regulations.
		24	Control access to the construction site.
		25	Control unauthorized use of space adjacent to permitted rights-of-way and use areas.
		26	Maintain temporary erosion control structures, such as silt fencing to prevent sediment flow during construction.
		27	All water utilized for dust abatement shall be suitable for meeting federal NPDES guidelines for water quality standards for revegetation. A minimum of 70% density (of pre-existing conditions) of native flora shall be successfully reestablished prior to release from permit requirements for ongoing inspections and maintenance of temporary ESC BMPs.
		28	When requested by the Commissioner, engage a compliance inspection officer to monitor quality control and compliance with NMSLO best management practices.
		29	Sample, test and monitor to ensure construction materials meet design specifications.
	Operation Practices	30	Dispose of unsuitable or excess excavation material in approved locations to minimize adverse impacts to water quality or other resources.
		31	Grade and shape roadway surfaces to maintain distinct inslope, outslope or crown shape to move water effectively off the road surface.
		32	Compact graded roadway surfaces to preserve hard driving surface; replace surface material when needed; implement dust abatement plans.
		33	Fill ruts and potholes with gravel or compacted fill or remove ruts through rolling dips and water bars; reshape structures to maintain proper function.
		34	Clean ditches and reshape when necessary to allow adequate flow capacity.
		35	Remove debris from the entrance of culverts to prevent plugging and overtopping; check for signs of damage.
		36	Replace or repair rock armor, erosion control structures, or vegetation used for slope protection, scour protection or energy dissipation.
		37	Inspect and repair fencing, gates, cattle-guards and other access control structures.
	Reclamation	38	Inspect reclamation, revegetation and noxious weed treatments and retreat as necessary to maintain proper functioning of erosion control and establishment of native vegetation.
		39	Seek a remediation right-of-entry for any reclamation of state trust land outside the bounds of the permitted right-of-way.
		40	Verify compliance with NMSLO biological and cultural resource policies (ADM-0105 and ADM-0106) for the area to be reclaimed.
		41	Sample, remove and properly dispose of any contaminated soils.
		42	Remove and properly dispose of any caliche or other surface base course.
		43	Contaminated soils and caliche should be disposed of only in state permitted disposal locations, such as land farms or hazardous disposal sites.
		44	Replace caliche, base course or contaminated soils with certified clean top soil comparable to undisturbed clean soils in the near vicinity.
		45	Contour the ground surface to blend in with the surrounding topography and to allow the natural hydrology of the basin to function without impediment or impact.
		46	Install erosion control structures as necessary to repair and control gullies, head-cuts, rills, and other forms of sediment movement.
		47	Erosion control structures should be designed to restore natural hydrologic function and to the extent possible should use local rock or bio-degradable materials and low-energy, minimum necessary designs.
		48	Structures may include, but are not limited to, one rock dams, rock mulch rundowns, zuni bowls, media lunas, swales, berms, terraces, wattles, rock or log mats, hay mulch, gabions, bales or other stabilizing enhancements to control erosion.
		49	Prepare the seedbed to maximize potential for success. This may include, but is not limited to, a combination of watering, mechanical packing to consolidate loose soils, disking to loosen compacted soils, or crimping hay mulch into the soil, (2 tons/acre), adding soil amendments, contouring and/or importing top soil.
		50	Install water bars, or other NMSLO approved flow control, at an angle of 30% to the grade along the contour of the road or right-of-way, up to two feet high and six feet wide; water bars should be placed on any slope greater than level, every ten feet in elevation change or every 300 feet, whichever is less.
		51	Seed the prepared seedbed with a drill seeder or hydraulic seeder. Hydroseeding will be used on 3:1 slopes or greater. The seed mix will be based on NMSLO revegetation guidelines and will be provided or approved by the NMSLO.
		52	In the event of a spill or hazardous materials release, the project SPCC Plan guidelines must be followed and reporting requirements set forth by NMED shall be followed. Provide draft copy of SPCC Plan to SLO for approval.
		53	A noxious weed plan will be developed and noxious weeds will be monitored and treated on an annual basis, or as needed, for three years post construction.

