Applicant’s Environmental Report - Operating License Renewal Stage

Limerick Generating Station, Units 1 and 2

Docket Numbers 50-352 and 50-353
License Numbers NPF-39 and NPF-85

Exelon Generation Company, LLC

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS, ACRONYMS, AND CONVERSION FACTORS

AEC	[U.S.] Atomic Energy Commission
AEPS	Alternative Energy Portfolio Standards
AWEA	American Wind Energy Association
BWR	boiling-water reactor
°C	degrees Celsius
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CCPC	Chester County Planning Commission
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
ComEd	Commonwealth Edison Company, the energy delivery subsidiary of Exelon Corporation serving retail customers in Northern Illinois
CWA	Clean Water Act
DCNR	Pennsylvania Department of Conservation and Natural Resources
DOE	[U.S.] Department of Energy
DRBC	Delaware River Basin Commission
DRM	Delaware River Mile
DSM	demand-side management
EPA	[U.S.] Environmental Protection Agency
ESA	Endangered Species Act
Exelon Generation	Exelon Generation Company, LLC
°F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
FES	Final Environmental Statement
fps	feet per second
FWS	[U.S.] Fish and Wildlife Service
GEIS	Generic Environmental Impact Statement for License Renewal of Nuclear Plants
gpd	gallons per day
gpm	gallons per minute
GW	gigawatts
GWh	gigawatt hours

HSM	horizontal storage module
ILOS	intersection level of service
IPA	integrated plant assessment
ISFSI	Independent Spent Fuel Storage Installation
km	kilometers
kV	kiloVolts
KW	kilowatts
kwh	kilowatt hours
LGS	Limerick Generating Station, Units 1 and 2
LLD	lower limit of detection
LOS	level of service
m	meters
MCPC	Montgomery County Planning Commission
MGD	million gallons per day
MW	megawatts
MWd/MTU	megawatt-days per metric ton of uranium
MWe	megawatts-electric
MWt	megawatts-thermal
NA	not applicable
NAAQS	National Ambient Air Quality Standards
NESC	National Electrical Safety Code
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	[U.S.] Nuclear Regulatory Commission
pCi/l	pico-curies per liter
psig	pounds per square inch gauge
PADEP	Pennsylvania Department of Environmental Protection
PECO	PECO Energy Company, the energy delivery subsidiary of Exelon Corporation serving retail customers in southeastern Pennsylvania (also used in this report as an acronym for Philadelphia Electric Company or PECO Energy Company, predecessors of Exelon Generation)
PennDOT	Pennsylvania Department of Transportation
PFBC	Pennsylvania Fish and Boat Commission
PGC	Pennsylvania Game Commission

PHMC	Pennsylvania Historical and Museum Commission
PJM	PJM Interconnection, LLC
$PM_{2.5}$	particulates with diameters 2.5 microns or less
PM_{10}	particulates with diameters greater than 2.5 microns to 10 microns
PNHP	Pennsylvania Natural Heritage Program
PPUC	Pennsylvania Public Utility Commission
PURTA	Pennsylvania Utility Realty Tax Act
RACT	Reasonably Available Control Technology
REMP	Radiological Environmental Monitoring Program
RERS	Reactor Enclosure Recirculation System
RMC	RMC Environmental Services
RMF	Restoration and Monitoring Fund
ROW	Right-of-Way
SAMA	Severe Accident Mitigation Alternatives
SCR	selective catalytic reduction
SGTS	Standby Gas Treatment System
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SMITTR	surveillance, monitoring, inspections, testing, trending, and recordkeeping
SO_2	sulfur dioxide
SOx	sulfur oxides
SRM	Schuylkill River Mile
su	standard units
state	Commonwealth of Pennsylvania (or other state if specified)
TAWA	Tamaqua Area Water Authority
tpy	tons per year
TMDL	Total Maximum Daily Load
TSP	total suspended particulates
twh	terawatt hours
UFSAR	Updated Final Safety Analysis Report
USCB	[U.S.] Census Bureau
USGS	[U.S.] Geological Survey
VOC	volatile organic compounds
WHC	Wildlife Habitat Council
WQBEL	Water Quality Based Effluent Limitation

CONVERSION FACTORS

This table is derived from Thompson and Taylor (2008), *Guide for the Use of the International System of Units*.

To convert from	To	Multiply by
Area		
acres	hectares	0.4047
square miles (mi^2)	square kilometers (km^2)	2.589
square feet (ft^2)	square meters (m^2)	0.0929
Flow		
cubic feet per second (ft^3/sec)	cubic meters per second (m^3/sec)	0.02831
gallons per minute (gpm)	liters per minute	3.7848
Length		
feet (ft)	meters (m)	0.3048
inches (in)	meters (m)	0.0254
inches (in)	centimeters (cm)	2.54
miles (mi)	kilometers (km)	1.609
Mass		
pounds	kilograms	0.4535
tons (short tons)	metric tons	0.9072
Temperature Interval		
°F (interval)	°C (interval)	0.555
Volume		
gallons (gal)	liters (l)	3.785
cubic meters (m^3)	cubic feet (ft^3)	35.3232
To convert from	**To**	**Use this formula**
Temperature		
degrees Fahrenheit (°F)	degrees Celsius (°C)	t °C = (t °F - 32°) / 1.8

1.0 INTRODUCTION

1.1 Purpose of and Need for Action

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants in accordance with the Atomic Energy Act of 1954, as amended, and NRC implementing regulations. Exelon Generation Company, LLC (Exelon Generation) operates Limerick Generating Station, Units 1 and 2 (LGS) pursuant to NRC Operating Licenses NPF-39 and NPF-85, respectively. The license for Limerick Unit 1 will expire on October 26, 2024 and the license for Limerick Unit 2 will expire on June 22, 2029.

Exelon Generation has prepared this environmental report in conjunction with its application to renew the operating licenses, as provided by the following NRC regulations:

> Title 10, Energy, Code of Federal Regulations (CFR), Part 54, Requirements for Renewal of Operating Licenses for Nuclear Power Plants, Section 54.23, Contents of Application- Environmental Information (10 CFR 54.23) and
>
> Title 10, Energy, CFR, Part 51, Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, Section 51.53, Postconstruction Environmental Reports, Subsection 51.53(c), Operating License Renewal Stage [10 CFR 51.53(c)].

NRC has clarified the purpose and need for its proposed action (renewal of the operating license for a nuclear power plant such as LGS) as follows:

> “The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than the NRC) decision makers.” (61 FR 28472; June 5, 1996)

The renewed operating licenses would allow an additional 20 years of operation for both Limerick Units 1 and 2 beyond their current licensed operating periods. The renewed license for Limerick Unit 1 would expire on October 26, 2044 and the renewed license for Limerick Unit 2 would expire on June 22, 2049.

1.2 Environmental Report Scope and Methodology

NRC regulations for domestic licensing of nuclear power plants require environmental review of applications to renew operating licenses. The NRC regulations in 10 CFR 51.53(c) require that an applicant for license renewal submit with its application a separate document entitled "Applicant's Environmental Report – Operating License Renewal Stage." In determining what information to include in the Applicant's Environmental Report for LGS (referred to herein as the "LGS License Renewal ER"), Exelon Generation has relied on NRC regulations and the following supporting documents that provide additional insight into the regulatory requirements:

1. NRC supplemental information in the Federal Register:

    - 61 FR 28467-28497; June 5, 1996
    - 61 FR 39555-39556; July 30, 1996
    - 61 FR 66537-66554; December 18, 1996
    - 64 FR 48496-48507; September 3,1999;

2. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (1996 GEIS) (NRC, 1996a and 1999);

3. Regulatory Analysis for Amendments to Regulations for the Environmental Review for Operating Licenses (NRC, 1996b); and

4. Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Report for Applications to Renew Nuclear Power Plant Operating Licenses (NRC, 2000).

Exelon Generation has prepared Table 1.2-1 to verify conformance with regulatory requirements. This table indicates where the LGS License Renewal ER responds to each requirement in 10 CFR 51.53(c). In addition, each responsive section is prefaced by a quote of the regulatory language and applicable supporting document language.

1.3 LGS Licensee and Ownership

LGS are owned and operated by Exelon Generation, the applicant and licensee. Exelon Generation is wholly owned by Exelon Corporation.

Exelon Corporation is formed under the laws of the Commonwealth of Pennsylvania and headquartered in Chicago, Illinois, and is one of the nation's largest electric utilities. Exelon Corporation's family of companies includes energy generation, power marketing, transmission, and energy delivery (Exelon Corporation, 2010a).

Exelon Corporation delivers energy via its two energy delivery subsidiaries: ComEd, serving retail customers in northern Illinois and PECO, serving retail customers in southeastern Pennsylvania (Exelon Corporation, 2010a). The transmission lines that connect LGS to the regional electricity grid are owned and operated by PECO. Like Exelon Generation, PECO is wholly owned by Exelon Corporation.

Exelon Generation has access to more than 31,000 megawatts (MW) of electricity, one of the industry's largest portfolios of electricity generation capacity with a nationwide reach and strong positions in the Midwest and Mid-Atlantic. It is the largest owner/operator of nuclear plants in the United States with 10 generating power plants and 17 reactors located in Illinois, Pennsylvania and New Jersey (Exelon Corporation, 2010b).

Table 1.2-1 Environmental Report Responses to License Renewal Environmental Regulatory Requirements

Regulatory Requirement	Responsive Environmental Report Section(s)	Subject of Regulatory Requirement
10 CFR 51.53(c)(1)	Entire Document	Submittal of Environmental Report – Operating License Renewal Stage
10 CFR 51.53(c)(2), Sentences 1 and 2	3.0	Description of Proposed Action
10 CFR 51.53(c)(2), Sentence 3 and 10 CFR 51.45(c)	7.2.2	Environmental Impacts of Alternatives to Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(1)	4.0	Environmental Impacts of the Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(2)	6.3	Unavoidable Adverse Impacts
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	7.0	Alternatives to the Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(3)	8.0	Comparison of Environmental Impacts of License Renewal with Alternatives
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(4)	6.5	Short-Term Use Versus Long-Term Productivity of the Environment
10 CFR 51.53(c)(2) and 10 CFR 51.45(b)(5)	6.4	Irreversible and Irretrievable Resource Commitments
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	6.1	Environmental Effects of the Proposed Action
10 CFR 51.53(c)(2) and 10 CFR 51.45(c)	6.2	Mitigation of Adverse Environmental Effects
10 CFR 51.53(c)(2) and 10 CFR 51.45(d)	9.0	Status of Compliance
10 CFR 51.53(c)(2) and 10 CFR 51.45(e)	4.0	Environmental Consequences of the Proposed Action and Mitigating Actions
10 CFR 51.53(c)(3)(ii)(A)	4.1	Water Use Conflicts (Plants with Cooling Towers or Cooling Ponds Withdrawing Make-up Water from a Small River)
10 CFR 51.53(c)(3)(ii)(A)	4.6	Groundwater Use Conflicts Associated With Impacts on Alluvial Aquifers (Plants With Cooling Towers or Cooling Ponds Withdrawing Make-up Water from a Small River at Low Flow)
10 CFR 51.53(c)(3)(ii)(B)	4.2	Entrainment of Fish and Shellfish Resources (Plants With Once-Through Cooling or Cooling Pond Heat Dissipation Systems)
10 CFR 51.53(c)(3)(ii)(B)	4.3	Impingement of Fish and Shellfish Resources (Plants With Once-Through Cooling or Cooling Pond Heat Dissipation Systems)
10 CFR 51.53(c)(3)(ii)(B)	4.4	Heat Shock of Fish and Shellfish Resources (Plants With Once-Through Cooling or Cooling Pond Heat Dissipation Systems)

