SUMMARY

This Letter of Notification (LON) is being submitted by PPL Electric Utilities Corporation (PPL Electric) pursuant to the Pennsylvania Public Utility Commission's ("PUC" or the "Commission") regulations at 52 Pa. Code §§ 57.71 through 57.77 for PUC approval to reconductor and reconstruct approximately 4.1 miles of the existing double-circuit Quarry-Seidersville #1 & #2 138/69 kV Transmission Line between the Quarry 230-69 kV Substation and the Seidersville 69-12 kV Substation. PPL Electric also proposes to reconstruct the approximately 0.2-mile single-circuit Homer Research 69 kV Tap (Homer Tap) between the Quarry-Seidersville Line and the customer-owned Homer Research Substation. The reconstructed Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap will be located in the City of Bethlehem, Freemansburg Borough, and Lower Saucon Township within Northampton County, Pennsylvania.

This proposed "Quarry-Seidersville Project" is needed to improve electric reliability in the region and resolve concerns for customers served by these facilities. The proposed Project is part of PPL Electric's Asset Optimization Strategy to address and modernize deteriorated existing facilities across PPL Electric's transmission system. The existing Quarry-Seidersville #1 & #2 138/69 kV Transmission Line is aging and does not meet PPL Electric's current design and lightning protection standards. Also, there are two critical customers, the Lehigh University and St. Luke's Hospital, that are directly served from aging Quarry-Seidersville #1 & #2 138/69 kV Transmission Line. These customers, as well as others served from this line, have experienced repeated and significant outages.

To modernize the existing transmission lines and to resolve the reliability concerns of customers served by these facilities, PPL Electric proposes to reconstruct the aging Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap to meet current design standards. The Quarry-Seidersville Project will begin at PPL Electric's Quarry 230-69 kV Substation in the City of Bethlehem near Freemansburg along the Lehigh River and terminate at PPL Electric's Seidersville Substation near Interstate 78 (I-78) in Lower Saucon Township.

The Quarry-Seidersville Project will be constructed entirely within PPL Electric's existing right-of-way easement. No new rights-of-way are required for this project. The outdated wood pole, steel lattice, and H-frame pole structures will be replaced with new steel monopoles. The new steel monopoles for the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap will have an average height of 100 feet and 115 feet, respectively, and will be placed in close proximity to the existing poles.

The total estimated cost of the proposed Quarry-Seidersville Project is $9.6 million, which includes temporary construction measures that will allow for the existing line to return to service if needed during construction.[1] The Quarry-Seidersville Project has a scheduled construction start date of Spring 2014 to meet an in-service date of November 2014.

This document, which describes the need for the Project and explains the engineering and siting analysis for the proposed rebuild, consists of the following attachments:

Attachment "1"	Necessity Statement
Attachment "2"	Engineering Description
Attachment "3"	Statement of the Impacts to the Right-of-Way
Attachment "4"	PPL Electric Design Criteria and Safety Practices
Attachment "5"	PPL Electric Magnetic Field Management Program

[1] The estimated cost for the proposed Quarry-Seidersville Project is an order-of-magnitude estimate developed using averages of recent costs for similar projects. The estimated cost is subject to change as the constructability of the project, sequence of construction, and other factors that may affect cost are identified and analyzed as the project progresses.

PPL ELECTRIC UTILITIES SERVICE TERRITORY

ATTACHMENT "1"
QUARRY-SEIDERSVILLE #1 & #2 138/69 kV LINE AND
HOMER TAP RECONSTRUCTION

NECESSITY STATEMENT

TABLE OF CONTENTS

LIST OF FIGURES/MAPS

ATTACHMENT "1"
QUARRY – SEIDERSVILLE #1 & #2 138/69 KV LINE AND HOMER TAP RECONSTRUCTION

NECESSITY STATEMENT

A. INTRODUCTION

PPL Electric Utilities (PPL Electric) proposes to reconductor and reconstruct the approximately 4.1-mile double-circuit Quarry-Seidersville #1 & #2 138/69 kV Transmission Line for double-circuit 138/69 kV operation in order to improve electric reliability in the region and to resolve concerns of two critical customers (Quarry-Seidersville Project). The Project also includes the reconstruction of the single-circuit Homer Research 69 kV Tap (Homer Tap), which extends approximately 0.2 miles from the customer-owned Homer Research Substation and taps into the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line. Together, the aging Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap have experienced repeated outages and cannot be relied upon to continue to provide reliable service into the future.

PPL Electric proposes to reconductor/reconstruct the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap to improve electric reliability in the region and resolve concerns for critical customers served by these facilities. The Quarry-Seidersville Project is part of PPL Electric's Asset Optimization Strategy, and involves reconstructing the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap to meet all current design and lightning protection standards. The modernization of these lines will help ensure reasonably continuous and reliable service, and will help to resolve the concerns of critical customers that have experienced repeated and extended power outages.

A PPL Electric system map showing existing transmission facilities with a design voltage of 35 kV or greater is included in the Attachment "1" map pocket. This filing addresses only the reconstruction of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and the Homer Tap in portions of Northampton County.

B. EXISTING SYSTEM

The existing Quarry-Seidersville #1 & #2 138/69 kV Transmission Line originates at the Quarry 230-69 kV Substation located in the City of Bethlehem, Northampton County, Pennsylvania. The Quarry-Seidersville #1 & #2 138/69 kV Transmission Line terminates at the Seidersville 69-12 kV Substation in Lower Saucon Township, Northampton, Pennsylvania. The first approximately 0.9 miles of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line were constructed in the 1990s using modern steel monopole design and heights. However, this segment does not meet current lightning protection standards and lacks optical overhead ground wires. The remaining 3.2 miles of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line were constructed in the 1970s using outdated wood pole, steel lattice, and H-frame pole structures that do not meet current design or height standards.

The Homer Tap serves Lehigh University and is located entirely on University property. The Homer Tap extends approximately 0.2 miles from the customer-owned Homer Research Substation and taps into the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line.

Figure 1-1 shows the functional arrangement of the existing Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and the Homer Tap. This schematic diagram also displays the number of customers and load served from each distribution substation off the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line.

C. DEFINITION OF THE PROBLEM

The Quarry-Seidersville 138/69 kV Transmission Line has been in-service for approximately 90 years. With the exception of the initial 0.9 miles extending from the Quarry 230-69 kV Substation, this Transmission Line is installed on short wood pole, steel lattice, and H-frame pole structures. Similarly, the Homer Tap which serves the Lehigh University-owned Homer Research Substation is installed on short H-frame wood pole structures. These aging transmission lines do not meet current design, height, or lightning protection standards.

Customers served from the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap have experienced significant and extended outages during major storm events, such as Super Storm Sandy in 2012 and the Halloween Snow Storm in 2011. These outages were mainly attributable to the failure of the outdated tower structures that were damaged during the storms. These interruptions have not only interrupted area residential customers, but have also interrupted the operations of Lehigh University and St. Luke's Hospital, two critical customers that are served from the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap.

PPL Electric has adopted an Asset Optimization Strategy to address and modernize deteriorated existing facilities across PPL Electric's transmission system. Based on the age of the Quarry-Seidersville 138/69 kV Transmission Line, PPL Electric hired an outside engineering consultant, DiGioia Gray and Associates (DGA), to perform an independent field investigation and assessment of the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap components. This assessment found significant deterioration of the structural components, foundations, insulators, line hardware, shield wire, grounding, signage, paint and galvanizing, as well as outdated structure design. Based on their study, DGA concluded that the lines, majority of the hardware, and the towers structures are nearing the end of their effective life and should be replaced. DGA recommended that the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap be rebuilt and upgraded to meet current engineering standards.

D. PROPOSED SOLUTION

To resolve the issues described above, PPL Electric proposes to reconstruct the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap to meet the current design, height, and lightning protection standards. The proposed reconstruction is consistent with PPL Electric's Asset Optimization Strategy and the independent recommendation of DGA.

