Before the
Pennsylvania Public Utility Commission

ALBURTIS 500 kV TERMINATION

ATTACHMENTS IN SUPPORT OF THE
LETTER OF NOTIFICATION

Application Docket No. ___________

Submitted by: PPL Electric Utilities Corp.

Attachment 1

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1.0 INTRODUCTION

PPL Electric Utilities Corporation ("PPL Electric") is proposing to re-terminate one span of the Breinigsville-Alburtis 500 kV Transmission Line at the PPL Electric and FirstEnergy shared Alburtis 500-230 kV Substation in Lower Macungie Township, Lehigh County (the "Project"). The proposed Project involves re-terminating the Breinigsville-Alburtis 500 kV Transmission Line from Bay 1 into Bay 2. As explained below, the Project is required to accommodate the relocation of relay and control equipment in the Alburtis 500-230 kV Substation in order to isolate PPL Electric equipment currently located in a control cubicle shared with FirstEnergy.

Subject to the Commission's approval, construction is scheduled to begin in September 2017 to support the Project's scheduled in-service date of October 2017. The total estimated cost of the Project is $430,500 which includes substation work and the transmission line re-termination.

2.0 TRANSMISSION SYSTEM PLANNING PROCESS

The nation's interconnected transmission grid serves as the backbone for the safe and reliable delivery of large amounts of electricity from generating stations over substantial distances to customers served by transmission and local distribution systems. It is critically important that this interconnected transmission system (transmission grid) be planned and designed to be highly reliable so that reliable electric service can be provided under peak and all loading conditions and when certain elements of the system are out of service (system contingencies) due to planned or unplanned outages.

System Planning is the process that assures that the transmission system can supply electricity to all customer loads in a manner that is reliable and economical. This System Planning process assures that both the Bulk Electric System ("BES")[1] and non-Bulk Electric System ("non-BES")[2] are planned and constructed so that:

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[1] Bulk Electric System (BES) – Includes transmission facilities operated at voltages of 100 kV or higher.

[2] Non-Bulk Electrical System (non-BES) – Includes transmission facilities operated at voltages less than 100 kV.

- They are able to accommodate forecasted system flows during summer and winter peak load;
- They can adequately serve each customer's need with regard to capacity, voltage and reliability for all load levels throughout the daily load cycle;
- They can sustain probable contingencies and disturbances with minimal customer service interruptions; and
- They are in conformance with North American Electric Reliability Corporation ("NERC"), PJM Interconnection, LLC ("PJM"), and the Transmission Owner's reliability criteria for all normal and emergency operating conditions.

PJM is a FERC-approved Regional Transmission Organization ("RTO") charged with ensuring the reliability of the electric transmission system under its functional control (100 kV and above), and coordinating the movement of electricity in all or parts of thirteen states and the District of Columbia, including most of Pennsylvania. In order to ensure reliable transmission service, PJM prepares an annual Regional Transmission Expansion Plan ("RTEP")[3] to identify system reinforcements that are required to, among other things, meet the NERC Reliability Standards, PJM reliability planning criteria, and Transmission Owner reliability criteria.

PJM conducts RTEP studies in conjunction with its Transmission Owners and applies NERC, regional, and Transmission Owner reliability criteria to specific conditions on the transmission system. PJM's RTEP is an annual process that encompasses a comprehensive series of detailed analyses to ensure power continues to flow reliably to customers under stringent reliability criteria set by NERC. PJM's manual 14B[4] outlines the RTEP process and reliability criteria use for this process. As mentioned in manual 14B, every year PJM perform various reliability tests

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[3] PJM's RTEP process is currently set forth in Schedule 6 of PJM's Amended and Restated Operating Agreement ("Schedule 6"). Schedule 6 governs the process by which PJM's members rely on PJM to prepare an annual regional plan for the enhancement and expansion of the transmission facilities to ensure long-term, reliable electric service consistent with established reliability criteria. In addition, Schedule 6 addresses the procedures used to develop the RTEP, the review and approval process for the RTEP, the obligation of transmission owners to build transmission upgrades included in the RTEP, and the process by which interregional transmission upgrades will be developed.

[4] PJM Manual 14B is available at http://www.pjm.com/~/media/documents/manuals/m14b.ashx

such as Baseline Thermal, Baseline Voltage, Load Deliverability, Generation deliverability and Baseline stability to ensure safe reliable of operation of electric grid.

When the studies show an inability of the transmission system to meet specific reliability criteria under these conditions, PJM opens an RTEP Window in accordance with FERC Order 1000[5] to identify the optimal solution to resolve the criteria violation.

PPL Electric, as a Transmission Owner and member of PJM, undertakes an independent analysis of both its BES transmission facilities, and its non-BES transmission facilities in concert with the PJM RTEP process. PPL Electric identifies all conditions where the future system does not meet the NERC criteria, PJM reliability criteria, or PPL Electric Transmission Owner criteria. In this way, PPL Electric actively participates in the PJM RTEP process, and through this participation PPL Electric provides results of its independent studies to PJM for consideration and inclusion in the PJM RTEP.

Alternatives that can mitigate violations to the reliability criteria are developed and analyzed to ensure that the PPL Electric transmission system meets the reliability criteria. Estimated costs and lead times to implement the reinforcements are prepared. PPL Electric then proposes solutions to PJM through an RTEP window. If the project is awarded to PPL Electric, it then becomes a baseline RTEP project.

PPL Electric's Transmission Owner criteria address thermal, voltage, short circuit, and stability limits specific to the PPL Electric zone and also ensure compliance with NERC and PJM reliability criteria. These criteria ensure adequate and appropriate levels of electric service to PPL Electric customers in accordance with good utility practices. In addition to these criteria, PPL Electric plans the system according to its own Transmission System Development Standards.