Table 1.2-1 Environmental Report Responses to License Renewal Environmental Regulatory Requirements

Regulatory Requirement	Responsive Environmental Report Section(s)	Subject of Regulatory Requirement
10 CFR 51.53(c)(3)(ii)(C)	4.5	Groundwater Use Conflicts (Plants Using >100 gpm of Groundwater)
10 CFR 51.53(c)(3)(ii)(C)	4.7	Groundwater Use Conflicts (Plants Using Ranney Wells)
10 CFR 51.53(c)(3)(ii)(D)	4.8	Degradation of Groundwater Quality (Plants at an Inland Site Utilizing a Cooling Pond)
10 CFR 51.53(c)(3)(ii)(E)	4.9	Impacts of Refurbishment on Terrestrial Resources
10 CFR 51.53(c)(3)(ii)(E)	4.10	Impact of Proposed Action on Threatened or Endangered Species
10 CFR 51.53(c)(3)(ii)(F)	4.11	Air Quality During Refurbishment (Plants In or Near Non-Attainment or Maintenance Area)
10 CFR 51.53(c)(3)(ii)(G)	4.12	Public Health Impacts From Thermophilic Organisms (Plants Using a Cooling Pond, Lake, or Canal Discharging Into a Small River)
10 CFR 51.53(c)(3)(ii)(H)	4.13	Electric Shock from Transmission Line-Induced Currents
10 CFR 51.53(c)(3)(ii)(I)	4.14	Housing Availability Impacts (from Refurbishment and During License Renewal Term)
10 CFR 51.53(c)(3)(ii)(I)	4.15	Public Water Supply Impacts (from Refurbishment and During License Renewal Term)
10 CFR 51.53(c)(3)(ii)(I)	4.16	Education Impacts (from Refurbishment)
10 CFR 51.53(c)(3)(ii)(I)	4.17	Offsite Land Use Impacts (from Refurbishment and During License Renewal Term)
10 CFR 51.53(c)(3)(ii)(J)	4.18	Local Highway Traffic Impacts (from Refurbishment and During License Renewal Term)
10 CFR 51.53(c)(3)(ii)(K)	4.19	Effects on Historic or Archaeological Properties (from Refurbishment and During License Renewal Term)
10 CFR 51.53(c)(3)(ii)(L)	4.20	Severe Accident Mitigation Alternatives
10 CFR 51.53(c)(3)(iii) and 10 CFR 51.45(c)	4.0, 6.2	Alternatives for Reducing Adverse Impacts for Category 2 Issues
10 CFR 51.53(c)(3)(iv)	5.0	Assessment of New and Significant Information
Appendix B to Subpart A of 10 CFR 51	2.6.2	Environmental Justice

2.0 SITE AND ENVIRONMENTAL INTERFACES

2.1 Locations and Features

This section describes Limerick Generating Station, Units 1 and 2 (LGS) features and existing environmental resources that may be affected by operation of these features during the license renewal term.

Features of the LGS project are predominantly situated in southeastern Pennsylvania. These features include:

- The LGS plant site, which hosts Limerick Units 1 and 2;
- The LGS cooling water system, which includes the makeup water supply system to convey water from approved sources to the LGS intake structures for use as makeup to the circulating and other water systems; and
- The LGS transmission system, which includes the transmission lines constructed to connect LGS to the regional electricity grid.

Figure 2.1-1 depicts the Exelon Generation Company, LLC (Exelon Generation) property boundaries that outline the LGS plant site and encompass the 762-meter (2,500-foot) radius exclusion area. Figure 2.1-2 and Figure 2.1-3 are the 80.5-kilometer (50-mile) and 9.7-kilometer (6-mile) vicinity maps, respectively. Figure 2.1-4 is a map showing the location of the Perkiomen Pumphouse, which is the LGS auxiliary intake structure, located about 12.9 kilometers (8 miles) east of LGS.

More information about the features themselves is provided in Section 3. Section 3.1 provides general plant information, and Sections 3.1.1, 3.1.2, and 3.1.3 provide additional information on the plant reactor, containment, and spray pond systems; water systems; and transmission system, respectively.

Figure 3.1-1 and Figure 3.1-2 show the LGS plant site layout and aerial view, respectively. Figure 3.1-3 depicts the relative locations of the elements that compose the LGS makeup water supply system. Figure 3.1-4 depicts the locations of the Schuylkill Pumphouse, which is the LGS primary intake structure located on the LGS plant site, and cooling tower blowdown discharge system components that are situated in the Schuylkill River, a public passageway that traverses the LGS plant site. Figures 3.1-5, 3.1-6, 3.1-7 and 3.1-8 depict the routes of the transmission lines that compose the LGS transmission system.

2.1.1 LGS Plant Site

The LGS plant site, as referred to throughout this report, consists of the following properties and components owned by Exelon Generation:

- The properties encompassing the reactor enclosures, turbine enclosures, cooling towers, electrical substations, independent spent fuel storage installation, Schuylkill River Pumphouse, and spray pond, as well as other land constituting an exclusion area; and
- The portion of the cooling tower blowdown discharge line and associated structures, which are submerged immediately downriver from the Schuylkill River Pumphouse.

Specifically excluded from the LGS plant site are properties owned by others that traverse the LGS plant site but are considered public passageways. These public passageways are two Consolidated Rail Corporation (Conrail) rights-of-way (ROWs) and the Schuylkill River, including one island in the river channel (Limerick Island). Figure 2.1-1 depicts the Exelon Generation property boundaries that outline the LGS plant site. This figure also shows the boundaries of the public passageways that traverse the LGS plant site and the land constituting the LGS 762-meter (2,500-foot) radius exclusion area. Figure 3.1-4 depicts the locations of Schuylkill Pumphouse, located on the LGS plant site, and cooling tower blowdown discharge system components, submerged in the Schuylkill River.

The LGS plant site is located approximately 2.7 kilometers (1.7 miles) southeast of the limits of the Borough of Pottstown, the nearest population center. Other population centers in the LGS plant site area include the City of Reading, about 30.6 kilometers (19 miles) northwest of the site, the Borough of Phoenixville, about 15 kilometers (9.3 miles) southeast of the site, the Municipality of Norristown, about 17.7 kilometers (11 miles) southeast of the site, and the City of Philadelphia, the city limits of which are about 33.8 kilometers (21 miles) southeast from the site. The LGS plant site and these population centers lie along the Schuylkill River, which flows in a southeasterly direction to its confluence with the Delaware River. The Schuylkill River passes through the LGS plant site and separates its western portion, which is located in Chester County, from its eastern portion, which is located in Montgomery County.

Parts of the LGS plant site in Montgomery County are located in Limerick Township and Lower Pottsgrove Township. Parts in Chester County are located in East Coventry Township. The major plant structures are almost all located in Montgomery County, Limerick Township. Other than a portion of the cooling tower blowdown discharge line and associated channel stabilization structures, which are submerged in the Schuylkill River, no plant structures or components are located in Chester County. The LGS plant site contains a total of 261.0 hectares (645 acres), including 198.7 hectares (491 acres) in Montgomery County and 62.3 hectares (154 acres) in Chester County.

The major transportation routes located within 8.0 kilometers (5 miles) of the site include: U.S. Highway (US-) 422, an east-west highway passing approximately 2.4 kilometers (1.5 miles) north of the site; Pennsylvania Route (PA-) 100, a north-south highway passing approximately 6.4 kilometers (4 miles) west of the site in Chester County; and PA-724, a southeast-northwest highway passing approximately 1.6 kilometers (1 mile) southwest of the site. There is one plant entrance/exit, which can only be accessed via Evergreen Road, either directly from the Sanatoga exit of US-422 or indirectly from the Limerick Linfield exit of US-422 via several local roads.

A Conrail line (formerly Reading Company) passes through the LGS plant site along the eastern side of the Schuylkill River. The line is comprised of two tracks, and has a rail spur serving LGS. Another Conrail line (formerly Penn Central Railroad) runs along the western side of the Schuylkill River, passing through the LGS plant site portion located in Chester County. All activities on the LGS plant site are under the control of Exelon Generation.

The LGS plant site is situated along the Schuylkill River approximately 6.4 river kilometers (4 river miles) downriver from Pottstown, 56.3 river kilometers (35 river miles) upriver from Philadelphia, and 78.8 river kilometers (49 river miles) above the confluence of the Schuylkill River with the Delaware River. The site is located in gently rolling countryside, traversed by numerous valleys containing small creeks or streams that empty into the Schuylkill River. Two parallel streams, Possum Hollow Run and Brooke Evans Creek, cut through the LGS plant site, running southwest into the Schuylkill River. Just upstream and to the north of the LGS plant site, Sanatoga Creek flows into the Schuylkill River. Further upstream and to the northwest of the LGS plant site, Sprogels Run flows into the Schuylkill River.

The Heritage Field Airport (formerly known as the Pottstown Limerick Airport), located about 2.4 kilometers (1.5 miles) northeast of the LGS plant site, serves local and transient general aviation and air taxi and charter service. Other airports in the vicinity used for similar purposes are the Pottstown Municipal Airport located in Pottstown about 8.0 kilometers (5 miles) northwest of the LGS plant site, and the Reading Regional Airport located near the City of Reading about 32.2 kilometers (20 miles) northwest of the LGS plant site. Larger airports in the general area include the Lehigh Valley International Airport located in Allentown, about 49.9 kilometers (31 miles) north of the LGS plant site, and the Philadelphia International Airport, located near Philadelphia, about 49.9 kilometers (31 miles) southeast of the LGS plant site.

2.1.2 LGS Makeup Water Supply System

The LGS makeup water supply system, as referred to throughout this report, is defined as the network of facilities and components used to supply makeup water to the LGS circulating water system and other LGS water systems. The LGS makeup water supply system and circulating water system, along with the cooling tower blowdown system, are components of the LGS cooling water system (see Sec. 3.1.2). Water withdrawn from the Schuylkill River through the Schuylkill Pumphouse is the primary source of water for the LGS makeup water supply system. However, the specific water source(s) from which LGS makeup water may be withdrawn at any particular time is subject to conditions and limitations established by the Delaware River Basin Commission (DRBC).