As described above, the first approximately 0.9 miles of the existing Quarry-Seidersville 138/69 kV Transmission Line was constructed in the 1990s using modern steel monopole design and heights. PPL Electric proposes to reconductor this portion of the Transmission Line with new high capacity conductors, and to add protective lightning arrestors and an optical ground wire.

The remaining segments of the Quarry-Seidersville 138/69 kV Transmission Line (3.2 miles) and Homer Tap (0.2 miles) will be reconstructed with new steel monopoles, high capacity conductors, lightning arrestors and an optical ground wire. The existing transmission line and structures, which include a combination of wood pole, steel lattice, and H-frame pole structures, will be replaced pole-for-pole with single-shaft steel poles carrying two circuits capable of accommodating future 138 kV operation.

In order to more effectively address future load growth, the new lines will be constructed for future double-circuit 138 kV operation but will initially operate it as a double-circuit 69 kV line until the load growth in the area makes it appropriate to increase the operating voltage. Rebuilding 69 kV lines for future double-circuit 138 kV operation is consistent with PPL Electric's planning and reliability practices.

Following completion of the project, the Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap will meet all current standards of PPL Electric and the National Electrical Safety Code (NESC). Further, the use of steel monopoles, increased pole heights, optical overhead ground wires, and new lightning protection will improve the

ATTACHMENT "2"
QUARRY – SEIDERSVILLE #1 & #2 138/69 KV LINE AND HOMER TAP RECONSTRUCTION

ENGINEERING DESCRIPTION

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF TABLES

LIST OF FIGURES

ATTACHMENT "2"
QUARRY – SEIDERSVILLE #1 & #2 138/69 KV LINE AND HOMER TAP RECONSTRUCTION

ENGINEERING DESCRIPTION

A. INTRODUCTION

PPL Electric Utilities (PPL Electric) proposes to reconductor and reconstruct the existing 4.1-mile double-circuit Quarry-Seidersville #1 & #2 138/69 kV Transmission Line between the Quarry 230-69 kV Substation and the Seidersville 69-12 kV Substation, and to reconstruct the 0.2-mile single-circuit Homer Research 69 kV Tap (Homer Tap) between the Quarry-Seidersville Line and the customer-owned Homer Research Substation. The "Quarry-Seidersville Project" is part of PPL Electric's Asset Optimization Strategy to address and modernize deteriorated existing facilities. The modernization of the aging Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap will help ensure continuous and reliable service, and will help to resolve the concerns of critical customers that have experienced repeated and extended power outages.

B. DESCRIPTION OF THE EXISTING LINES

The existing Quarry-Seidersville #1 & #2 138/69 kV Transmission Line originates at the Quarry 230-69 kV Substation located in the City of Bethlehem, Northampton County, Pennsylvania and terminates at the Seidersville 69-12 kV Substation in Lower Saucon Township, Northampton County, Pennsylvania. The first approximately 0.9 miles of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line were constructed in the 1990s using modern steel monopole design and heights. However, this segment does not meet current lightning protection standards and lacks optical overhead ground wires. The remaining 3.2 miles of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line were constructed in the 1970s using outdated wood pole, steel lattice, and H-frame pole structures that do not meet current design, height, or lightning protection standards.

The Homer Tap serves Lehigh University and is located entirely within an existing PPL Electric right-of-way across Lehigh University property. The Homer Tap extends approximately 0.2 miles from the customer-owned (Lehigh University) Homer Research Substation and taps into the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line. The Homer Tap is installed on short H-frame wood pole structures and does not meet current design, height, or lightning protection standards.

C. DESCRIPTION OF THE REBUILT/RECONDUCTORED LINES

The first approximately 0.9 miles of the Quarry-Seidersville #1 & #2 138/69 kV Transmission Line currently meets modern steel monopole design and heights, but lacks current lightning protection and optical overhead ground wires. PPL Electric therefore proposes to reconductor this portion of the transmission line with new high capacity conductors, and to add protective lightning arrestors and an optical ground.

The remaining 3.2 miles of the Quarry-Seidersville 138/69 kV Transmission Line and 0.2-mile Homer Tap will be reconstructed with new steel monopoles, high capacity conductors, lightning arrestors, and an optical ground wire. The existing transmission structures, which include a combination of wood pole, steel lattice, and H-frame pole structures, will be replaced pole-for-pole with double-circuit, weathering steel monopoles equipped with upswept weathering steel arms and glass 138 kV insulator assemblies. All new poles for this segment of the project will be self-supported, either direct embedded or on concrete caisson foundations. The new poles for the Quarry-Seidersville 138/69 kV Transmission Line will have an average height of 100 feet, and the new poles for the Homer Tap will have an average height of 115 feet.

The reconductored and reconstructed double-circuit Quarry-Seidersville 138/69 kV Transmission Line and Homer Tap will utilize six power conductors and two overhead ground wires. The power conductors will be six 556.5 kcmil,[1] 24/7 stranding, ACSR[2]

[1] Kcmil stands for thousand circular mills. Kcmil wire size is the equivalent cross sectional area in thousands of circular mils. A circular mil is the area of a circle with a diameter of one thousandth (.001) of an inch.

[2] ACSR stands for aluminum conductor steel reinforced.

conductors. The overhead ground wires will be two 0.567-inch diameter Optical Ground Wires (OPGW). The new lines will be constructed for future double-circuit 138 kV operation but will initially operate as double-circuit 69 kV lines until the load growth in the area makes it appropriate to increase the operating voltage.

The new reconductored and reconstructed lines will be designed according to, and generally exceed, all National Electrical Safety Code (NESC) minimum standards. Design specifications and safety rules practiced by PPL Electric are included in Attachment 4.

The minimum conductor to ground clearance will be 30 feet, which occurs at a maximum thermal conductor temperature of 125 degrees Celsius. The designed minimum conductor clearances and conductor thermal ratings for the reconductored and reconstructed lines are shown in Tables 2-1 and 2-2.

TABLE 2-1

DESIGN MINIMUM CONDUCTOR CLEARANCES
FOR 556.5 KCMIL 24/7 STRANDING ACSR*

Condition	Transmission Double-Circuit Design Clearance-to-Ground
Normal load; average weather (16°C ambient temperature)	39 feet
Predicted extreme thermal load (125°C conductor temperature)	30 feet
Predicted extreme wind load (25lb wind, 16°C ambient temperature)	36 feet
Predicted extreme weather conditions (1/2-inch ice, 8 lbs. wind, -18°C)	38 feet

*Clearances based on a maximum tension of 7,000 pounds at 1/2 inch ice, 0°F, 8# wind and maximum ruling span of 700 feet.

TABLE 2-2
CONDUCTOR THERMAL RATING
556.5 KCMIL 24/7 STRANDING ACSR
(257°F) 125°C MAXIMUM CONDUCTOR

Condition	Ambient Temperature °C	Wind Speed Ft/sec	Ampacity Amps
Summer Normal	35	0	800
Winter Normal	10	0	923
Summer Emergency	35	2.533	1047
Winter Emergency	10	2.533	1180

D. MAGNETIC FIELD MANAGEMENT

PPL Electric's Magnetic Field Management Program is included in Attachment 5 and is applied to new and reconstructed transmission line projects. In order to lower magnetic field exposures, the program generally prescribes the use of ground clearances that are five feet higher than the minimum ground clearance required by NESC, and reverse 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.

Consistent with its Magnetic Field Management Program, PPL Electric will construct the Quarry-Seidersville Project for ground clearances that are a minimum of five feet higher than the required NESC minimum ground clearance for 138/69 kV lines. The rebuilt Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap will be constructed as a double circuit transmission line and will utilize reverse phasing to help reduce magnetic field exposures.