[5] http://www.ferc.gov/industries/electric/indus-act/trans-plan.asp

In addition to NERC, PJM, and Transmission Owner criteria-based projects, PPL Electric also initiates projects based on the Transmission System Development Standards. These projects address local load growth, provide load restoration flexibility, improve operational performance, and replace poor performing transmission assets in order to provide an advanced level of reliability on the local system.

PPL Electric's Transmission System Development Standards also consider transmission needs to support the development of the distribution system. When the distribution system needs to either expand existing distribution substations with new transformation or install new distribution substations to support local load growth on the distribution system, new transmission facilities are required to accommodate that expansion.

Projects created to support PPL Electric's Transmission System Development Standards are presented to PJM stakeholders at either a TEAC or Sub-Regional RTEP meeting and are assigned a Supplemental project number in the RTEP. PJM incorporates these projects into the power flow model which they use to perform various reliability analyses for the RTEP.

As explained below, the proposed Project is necessary to comply with NERC Critical Infrastructure Protection standards.

3.0 NEED FOR THE PROJECT

PPL Electric and FirstEnergy share the Alburtis 500-230 kV Substation. The PPL Electric-owned Breinigsville-Alburtis 500 kV Transmission Line currently terminates into Bay 1 of a PPL Electric owned switchyard at the Alburtis 500-230 kV Substation. A one-line diagram and map of the existing system are provided as **Figure 1-1** and **Figure 1-2**, respectively.

On January 26, 2015, FERC approved the NERC Critical Infrastructure Protection Standard "CIP-014-1 - Physical Security," which addresses the physical security threats to and vulnerabilities of the electric grid and reduces the overall susceptibility of the system to physical attacks. The standard outlines a security approach that focuses on the most critical facilities and incorporates risk management planning to mitigate a range of threat profiles. The NERC CIP-

014-1 mandates that each Transmission Owners, such as PPL Electric, establish a physical security perimeter around non-exempt transmission substation and the related primary control centers.

PPL Electric is currently sharing a control cubicle in the Alburtis 500-230 kV Substation with FirstEnergy. There is no secure separation between the FirstEnergy controls and the PPL Electric controls inside the control cubicle. In order to comply with the requirements of NERC CIP-014-1, PPL Electric needs to establish a physical security perimeter around its relay and control equipment. This physical security perimeter is not possible to implement in a shared control cubicle.

4.0 PROPOSED SOLUTION

In order to comply with the requirements of NERC CIP-014-1, PPL Electric proposes to realign one span of the Breinigsville-Alburtis 500 kV Transmission Line into a new bay at the Alburtis 500-230 kV Substation. PPL Electric has built a new bay (Bay 2) at the Alburtis 500-230 kV Substation with PPL Electric-owned relay and control equipment in a new control cubicle. The use of the new bay allows PPL Electric to separate its relay and control equipment at the Alburtis 500-230 kV Substation from the control cubicle currently shared with FirstEnergy.

In order to interconnect the Breinigsville-Alburtis 500 kV Transmission Line into the new bay, one span of conductors will be moved from their current position in Bay 1 to the new Bay 2. Due to a difference in the positions of Bay 1 and Bay 2, this realignment involves replacing one span of conductors with a new, slightly longer 500 kV conductors that will extend approximately 200 feet from the dead end structure to the new Bay 2 position. The realignment will remain on property owned in fee by PPL Electric and will not require any additional land.

A one-line diagram and map of the proposed system are provided as **Figure 1-3** and **Figure 1-4**, respectively.