The DRBC has jurisdiction over withdrawals and uses of water in the Delaware River Basin, which includes the Schuylkill Valley Subbasin, in which LGS is located. Figure 2.1-5 is a map showing the Delaware River Basin boundary. Pursuant to DRBC rules and regulations, dockets are used to place limitations and conditions on individual projects, such as LGS, that withdraw and use water within the Delaware River Basin.

For varied time periods, normally between April and November each year, the naturally occurring (unaugmented) flow in the Schuylkill River can drop and remain below a DRBC-prescribed threshold. Under such low flow conditions, Exelon Generation obtains its consumptive use makeup water from other approved sources either directly or through augmentation of the Schuylkill River flow. The DRBC docket for LGS (i.e., DRBC Docket No. D-69-210 CP, as revised) prescribes the low flow conditions that trigger the requirement for LGS to switch to an alternative source of consumptive use makeup water. These DRBC Docket provisions applicable to LGS, and similar requirements on other DRBC-governed projects, are intended to avoid potential water use conflicts that might otherwise arise during seasonal low flow periods in the Schuylkill River. The water management operating plan is further described in Section 3.1.2.1.

Figure 3.1-3 shows the locations of the LGS makeup water supply system facilities and components used to convey makeup water from DRBC-approved water sources to LGS. Included are water storage reservoirs, a mine pool, pumping and treatment facilities, transmission mains and pipelines, and gage stations. These facilities and components are briefly discussed below and are more fully described in Section 3.1-2.

Exclusively for LGS, Exelon Generation owns and operates the Perkiomen Pumphouse and the Perkiomen Pumphouse-to-LGS pipeline. The Perkiomen Pumphouse is located in Graterford Township, Montgomery County. The pumphouse and the pipeline to LGS are located in a PECO (a power delivery company wholly owned by Exelon Corporation) transmission line ROW with Exelon Generation having an easement from PECO.

Exelon Generation also owns the Bradshaw Reservoir and Pumphouse and the Bedminster Water Processing (Treatment) Facility. The Bradshaw Reservoir and Pumphouse are co-located approximately 43.5 kilometers (27 miles) northwest of LGS in Plumstead Township, Bucks County, on parcels totaling 17.0 hectares (42 acres) in size. The Bedminster facility is located about 4.8 kilometers (3 miles) west of the Bradshaw facility on a 1.2-hectare (3-acre) parcel in Bedminster Township, Bucks County.

The East Branch transmission main conveys water from the Bradshaw Pumphouse through the Bedminster facility to its terminus at the East Branch Perkiomen Creek. The underground main is located in a natural gas pipeline ROW with Exelon Generation having an easement from the natural gas pipeline's current owner. The natural gas pipeline is not associated with LGS.

While the Bradshaw Pumphouse, the Bedminster facility and the transmission main are exclusive to LGS, the Bradshaw Reservoir is also used for public water supply.

Exelon Generation is a member of the Merrill Creek Owner's Group, whose seven utility members jointly own the Merrill Creek Reservoir Project. The project includes a reservoir, pumping station, and a transmission main located in Washington Township, Warren County, New Jersey. The reservoir stores water for release when required to mitigate consumptive use at designated electric generating facilities, including LGS, in the event of a DRBC-declared drought emergency causing low flow conditions in the Delaware River. Operation of the reservoir project is governed by a DRBC docket (No. D-77-110 CP, as amended) and a DRBC-approved Plan of Operation. A Merrill Creek Reservoir Compensation Release Manual and companion procedure provide the methodology and instructions, respectively, for conducting compensating release operations. This facility does not exist solely to serve LGS and, accordingly, is expected to remain in service whether or not the LGS operating licenses are renewed.

Facilities and components of the LGS makeup water supply system not owned or controlled by Exelon Generation are:

- The Wadesville Mine Pool, Pumphouse, and discharge channel;
- The Still Creek Reservoir;
- The Point Pleasant Pumping Station and combined transmission main to the Bradshaw Reservoir; and
- The Pottstown Gage Station, the Graterford Gage Station and the Bucks Road Gage Station (the latter located near Dublin Borough, Bucks County).

Exelon Generation has contractual arrangements with the respective owners of the Wadesville, Still Creek and Point Pleasant facilities for services to supply water on behalf of LGS. None of these three facilities exists solely to serve LGS and, accordingly, are expected to remain in service whether or not the LGS operating licenses are renewed. The gage stations are owned and operated by the U.S. Geological Survey (USGS). Exelon Generation shares in the cost for operation and maintenance of the Pottstown and Bucks Road gage stations, but not the

Graterford Gage Station. None of the gage stations exists solely to serve LGS and, accordingly, all may remain in service whether or not the LGS operating licenses are renewed, subject to the discretion of the USGS and DRBC.

2.1.3 LGS Transmission System

The LGS transmission system, as referred to throughout this report, means:

- The transmission lines and associated structures from the three main power transformers of Limerick Unit 1 to the Limerick 230-kV Substation, located on the LGS plant site;
- The transmission lines and associated structures from the three main power transformers of Limerick Unit 2 to the Limerick 500-kV Substation, located on the LGS plant site;
- The substations, transmission lines, and associated structures constructed to connect LGS to the regional electricity grid, including:
    - Two 230-kV lines, designated 220-60 and 220-61, connecting the Limerick 230-kV Substation to the Cromby Substation located at Exelon Generation's Cromby Generating Station;
    - One 230-kV line, designated 220-62, connecting the Cromby Substation to the North Wales Substation and the regional electricity grid;
    - One 230-kV line connecting the Cromby Substation to the Plymouth Meeting Substation and the regional electricity grid, consisting of:
        - One segment, designated 220-63, connecting the Cromby Substation to the Barbadoes Substation; and
        - One segment, designated 220-64, connecting the Barbadoes Substation to the Plymouth Meeting Substation; and
    - One 500-kV line, designated 5031, connecting the Limerick 500-kV Substation to the Whitpain Substation and the regional electricity grid; and
- The ROWs for the above-identified transmission lines, which either were pre-existing at the time LGS was built (i.e., the lines are being shared with other linear features that were already in place) or were added in conjunction with LGS construction.

The current LGS transmission system is essentially the same as that originally constructed for LGS. Figure 2.1-6 is a map that provides an overview of the transmission line ROW routes, which traverse Montgomery County and Chester County. The four offsite 230-kV lines exclusively serve Limerick Unit 1, and the one offsite 500-kV line exclusively serves Limerick Unit 2. Even though these lines were constructed solely to serve the Limerick units, it is anticipated that some or all of these lines would continue to be used for transmitting electricity produced by other generating sources even if the LGS operating licenses are not renewed.

The LGS transmission system is more fully described in Section 3.1.3. Figures 3.1-5, 3.1-6, 3.1-7 and 3.1-8 are maps that show the individual transmission line ROW routes.

PECO, the energy delivery subsidiary of Exelon Corporation serving retail customers in southeastern Pennsylvania, owns in fee the offsite substations and a portion of the transmission line ROWs associated with the LGS transmission system. A significant portion of the LGS transmission system is located over or under highways, streets, other public places or property owned by others, for which PECO has permits, grants, easements, or licenses.

The two LGS substations are shown on the LGS plant site layout Figure 3.1-1. The Limerick 230-kV Substation is located about 76.2 meters (250 feet) northwest of the main Limerick Unit I structures and occupies 1.9 hectares (4.7 acres). The Limerick 500-kV Substation is located about 365.8 meters (1,200 feet) southeast of the main Limerick Unit 2 structures and occupies 6.5 hectares (16.1 acres).

A description of the routes taken by the offsite transmission line ROWs associated with the LGS transmission system follows below.

2.1.3.1 220-60 and 220-61 Lines (Figure 3.1-5)

From the Limerick 230-kV Substation, the 220-60 and 220-61 lines run for about 12.9 kilometers (8 miles) in separate ROWs located on opposite sides of, and generally following along, the Schuylkill River. The two lines were constructed along two existing Conrail ROWs. The 220-60 line, on the Montgomery County side, runs through Limerick Township, Royersford Borough, and Upper Providence Township, and then crosses over the Schuylkill River into East Pikeland Township, Chester County, terminating at the Cromby Substation. The 220-61 line, on the Chester County side, runs through East Coventry Township, East Vincent Township, Spring City Borough, and into East Pikeland Township, also terminating at the Cromby Substation. The width of the 220-60 line ROW is 18.3 meters (60 feet) for the first 10.1 kilometers (6.3 miles). The line then leaves the railroad ROW and joins an existing PECO ROW that is 76.2 meters (250 feet) in width for a distance of 1.8 kilometers (1.1 miles) until crosses the Schuylkill River (Milner, 1984a). The 220-61 ROW is 18.3 meters (60 feet) over its entire length (Milner, 1984b).

The 220-61 line generally parallels a planned portion of the Schuylkill River Trail that runs for about 24.1 kilometers (15 miles) between Cromby and Pottstown (Chester County, 2009a). The partially completed Schuylkill River Trail has a total planned 209.2-kilometer (130-mile) route running along the river from Philadelphia to the City of Pottsville, Schuylkill County (Schuylkill River Trail Association, 2009). The total route is within the Schuylkill River National and State Heritage Area (DCNR, Undated).

2.1.3.2 220-62 Line (Figure 3.1-6)

The 220-62 line was constructed on an existing PECO transmission line ROW. From the Cromby Substation, this line crosses over the Schuylkill River and runs northeasterly through Upper Providence Township, then crosses over US-422 and runs through Trappe Borough before re-entering Upper Providence Township. The line continues easterly through Perkiomen Township, crossing over PA-29 and the Perkiomen Creek into Skippack Township. The line continues through Skippack Township, crossing PA-113 and the Evansburg State Park into Worcester Township. The line traverses Worcester, crossing over PA-363 and I-476, the Northeast Extension of the Pennsylvania Turnpike, into Upper Gwynedd Township, where it terminates at the North Wales Substation. The total length of this line is about 25.7 kilometers (16 miles). The width of the ROW varies from 45.7 meters (150 feet) to 137.2 meters (450 feet) (Milner, 1984c).

2.1.3.3 220-63 and 220-64 Lines (Figure 3.1-7)

The 220-63 and 220-64 lines were constructed using a combination of existing PECO and Conrail ROWs. From the Cromby Substation, the 220-63 line runs southeasterly and crosses over the Schuylkill River at five locations where the river meanders, traversing Upper

Providence Township (in Montgomery County) and Phoenixville Borough and Schuylkill Township (in Chester County). The last of the five crossings is at the confluence of the Schuylkill River with the Perkiomen Creek at the Village of Oaks (in Upper Providence Township). The line then continues easterly through Lower Providence Township (in Montgomery County), crosses over US-422, and runs through West Norriton Township and Norristown (both in Montgomery County) where it terminates at the Barbadoes Substation, located on Barbadoes Island in the Schuylkill River channel between Norristown and West Norriton. From the Barbadoes Substation, the 220-64 line runs through Norristown, crossing over US-202 and then into Plymouth Township where it terminates at the Plymouth Meeting Substation. The length of the 220-63 and 220-64 lines are about 16.1 kilometers (10 miles) and 5.6 kilometers (3.5 miles), respectively. The width of the ROW varies from 45.7 meters (150 feet) to 137.2 meters (450 feet) (Milner, 1985).