ATTACHMENT "3"
QUARRY-SEIDERSVILLE #1 & #2 138/69 kV LINE AND
HOMER TAP RECONSTRUCTION

STATEMENT OF THE IMPACTS TO THE RIGHT-OF-WAY

TABLE OF CONTENTS

SECTION **PAGE NO.**

LIST OF TABLES

ATTACHMENT "3"
QUARRY-SEIDERSVILLE #1 & #2 138/69 kV LINE AND HOMER TAP RECONSTRUCTION

STATEMENT OF THE IMPACTS TO THE RIGHT-OF-WAY

A. INTRODUCTION

PPL Electric Utilities (PPL Electric) proposes to reconductor and reconstruct the existing 4.1-mile double-circuit Quarry–Seidersville #1 & #2 138/69 kV Transmission Line between the Quarry 230-69 kV Substation and the Seidersville 69-12 kV Substation, and to reconstruct the 0.2-mile single-circuit Homer Research 69 kV Tap (Homer Tap) between the Quarry–Seidersville Line and the Lehigh University-owned Homer Research Substation. The "Quarry-Seidersville Project" is part of PPL Electric's Asset Optimization Strategy to address and modernize deteriorated existing facilities. The modernization of the aging Quarry-Seidersville #1 & #2 138/69 kV Transmission Line and Homer Tap will help ensure continuous and reliable service, and will help to resolve the concerns of critical customers that have experienced repeated and extended power outages.

The proposed reconductoring and reconstruction activities will occur within the City of Bethlehem, Freemansburg Borough and Lower Saucon Township. Table 3-1 identifies the distance traversed within each municipality.

Table 3-1. Municipalities Crossed

Municipality	Quarry – Seidersville Line Distance (miles)	Homer Tap Line Distance (miles)
City of Bethlehem	3.3	0.2
Freemansburg Borough	0.2	0.0
Lower Saucon Township	0.6	0.0

Rounded to the nearest 0.1 mile

The proposed Quarry-Seidersville Project was reviewed with each municipality and Northampton County. These entities have not objected to the proposed Project.

B. NO SUBSTANTIAL ALTERATION OF THE RIGHT-OF-WAY

The Quarry-Seidersville Project will be constructed entirely within PPL Electric's existing right-of-way or land owned by PPL Electric in fee. The existing rights-of-way for the Quarry–Seidersville Transmission Line and Homer Tap vary from 100-foot wide right-of-way to centerline rights with danger tree clearing rights. In some areas PPL Electric also has tree clearing/tree trimming rights and/or building restrictions in place to prevent encroachments and minimize the potential impacts of danger trees. Based on an engineering review, PPL Electric determined that it does not require any additional right-of-way for the construction of the Quarry-Seidersville Project.

As explained in Attachment 2, the first approximately 0.9 miles of the existing Quarry-Seidersville 138/69 kV Transmission Line can be reconductored using the existing structures. The remaining 3.2 miles of the Quarry-Seidersville 138/69 kV Transmission Line and the 0.2-mile Homer Research Tap, will be reconstructed with new steel monopoles. The outdated wood pole, steel lattice, and H-frame pole structures will be replaced with new steel monopoles. The replacement of the existing lattice tower structures with new steel monopoles will result in smaller structure footprints within the right-of-way.

The existing outdated structures average approximately 75 to 80 feet in height. The new poles for the Quarry-Seidersville 138/69 kV Transmission Line will have an average height of 100 feet, and the new poles for the Homer Tap will have an average height of 115 feet. Although the new poles will slightly increase in height as compared to the existing outdated structures, impacts of the new poles are anticipated to be minimal because the new poles will be placed in close proximity to the existing poles so the new pole can be installed immediately before the old one is removed. Further, no new poles will be placed on any property that currently does not have an existing pole.

The existing rights-of-way currently are scheduled for vegetation maintenance under PPL Electric's three-year cycle vegetation management plan. Importantly, these regularly scheduled vegetation clearing activities are being planned to coordinate with the construction of the proposed Quarry-Seidersville Project to minimize the disturbance to nearby landowners. Because the existing rights-of-way will be cleared of trees and other vegetation under PPL Electric's scheduled vegetation management plan, no additional tree clearing is required for the construction of the proposed Quarry-Seidersville Project.

C. CULTURAL RESOURCES

PPL Electric submitted a letter to the Pennsylvania Historical and Museum Commission (PHMC) on March 8, 2013, to request information on any additional archeological or historic architectural resources located within the Quarry-Seidersville Project area. In a response dated April 25, 2013, the PHMC indicated that Phase I archeological surveys should be conducted if any ground-disturbing activities will occur through previously identified cultural resource sites crossed by the right-of-way or if ground-disturbing activities will occur adjacent to the Lehigh River or Saucon Creek. The PHMC April response indicated that additional information is needed to assess potential impacts to historic architectural resources. PPL Electric will continue to consult with the PHMC to avoid impacts to cultural resources. However, it is anticipated that the Quarry-Seidersville Project will have minimal impacts to cultural and archeological resources because the new tower structures will be placed in close proximity to the existing tower structures.

D. LAND USE AND NATURAL FEATURES

Impacts to land use are anticipated to be minimal because the Quarry-Seidersville Project will be constructed within the existing rights-of-way and no additional property will be required to complete the Project. PPL Electric will use and update previously established access roads for construction to further reduce interference with existing land uses.

No communication towers, pipelines, or other utilities will be affected by the proposed Quarry-Seidersville Project. The closest airport is the Bethlehem Steel Plant Heliport, a privately owned facility, located approximately 0.33 miles west of the right-of-way for the Quarry-Seidersville 138/69 kV Transmission Line. PPL Electric will file the appropriate notifications with the

PennDOT Bureau of Aviation and the Federal Aviation Administration to confirm that the proposed new tower structures and conductors will not pose a hazard to flight operations at this airport.

The proposed Quarry-Seidersville Project will not affect any unique geological, scenic or natural areas. Further, there are no state lands, national parks, state parks, local parks, recreational areas or natural landmarks located within the Project area.

The proposed Quarry-Seidersville Project will cross five streams and seven wetlands. However, it is anticipated that the Project will have minimal impacts on these streams and wetlands because the entire Project will be built within the existing right-of-way, and because the new tower structures will be placed in close proximity to the existing tower structures. PPL Electric will avoid impacts to wetlands to the maximum extent practical. PPL Electric will obtain all necessary permits from Pennsylvania Department of Environmental Protection and the United States Army Corps of Engineers and will comply with all of the terms and conditions placed on those permits. PPL Electric also will acquire any required soil erosion and sedimentation control permits and will comply with any conditions placed on those permits.

E. <u>THREATENED AND ENDANGERED SPECIES</u>

PPL Electric conducted an online Pennsylvania Natural Diversity Inventory (PNDI) database review on March 5 and 6, 2013[1]. Based on this review, the Pennsylvania Game Commission (PGC), Pennsylvania Fish and Boat Commission (PFBC), the Pennsylvania Department of Conservation and Natural Resources (DCNR), and the U.S. Fish and Wildlife Service (USFWS) reported that the Quarry-Seidersville Project will not impact any threatened and endangered species, or special concern species and resources located within the Project area.

Because Northampton County is located within the range of the federally threatened bog turtle (*Clemmys muhlenbergii*), PPL Electric retained a qualified bog turtle surveyor to conduct a

[1] PNDI Project Search ID: 20130305393846 (Quarry – Seidersville section) and 20130306393882 (Homer Research Tap Line).

Phase I bog turtle survey for wetlands delineated within the Quarry-Seidersville Project area. Based on the Phase I survey, one wetland was identified as potential bog turtle habitat. Therefore, a Phase I survey report was submitted to the USFWS and a Phase II bog turtle survey was conducted for the single potential bog turtle wetland. No bog turtles or evidence of bog turtles was observed during the Phase II survey. PPL Electric has submitted a Phase II survey report to USFWS.