New Mexico State Land Office Minimum Requirements for Surface Reclamation			
New Mexico State Land Office Minimum Requirements for Surface Reclamation	**Objective**	**1**	To reduce and prevent erosion, remove contaminants and contaminated materials, restore clean soils, restore native plant diversity and abundance, restore and maintain hydrological regime, and restore and maintain productive habitat for livestock and wildlife.
	Applicability	**2**	These Minimum Requirements are applicable to all reclamation activities on state trust lands including: hazardous materials spills/releases, site closure for oil and gas, mineral and business leases, plug and abandon site reclamation, mine site reclamation, pit, pad, or pond reclamation, illegal dump reclamation, road and pipeline reclamation, dairy farm or other agricultural impact reclamation, and any other clean up or reclamation activity on state trust land.
	Access	**3**	If the spill/release or reclamation project extends beyond the lease boundary or permitted right of way, contact the NMSLO Rights Of Way Division and obtain a remediation right-of-entry.
	Compliance	**4**	Before commencing any new ground disturbing activity:
		5	(a). Conduct an archaeological survey of the impacted area, or verify that the area has already been surveyed and that no cultural properties will be impacted by ground disturbing activities;
		6	(b). If cultural properties have been impacted by a spill/release or reclamation project, immediately stop all ground disturbing activities and contact NMSLO for further direction;
		7	(c). Verify compliance with NMSLO biological and cultural resource policies (ADM-0105 and ADM-0106) for the area to be reclaimed; conduct surveys where necessary;
		8	(d). Verify compliance with all state and federal regulations, including but not limited to storm water pollution and prevention, air quality control, and hazardous materials disposal;
	Hazard Material Spill / Releases	**9**	Other Spills/Releases: (i). Upon discovery of any non-oil and gas related hazardous material release, including mine waste, either current or historic, immediately notify NMED and NMSLO;
	Delineation	**10**	Upon discovery of contaminated soils, delineate the horizontal and vertical extent of the contamination;
		11	For any spill on State Trust Lands: Written Report for all spills. For spills greater than 25 gallons, immediate notification (email address to be defined) to SLO within 24 hours;
		12	For non-oil and gas related contamination, the NMED may require delineation and monitoring related to surface and ground water impacts;
		13	The NMSLO may require any necessary sampling or reclamation related to the restoration of surface conditions within 60 days post-notification.
	Reclamation Plan	**14**	A project revegetation plan will be designed to meet NPDES requirements and submitted to NMSLO for review and approval.
	Removal/ Containment	**15**	Remove and replace, or stabilize and contain any contaminated soils, including contaminated caliche or base course; remove and replace all caliche or base course; contaminated soils and caliche should be disposed of only in state permitted disposal locations, such as land farms or hazardous disposal sites, and in accordance with state and federal regulations.
	Soil Replacement	**16**	Replace contaminated soils, caliche or base course, and uncontaminated caliche or base course, with certified clean top soil; soils should have comparable structure and chemistry to healthy, native undisturbed soils in the vicinity.
	Trash and Debris	**17**	Unless equipment is to be re-used onsite, any trash, debris, garbage, rubbish, junk, scrap, or broken or contaminated equipment, such as pipelines, plastic lining, surface flowlines, tanks, scrap materials of any kind, or other equipment must be removed and disposed of in accordance with state and federal regulations within 30 days of final use or completion of construction.
		18	No hazardous substances, trash or litter will be buried or placed in pits.
	Surface Preparation	**19**	Contour the ground surface to blend in with the surrounding topography to allow the natural hydrology of the basin to function without impediment or impact.
		20	No major depressions or pits will be left that will trap water or cause ponding except where the project involves a mining pit where there is no possible outlet, such as a caliche pit.
	Erosion Control	**21**	Where active transportation of sediment through gullying, headcutting, slumping or deep or excessive rills (greater than 3 inches deep) occurs within the lease area or within the adjacent area of impact, install erosion control structures to repair and control gullies, head-cuts, rills, and other forms of sediment movement.
		22	(a). Erosion control structures should be designed to restore natural hydrological function and flood regime, and to the extent possible should use local rock or biodegradable materials and low-energy, minimum-necessary designs.
		23	(b). Erosion control structures may include, but are not limited to, one rock dams, rock mulch rundowns, zuni bowls, media lunas, swales, berms, terraces, wattles, rock or log mats, hay mulch, gabions, bales or other stabilizing enhancements to control erosion.