These lines generally parallel an active portion of the Schuylkill River Trail between Phoenixville Borough and Philadelphia (Schuylkill River Trail Association, 2009).

2.1.3.4 5031 Line (Figure 3.1-8)

From the Limerick 500-kV Substation, the 5031 line was constructed in the ROW for a pre-existing 500-kV line (designated 5030) routed from Exelon Generation's Peach Bottom Atomic Power Station. The ROW generally travels easterly from LGS for a distance of about 27.4 kilometers (17 miles) through Montgomery County to the Whitpain Substation located in Whitpain Township. Approximately 4.8 kilometers (3 miles) of the 5031 line ROW also is coincident with the 220-62 line ROW. The 5031 line traverses through Limerick Township and Perkiomen Township for about eight miles until it crosses over PA-29 and the Perkiomen Creek into Skippack Township. After crossing over the Perkiomen Creek, the 5031 line continues on for about 14.5 kilometers (9 miles) through Skippack Township, Worcester Township, and Whitpain Township. Over this 14.5-kilometer segment, the line crosses over PA-113, the Evansburg State Park, and PA-363, and terminates at the Whitpain Substation just west of I-476, the Northeast Extension of the Pennsylvania Turnpike. The width of the ROW varies from 91.4 meters (300 feet) to 137.2 meters (450 feet) (Milner, 1989).

2.2 Aquatic Resources

This section describes aquatic resources that may be affected by water use and discharge during the extended operation of LGS. Section 2.1 defines the features of the LGS project, which includes the LGS plant site and the LGS makeup water supply system. As Section 3.1.2 explains, makeup water is withdrawn primarily from the Schuylkill River to satisfy both consumptive and non-consumptive water uses of the LGS cooling water system. In addition, the secondary source of water for consumptive use makeup is the Perkiomen Creek, which may be flow-augmented by water from the Delaware River via a diversion of water pumped to the Bradshaw Reservoir and then re-pumped to the East Branch Perkiomen Creek. Cooling tower blowdown is discharged to the Schuylkill River through a pipeline common to both LGS units.

2.2.1 Hydrology

The following subsections describe the hydrology for the four water bodies associated with the LGS makeup water supply system.

2.2.1.1 Schuylkill River

The Schuylkill River originates at Tuscarora Springs in Schuylkill County, PA and flows southeasterly for about 209.2 kilometers (130 miles) to its confluence with the estuarine portion of the Delaware River in Philadelphia at Delaware River Mile (DRM) 92.5. The Schuylkill River watershed encompasses an area of approximately 4,962 square kilometers (1,916 square miles). The Schuylkill River is in the Schuylkill Valley Subbasin of the Delaware River Basin (Figure 2.1-5). Near LGS, the Schuylkill River is a meandering stream with a bed slope of 0.04 to 0.05 percent (NRC, 1984). The Schuylkill Pumphouse is located just downstream of a river bend at Schuylkill River Mile (SRM) 48.0. The LGS discharge structure is located about 213.4 meters (700 feet) downstream of the Schuylkill Pumphouse.

The U.S. Geologic Survey (USGS) operates a gage station (No. 01472000) on the Schuylkill River at Pottstown, PA about 7.7 river kilometers (4.8 river miles) upstream of LGS. The average annual mean flow for 1979 through 2009 at this station is 56.51 cubic meters per second (1,996.2 cubic feet per second) or 1.78×10^{8} cubic meters per year (6.3×10^{10} cubic feet per year) (USGS, 2010a). The Schuylkill River near LGS meets the U.S. Nuclear Regulatory Commission (NRC) definition of a small river since its annual flow rate is less than 9×10^{10} cubic meters per year (3.15×10^{12} cubic feet per year).

2.2.1.2 Perkiomen Creek

The Perkiomen Creek is a major tributary to the middle reach of the Schuylkill River, entering the river at about Schuylkill River Mile (SRM) 32.3 in Montgomery County about 25.7 stream kilometers (16 stream miles) downstream from LGS. The total drainage area of Perkiomen Creek is approximately 937.2 square kilometers (362 square miles). The Perkiomen Creek is a low to moderate gradient stream with flow rates variable, generally high in spring due to snowmelt and precipitation and low in late summer and early autumn. At times, the flow rate is rapid due to local thunderstorms (RMC, 1986).

The USGS operates a gage station (No. 01473000) on the Perkiomen Creek at Graterford, PA, about 1.0 stream kilometer (0.6 stream miles) upstream from the Perkiomen Pumphouse. The average annual mean flow for 1990 through 2009 at this station is 13.75 cubic meters per second (485.7 cubic feet per second) or 4.34×10^{7} cubic meters per year (1.53×10^{10} cubic feet per year) (USGS, 2010b).

2.2.1.3 East Branch Perkiomen Creek

The East Branch Perkiomen Creek is a warm water stream flows southwest approximately 39 kilometers (24.2 miles) from its source in Bedminster Township, PA and meets the main stem of Perkiomen Creek just below Schwenksville, PA, about 18.0 stream kilometers (11.2 stream miles) upstream of the confluence of the Perkiomen Creek and the Schuylkill River. The Creek has a low gradient, about 1.9 meters/kilometer (3.9 feet/mile), and consists of riffle and run habitats with a few natural pools in about one-third of the stream length where conditions tend to be quiescent and several manmade impoundments (RMC, 1986; NRC, 1984, p. 4-38).

The USGS operates a gage station (No. 01472620) on the East Branch Perkiomen Creek near Dublin, PA. The average annual mean flow for 1990 through 2009 at this station is 1.04 cubic meters per second (36.9 cubic feet per second) or 3.29×10^{6} cubic meters per year (1.16×10^{9} cubic feet per year) (USGS, 2010c). The flow regime is extremely variable and often flashy due to low natural base flow and frequent localized storms. Spring flows tend to be higher due to snow melt and precipitation; summer flows become lower and, until a minimum flow was maintained in conjunction with the water diversion, often ceased in late summer and fall until a storm event occurred (RMC, 1986).

2.2.1.4 Delaware River

The Delaware River originates in the highlands of southern New York, on the western slopes of the Catskills Mountains, and flows for about 531 kilometers (330 miles) from the confluence of its East and West branches at Hancock, New York to the mouth of the Delaware Bay (DRBC, Undated). At Trenton (about 215.6 river kilometers or 134 river miles from its mouth), the Delaware River crosses the fall line[1] and begins to broaden into an estuary. The drainage area of the river and its tributaries encompasses more than 32,880 square kilometers (12,700 square miles) (USGS, 2010d). The salt line (an estimation of where the seven-day average sodium chloride concentration equals 250 parts per million along the tidal Delaware River) is maintained at Delaware River Mile (DRM) 98 by maintaining a minimum flow at Trenton of 84.93 cubic meters per second (3,000 cubic feet per second).

The USGS operates a gage station (No. 01463500) on the Delaware River at Trenton, NJ (DRM 134.5) about 19.3 river kilometers (12 river miles) downstream stream from the Point Pleasant Pumping Station. This is the facility through which water from the Delaware River is withdrawn and pumped to the East Branch Perkiomen Creek via the Bradshaw Reservoir. The average annual mean stream flow for 1913 through 2009 at the USGS Trenton gage station is 332.10 cubic meters per second (11,730 cubic feet per second) or 1.05×10^9 cubic meters per year (3.7×10^{11} cubic feet per year) (USGS, 2010d). Hence, the Delaware River at Trenton meets the NRC definition of a small river since its annual flow rate is less than 9×10^{10} cubic meters per year (3.15×10^{12} cubic feet per year).

2.2.2 Water Quality

The following subsections describe the water quality for the four water bodies associated with the LGS makeup water supply system, and the regulatory framework that defines water quality standards and measures to achieve or maintain those standards.

2.2.2.1 Schuylkill River

The Environmental Report Operating License Stage ("ER-OL") (PECO, 1984) provides a historical perspective of water quality degradation of the Schuylkill River starting in early 1800s. Extensive water quality degradation had occurred in the Schuylkill River in the past from coal mining activities in the upper watershed (the discharge of excess acidic mine water reducing the assimilative capacity of the river and the dumping of culm leading to channel siltation and anoxic conditions), and from increases in releases of municipal and industrial wastes due to development along the river.

Further historical background is provided in the Delaware River Basin Commission's (DRBC) 2008 State of the Basin Report (DRBC, 2008b). Surveys in 1929 and 1937 indicated that the entire Delaware River Estuary from Trenton to Wilmington was "substantially" polluted with a zone of "gross" pollution in the Philadelphia-Camden area (the area where the Schuylkill empties into the Delaware Estuary). Serious efforts to control the pollution problems at the

[1] The fall line is where the Appalachian Highlands physiographic division, made predominantly of consolidated sedimentary rock, transitions in elevation to the Atlantic Coastal Plain, a great wedge of unconsolidated sediment.

source did not occur until 1936 with the creation of the Interstate Commission on the Delaware River (INCODEL), a predecessor of DRBC. Through INCODEL, a basinwide program was implemented and the first set of interstate water quality standards was adopted in the 1939–1945 period. At the same time, industrial and port-related activity increased, which exacerbated the pollution problems in the estuary. However, as a result of the INCODEL program, new sewage treatment plants were built throughout the basin after 1945 and, by the end of the 1950s, 75 percent of the basin communities, including the major cities responsible for 60 percent of the sewage discharges, had adequate sewage treatment. During this time, problems from coal mining and processing were also tackled. Desilting basins were constructed and desilting of the Schuylkill River to as far as Norristown was started in 1945. As a result of these efforts, 30 to 40 tons of coal silt were dredged from the Schuylkill River and water quality improved even in the most grossly polluted portion of the estuary (DRBC, 2008b). Dissolved oxygen levels rose; the river was no longer anoxic, which produced dramatic water quality improvements (PECO, 1984, Section 2.2.2.1.1).

In 1972, the Federal Water Pollution Control Act amendments required discharge permits, provided construction funds, added enforcement, and other incentives to ensure implementation of water pollution control efforts. Regulation under the PA Clean Streams Law (Act of 1937, P.L.1987, No. 394) and by DRBC (established in 1961) led to improved treatment and discharge standards, resulting in gradual improvement in overall water quality since the 1960s. In 1967 DRBC adopted higher water quality standards for dissolved oxygen, and new bacteria standards for recreational use. To meet the criteria, some 90 municipal and industrial dischargers were given waste load allocations in 1968. This resulted in the construction of many municipal and wastewater treatment facilities, decreased discharges of oxygen demanding waste, and long-lasting improvements in dissolved oxygen levels that have benefited fish populations, especially the American shad (DRBC, 2008b).