ATTACHMENT 4
QUARRY – SEIDERSVILLE #1 & #2 138/69 KV LINE AND
HOMER TAP RECONSTRUCTION

PPL ELECTRIC DESIGN CRITERIA AND SAFETY PRACTICES

The National Electrical Safety Code (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 Utilities Corp. (PPL Electric) has developed design specifications and safety rules which meet or surpass all requirements specified by the NESC.

Engineering Design Criteria and Parameters

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 larger-minimum crossarm dimensions, larger-minimum conductor size, and increased safety factors.

Another example is the design parameters utilized to account for ice and wind loadings on the overhead ground wire (OHGW) and power conductors. The NESC standard ice and wind design magnitudes for the PPL Electric territory are 0.5 inch thickness of radial ice combined with four pounds per square foot horizontal wind pressure (equivalent to 40-mile per hour wind velocity). The conductor sags and tensions used in line designs are the result of various ice and wind combinations, depending on the elevation at the line location and line design voltage. The conductor sags and tensions used in the design of all PPL Electric transmission lines are at least 0.5-inch ice combined with eight pounds wind pressure (equivalent to 57 miles per hour wind velocity). 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. The tables below compare PPL Electric and NESC ground clearances for lines of various voltages.

138 kV

Surface Underneath Conductors	Vertical Clearance to Ground	
	NESC Standard	PPL Electric Design
Roads, streets, alleys	21 feet	30 feet
Other land traversed by vehicles (such as cultivated field, forest, etc.)	21 feet	30 feet
Spaces accessible to pedestrians only	17 feet	30 feet
Railroad tracks	29 feet	35 feet

230 kV

Surface Underneath Conductors	Vertical Clearance to Ground	
	NESC Standard	PPL Electric Design
Roads, streets, alleys	23 feet	32 feet
Other land traversed by vehicles (such as cultivated field, forest, etc.)	23 feet	32 feet
Spaces accessible to pedestrians only	19 feet	32 feet
Railroad tracks	31 feet	36 feet

500 kV

Surface Underneath Conductors	Vertical Clearance to Ground	
	NESC Standard	PPL Electric Design
Roads, streets, alleys	28 feet	53 feet
Other land traversed by vehicles (such as cultivated field, forest, etc.)	28 feet	53 feet
Spaces accessible to pedestrians only	24 feet	53 feet
Railroad tracks	38 feet	53 feet

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.

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 and structure climbing patrols. A number of helicopter patrols are performed on all lines annually. 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.

Foot and structure climbing patrol programs for a transmission line begin approximately three to five years after the line is energized, unless a helicopter patrol reports a need for earlier action. The frequency of foot patrols varies from once every year to once every several years depending on line type and age.

An assigned foot patroller checks right-of-way conditions, including access roads, bridges, pole washouts, tower footers, vegetation height and clearance to conductors, pole and tower deterioration and, with the use of binoculars, insulators, and condition of hardware. Identified problems are included in a report that is forwarded to the appropriate department for corrective action.

A scheduled line outage is required to perform an overhead patrol because of "hands-on" inspection of hardware. Overhead patrols are conducted on a schedule determined by line age, operating record, and observed general condition. The necessary repairs are also done during the inspection outage.

Personnel Safety Rules

The following are a few of the PPL Electric safety rules that demonstrate the Company's concern for employee 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 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 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. The conductor size and attachment clamps of temporary safety grounds must be capable of conducting anticipated fault currents. Rubber gloves, rubber sleeves, and additional rubber protective equipment are used as required when applying or removing temporary safety grounds to or from the lines or apparatus to be grounded. An approved nonconductive working stick of sufficient length to allow workers to maintain the following required minimum clearances is used to test that the line has been de-energized and to apply temporary safety grounds:

Voltage-kV	Minimum Clearance
138	3’-7”
230	5’-3”
500	11’-3”

- 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. When ground pins are used to establish proper ground points, they are driven to a depth of not less than four feet as near vertical as possible.

- 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.

ATTACHMENT 5
QUARRY – SEIDERSVILLE #1 & #2 138/69 KV LINE AND HOMER TAP RECONSTRUCTION

PPL ELECTRIC MAGNETIC FIELD MANAGEMENT PROGRAM

MAGNETIC FIELD MANAGEMENT

PPL Electric Utilities Corporation

DECEMBER 2004

TABLE OF CONTENTS

INTRODUCTION

At PPL Electric Utilities Corp. (PPL EU), magnetic field management means investigating and implementing methods at low or no cost to reduce magnetic fields in new or rebuilt transmission and distribution lines. This document explains PPL EU's Magnetic Field Management Program, which is part of PPL EU's larger Electric and Magnetic Fields (EMF) policy.

PPL EU's View

Some people are worried that electric and magnetic fields are harming their health. Others think the scientific research does not show a problem at all, and still others believe there's just too much scientific uncertainty to draw any conclusions.

Here's what we do know now. Various panels of scientists that have reviewed the EMF research generally have drawn two main conclusions. First, the large body of evidence does not demonstrate that EMF are harmful. Second, additional research is recommended to explore questions raised in some studies.

Given these conclusions, PPL EU is taking a reasoned approach in responding to the EMF issue. PPL EU's approach to the EMF issue consists of five elements:

- Providing EMF information to customers and employees
- Providing magnetic field measurements
- Establishing and implementing a magnetic field management program to reduce magnetic fields in new or rebuilt facilities when it can be done at no, or low, cost
- Integrating EMF in the public involvement process that PPL EU undertakes in the siting of transmission lines
- Have supported additional research

EMF Are All Around Us

Electric and magnetic fields occur in nature and in all living things. The earth, for instance, has a magnetic field, which makes the needle on a compass point north.

Electric fields and magnetic fields of a different type also surround every wire that carries electricity. In everyday life, these EMF arise from several basic sources, including power lines, electrical appliances, home and building wiring, other utility lines and cables, and currents flowing on water pipes. Though they often occur together, EMF are made up of two separate components:

Electric Fields

Electric fields are produced by the voltage—or electrical pressure—on a wire. The higher the voltage, the higher the electric field. As long as a wire is energized—has voltage present—an electric field is present (see Figure 1). In other words, an appliance, or an electric power line, doesn't actually have to be turned on to create an electric field. It just has to be plugged in. Electric fields diminish with distance and can be blocked or partially shielded by objects such as trees and houses.

Magnetic Fields

Magnetic fields are created by the current or flow of electricity through a wire. Generally speaking, the higher the current, the higher the magnetic field. Because they only occur when current is flowing, magnetic fields are present only when the power is turned on (see Figure 1). Magnetic fields also diminish with distance, but—unlike electric fields—are not blocked by common objects. In recent years, public and scientific interest has turned toward the magnetic field component of EMF because of some scientific studies regarding these fields.