Figure 1-1 - Existing 500 kV Configuration

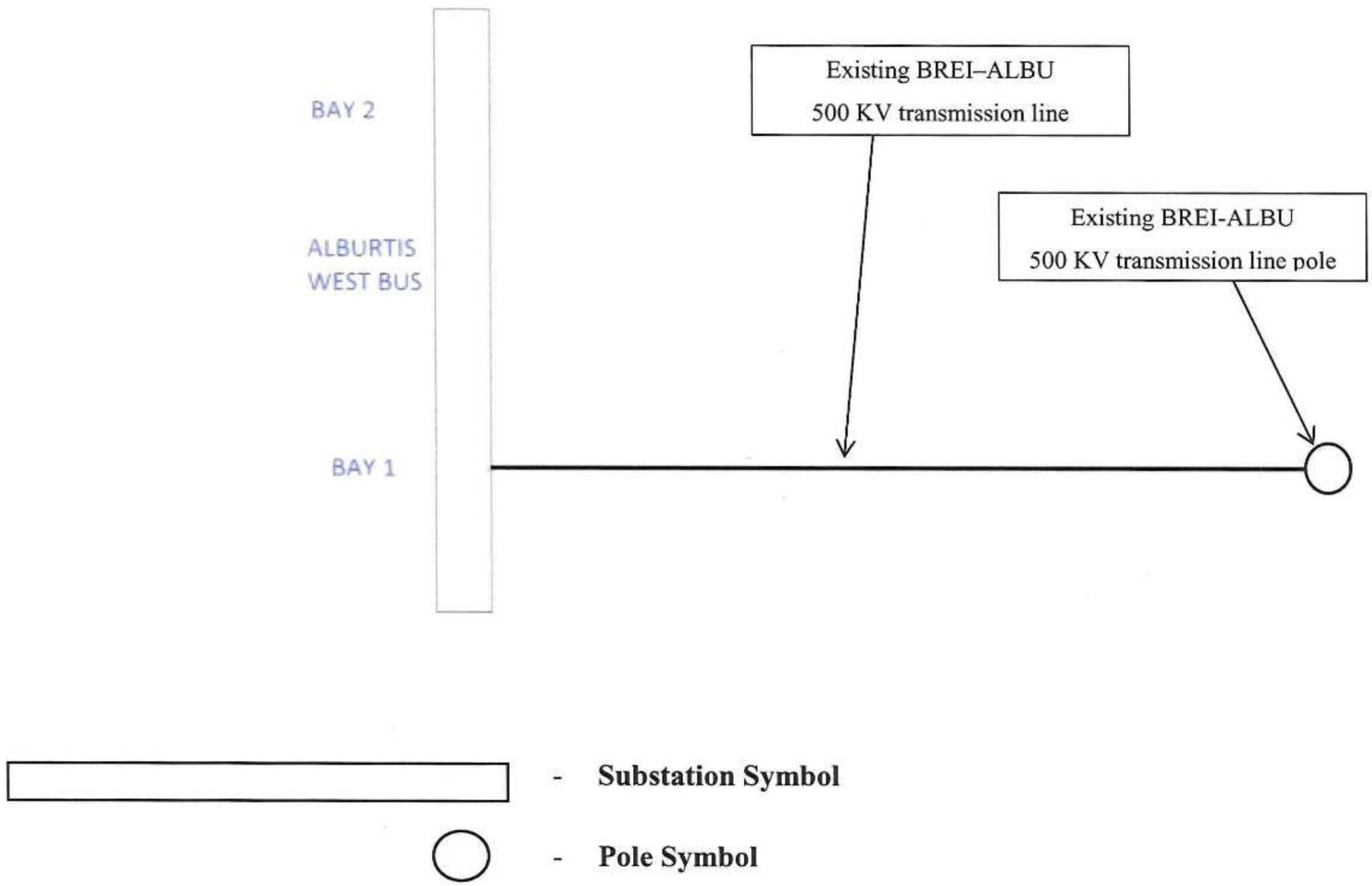


Figure 1-2 - Existing System Map