The status of Schuylkill River quality was deemed in 1976 by the Pennsylvania Department of Environmental Resources (predecessor of Pennsylvania Department of Environmental Protection or PADEP) in the range of poor to good, with relatively good quality near LGS (PECO, 1984, Section 2.2.2.1.1).

Other water quality issues unrelated to LGS include nutrient loading from point and non-point sources, heavy metals from industrial activity and spills contained in sediments, and polychlorinated biphenyls (PCBs) from landfill runoff (DRBC, 2008b). In April 2007, the U.S. Environmental Protection Agency (EPA) established a Total Maximum Daily Load (TMDL) for PCBs for the Schuylkill River after elevated PCB concentrations in fish tissue prompted a fish consumption advisory (EPA, 2007).

Monthly water quality data were collected for the Schuylkill River near LGS during the period of 1975 through 1978 and tabulated in the ER-OL (PECO, 1984, Tables 2.4-12). Sampling parameters for this and the other water bodies associated with the LGS makeup water supply system were similar to those listed in Table 2.2-1 with several additions (e.g., alkalinity, temperature, dissolved oxygen, and coliform). Although the detailed data are not repeated in this report, based on the collected data, the river was characterized as a moderately hard warm water stream that receives moderate amounts of pollution (PECO, 1984, Section 2.4.7.1.2). The anionic base is sulfate and the water contains relatively high concentrations of major cations. The concentrations of anions and cations tend to be higher during low flow periods (typically July through November). Concentrations of nutrients, while generally also higher at lower flows, are subject to increases during periods of high flow, due to increased runoff and waste discharges that occur during the increased flow periods.

Quality of the Schuylkill River water near LGS also was assessed from 1979-1988 and reported in the annual non-radiological monitoring reports for LGS (RMC Environmental Services [RMC], 1984, 1985, 1986, 1987, 1988, and 1989). Water quality data were collected at two sampling stations near LGS, one downstream influenced by the LGS discharge and the other upstream uninfluenced by the discharge. Although detailed results are not presented in this report, in general, except for new extremes associated with new minimum recorded flows, the water quality of the Schuylkill River in this area remained similar to that described in the ER-OL. Water quality values at both sampling stations tend to respond to the same rainfall, flow, and plant photosynthetic activity conditions.

Table 2.2-1 shows analytical results for the Schuylkill River samples taken at the Schuylkill Pumphouse intake for the 2005 and 2010 LGS NPDES permit renewal applications, and how the results compare to the parameters measured from 1975 to 1978. The recent results are generally within the historical ranges, except that sulfates were below the range, which indicates a positive trend.

The DRBC, in 2008, issued its first State of the Basin Report (DRBC, 2008b), which was intended to serve as a benchmark of current conditions and a point of reference for gauging progress toward water quality-related management goals. The overall assessment for the Delaware River Basin's water-related resources (using the categories of "Good", "Fair", and "Poor") was "Fair." Water quality indicators with a status of "Good" include dissolved oxygen, water clarity, drinking water use, and recreational use. DRBC-identified water quality challenges (with a less than "Good" status) that may apply to the Schuylkill River above the tidal zone include:

- Consumptive use ("Fair" status);
- Increases in ambient water temperatures and its impact on dissolved oxygen levels (no status given);
- High nutrient levels ("Fair" status);
- Pesticide (Atrazine and Metolachlor) concentrations levels ("Fair" status);
- PCB levels ("Poor" status); and
- Attainment of designated uses (ranges from "Poor" status for fish consumption and aquatic life [specifically, Zone 4 does not meet temperature criteria] to "Good" status for drinking water and recreational use).

2.2.2.2 Perkiomen Creek

Monthly water quality data were collected for Perkiomen Creek during the period of 1975 through 1978 and tabulated in the ER-OL (PECO, 1984, Tables 2.4-13). Although the detailed data are not repeated in this report, based on the collected data, the Perkiomen Creek was characterized in the ER-OL as a moderately hard warm water stream that receives moderate amounts of pollution (PECO, 1984, Section 2.4.7.1.2). The anionic base fluctuates between sulfate and carbonate, and the water contains relatively high concentrations of anions and cations, which are more pronounced during the July through November lower flow periods. Essential plant nutrients are present in relatively high concentrations as well. Water quality near Graterford is relatively good; nutrients from both point and non-point sources (sewage treatment and agricultural runoff) and from Green Lane Reservoir are the most serious stressors (PECO, 1984, Section 2.2.2.2.1).

Bi-weekly water quality sampling of the Perkiomen Creek also was assessed from 1979-1987 and reported in the annual non-radiological monitoring reports for LGS (RMC, 1984, 1985, 1986, 1987, and 1988). The purpose of the sampling program was to assess the impacts of operation of the LGS makeup water supply system on water quality of the creek. Two sampling stations were used on the creek, one upstream of where the East Branch Perkiomen Creek joins the main stem, and the other in the vicinity of the Perkiomen Pumphouse intake. The reports indicated that, although new maximum and minimum values have occurred during this time period, Perkiomen Creek water quality is generally similar to that described in the ER-OL. Differences are attributable to flow events that occurred during the monitoring period.

Table 2.2-2 shows analytical results for Perkiomen Creek samples taken at the Perkiomen Pumphouse intake for the 2005 and 2010 LGS NPDES permit renewal applications, and how the results compare to the parameters measured from 1975 to 1978. The recent results are generally within the historical ranges.

2.2.2.3 <u>East Branch Perkiomen Creek</u>

Monthly water quality data were collected at four stations along the East Branch Perkiomen Creek during the period of 1975 through 1978 and tabulated in the ER-OL (PECO, 1984, Tables 2.4-14 and 2.4-15). The first sample station was located approximately 4.7 kilometers downstream from the water diversion outfall, the fourth station was located approximately 2.5 kilometers upstream of the confluence with Perkiomen Creek, and the other two stations located at intermediate points. Although these data are not repeated in this report, based on the collected data, the water quality at the uppermost monitoring station was termed good, not unlike that of the Delaware River at Point Pleasant, while the water quality at the lowermost station was termed degraded and resembling more the Schuylkill River near LGS. This change in water quality was attributed to point and non-point source pollutants from a variety of industrial and municipal point sources and non-point sources that shift the ionic base from carbonate to sulfate, add to cationic and anionic loading, and add nutrients. The effects of these discharges become more pronounced in July through November when flows become intermittent (PECO, 1984, Section 2.4.7.1.3).

Water quality sampling was resumed at the four water quality stations in 1983 and performed through 1987 to:

- Assess any changes that may have occurred since 1978;
- Provide a more extensive database with which to predict and assess diversion-induced water quality changes on the stream; and
- Provide water quality information for concurrent aquatic ecological programs on the stream.

Results are reported in the LGS annual non-radiological environmental operating reports (RMC, 1984, 1985, 1986, 1987, and 1988). Although detailed results are not repeated in this report, in general, the water quality of the East Branch Perkiomen Creek during that time period was reported to be similar to that described in the ER-OL, allowing for some new values outside previous ranges due to flow events occurring during the monitoring period. This typically occurred shortly after a heavy rainfall following a long period of dry weather when the stream is flushed, resulting in new minimum values for some parameters (e.g., pH, alkalinity, hardness, and conductivity) and new maximum values for other parameters (e.g., metallic cations and total suspended solids).

Generally, water quality monitoring for the parameters included in the previous sampling programs was discontinued after 1987, and the focus of investigation was shifted to the biological effect of discharging water into the East Branch Perkiomen Creek via the Delaware River water diversion system. Exelon Generation has performed aquatic biology assessments of the East Branch Perkiomen Creek yearly since 1988 in accordance with PADEP Permit No. E 09-077A to operate an encroachment (Refer to Table 9.1-1). Water quality observations were reported in these assessments (NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, and 2010b). In general, it was reported that the discharges tend to have a beneficial effect on the water quality of East Branch Perkiomen Creek due to maintenance of a minimum base flow and dilution during the operation of the diversion system, which have persisted during the sampling years. Ambient bacterial concentrations are generally reduced when commingled with the diversion discharge, which is treated via ozonation to meet NPDES permit limits. Water quality was likely more protective of designated instream uses; particularly the use as a seasonal fishery for stocked trout (NAI, 2005).

Since 2003, Exelon Generation has been conducting a demonstration project (refer to Section 3.1.2) under DRBC oversight for requested modifications to the LGS makeup water supply system As part of the demonstration, selected water quality parameters (temperature, dissolved oxygen, *E. coli*, and fecal coliform) were measured three to five times per month from April through October at the discharge outfall and at three locations in the East Branch Perkiomen Creek (NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, and 2010b). The data indicated that dissolved oxygen levels were similar upstream and downstream of the discharge, except for 2007-2008 when levels were higher downstream from the outfall. *E. coli* and fecal coliform numbers were much higher upstream of the discharge outfall and the results suggest that the densities of bacteria within the stream are reduced even at the minimum-required discharge flows (NAI, 2010a).

2.2.2.4 Delaware River

Monthly water quality data were collected for the Delaware River near Point Pleasant during the period of 1975 through 1978 and tabulated in the ER-OL (PECO, 1984, Tables 2.4-16). Although these data are not repeated in this report, based on the collected data, the river was characterized as a moderately hard warm water stream with a carbonate ionic base (PECO, 1984, Section 2.4.7.1.4). The quality of the Delaware River is relatively good in this area in that it is well buffered and does not contain excessively high concentrations of major cations, anions, and nutrients. Temporal changes do occur in the river, but are not as pronounced due to the greater flow. Lead and zinc were the only two metals present in significant quantities.

Water quality monitoring of the Delaware River near the Point Pleasant Pumping Station intake continued from 1979 through 1987 and was reported in the annual LGS non-radiological environmental monitoring reports (RMC, 1984, 1985, 1986, 1987, and 1988). Although detailed results are not repeated in this report, in general, the data show that, except for several new flow-related extremes, the water quality of the Delaware River at this location has remained similar to that reported in the ER-OL.

2.2.2.5 Regulatory Framework

The Federal Clean Water Act (CWA) Section 401 requires an applicant seeking a federal license for an activity that may result in a discharge to navigable waters to provide the licensing agency with a certification by the state where the discharge would originate indicating that applicable state water quality standards will not be violated as a result of the discharge (33 USC 1341). The Pennsylvania Department of Environmental Resources (now the Pennsylvania Department of Environmental Protection [PADEP]) issued a Section 401 State Water Quality Management Permit on July 16, 1976 for LGS prior to its initial operation. The permit transmittal letter states that the facilities, if operated properly, will meet the water quality standards for the Schuylkill River. Subsequent guidance published by PADEP states that water quality certifications have been integrated with other required permits, such as NPDES permits, and that individual water quality certifications are issued only for activities that are not regulated by other water quality approvals or permits. Hence, the current LGS and Bradshaw Reservoir NPDES permits (PA0051926 and PA0052221, respectively) are evidence of continued CWA Section 401 certification by Pennsylvania.