Figure 1

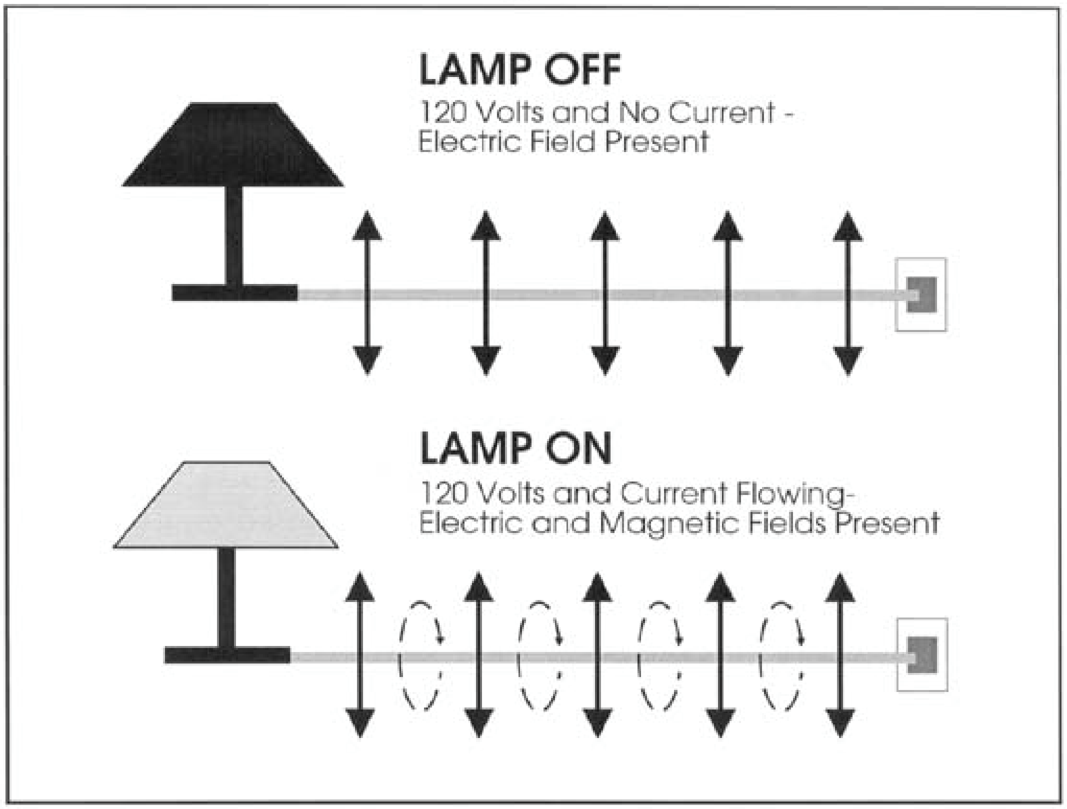

LAMP OFF
120 Volts and No Current -
Electric Field Present
LAMP ON
120 Volts and Current Flowing-
Electric and Magnetic Fields Present

Figure 2

Magnetic field strengths decrease with distance
Magnetic fields are measured in milligauss

Source: "EMF In Your Environment", U.S. Environmental Protection Agency 1992

	At 6 inches	At 1 foot	At 2 feet
Clothes dryer	2 to 10	* to 3	*
Microwave oven	100 to 300	1 to 200	1 to 30
Toaster	5 to 20	* to 7	*
Power drill	100 to 200	20 to 40	3 to 6
Can opener	500 to 1500	40 to 300	3 to 30
Mixer	30 to 600	5 to 100	* to 10
Hair dryer	1 to 700	* to 70	* to 10
Color television	Data not available	* to 20	* to 8

FIGURE 2 * The magnetic field measurement at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.

Measuring Magnetic Fields

Magnetic fields usually are measured in a unit called a milligauss. Magnetic field levels found in the living areas of homes typically range from less than 1 milligauss to about 4 milligauss according to the U.S. Environmental Protection Agency. They can be higher in some cases. The levels next to appliances can exceed 1,000 milligauss (1 gauss). Figures 2 and 3 show how the strength of the field falls off as you move away from the source, just as the heat of a campfire grows weaker as you walk away from it. For overhead power lines, the strength of the magnetic fields is dependent upon a number of factors that will be explained later. Those factors produce a magnetic field that drops off rapidly as you move away from the power line.

Figure 3

Sample Magnetic Field Levels in Milligauss				
Type of Overhead Power Line	**Distance from the line**			
	Under the line	**50 ft.**	**100 ft.**	**200 ft.**
220 kV and 500 kV	5-400	5-250	1-75	0.5-20
69 kV and 138 kV	3-80	0.5-2.5	0.1-10	0.1-3
12 kV and below	0.4-20	0.1-1	-	-

The magnetic field values provided in this table represent a general range of values associated with the types of overhead power lines listed and are provided for illustration. There will be circumstances in which there will be magnetic field levels above or below the range of values provided due to variations in such factors as height of the wires, current flow and so on.

DEVELOPMENT OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM

One element of our response to EMF concerns expressed by some of our customers is PPL EU's Magnetic Field Management Program. The program was initiated in March 1991 because PPL EU believes it makes good sense, as a matter of policy, to respond to the concerns expressed by some of our customers and to reduce magnetic fields in new and rebuilt facilities where it can be done with either no-cost or low-cost design changes.

This document updates the original program which has been revised several times since 1991. These guidelines were developed by PPL EU's EMF Working Group.

VARIABLES THAT AFFECT MAGNETIC FIELDS

Magnetic fields from transmission and distribution lines are a function of a number of design variables. The following parameters affect the magnetic field levels produced by transmission and distribution lines:

- Current
- Height of conductors above ground
- Configuration of conductors
- Distance from the line

EFFECT OF PHASE CURRENT ON MAGNETIC FIELDS

At power frequencies (i.e., 60 hertz), the magnetic field level is a function of the current or flow of electricity through a wire. Keeping all other parameters the same, the magnetic field is proportional to the current. Hence, if the current increases by 25 percent, the resulting magnetic field level will increase by 25 percent.

The overall load current on any line varies with the demand for power. It's usually highest during daytime hours and lowest at night. There also are weekly, monthly, seasonal and yearly variations.

The difference in the currents between each phase in a multiphase line also can affect the magnetic field. This difference is called phase unbalance. For a constant load, a statistical analysis of this phase unbalance can be made to determine its effect on the magnetic field. Close to the line, there is very little effect. However, the phase unbalance slows the rate at which the magnetic field decreases with distance from the line.

EFFECT OF CONDUCTOR CONFIGURATION ON MAGNETIC FIELDS

In the transmission and distribution of power, utilities like PPL EU presently use both three-phase and single-phase lines. Each phase on a three-phase power line has either a single conductor or a bundle of two or more conductors. In a three-phase system, the ground-level magnetic field is a result of the fields produced by the currents in each of the phases. Placing the three phases as close together as possible (compaction) creates some field cancellation, and the ground-level magnetic field is reduced. However, appropriate phase separation is required for the reliable operation of the line. In addition, the arrangement of the phases can create some; field cancellation and reduction of the ground-level magnetic field.

EFFECT OF DISTANCE FROM THE MAGNETIC FIELD SOURCE

Magnetic field strength diminishes with the vertical and lateral distances from the magnetic field source. Increasing the height of the conductors above ground is useful for magnetic field reduction at ground level, but may result in increased structure costs and increased aesthetic impact of the structures. Another possible method of increasing the distance to the magnetic field source is to increase the right-of-way requirements. By keeping buildings off increased rights of way, thereby requiring the public to live and work further away from lines, exposure to magnetic fields produced by the lines can be reduced. Increases in right of way are not always practical and may increase costs significantly, however.

SUMMARY OF PPL EU's
MAGNETIC FIELD MANAGEMENT PROGRAM

Under its Magnetic Field Management Program, PPL EU has changed the way it builds and rebuilds some of its transmission and distribution lines. These design changes reduce magnetic field levels (assuming balanced circuit loadings and phase currents) by up to 69 percent in most of the company's new transmission lines. These guidelines now are being applied to new and reconstructed transmission facilities, based on this program.

The distribution component of the program focuses on 12 kV lines, the company's standard distribution voltage. It concentrates on the three-phase, primary 12 kV lines, since these are the most heavily loaded facilities and often are located in densely populated areas. The guidelines in this program are being applied to these three-phase, primary 12 kV lines.

A maximum 3-5 percent change in estimated cost was used as the limit for the guidelines since this value is consistent with low cost, is within estimating accuracy and is likely to have little impact on overall line costs.

The magnetic field calculations used in this document for the design of PPL EU's overall magnetic field management plan assume balanced load conditions among the phases and a fixed level of current, not necessarily representative of specific transmission or distribution lines. These levels were calculated using the Electric Power Research Institute’s ENVIRO computer program. Under actual operating conditions, the magnetic field levels that result may vary due to such things as actual load per circuit, overall current on each phase conductor and the electrical configuration and operation of each line.

MAGNETIC FIELD MANAGEMENT PROGRAM GUIDELINES

The guidelines for magnetic field management are noted below, with discussion points for each.