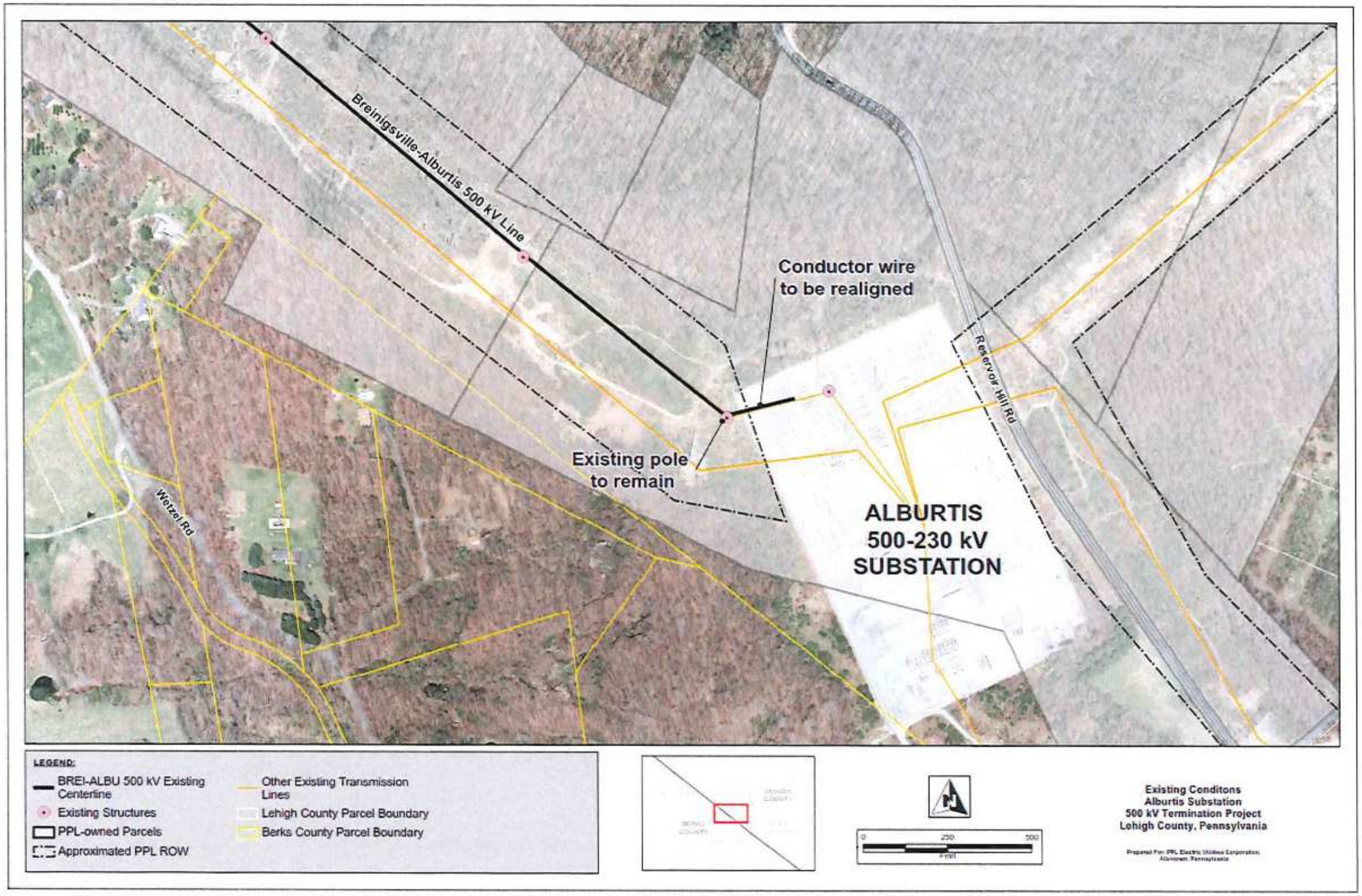
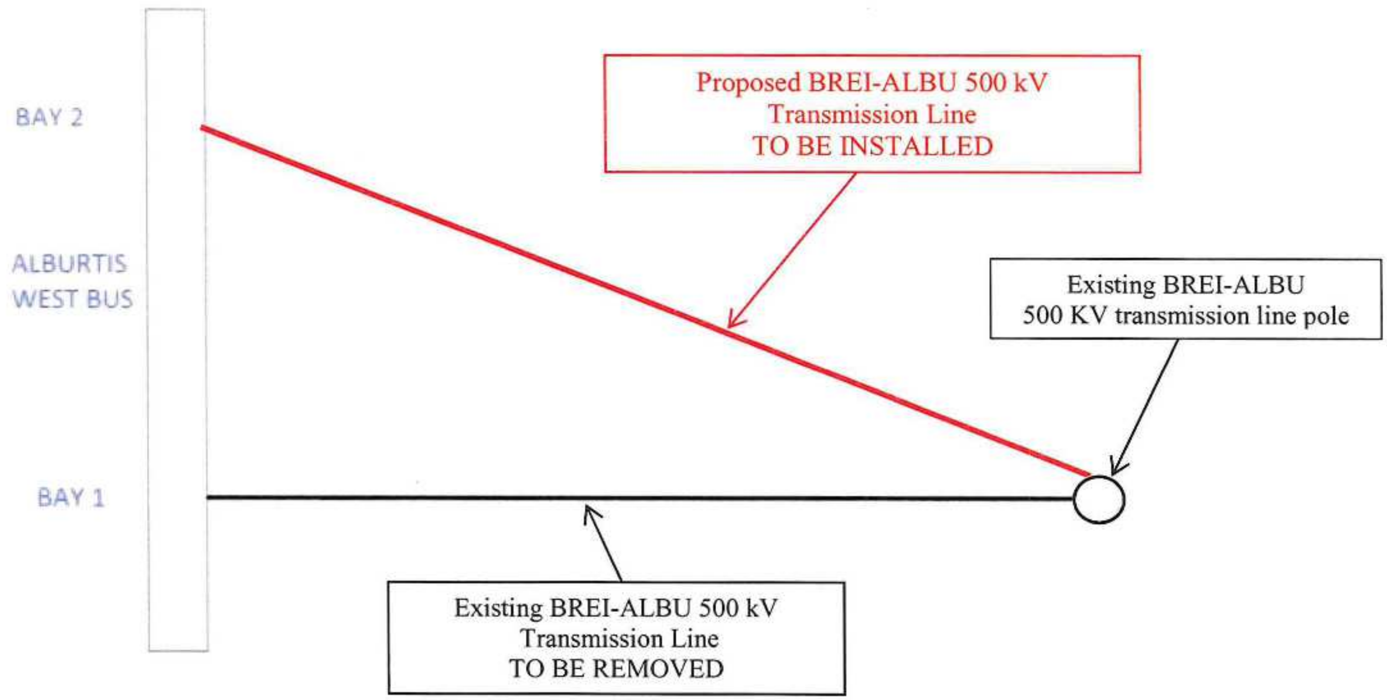
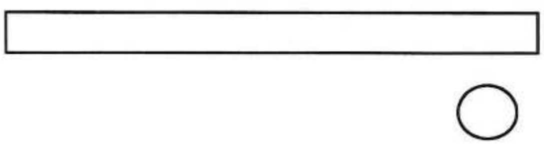