New Mexico State Land Office Minimum Requirements for Surface Reclamation	**Drainage Control**	**24**	Drainage control structures should be designed to mimic natural hydrological function and flood regime as much as possible so as not to increase the erosional impact of hydrologic flows to the structure or to the upstream or downstream landscape; drainage control designs should be engineered and stamped by a PE.
		25	Drainage control structures may include but are not limited to road bars, culverts, water bars, parallel and lateral ditches, drains, and low water crossings.
	Seedbed Preparation	**26**	Revegetation to meet or exceed 70% density of surrounding cover. If straw/hay mulching is used, straw/hay must be certified weed free.
	Revegetation	**27**	On 3:1 slopes or greater additional revegetation BMPs shall be deployed (such as: hydromulching, crimp mulching, or erosion control blanket).
	Access Control * applicable to SLO properties	**28**	a. Gate and Fencing Specifications: Unless otherwise directed by the NMSLO, a locked metal gate with 4-inch H-braces and a permanent fence extending at least 100 feet from either side of the gate, or to the next adjacent gate, will be installed to block public access to all closed reclamation sites; fence will be constructed with steel T-posts on 16-foot spacing, with stays every 8 feet and 4 strands of barbed wire; the top wire should be set at 42 inches above the ground surface; inline braces will be used at intervals not to exceed 660 feet; corners will be braced and set in concrete; fence wire will be attached on the outside of the T-posts with wire ties.
		29	b. Permanent Closure Specifications: Dirt berms, permanent hard barriers or rock barricades will be installed to block unauthorized access points to reclamation sites; berms and barriers will be at least 3 feet high and will extend the width of the access point; berms will be hard packed; barriers and barricades may be constructed of metal pipe rail, concrete, or rock and may be used in combination with berm work to ensure closure of an access point; Keep these areas from being general access routes for the public. Require fencing with requests for other options on a case-by- case basis.
	Monitoring	**30**	The responsible party will monitor the reclamation site annually until relinquished by the NMSLO during restoration sign-off process and completion of action item list.
		31	Prior to relinquishment, the NMSLO will retain the right to inspect and to provide sign-off prior to release and may require supplemental clean up, maintenance of erosion control structures, additional reseeding efforts, or noxious weed treatments to ensure success of reclamation.
		32	The NMSLO may request detailed annual monitoring reports depending on the severity of the situation.
	Reporting	**33**	The NMSLO may require monthly updates during the course of the initial reclamation work; monthly updates will include a brief narrative statement of work completed with photo documentation; upon completion of the initial reclamation work, the responsible party will notify the NMSLO that the site is ready for inspection; rights of way lessees will provide an affidavit of completion (NMAC 19.2.10.21); annual monitoring reports may be required depending on the severity of the situation.
	Relinquishment	**34**	The NMSLO will inspect the initial reclamation work upon completion and will provide the responsible party with a statement indicating that the initial work has been completed as required and detailing any follow up work that may be necessary prior to relinquishment; notice of relinquishment will be provided upon complete satisfaction of all NMSLO reclamation requirements.
New Mexico Forest Practices Guidelines			
New Mexico Forest Practices Guidelines	**Watershed**	**1**	Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership, and foreseeable future uses.
		2	All personnel appointed as fire watch under hot work permitting will have immediate access to shovel, fire extinguisher, and backpack water sprayer. In addition, all project work will follow guidelines detailed in the site fire protection and prevention plan.
	Riparian/ Wetland Edge	**3**	No constructed features of the project should be located in a wetland. Linear features which must cross a riparian area will be required to follow U.S. Army Corps of Engineers regulations.
		4	Wetlands and other environmentally sensitive areas will be marked in the field for easy identification by crews. Sensitive features will be defined in a wetland delineation report.
	Streamside Management Areas	**5**	200' minimum for Streamside Management Area (SMA) boundaries.
		6	Leave trees on the bank that will eventually fall across the stream, helping to create a stair step of pools in the stream channel, providing a fish habitat component. Larger trees increase the benefits for the habitat. Hazard trees may be felled and left in place at contractor's discretion.
		7	Do not service vehicles where chemicals, oil, or other toxic substances might contaminate soils, waterways, or waterbodies.