OVERHEAD LINES

NEW OR REBUILT TRANSMISSION LINES

1. Balance transmission circuit loads and phase currents as much as possible.

- PPL EU should continue to make every effort to balance loadings between the two circuits of a double circuit line when planning new or rebuilt facilities to maximize the effects of reverse phasing.
- PPL EU should continue the practice of balancing single-phase loads across the three phases of the distribution system. (Unbalanced phase currents on the distribution system are reflected through to the transmission system.)
  - Unbalanced phase currents result in higher magnetic fields that do not drop off as quickly with distance as do the fields resulting from balanced phase currents.
  - For a 5 percent phase current unbalance, the magnetic field 50 feet from the centerline of a single circuit 138 kV line could be more than twice the value than if the same line had balanced phase circuits.
- Balanced phase currents on each three-phase distribution circuit also reduce magnetic fields from the distribution circuits themselves. In addition, they reduce magnetic fields on the transmission system from which the distribution system circuits are supplied and connected through substations.
- Apart from magnetic field considerations, balanced phase currents on each three-phase distribution circuit also reduce line losses and improve the system voltage.

2. **Continue with the present practice of using long-span construction as the PPL EU 138/69 kV standard**

- Structure designs for short-span and long-span construction are illustrated on Charts I and II, respectively.
  - Short-span design does not significantly reduce magnetic fields when compared to long-span design even though it is more compact than long-span design. Comparison of the magnetic field values from Chart III indicates essentially the same values. Therefore, short-span design should not be used solely to reduce magnetic fields.
  - PPL EU will continue to use long-span construction for 138/69 kV double-circuit lines and for single-circuit/future-double-circuit lines.
  - For single-circuit/future-double-circuit lines, PPL EU will continue to install two conductors on the top positions and one in the middle position as shown in Chart IV.
    - This arrangement minimizes magnetic fields as shown in Chart V by placing the three initial conductors higher on the structure, which increases the ground clearances, and by placing the conductors in a triangular configuration.

3. **Compact design structures are not a low-cost alternative and should be used for magnetic field reduction only in special applications.**

Chart VI illustrates the compact design structure.

- The compact design increases the initial installation costs by 79 percent when compared to the long-span design but reduces the magnetic field from 9 mG to 3 mG (about 67 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.

4. **Reverse phase new or rebuilt double-circuit transmission lines for all voltage levels.**

- Reverse phasing was adopted by PPL EU in March 1991 for double-circuit 138/69 kV transmission lines and in April 1992 for all other double circuit transmission lines. Reverse phasing is shown in Chart VII. Reverse phasing will reduce the magnetic fields when the current flow on both circuits is in the same direction. Calculated values contained here are based on balanced and equal phase currents on both circuits.

- Reverse phasing reduces the magnetic field of a double circuit 138 kV single pole transmission line from 29 mG to 9 mG (about 69 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.
- Reverse phasing reduces the magnetic field of a double circuit 230 kV single pole transmission line from 49 mG to 16 mG (about 67 percent) at the edge of the 150-foot-wide right of way as shown on Chart VIII.
- Reverse phasing reduces the magnetic field of a double-circuit 500 kV single pole transmission line from 37 mG to 21 mG (about 43 percent) at the edge of the 200-foot-wide right of way as shown on Chart IX.

- When new or rebuilt double-circuit lines require tapping existing double-circuit lines, PPL EU will review the existing lines to determine if reverse phasing can be provided at low cost.
- Computer modeling is required to develop the optimum phasing and overall conductor arrangements for lines added to, or rebuilt in, multiple-line corridors.
  - Merely adding a reverse-phase double-circuit line to an existing transmission line corridor or reverse phasing a rebuilt line in the multiple-line corridor will not necessarily produce lower magnetic field levels at the edge of the corridor right of way.
  - The corridor must be computer modeled with all the lines, existing phase conductor locations and currents. Then, magnetic field calculations must be made varying the phase arrangements of the new or reconstructed line to determine the appropriate phasing arrangement.
  - Current flow direction on a line also must be considered. For example, a reverse-phased line should have the current flowing in the same direction on both circuits. If the current flow is in the opposite direction for one circuit, reverse phasing will not produce the lowest magnetic field and another phase arrangement that produces lower fields may need to be utilized.

5. **Increase the minimum ground clearance for all new transmission lines.**

138/69 kV Transmission Lines

- Increasing the minimum line design ground clearance from 25 feet to 30 feet may add up to about 5 percent to the installed cost of a new double-circuit single pole 138/69 kV line. For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. With long-span reverse-phase design, the, magnetic field is reduced from 9 mG to 7 mG (about 22 percent) at the edge of a 100-foot-wide right of way as shown in Chart X.
  - In the actual design of transmission lines to include higher minimum ground clearances, there may be limited segments (such as highway crossings, severe slopes and transmission line crossing locations) where National Electrical Safety Code (NESC) minimum ground clearances may need to be used. The NESC minimum ground clearances are less than the increased ground clearance discussed previously.

230 kV Transmission Lines

- Increasing the minimum line design ground clearances from 27 feet to 32 feet may add up to about 5 percent to the cost of a single-circuit single-pole line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 30 mG to 28 mG (about 7 percent) at the edge of a 150-foot-wide right of way.
- Increasing clearances from 27 feet to 32 feet could theoretically add up to about 2.8 percent to the cost of a double-circuit single-pole line (current standard) and reduce the magnetic field of a reverse-phase line from 16 mG to 15 mG (about 6 percent) at the edge of a 150-foot-wide right of way. Chart XI is a summary of this data.
- Studies are required for each new 230 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such

studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced phase spacing (a "Delta" configuration on a single-circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

500 kV Transmission Lines

- Increasing ground clearances from 33 feet to 53 feet may add up to about 4.5 percent to the cost of a single-circuit "H-frame" line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 42 mG to 35 mG (about 17 percent) at the edge of a 200-foot-wide right of way.
- Increasing ground clearances from 33 feet to 53 feet could theoretically add up to 2.8 percent to the cost of a double-circuit "H-frame" line (current standard) and reduces the magnetic field of a reverse-phase line from 21 mG to 16 mG (about 24 percent) at the edge of a 200-foot-wide right of way. Chart XII is a summary of this data.
- Studies are required for each new 500 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced-phase spacing (a "Delta" configuration on a single circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

RECONDUCTORING OR ADDING ADDITIONAL CIRCUITS TO EXISTING TRANSMISSION LINES

When reconductoring or adding additional circuits to existing transmission lines, PPL EU will evaluate low-cost or no-cost options for magnetic field management on a case-by-case basis.

When reconductoring existing transmission lines or adding additional circuits, low-cost alternatives may not exist; however, the following steps will be taken:

- For a single-circuit line, the use of a Delta arrangement or other modifications on the existing structure, with reduced-phase spacing, will be evaluated.
- For double-circuit lines, application of reverse phasing may reduce the magnetic field under the line and within the right of way and will be evaluated.
- For single- and double-circuit lines, evaluate using higher conductor tensions that can increase the minimum line design ground clearance.

DISTRIBUTION LINES

At the 12 kV distribution level, new main three-phase lines will continue to be constructed with five feet of additional ground clearance.