PADEP has the authority to promulgate and enforce regulations implementing the water quality standards of the federal CWA in PA; the PA Clean Streams Law provides the statutory authority under Pennsylvania law. As an EPA-delegated authority, PADEP also regulates (1) thermal discharges in order to control adverse ecological effects, as required by CWA Section 316(a), and (2) the design and operation of cooling water intake structures to limit fish and shellfish mortality associated with entrainment and impingement, as required by CWA Section 316(b).

In addition, PADEP requires that water users submit water use information annually, in support of its State Water Plan. Accordingly, Exelon Generation reports LGS water usage to PADEP. The State Water Plan serves as a functional planning tool to establish vision, goals and recommendations for meeting the challenges of sustainable water use over a fifteen year planning horizon. The fundamental intent of this plan is to identify and recommend strategies to avoid and resolve water use conflicts, and to ensure that water demands are met in a sustainable manner while providing natural resource protection. The State Water Plan consists of inventories of water availability, an assessment of current and future water use demands and trends, assessments of resource management alternatives, and proposed methods of implementing recommended actions. The State Water Plan is intended to provide a systematic, proactive approach to water use, which could result in legislative initiatives to implement the recommendations on a statewide or regional basis.

The Water Resources Planning Act (Act 220), signed into law in Pennsylvania on December 16, 2002, established Statewide and Regional Water Resources Committees charged with guiding PADEP through the development of the State Water Plan. In December 2008, the Statewide Committee developed recommended legislative priorities to implement the State Water Plan. Subcommittees have been established under the Statewide Committee, including one that is focused on concerns around the Delaware River Basin. At this time, no legislation stemming from the State Water Plan has been promulgated other than water use reporting.

The Delaware River Basin Commission (DRBC) also has authority to promulgate and enforce regulations related to water use, as provided by the Delaware River Basin Compact (U.S. Public Law 87-328, approved September 27, 1961; PA Act No. 268, approved July 7, 1961; and comparable approved laws in Delaware, New Jersey, and New York).

PADEP and DRBC each have water quality standards that support use designations for the water bodies of interest. The following discussion is limited to the Schuylkill River, since:

- Only its water quality is influenced by the discharges from LGS; and
- As described previously, the water quality of the Delaware River near Point Pleasant, East Branch Perkiomen Creek, and Perkiomen Creek are generally equivalent to or better than that of the Schuylkill River.

In general, PADEP requires that sources of pollutants in a basin, watershed, or surface waters that are defined in Pennsylvania (PA) Code Chapter 93 comply with the water quality standards and protection levels in PA Code Chapters 16 (relating to toxics management), 93 (relating to water quality standards), and 95 (relating to wastewater treatment requirements). In addition, PA Code Chapter 96 establishes the process for achieving and maintaining water quality standards, prescribing protection requirements (e.g., antidegradation), and use of TMDLs and Water Quality Based Effluent Limitations (WQBELs), and requiring monitoring by dischargers to develop limitations and determine their effectiveness.

Unless conditions exist that warrant a less restrictive use (e.g., naturally occurring pollutant concentrations are present that prevent the attainment of use), all surface waters in Pennsylvania at a minimum are to be protected for maintaining aquatic life (warm water fishes), water supply (potable, industrial, livestock, wildlife, and irrigation), and recreation (boating, fishing, water contact sports, and esthetics) (PA Code § 93.4). These statewide standards generally apply to the Schuylkill River with the additional designated use of protecting the passage, maintenance, and propagation of migratory fishes, which move to or from flowing waters to complete their life cycle in other waters (PA Code § 93.9f).

The DRBC also prescribes water and effluent quality standards (or stream quality objectives). Minimum standards and objectives apply basin-wide and additional standards and objectives apply to specific streams, which are intended to protect designated uses for various parts ("zones") of the Delaware River Basin (DRBC, 2008a). In general, uses for Basin waters to be protected include agricultural, industrial, and public water supplies after reasonable treatment except where natural salinity precludes such use; maintenance of wildlife, fish and other aquatic life; recreation; navigation; controlled and regulated waste assimilation to the extent that such use is compatible with other uses, and such other uses as may be provided by DRBC's Comprehensive Plan (DRBC, 2008a, Section 3.10.2). Additional standards for Zone 4 of the Delaware River, into which the Schuylkill River empties, extend only to the tidal zone of tributaries, which is well downstream of LGS.

DRBC is charged with allocating water use and protecting designated uses within the basin in a balanced manner that limits water use conflicts and impacts to instream and riparian ecological communities. The DRBC accomplishes this through a comprehensive planning process, regulating water usage and wastewater discharge via project review, and requiring appropriate impact mitigation. The planning process is codified in the Comprehensive Plan (DRBC, 2001) and Water Resource Plan for the Delaware River Basin (DRBC, 2004). The plans, designed to be continuously updated, include all significant public and private projects, including LGS, which are required for the optimum planning, development, conservation, utilization, management, and control of the water resources of the Basin to meet present and future needs. The plans provide a unified framework for the orderly development of the water and related resources, and addressing and redressing new and historic water resource issues and problems in the Delaware River Basin.

PADEP and DRBC regulations will continue to govern the operation of LGS during the period of extended operation. These regulations are intended to limit impacts of the LGS discharge in order to maintain the water quality and availability necessary to sustain the designated uses of the Schuylkill River, as described previously.

2.2.3 Aquatic Communities

The following subsections describe the historical and recent aquatic ecology for the four water bodies associated with the LGS makeup water supply system, including invasive species.

2.2.3.1 Historical Background

Pre-Operational

The bases for the pre-operational (pre-1985) information provided in this section include:

- *Final Environmental Statement Related to the Proposed Limerick Generating Station Units 1 and 2* ("LGS Construction Phase FES") (AEC, 1973);
- *Environmental Report Operating License Stage* ("ER-OL") (PECO, 1984);
- *Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2.* NUREG-0974 ("LGS Operating Phase FES") (NRC, 1984); and
- Monitoring data collected from 1979 through 1984 (RMC, 1984 and 1985).

Exelon Generation[2] initiated ecological monitoring in the Schuylkill River, Perkiomen Creek, and several small tributaries to the Schuylkill River in 1970. Such monitoring was intended to acquire baseline information from which ecological changes attributable to LGS operation could be identified. Pre-operational aquatic monitoring data for benthic invertebrates and fishes collected from the Schuylkill River and Perkiomen Creek during studies through 1971 were summarized in the LGS Construction Phase FES (AEC, 1973, Appendix B, Tables B.1, B.2, and B.3).

After the Construction Phase FES was published, data collection continued in the Schuylkill River and Perkiomen Creek, and was initiated in the East Branch Perkiomen Creek. Summaries of sampling history by river system and biotic component and for each program are given in the ER-OL (PECO, 1984, Tables 2.2-7, 2.2-8, and 2.2-9). Aquatic biota of the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek was studied from 1970-1978, including phytoplankton, periphyton, macrophytes, macroinvertebrates, and fish at various times, using multiple methods and equipment (PECO, 1984; p. 6.1-2).

Study data for the Schuylkill River near LGS are summarized in the ER-OL (PECO, 1984), as follows:

- Table 2.2-10 – Phytoplankton (1973 and 1974);
- Table 2.2-11 – Periphyton (1973 and 1974);
- Tables 2.2-12 – Macrophytes (1974 and 1977);
- Tables 2.2-13 through 2.2-21 – Macroinvertebrates (1970 through 1976); and
- Tables 2.2-22 through 2.2-39 – Fishes in the Schuylkill River and its tributaries near LGS (1970 through 1978).

[2] Before being renamed in 2001, Exelon Generation was known as Philadelphia Electric Company (PECo) and then PECO Energy Company (PECO). For simplification, references provided herein for PECo and PECO will use PECO.

A summary of sampling history by program for Perkiomen Creek below its confluence with the East Branch Perkiomen Creek is given in the ER-OL (PECO, 1984, Tables 2.2-40 and 2.2-41). Macrophytes were not studied. Study data for Perkiomen Creek are summarized in the ER-OL (PECO, 1984), as follows:

- Tables 2.2-42 – Phytoplankton (1974);
- Tables 2.2-43 – Periphyton (1973);
- Tables 2.2-44 through 2.2-52 – Macroinvertebrates (1970 through 1976); and
- Tables 2.2-53 through 2.2-69 – Fishes (1970 through 1977).

A summary of sampling history by program for East Branch Perkiomen Creek is given in the ER-OL (PECO, 1984, Tables 2.2-70 and 2.2-71). Phytoplankton and Macrophytes were not studied. Study data for East Branch Perkiomen Creek are summarized in the ER-OL (PECO, 1984), as follows:

- Table 2.2-72; Section 2.2.2.3.3 – Periphyton (1973 and 1974);
- Tables 2.2-44 through 2.2-52 – Macroinvertebrates (1970 through 1976); and
- Tables 2.2-73 through 2.2-86 – Fishes (1970 through 1976).

The LGS Operating Phase FES (NRC, 1984) captures historical information provided in the LGS Construction Phase FES and the ER-OL and, additionally, summarizes 1972-1973 fish and benthic invertebrate data for the Delaware River in the vicinity of Point Pleasant, PA.

RMC-Environmental Services (RMC) summarized pre-operational sampling data for the four waterbodies of interest from 1979 through 1984 (RMC, 1984 and 1985). The sampling encompassed benthic invertebrates and fishes for the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek, and ichthyoplankton for the Delaware River.

<u>Post-Operational</u>

The bases for the post-operational (1985 and later) information provided in this section include:

- Monitoring data collected for the annual non-radiological environmental monitoring reports from 1985 through 2004, as follows:
    - o Schuylkill River and East Branch Perkiomen Creek benthic invertebrates and fishes, Perkiomen Creek fishes, and Delaware River ichthyoplankton (1985 and 1986, except Delaware River ichthyoplankton sampling discontinued after 1985) (RMC, 1986, 1987, and 1988);
    - o Schuylkill River benthic invertebrates and fishes, and Asiatic clam studies of the Schuylkill River, Perkiomen Creek, and the Delaware River (1988) (RMC, 1989);
    - o Schuylkill River fish species and zebra mussel surveys for the Schuylkill River and Perkiomen creek intakes and points along the Delaware River water diversion system (1989-2004) (PECO, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000; Exelon Generation, 2001, 2002, 2003, 2004, and 2005)
- East Branch Perkiomen Creek aquatic biology assessments performed yearly since 1988 in accordance with PADEP Permit No. E 09-77A to operate an encroachment (Refer to Table 9.1-1); only recent fish data (since 2004) are tabulated in this section (NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, and 2010b)
- Schuylkill River aquatic community study performed in 2009 [NAI, 2010c]

In regard to requirements for post-operational aquatic monitoring, the NRC stated in the Final Environmental Statement for LGS Units 1 and 2 (NRC, 1984):

> The certifications and permits required under the Clean Water Act provide mechanisms for protecting water quality and, indirectly, aquatic biota. The NRC will rely on the decisions made by the Commonwealth of Pennsylvania, under the authority of the Clean Water Act, for any requirements for aquatic monitoring.