New Mexico Forest Practices Guidelines	Roads	8	Properly design roads and drainage facilities to prevent potential water quality problems before construction starts.
		9	Minimize the number of roads constructed in a watershed through comprehensive planning, recognizing intermingled ownership, and future uses.
		10	Road design specifications should be included in a contract between the landowner and the road builder. The contract should include exact road locations, dimensions, erosion control and drainage features, stream crossing and structure specifications, season(s) of construction and use, and maintenance schedule, road closure and re-vegetation procedures, and penalties for non-compliance. The more specific the road contract, the more protection there is for the resources and landowner.
		11	Fit the road to the landscape. This entails altering natural drainage patterns as little as possible by following contours and minimizing cuts, fill, and stream crossings. Utilize natural road building locations away from streams.
		12	Avoid problem areas such as flood zones, narrow canyon bottoms, wet areas and highly erodible or unstable soils. Do not locate roads on slopes more than 60 percent.
		13	Keep the road grade to a minimum, usually less than 10 percent. This can be exceeded for short distances where necessary. An easy grade prevents runoff from building up erosive force and also provides for safer and more efficient travel.
		14	Prevent the concentration of water on the road by designing adequate drainage features. Some suggested drainage methods are insloping and outsloping the road surface, and installation of grade dips and cross drains. Installation of these features is explained in the civil details.
		15	When a stream crossing is necessary, locate the site on a stable, straight portion of the stream. The approach to the crossing should be at a minimal grade and a right angle to the stream.
		16	Leave 200' buffer of undisturbed soil and vegetation on either side of a stream being impacted.
		17	Schedule construction activities to avoid heavy seasonal rains. Excavation operations may expose mineral soil which is highly susceptible to erosion. Soil stabilization and erosion control measures should be completed before the monsoon (thunderstorm) season of July, August, and September. Clear only that part of the route that can be completed in the current season.
		18	Minimize disturbance during construction activities by restricting machinery to the designated road. Clear vegetation to the width required for cut and fill slopes. Excessive removal of vegetation further increases erosion and is more costly. Keep machinery out of streams except when absolutely necessary for culvert installation and bridge construction. Round the top of cut slopes only when this will provide more stability than a vertical cut.
		19	During clearing operations, do not mix organic debris with fill materials. Trees and brush will eventually decay in the fill material causing the road surface to become unstable. Dispose of organic debris properly by utilization, piling and burning, chipping, or lopping and scattering. A good use for slash is to place it along fill slopes to slow runoff and trap sediment.
	Culverts	20	Remove debris from stream channels that was added during construction. It is a good practice to remove all debris from channels for at least 100 feet upstream from culverts to reduce the chance of the culvert becoming plugged. However, never remove well established logs from a stream, as this will likely cause accelerated channel erosion.
		21	Deposit surplus soil and rock in designated areas where sediment from this material will not threaten streams. Do not simply cast surplus material downslope from the road. This material is highly susceptible to erosion and may have future value as fill.
		22	Compact all fill material. This can be done simply by running a bulldozer up and down the fill slope where it is safe to do so. Large fills should be constructed and compacted in layers of approximately 18 inches. The slots made perpendicular to the slope in the soil by the bulldozer's tracks retard runoff and moisture, thus inhibiting erosion and encouraging re-vegetation. In addition, the chance of fill slumping and requiring expensive repair will be reduced.
		23	Servicing and refueling machinery must be conducted well away from wetlands, lakes or watercourses. Fluids such as oil, diesel fuel, and antifreeze are easily washed or leached into streams and present a significant threat to water quality and aquatic life.
		24	Make certain the road surface is adequately drained. This can be accomplished in a number of ways depending on the site factors, the type and level of use, and the standard to which the road is built.
		25	A shallow gravel fill on either side of the culvert will lessen maintenance requirements. As with any cross drain, rocks and slash should be placed at the outlet to slow runoff and spread sediment. Size of the culverts, of any type, should follow recommendations. Care must be taken to disperse the discharge from these cross drains through vegetation.
		26	The culvert must be long enough to extend at least one foot beyond the fill.
		27	Align the culvert exactly with the stream, on the existing grade, and at the depth of the streambed.
		28	Culverts on fish-bearing streams must be installed to allow fish passage so as not to isolate populations.