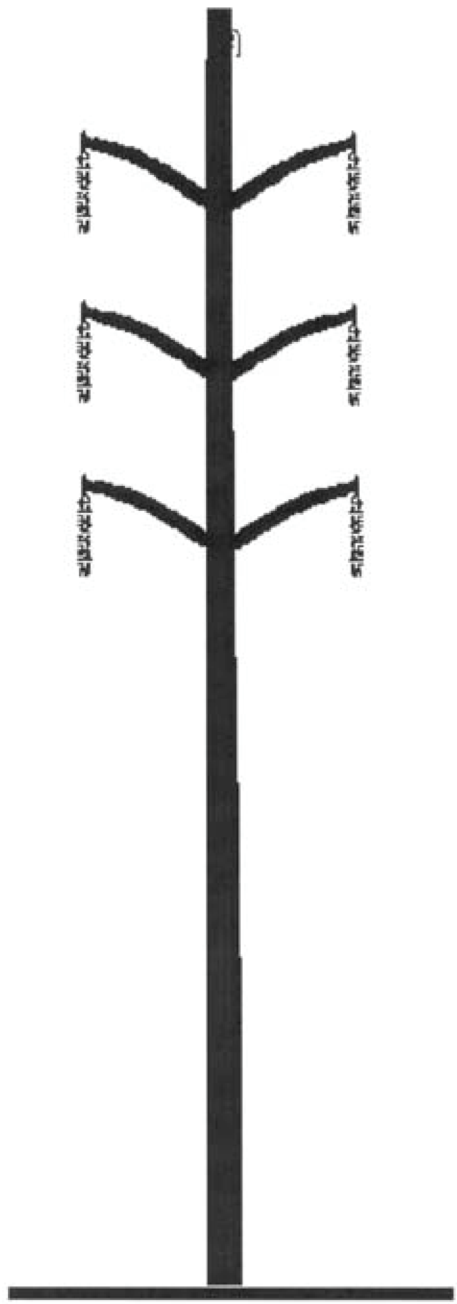
- Main lines are the most heavily loaded sections of a distribution line and therefore have the highest magnetic fields associated with them.
- Increasing the ground clearance by five feet reduces the magnetic field under the line from 14 mG to 11 mG using the standard eight-foot crossarm design. These values are based on increasing pole heights from 45 feet to 50 feet and a typical operating current of 300 amps per phase.
- Chart XIII is a summary of this data. Increasing ground clearance by five feet could theoretically add about 5 percent to the cost of a typical distribution line.

UNDERGROUND TRANSMISSION LINES

Underground transmission lines are required due to environmental or land use factors or restrictions on available clearances, PPL EU will evaluate options for magnetic field management techniques on a case-by-case basis.

- The phase arrangement that produces the lowest field will be determined.
- The depth of burial of the line will be determined considering the cost of excavation and the location of other buried utilities in the area.
- The use of steel pipe ferromagnetic shielding that reduces magnetic fields will be evaluated.

Short-Span Construction



- **More compact design**
- **Should not be used solely to reduce magnetic fields**
- **Typical conductor data:**

1 3/8" HS steel overhead ground wire - 7.3 feet sag
6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 10.0 feet sag
Average span - 400 feet

Long-Span Construction Remains PPL EU 138 kV Standard

- **Lower cost alternative**
- **Reduces magnetic fields due to higher structures**
- **Typical conductor data:**

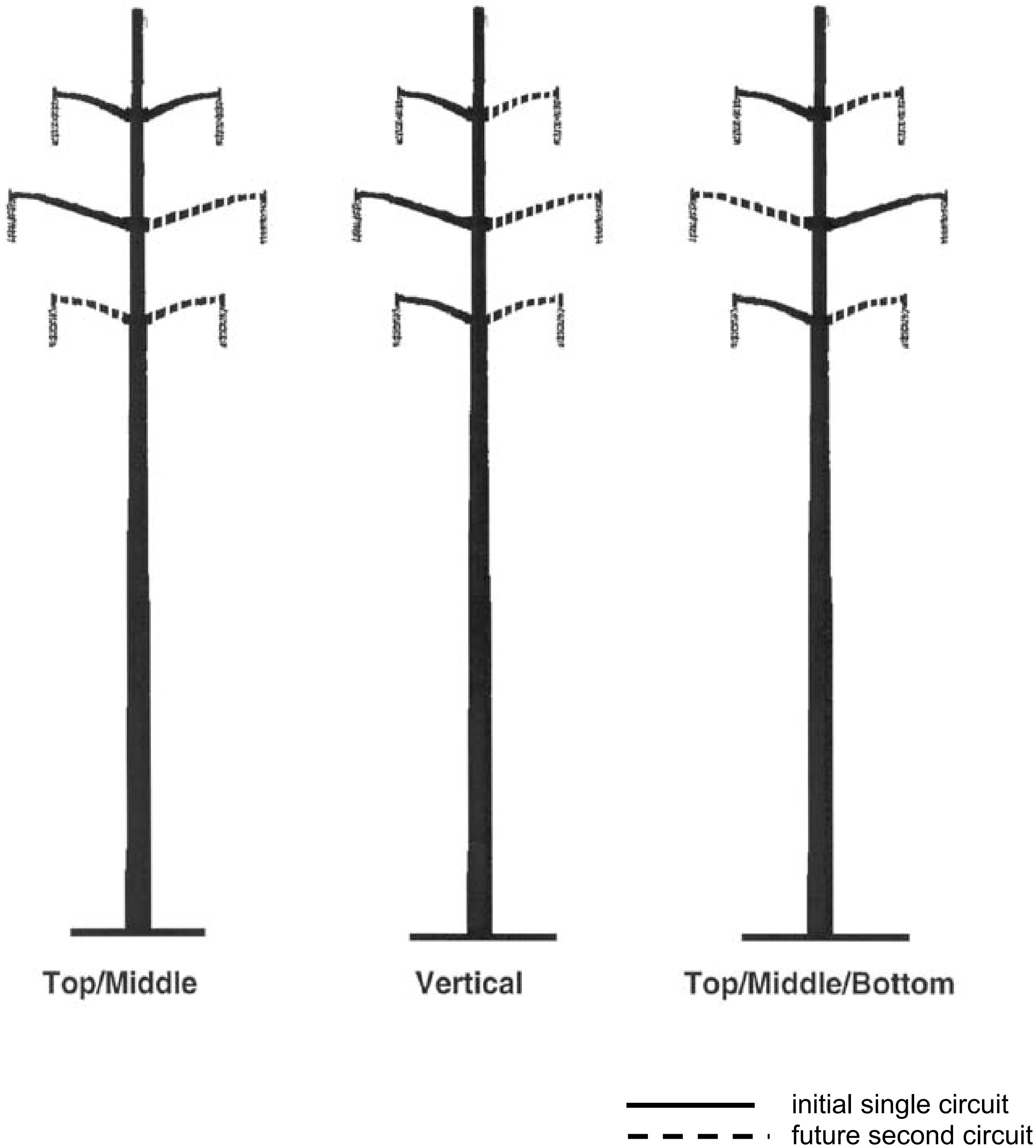
1 3/8" HS steel overhead ground wire - 17.3 feet sag
6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 23.0 feet sag
Average span - 600 feet

138/69 kV REVERSE-PHASE TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SHORT SPAN (CHART I)	30
SHORT SPAN (REVERSE PHASE)	8
LONG SPAN (CHART II)	29
LONG SPAN (REVERSE PHASE)	9
COMPACT (CHART VI)	14
COMPACT (REVERSE PHASE)	3

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 25 feet.
LONG SPAN, SHORT SPAN and COMPACT are double-circuit lines.