Accordingly, Exelon Generation reported monitoring results, as required by the National Pollutant Discharge Elimination System (NPDES) permits applicable to the discharges to the Schuylkill River from LGS and to the East Branch Perkiomen Creek from the Bradshaw Reservoir, to the Pennsylvania Department of Environmental Protection (PADEP) and the U.S. Environmental Protection Agency (EPA) on Discharge Monitoring Reports. The permits did not require monitoring of aquatic biota, although fish tissues were collected bi-annually as part of the Radiological Environmental Monitoring Program in the Schuylkill River in the vicinity of LGS. Fish species found during these collections were noted in the annual non-radiological reports. Other discretionary observations were made, including the presence of the exotic zebra mussel at the LGS water intakes on the Schuylkill River and Perkiomen Creek and at several points along the Point Pleasant water diversion route.

In 2006, the NRC amended the operating licenses for Limerick Units 1 and 2 to incorporate their respective Environmental Protection Plans into their operating licenses (NRC, 2006). Among the changes associated with this action, Exelon Generation was no longer required to submit an annual non-radiological monitoring report; thus, no annual non-radiological aquatic monitoring data were reported to the NRC for the years 2005 and later. Exelon Generation was, however, required to continue to review potentially unreviewed environmental questions and obtain prior NRC approval of plant changes that constitute an unreviewed environmental question; and also required to provide changes to the NPDES permit or State certification to the NRC within 30 days of approval. LGS instituted an onsite process to ensure that all environmental activities were screened prior to implementation.

The focus of the following subsections is to describe the aquatic ecology of the Schuylkill River, Perkiomen Creek, East Branch Perkiomen Creek, and Delaware River for the post-operational period. Therefore, the more recent studies performed in relation to LGS (i.e., after 1984) are summarized here. However, pre-operational data are included when more recent studies are not available (e.g., for phytoplankton). The most recent aquatic studies report for the Schuylkill River currently available covers calendar year 2009 and evaluates water quality, fish, and macroinvertebrates in the vicinity of LGS (NAI, 2010c). The most recent available report specific to the East Branch Perkiomen Creek is for the 2009 study period (NAI, 2010b). The most recent studies performed in Perkiomen Creek specifically related to LGS operations were made in the 1980s. Results of evaluations through 1987 are reported here (RMC, 1984, 1985, 1986, 1987, and 1988). Only limited aquatic studies were performed in the Delaware River for LGS since the 1970s (i.e., for ichthyoplankton near Point Pleasant). The most recent data available are summarized in this report (RMC 1984, 1985, and 1986).

2.2.3.2 Schuylkill River

Plankton and Macrophytes

Phytoplankton and periphyton communities in the Schuylkill River near LGS were last investigated in 1973-74 (PECO, 1984, pp. 2.2-19 and 2.2-20). Results of these studies determined that the major groups of phytoplankton were typical of a temperate river and seasonal succession of the phytoplankton and periphyton communities followed the changes in water temperature throughout the year (PECO, 1984).

Aquatic macrophytes, including aquatic angiosperms, filamentous green algae, and a bryophyte (moss), were observed during the 1974 study and in 1977 (PECO, 1984, Table 2.2-8). The mostly submerged vegetation was characterized as seasonally abundant primary producers that provided habitat for numerous macroinvertebrates, epiphytic algae, and fish (PECO, 1984, pp. 2.2-21 and 2.2-22).

The zooplankton community in the vicinity of the LGS has not been investigated. However, results from plankton samples collected 13 km (8.1 mi) downriver in 1975 and 1976 are likely representative of conditions near the station. During that time, the mainstream zooplankton community was dominated by rotifers (Rotifera), copepods (Copepoda), and water fleas (Cladocera) and was not considered to have a dominant role in the trophic structure (PECO, 1984, p. 2.2-23).

Benthic Macroinvertebrates

Benthic macroinvertebrates collected from the Schuylkill River from 1970 through 1976 were represented by a wide variety of taxa, with at least 297 species (PECO, 1984, p. 2.2-24). True flies (Diptera) and mayflies (Ephemeroptera) were the most diverse orders found in these collections (PECO, 1984, p. 2.2-24). General results of the various collections made in the vicinity of LGS indicated that the kinds and numbers of macroinvertebrate species were similar to those in previous studies and in other eastern U.S. temperate rivers (PECO, 1984, p. 2.2-24). Studies of the macrobenthic invertebrate community in the Schuylkill River near LGS ceased after 1976, and were not resumed until October 1983 (RMC, 1988, p. 3.2-1).

Macroinvertebrate sampling conducted from 1984 through 1987 was compared to results of sampling performed in 1988. The comparison showed that the total number of taxa collected at each station decreased in 1988; however, the community composition remained similar (RMC, 1989; p. 3.2-6). The results suggest that differences between the five years of sampling were natural seasonal and annual variability and support the previous conclusion that operation of LGS does not negatively impact benthic macroinvertebrates in the Schuylkill River (RMC, 1989; pp. 3.2-7and 3.2-8).

The most recent study of the macrobenthic invertebrate communities in the Schuylkill River in the vicinity of LGS was performed in 2009 to update the historic data (NAI, 2010c). During this study, the benthic macroinvertebrate community was sampled with a D-frame dipnet (NAI, 2010c, p. 3); historic samples were collected using cylinder samplers (NRC, 1984, p. 4-45; RMC, 1989; p. 3.2-2). The 2009 macroinvertebrate sampling was performed at six upstream and six downstream locations in March and October 2009 (NAI, 2010c, p.3). Fifty-eight taxa of invertebrates were collected, dominated by true flies, beetles (Coleoptera), mayflies, caddisflies (Trichoptera), and snails (Gastropoda) (NAI, 2010c, p. 6). Descriptive metrics used to evaluate the samples at the upstream and downstream stations generally indicated a similarity in the community composition among sampling locations (NAI, 2010c, p. 7). Measures of total richness and EPT richness (total number of 'Ephemeroptera, Plecoptera, and Trichoptera' taxa) were slightly greater in upstream samples than in downstream locations (NAI 2010c, Table 18). No seasonal differences were apparent in the number of organisms collected. However, total richness, EPT richness, and Shannon Diversity metrics were greater in October collections (NAI, 2010c, Tables 17 and 18). Although differences in collection time and methodology precluded detailed comparisons with historic data, NAI (2010c, p. 9) concluded that, in general, the overall community composition and relative abundance of macroinvertebrates was similar to historic collections. Almost all of the taxa collected in 2009 (95 percent) were also present during 1987 sampling events and many of the taxa that were abundant historically were again abundant in 2009, such as Chironomidae, *Stenelmis*, and *Cheumatopsyche*. Taxa that differed between the historic and recent sampling events were typically uncommon and represented by only a few individuals (NAI, 2010c, p. 9).

Ichthyoplankton

Fish eggs and larvae, collectively called ichthyoplankton, have historically been sampled in the Schuylkill River near LGS from 1974-1976, when unidentified minnows (Cyprinidae), goldfish (*Carassius auratus*), carp (Cyprinidae spp.), white sucker (*Catostomus commersoni*), and tessellated darter (*Etheostoma olmstedi*) were the most abundant taxa in the drift collections (PECO, 1984, p. 2.2-33). Shoreline larvae, collected by trap in 1975, were also dominated by minnows, goldfish, and carp (PECO, 1984, p. 2.2-34). Ichthyoplankton drift density was found to be greater near the bottom during the day and higher near the surface during nighttime collections (PECO, 1984, p. 2.2-34).

The most recent ichthyoplankton collections made in the Schuylkill River near LGS was in 1986 to evaluate potential entrainment losses (RMC, 1987, p. 6.4-1). The 1986 survey collected seven fish eggs (not identified to species) and 19 taxa of larvae, which were dominated by minnows and sunfishes (*Lepomis* sp.) (RMC, 1987, p. 6.4-1). The species composition and relative abundance found in this sampling program was similar to historic results (RMC, 1987, p. 6.4-1).

Adult Fish

Table 2.2-3 of this report provides a list of fish species collected from the Schuylkill River as reported in 2009 and in previous study years. Data for other aquatic species are not repeated in this report. It is important to note that field surveys varied over the study period (i.e., 1971 through 2009). Specifically, the timing and effort of the surveys were decreased in 2009. The 2009 survey included only two field events, one in September and one in October. Most of the previous field work was performed monthly during Spring, Summer, and Fall. The increased level of effort in previous surveys likely accounts for many of the species previously collected, but not captured in 2009.

Fish were collected during the 1971 ecological studies of the Schuylkill River. Although the field sampling methods did not allow for quantitative analysis of abundance or distribution, it was reported that the most abundant fish collected were swallowtail shiner (*Notropis procne*), spotfin shiner (*Cyprinella spiloptera*), brown bullhead (*Ameiurus nebulosus*), pumpkinseed (*Lepomis gibbosus*) and redbreast sunfish (*L. auritus*) (AEC, 1973, Table 2.10). Adult fish population estimates and catch-per-unit effort programs were also conducted in Schuylkill River near LGS from 1973 to 1975. The catches were dominated by brown bullhead, redbreast sunfish, pumpkinseed, white sucker, and goldfish (PECO, 1984, p. 2.2-36).

In 1984, the fish community in the Schuylkill River was described as typical of large warmwater rivers in the mid-Atlantic and was dominated by minnows, sunfish (Centrarchidae), and catfish (Ictaluridae) (PECO, 1984, p. 2.2-32). Pre-operational studies between 1970 and 1983 reported 48 taxa of fish; post-operational monitoring collected a similar diversity in taxa (49 taxa). None of these were considered state or federally threatened or endangered species.

Adult fish population estimates and catch-per-unit effort programs were also conducted in Schuylkill River near LGS from 1984 through 1988 using electroshocking and seining field methods. Approximately 25 to 30 species of fish were collected in seining samples (summarized from Tables 6.3-1 in RMC, 1984; RMC, 1985; RMC, 1986; Table 6.3-5 in RMC, 1987; Table 6.3-4 in RMC, 1988; Table 3.3-4 in RMC, 1989). Between 1984 and 1988, shiner species (especially spottail [*Notropis hudsonius*], swallowtail, and spotfin), redbreast sunfish, and banded killifish (*Fundulus diaphanus*) were most abundant in seine collections (RMC, 1989, Table 3.3-6). Approximately 20 to 30 species of fish were collected in electrofishing samples (summarized from RMC, 1984, Table 6.4-2; RMC, 1985, Tables 6.4-1 through 6.4-5; RMC, 1986, Table 6.4-2; RMC, 1987, Table 6.3-6; RMC, 1988, Table 6.3-4; RMC, 1989; Table 3.3-3). The catch-per-unit-effort for the more abundant fishes was similar in pre- and post-operational years, with goldfish as the most readily electrofished species (RMC, 1989, Table 3.3-12).