Figure 1-3 - Proposed 500 kV Configuration

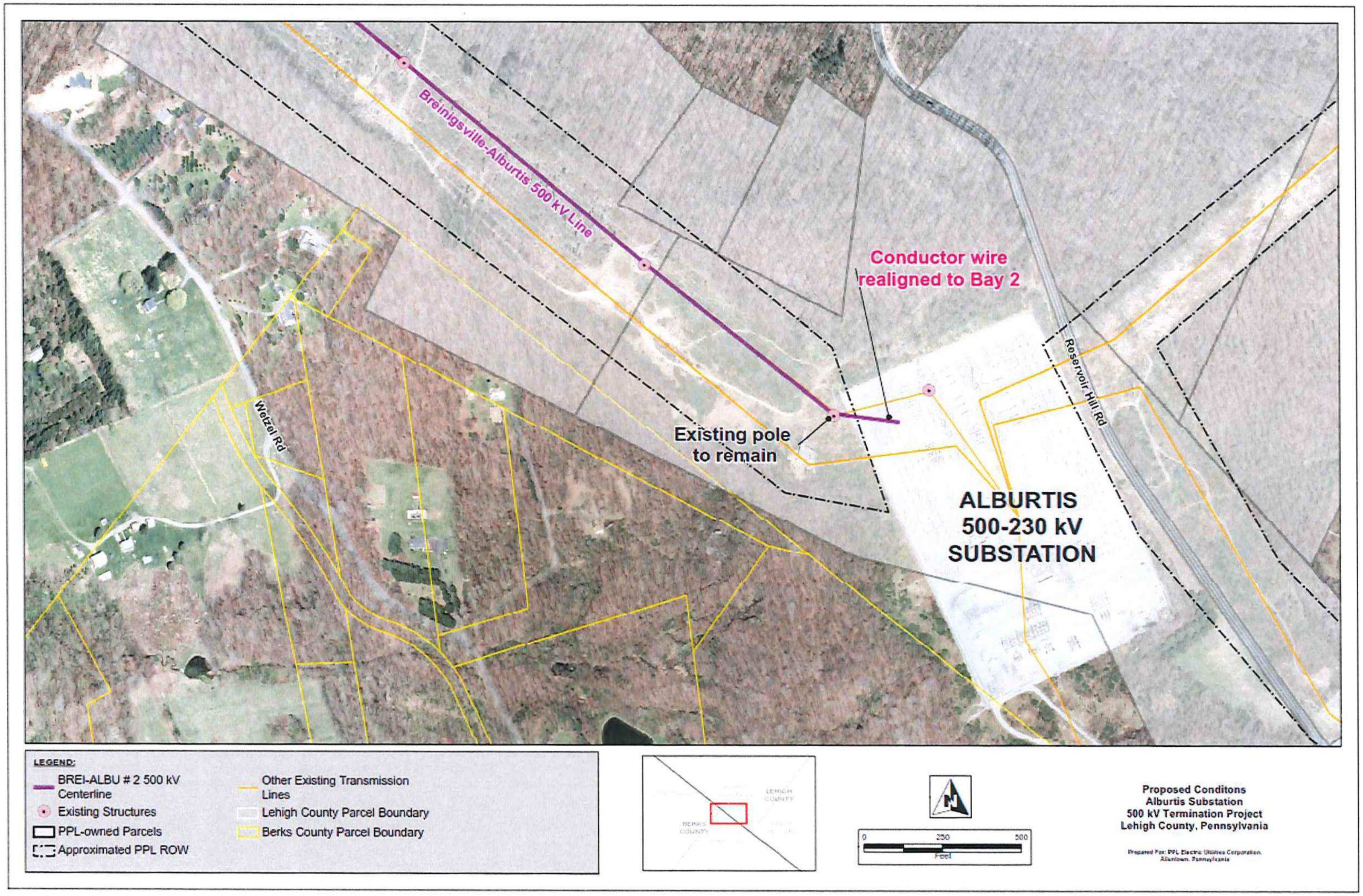




- **Substation Symbol**

- **Pole Symbol**

Figure 1-4 - Proposed System Map



Attachment 2

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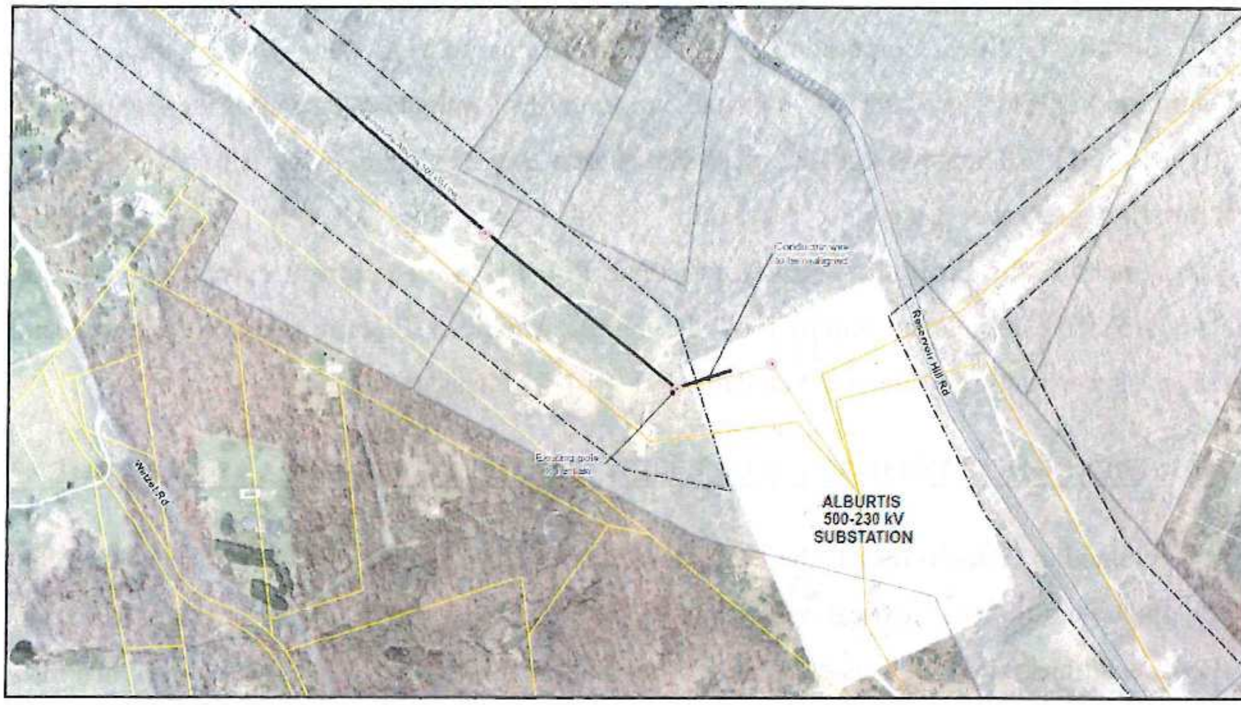
1.0 INTRODUCTION

PPL Electric Utilities Corporation (PPL Electric) is requesting Pennsylvania Public Utility Commission ("PUC" or "the Commission") approval re-terminate one span of the Breinigsville-Alburtis 500 kV Transmission Line from Bay 1 into Bay 2 at the existing Alburtis 500-230 kV Substation in Lower Macungie Township, Lehigh County (the "Project"). As explained in **Attachment 1**, the Project is required to isolate PPL Electric equipment currently located in a shared control cubicle as required by the North American Electric Reliability Corporation Critical Infrastructure Protection Standard "CIP-014-1 - Physical Security."

2.0 DESCRIPTION OF THE PROPOSED 500 kV CONDUCTOR AND ALIGNMENT

As explained in **Attachment 1**, the Project will involve the realignment of one span of new 500 kV conductors that will extend approximately 200 feet from the dead end structure to the new Bay 2 position at the Alburtis 500-230 kV Substation (**Figure 2-1**). Due to a difference in the positions of Bay 1 and Bay 2, the existing conductors will be replaced with new, slightly longer conductors. No additional poles or tower structures are required for this Project. As described in **Attachment 3**, the Project will be constructed entirely within PPL Electric-owned property. No new additional right-of-way will be required.

FIGURE 2-1: Alburtis 500-230 kV Substation 500 kV Transmission Line



The approximately 200-foot segment of new 500 kV conductors will utilize three power conductors and one overhead ground wire. The power conductors will be 3 phases of double bundle 2493 kcmil,[1] 54/37 stranding aluminum conductor alloy reinforced ("ACAR") conductors. The overhead ground wire will be a 19#9 Alumoweld wire with a diameter of 0.572 inches.