Typical Single-Circuit Structure Designs

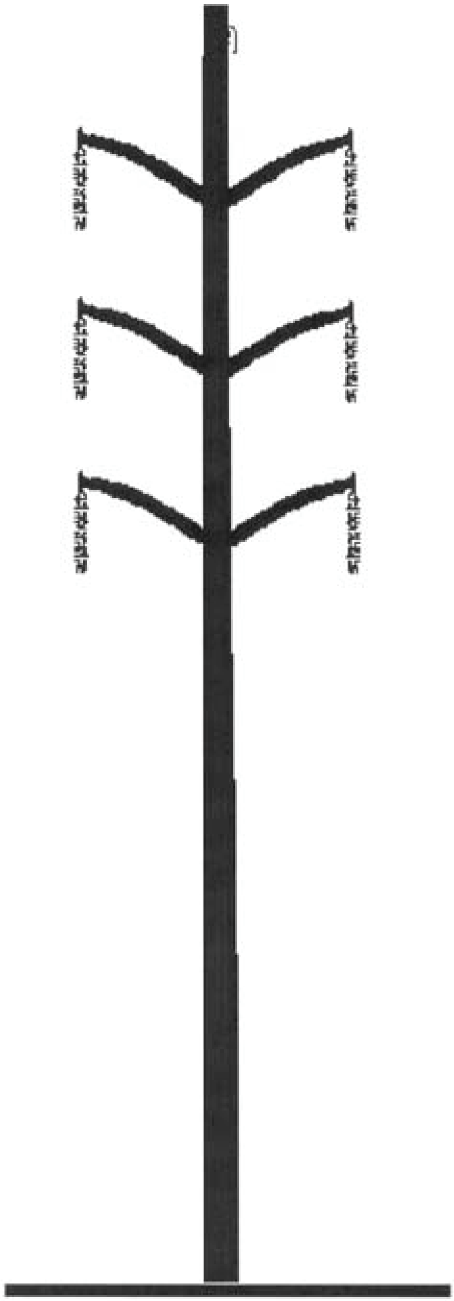


138/69 kV SINGLE CIRCUIT TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
TOP/MIDDLE/BOTTOM	20
VERTICAL	17
TOP/MIDDLE	12

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 25 feet.

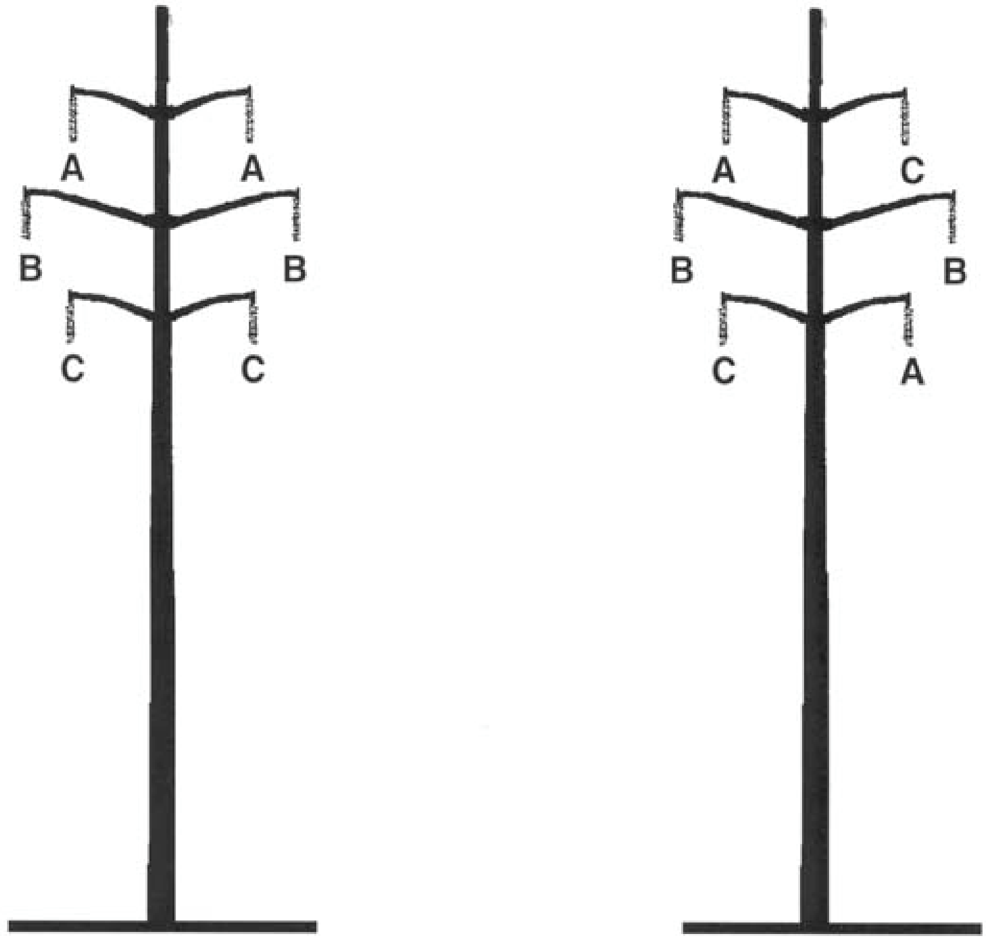
Compact Design Structure



- **Minimize magnetic fields due to compact design**
- **Not a low-cost alternative**
- **Typical conductor data:**

1 3/8" HS steel overhead ground wire - 9.0 feet sag
6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 9.0 feet sag
Average span - 300 feet

Reverse Phasing of Double-Circuit Transmission Lines



From: ⟶ ⟶ ⟶ ⟶ **To:**

Reverse phasing also can be one of the following phase arrangements:

A	**B**		**B**	**A**		**B**	**C**		**C**	**A**		**C**	**B**
C	**C**	**or**	**C**	**C**	**or**	**A**	**A**	**or**	**B**	**B**	**or**	**A**	**A**
B	**A**		**A**	**B**		**C**	**B**		**A**	**C**		**B**	**C**

CHART VIII

230 kV REVERSE-PHASE TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 800 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	49
DOUBLE CIRCUIT POLE (REVERSE-PHASE)	16

The edge of right of way is 75 feet from the line centerline.
The 800 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 27 feet.

CHART IX

500 kV REVERSE-PHASE TRANSMISSION LINES
CALCULATED MAGNETIC FIELDS AT 1100 AMPERES

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	37
DOUBLE CIRCUIT POLE (REVERSE PHASE)	21

The edge of right of way is 100 feet from the line centerline.
The 1,100 ampere phase current is balanced between phases.
Calculations are based on a minimum ground clearance of 33 feet.

INCREASED 138/69 kV MINIMUM GROUND CLEARANCE
CALCULATED MAGNETIC FIELDS AT 400 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	25	12
SINGLE CIRCUIT TOP/MIDDLE	30	10
LONG SPAN	25	29
LONG SPAN	30	26
LONG SPAN (REVERSE PHASE)	25	9
LONG SPAN (REVERSE PHASE)	30	7

The edge of right of way is 50 feet from the line centerline.
The 400 ampere phase current is balanced between phases.

INCREASED 230 kV MINIMUM GROUND CLEARANCE CALCULATED MAGNETIC FIELDS AT 800 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	27	30
SINGLE CIRCUIT TOP/MIDDLE	32	28
DOUBLE CIRCUIT POLE	27	49
DOUBLE CIRCUIT POLE	32	46
DOUBLE CIRCUIT POLE (REVERSE PHASE)	27	16
DOUBLE CIRCUIT POLE (REVERSE PHASE)	32	15

The edge of right of way is 75 feet from the line centerline.
The 800 ampere phase current is balanced between phases.

INCREASED 500 kV MINIMUM GROUND CLEARANCE CALCULATED MAGNETIC FIELDS AT 1,100 AMPERES

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT "H" STRUCTURE	33	42
SINGLE CIRCUIT "H" STRUCTURE	53	35
DOUBLE CIRCUIT POLE	33	37
DOUBLE CIRCUIT POLE	53	31
DOUBLE CIRCUIT POLE (REVERSE PHASE)	33	21
DOUBLE CIRCUIT POLE (REVERSE PHASE)	53	16

The edge of right of way is 100 feet from the line centerline.
The 1,100 ampere phase current is balanced between phases.

12 kV DISTRIBUTION LINES
CALCULATED MAGNETIC FIELDS AT 300 AMPERES

TYPE CONSTRUCTION	POLE HEIGHT FEET	MAGNETIC FIELD IN MILLIGAUSS*	
		AT CENTERLINE	AT 30 FEET FROM CENTERLINE
STANDARD CROSSARM	45	14	7
STANDARD CROSSARM	50	11	6

* Field level under the line at mid-span based on 300 amps, balanced loading, one meter above ground level.