New Mexico Forest Practices Guidelines	Recommendations	29	Fill should be well compacted to half the diameter of the culvert, and fill over the culvert should be to a depth of half the diameter but not less than one foot. Compaction will prevent water from seeping around the culvert and washing away the fill material. Fill over the culvert must be deep enough to prevent damage from heavy vehicles. If more than one culvert must be installed side by side, they should spread half their diameter so that the fill may be compacted between them.
		30	Protect the fill material around the culvert inlets and outlets with riprap. Deep fills or culverts on large streams may require more elaborate protection such as wingwalls constructed of concrete or gabions.
		31	Inspect newly constructed roads after the first good rain to insure all drainage structures and erosion control features are functioning properly. Gullies forming on cut and fill slopes should be filled in and the drainage formed.
		32	Grade the road surface as needed to correct washboarding and rutting. Maintain the proper inslope, outslope, or crown, and reshape grade dips. Ditches should be disturbed only if they are becoming clogged with sediment. Apply gravel to spots on the road that are persistently wet.
		33	Inspect drainage structures frequently. Culverts and ditches should be cleared of sediment and debris.
		34	Application of chemicals to roads to reduce dust should be limited to those road sections where dust will cause major discomfort. Applications should be avoided where road runoff discharges into or near a stream.
		35	Inspect all tracked equipment for excessive soil prior to entering the site.

Notes:
These BMPs were developed in coordination with the NM State Land Office for the portions of Western Spirit Wind and SunZia Wind South located on New Mexico State Trust Lands (2022).

Practicability of these BMPs means capable of being done or feasible without significant or unreasonable costs or delay. Any such costs or delays must take into account the overall activity (e.g., a minor route adjustment of a road may increase cost in a non-significant degree but could result in a significant delay in construction schedule depending on the circumstance).

Any BMP that references coordination with or reporting to NM State Land Office or other agencies will be followed as applicable (e.g., on State Trust Lands for NM State Land Office).

Consulted Agencies

PNM Exhibit IE-6

Is contained in the following 1 page.

Agencies Consulted to Date for the Mid-State Transmission Project
Federal
United States Fish and Wildlife Service
United States Forest Service
Bureau of Land Management
State
New Mexico Department of Wildlife (formerly New Mexico Department of Game and Fish)
New Mexico Public Regulation Commission
New Mexico State Lands Office
Local
Middle Rio Grande Conservancy District
Valencia County
Torrance County
Socorro County

BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF PUBLIC SERVICE COMPANY OF NEW MEXICO'S APPLICATION FOR A CERTIFICATE OF PUBLIC CONVENIENCE AND NECESSITY TO CONSTRUCT, OWN, AND OPERATE, LOCATION APPROVAL, AND RIGHT-OF-WAY DETERMINATION FOR THE MID-STATE 345 KV TRANSMISSION PROJECT	)	**Docket No. 26-0000XXX**
PUBLIC SERVICE COMPANY OF NEW MEXICO,	)	
Applicant.	)	

AFFIDAVIT

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

IAN EVANS, Environmental Senior Manager for Pattern Energy Group LP, upon being duly sworn according to law, under oath, deposes and states: I have read the foregoing **Direct Testimony of Ian Evans,** and it is true and accurate based on my own personal knowledge and belief.

Dated this 30th day of October, 2026.

/s/ Ian Evans
IAN EVANS

GCG # 535976