The new 500 kV conductor wire will be installed to meet, and generally exceed, National Electrical Safety Code ("NESC") minimum standards. Design specifications and safety rules practiced by PPL Electric are included in **Attachment 4**. The designed minimum conductor clearances and conductor thermal ratings are set forth in **Table 2-1** and **Table 2-2** below.

[1] A kcmil is a thousand circular mils. A circular mil is the cross-sectional area of a wire 1 mil in diameter, where 1 kcmil = 0.5067 square millimeters.

TABLE 2-1: DESIGN MINIMUM 500 kV CONDUCTOR CLEARANCES*

Condition	Line Design Clearance-to-Ground
Normal load; average weather (16°C ambient temperature)	79.6 feet
Predicted extreme thermal load (100°C conductor temperature)	76.1 feet
Predicted PPL Extreme wind load (100 mph, 16°C)	79.6 feet
Predicted extreme weather conditions (1.5 inch ice, 0 lbs. wind, 0°C)	77.7 feet
*Clearances based on a maximum tension of 17,400 pounds at 1.25 inch ice, 0° F, 0# wind	

*Based on 2493 kcmil 54/37 stranding ACAR

TABLE 2-2: 500 kV CONDUCTOR THERMAL RATING*

Condition	Ambient Temperature °C	Wind Speed ft/sec	Ampacity Amps
Summer Normal	35	0	1697
Winter Normal	10	0	2089
Summer Emergency	35	2.533	2155
Winter Emergency	10	2.533	2554

*Based on 2493 kcmil 54/37 stranding ACAR (212°F) 100°C Maximum Conductor Temperature

3.0 MAGNETIC FIELD MANAGEMENT

PPL Electric's Magnetic Field Management Program is applied to new and reconstructed transmission line projects. The Company does not believe that the current scientific evidence demonstrates that magnetic fields cause any adverse health efforts or pose a health or safety danger to the public. Nevertheless, PPL Electric has determined, as a matter of policy, to design its new and rebuilt transmission lines to reduce magnetic fields when that can be done at low or no cost and consistent with functional requirements. PPL Electric's Magnetic Field Management Program has been developed to implement that policy decision. To reduce magnetic field exposures, the program generally prescribes the use of a line design with ground clearance that is five feet higher than NESC standards and reverses phasing of new double-circuit lines where it is feasible to do so at low or no cost.

The Project will be designed to have a ground clearance that is at a minimum five feet higher than NESC standards. Because the 500 kV line will be a single-circuit, it cannot be reverse-phased.

Attachment 3

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1.0 INTRODUCTION

PPL Electric Utilities Corporation (PPL Electric) is requesting Pennsylvania Public Utility Commission ("PUC" or "the Commission") approval re-terminate one span of the Breinigsville-Alburtis 500 kV Transmission Line from Bay 1 into Bay 2 at the existing Alburtis 500-230 kV Substation in Lower Macungie Township, Lehigh County (the "Project"). As explained in **Attachment 1**, the Project is required to isolate PPL Electric equipment currently located in a shared control cubicle as required by the North American Electric Reliability Corporation Critical Infrastructure Protection Standard "CIP-014-1 - Physical Security."

2.0 DESCRIPTION OF THE RIGHT-OF-WAY

The proposed Project will extend for approximately 200 hundred feet from an existing transmission line dead-end structure (PPL Grid Number 60206S42601) located adjacent to the Alburtis 500-230 kV Substation into a new Bay 2 position at the substation. The entire extent of the proposed Project, as explained in **Attachment 2**, will be located on property that is owned in fee by PPL Electric. **Figure 3-1** is an aerial map that depicts the location of the proposed Project.

3.0 LAND USE

Evaluation of existing land uses in the Project area focused on the PPL Electric owned parcel on which the Alburtis 500-230 kV Substation is located and adjacent lands. Land uses were determined based on review of the 2011 National Land Cover Data ("NLCD").

Assessment of the data shows that the industrial based Alburtis 500-230 kV Substation is the dominant land use, accounting for over 60% of the review area. Adjacent forested areas account for approximately 25% of the area and the shrub/grass dominated open lands under the existing transmission lines account for another 15% of the land use.

Impacts to land use to complete the Project are anticipated to be minimal because the work will be conducted in the open areas under the existing transmission line or within the Alburtis 500-230 kV Substation.

State and Conserved Lands

No State-owned lands are located in the Project area.

Airports

The Lehigh Valley International Airport is located approximately 14.7 miles northeast of the Alburtis 500-230 kV Substation. PPL Electric does not anticipate any interference with airport operations because the Project will not involve the development of any new transmission structures.

Cultural Resources

No cultural resources are located in the Project area.

4.0 ENVIRONMENTAL FACTORS

Environmental factors reviewed for the Project included unique natural features, soils, waterways, wetlands, 100-year floodplains, vegetation, and threatened and endangered species.

Unique Natural Features

No unique geological, scenic, or natural areas are located within the Project review area.

Soils

No earth disturbance is anticipated for the Project, thus no erosion and sedimentation control plans will be developed.

Waterways

Based on review of U.S. Geological Survey ("USGS") maps, no waterways are located in the Project area.

Wetlands

Based on review of the U.S. Fish and Wildlife Service's ("USFWS") National Wetlands Inventory ("NWI"), no wetlands are located in the Project area.

100-year Floodplains

The National Flood Hazard Layer ("NFHL") for Pennsylvania was obtained through the Pennsylvania Spatial Data Access ("PASDA") database and analyzed for 100-year floodplains within the Project area and surrounding landscape. No Federal Emergency Management Agency ("FEMA") floodplains are located in the Project area.

Vegetation

Vegetative cover surrounding the Project area is composed of second growth hardwood forest that includes oaks, maples, and hickories. The maintained area under the transmission lines consists of herbaceous plants and shrubs that are compatible with the overhead transmission line.

Limited vegetation management required to complete the Project may include clearing branches located along the access roads or shrubs in the immediate area between the existing dead-end structure (PPL Grid Number 60206S42601) and the Alburtis 500-230 kV Substation. In areas where vegetation management is required, PPL Electric will apply its "*Specifications for Transmission Vegetation Management LA-79827*" to minimize any potential impacts.

Threatened and Endangered Species

A review of the threatened and endangered species that may be located in the Project area was not conducted as the proposed activity will not involve any earth disturbance and only minimal vegetation management.

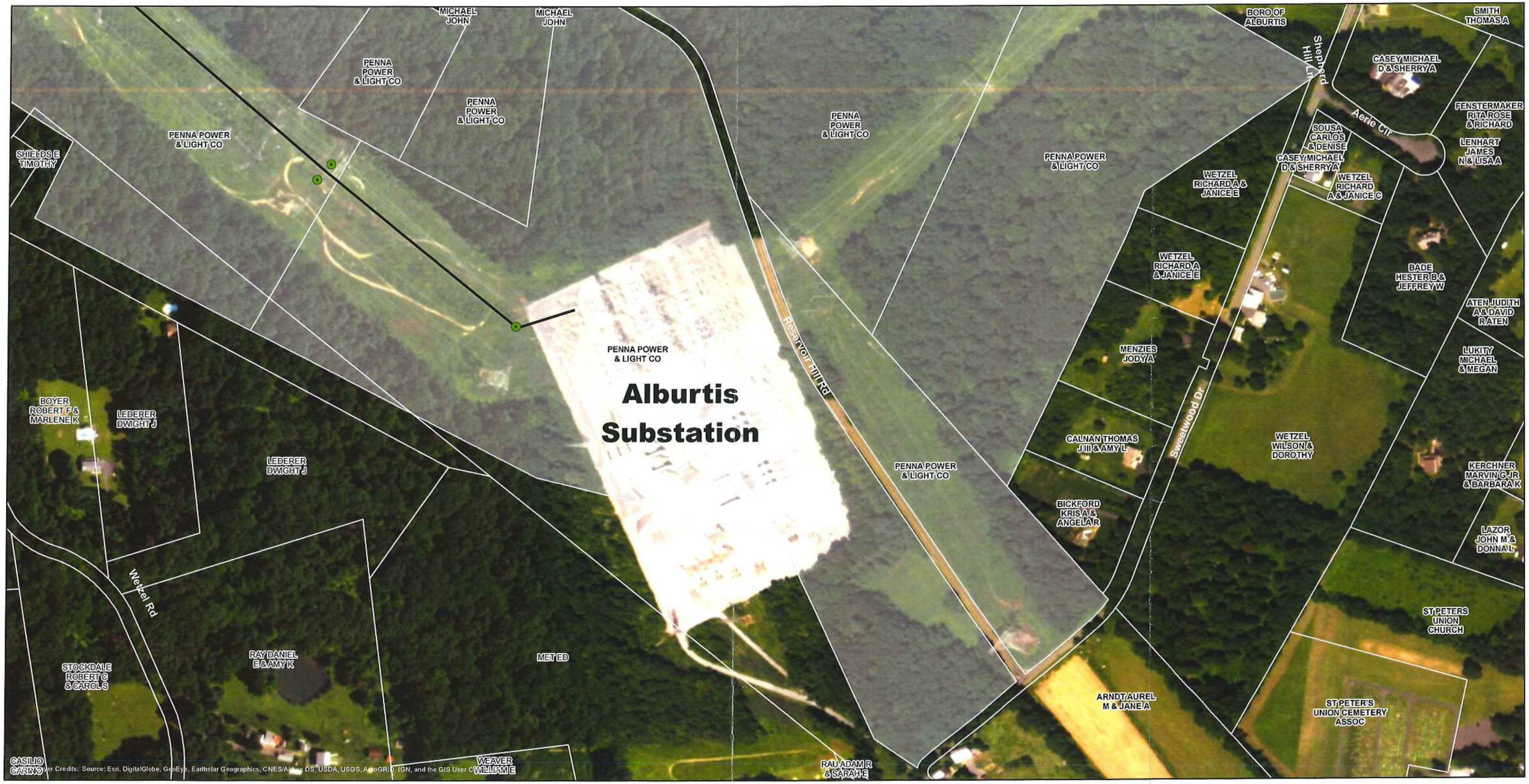
Natural Areas Inventory

The *Natural Areas Inventory for Lehigh County*, prepared by the Pennsylvania Natural Heritage Program ("PNHP"), noted that none of these potentially sensitive areas are located near the Project.

PNDI Review

A Pennsylvania Natural Diversity Inventory ("PNDI") review was not completed for the Project due to the minimal environmental impacts anticipated and further because no state permits are required for the Project.

FIGURES



Legend

- Existing Structures
- Existing Transmission Line Centerline
- County Parcel Boundary
- PPL-owned Parcels

Notes

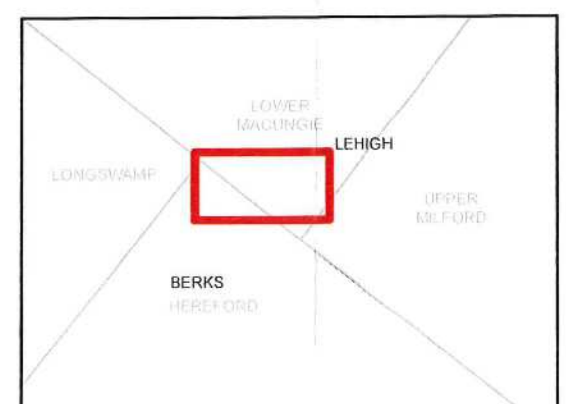
- Existing Project Centerline and Existing Poles digitized from files recieved from PPL in June 2014.

NAD 1983 State Plane
Pennsylvania North FIPS 3701
Projection: Lambert Conformal Conic
Linear Unit: US Foot

References:
World Imagery Basemap (ESRI)
Lehigh Parcel Data (2013)
Berks Parcel Data (2010)

N

0 150 300 600
Feet
1 inch = 300 feet



AECOM

Figure 3-1: Aerial Overview Map
Alburtis Substation
500 kV Termination Project

Lehigh County, Pennsylvania

PPL Electric Utilities
Allentown, Pennsylvania

Prepared By: NB/BF	Checked By: DY
Job: Susquehanna-Jenkins	Date: 4/4/2017

Attachment 4

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1.0 DESIGN CONSIDERATIONS

The new 500 kV transmission line will be designed according to, and generally exceed, all NESC minimum standards. The NESC is a set of rules to safeguard people during the installation, operation, and maintenance of electric power lines. The NESC contains the basic provisions considered necessary for the safety of employees and the public. Although it is not intended as a design specification, its provisions establish minimum design requirements. PPL Electric has developed design specifications and safety rules which meet or surpass all requirements specified by the NESC.

The NESC includes loading requirements and clearances for the design, construction, and operation of power lines. The "loads" on conductors and supporting structures are the mechanical forces that develop from the weight of the conductors, the weight of ice on the conductors, plus wind pressure on the conductors and supporting structures. Loading requirements are the loads on the conductors and structures that are anticipated assuming certain ice and wind conditions. Loading requirements always contain "safety factors" to allow for unknown or unanticipated contingencies. The clearances and loading requirements contained in the NESC were developed to ensure public safety and welfare.

PPL Electric transmission line design standards meet or surpass the NESC standards. For example, the relative order of grades of construction for conductors and supporting structures is B, C, and N; Grade B being the highest. According to the NESC standards, construction Grades B, C, or N may be used for transmission lines (except at crossings of railroad tracks and limited access highways where Grade B construction is specified). However, PPL Electric designs all of its transmission lines for Grade B construction. The use of Grade B design and construction specifies enhancements such as increased safety factors.

Another example is the design parameters utilized to account for ice and wind loadings on the wires and structure. The conductor sags and tensions along with the structure loading used in line designs are the result of various ice and wind combinations. PPL transmission lines are designed to exceed

NESC requirements including up to 1.5" of radial ice and in excess of 100 mph wind loads. This means that PPL Electric lines are designed to operate safely and reliably during inclement weather even more severe than assumed by the NESC. In addition, PPL Electric transmission lines are designed with more clearance to the ground than required by the NESC. **Table 4-1** compares PPL Electric and NESC ground clearances for 500 kV lines.

TABLE 4-1: 500 kV Vertical Clearance to Ground

Surface Underneath Conductors	NESC Standard	PPL Electric Design
Roads, streets, alleys	29 Ft.	40 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	29 Ft.	40 Ft.
Spaces accessible to pedestrians only	25 Ft.	40Ft.
Railroad tracks	37 Ft.	53 Ft.

A relay protection system is used to protect the public safety and welfare as well as equipment and the transmission system. Relay protection is installed for all transmission lines to automatically de-energize the line in the unlikely event that the line or supporting structure fails and the line contacts the ground.

2.0 PERIODIC MAINTENANCE PROGRAM ON ALL TRANSMISSION LINES

To ensure continued public safety and integrity of service, a periodic maintenance and inspection program is implemented for every transmission line. The program is administered through the use of helicopter patrols, with supplemental foot patrols as needed. A number of helicopter patrols are performed on all lines annually depending on voltage level. The two-man helicopter crew flies parallel, to the left, and above the line so that the observer can look for signs of line damage or deterioration and observe clearances between vegetation and conductors. The observations are included in a report that is forwarded to the appropriate department for corrective action.

3.0 PERSONNEL SAFETY RULES

Overall PPL Electric designs and constructs projects with high regards to public safety and follows or exceeds all codes and requirements.

The following are a few of the PPL Electric safety rules that demonstrate the Company's concern for employee and contractor safety:

- Work procedures have been developed to allow work to be performed on energized facilities in a safe manner. When lines or apparatus are removed from service to be worked on, the Energy Control Process system is applied. This system provides that a red tag must be physically placed on the control handle of the de-energized equipment.
    - The red tag may be removed only after proper authorization to energize the equipment.
    - Various other tags are used for limited operations and informational purposes.
    - Employees or contractors will not apply or remove a tag or change the status of tagged equipment unless authorized.
- Temporary safety grounds are used on de-energized facilities for employee lineman safety during maintenance, construction, or reconstruction work. Safety grounds are wires connecting the de-energized facility to an electrical ground. If the facility should be energized, the safety grounds will divert the current directly to ground and reduce the likelihood of personal injury.
- Before applying grounds, a test is done to confirm that the line is de-energized. The voltage test device is checked before and after use to assure reliability.
- Poles or structures are inspected and examined for structural integrity before climbing. If there is any reason to believe that a pole is unsafe, it is stabilized before work is performed. Appropriate safety gear in the form of body belts, safety straps, hard hats, gloves, etc., is worn by linemen during line work activity.

4.0 MAGNETIC FIELD MANAGEMENT PLAN

PPL Electric's Magnetic Field Management Program is applied to new and reconstructed transmission line projects. In order to lower magnetic field exposures, the program generally prescribes the use of a line design that provides ground clearances of five feet higher than the required minimum NESC ground clearance and reverses phasing of new double circuit lines where it is feasible to do so at low or no cost. The implementation of additional modifications will be considered, provided those modifications can be made at low or no cost and will not interfere with the operation of the line.

Due to the use of existing structures along the length of this project, PPL Electric will maintain a ground clearance that is typically three feet or more higher than the required NESC minimum ground clearance. PPL Electric may conduct both electric field and magnetic field analysis to identify the optimal phasing for the second circuit to reduce these affects as well as confirm all anticipated EMF values are consistent with PJM identified limits.