Fish are collected from the Schuylkill River for tissue analysis as part of the REMP. Collections made using a boat electrofisher allow for a qualitative assessment of the fish community near LGS. Recent samplings have found that the fish communities upstream and downstream of the station are similar and the most common species were shiners, carp, goldfish, white sucker, redbreast sunfish, pumpkinseed, rock bass (*Ambloplites rupestris*), smallmouth (*Micropterus dolomieu*) and largemouth basses (*M. salmoides*), brown and yellow bullheads (*Ameiurus natalis*), and channel (*Ictalurus punctatus*) and white catfishes (*Ameiurus catus*) (PECO, 1992, p. 2; PECO, 1993, p. 2; PECO, 1994, p. 2; PECO, 1995, p. 2; PECO, 1996, p. 2; PECO, 1997, p. 2; PECO, 1998, p. 2; PECO, 1999, p. 2; PECO, 2000, p. 2; Exelon Generation, 2001, p. 2; Exelon Generation, 2002, Section 2.1; Exelon Generation, 2003, p. 3; Exelon Generation, 2004, p. 3; Exelon Generation, 2005, p. 3).

The most recent fish surveys were conducted in September and October 2009 using electroshocking and seining field methods (NAI, 2010c). Electrofishing was performed at two locations upstream and two locations downstream of LGS; seining was conducted at four upstream and four downstream locations (NAI, 2010c, p. 2). These surveys yielded a combined total of 3,138 fish from 27 species (NAI, 2010c, p. 4). Minnows and sunfishes were the dominant families collected (NAI, 2010c, p. 4). Spotfin shiner numerically comprised more than half the total catch (NAI, 2010c; p.4).

Spotfin shiner was the most abundant species collected in seine samples in both September and October (NAI, 2010c, p. 5). Differences in the number of individuals collected between sample locations were due mostly to the variability of spotfin shiner collection, which can be explained by their schooling behavior (NAI, 2010c, p. 5). Assessment of length-frequency histograms indicates that young-of-year (YOY), juveniles, and adults were collected for most families, except sunfishes, which was comprised mostly of YOY and juveniles (NAI, 2010c, p. 6).

Electrofishing collected approximately one-third of the total fish caught (1,001), with nearly identical number collected in September and October (NAI, 2010c, pp. 4 and 5). Redbreast sunfish was the most abundant species collected by this gear (NAI, 2010c, p. 4). Evaluations of length-frequency data indicated that juveniles and adults of most species were collected by this method (NAI, 2010c, p. 5).

General conclusions from the 2009 study of the fish community in the Schuylkill River near LGS (NAI, 2010c) are as follows:

- The community is represented by both sport and forage fishes, including recreationally-important species such as smallmouth bass and channel catfish;
- Most forage fishes are native to the watershed except for common carp (*Cyprinus carpio*)
- Eight of the 27 collected species are non-native, including the common carp;
- Overall composition of the fish community is generally similar to historic surveys. Nearly 80 percent of taxa collected in 1987 were also collected in 2009. The majority of the taxa that were not collected in 2009 were represented by 10 or fewer individuals. Some notable changes in the fish community include:
    - In electrofishing catches, common carp replaced goldfish among the top five most abundant species. Goldfish were once abundant near LGS, and although they are known to occur near LGS, none were collected during the 2009 survey;
    - Flathead catfish (*Pylodictis olivaris*), a recently-introduced species, is a new addition which can impact the fish community through predatory interactions;
    - Only one brown bullhead was collected in 2009 compared to the 1985-1987 period when this species comprised over seven percent of the electrofishing catch;
    - Three northern hog suckers (*Hypentelium nigricans*) were collected. This is a native species that was not reported during surveys from 1970 through 1987;
- No American shad (*Alosa sapidissima*) were collected despite on-going restoration efforts, including the removal of downstream dams, construction of fishways around remaining dams, and an intermittent stocking program;
- Three American eels (*Anguilla rostrata*) were collected via electroshocking in 2009, which is similar in catch-per-unit effort to collections in 1985-1987, but lower than historic surveys (1976-1984); and
- “No federal or state listed endangered, threatened, or candidate fish or invertebrate species were collected or observed during field surveys nor are any known to occur in the Schuylkill River in the vicinity of LGS” (NAI, 2010c).

Many years of electrofishing, seining, and other fish collections in the Schuylkill River in the vicinity of LGS has provided a robust species list of over 50 species. More than half of these species were collected in most, if not all, years of sampling. It is important to note, however, that sampling methods, equipment, and locations vary between studies and over time.

Recreational fishing is important on the Schuylkill River. However, little public access to the river is available near LGS (NRC, 1984, p. 4-48). Although 25 species were recreationally caught, as determined by a creel survey in 1976, sunfishes dominated (57 to 72 percent of the total catch) (NRC, 1984, p. 4-48). An additional survey performed in 1980 and 1981 covering an 8.6 km (5.3 mi) area bracketing LGS found virtually no fishing near LGS (NRC, 1984, p. 4-50). Most anglers were found upstream near Sanatoga and downstream near the Linfield Bridge and Vincent Dam tailrace (NRC, 1984, p. 4-50). Creel surveys performed from 1980 – 1985 were made for a portion of the Schuylkill River bracketing LGS (Sections 6.6 of RMC, 1984; RMC, 1985; RMC, 1986). Fifteen or more taxa were caught each year and were dominated by *Lepomis* sunfish (RMC, 1984, p. 6.6-6; RMC, 1985, p. 6.6-2; RMC, 1986, p. 6.6-5). The results of the more recent studies were generally consistent with historic creel surveys, with the exception of increased catch-per-hour and the development of a smallmouth bass fishery (RMC, 1984, p. 6.6-12). Additionally, anglers access the river by boat more frequently as shoreline access became more restricted over the years (1980 – 1985) (RMC, 1986, p. 6.6-7).

An on-going effort to restore anadromous fish populations to the Schuylkill River includes stocking American shad by the Pennsylvania Fish and Boat Commission (PFBC) and installation of fish passageways around dams on the river (NRC, 1984, p. 4-50; NAI, 2010c, p. 8). Of the 10 dams that historically blocked shad migrations, four have fishways (Fairmount, Flat Rock, Norristown, and Black Rock Dams) and three are breached and/or in the process of being removed (Plymouth, Vincent, and Felix Dams) (PFBC, 2010a). The three remaining dams are upstream of LGS. Based on analysis of American shad collected at Fairmount Dam from 2003 to 2007, yearly stocking near Reading has been successful and a fishery has developed on an annual basis in the tailrace of that dam (PFBC, 2010a). Ninety-one individuals passed through the Fairmount fishway in 2004 and 41 were counted in 2005 (PFBC, 2010b). PFBC believes the numbers of fish passing the fishway in 2005 are higher, though, because power and software failures with the video monitoring equipment occurred during peak times of the spring migration (PFBC, 2010b). A June 2009 survey of the Schuylkill River upstream of Flat Rock Dam captured two male American shad, indicating that shad were using the Flat Rock fishway (PFBC, 2009). These were the first collections of American shad adults near Conshohocken since the Fairmount Dam was built around 1820 (PFBC, 2009).

2.2.3.3 Perkiomen Creek

Plankton and Macrophytes

Between 1972 and 1977, the aquatic ecology of Perkiomen Creek was studied from the Spring Mount Road bridge downstream to below the PA-113 bridge (PECO, 1984, p. 2.2-51 and Table 2.2-40). A qualitative study of phytoplankton in 1974 indicated the community was dominated by diatoms, green algae, and blue-green algae (PECO, 1984, p. 2.2-52). In general, low densities of phytoplankton were reported and most were periphytic in origin (PECO, 1984, p. 2.2-52). Periphyton was studied from July through December 1973 and results showed the community was comprised almost entirely of diatoms (PECO, 1984, p. 2.2-53). Although macrophytes were not studied, qualitative observations indicate that macrophytes are not common (PECO, 1984, p. 2.2-53). The zooplankton community was not evaluated because studies in other small, temperate streams have shown that zooplankton is not dense and therefore of low potential impact (PECO, 1984, p. 2.2-53).

Benthic Macroinvertebrates

Macroinvertebrates were surveyed in Perkiomen Creek from 1970 through 1974 and 1976 (PECO, 1984, p. 2-53). Results indicated a diverse macroinvertebrate assemblage, including all major orders of aquatic insects, planarians, annelids, isopods, amphipods, decapods, mollusks, and others (NRC, 1984, p. 4-43). The most abundant taxa collected historically included caddisflies (50 percent), black flies (Simuliidae) (15 percent), and non-biting midges (Chironomidae) (14.9 percent) (AEC, 1973, Table 2.5). Standing crop (number and biomass) data were highly variable between survey locations and over time (PECO, 1984, p. 2.2-55). Generally, total numbers and biomass were greatest in the fall (PECO, 1984, p. 2.2-55).

Macrobenthic invertebrates in Perkiomen Creek were not surveyed during the non-radiological environmental program from 1979 through 1988, nor was this community monitored for the annual operating report.

Long-term monitoring of the macroinvertebrate community in the Perkiomen Creek was performed by Stroud Water Research Center from 1996 through 2007 (Stroud, 2011). The benthic macroinvertebrate community was evaluated using the Macroinvertebrate Aggregated Index for Streams (MAIS) score. Long-term sampling at the lower Perkiomen Creek station, located downstream of the pumping station, resulted in a “fair” score in all but one year, when it was considered “good”. The most abundant taxa were midges (Chironomidae), riffle beetles (Elmidae), and oligochaete earthworms (Stroud, 2011).

Ichthyoplankton

Ichthyoplankton were collected near the area of the Graterford intake on Perkiomen Creek from 1973 through 1975 (PECO, 1984, p. 2.2-70). Carp, minnows, sunfishes, and white sucker dominated the drift and shoreline larvae collected (PECO, 1984, p. 2.2-70). Diel variability in the drift community was noted; peak densities of larval fishes occurred during the late night-early morning hours (PECO, 1984, p. 2.2-70).

Adult Fish

Table 2.2-4 of this report provides a list of fish species collected from Perkiomen Creek during the study years. Data for other aquatic species are not repeated in this report. Many species were only reported from early studies (e.g., those from the 1970s), but not in the more recent studies from the 1980s. This is likely due to differences in sampling methodology and equipment, as well as level of effort. Fish sampling performed as part of the non-radiological environmental monitoring focused on electrofishing and, in some years, creel surveys (RMC, 1984, 1985, 1986, 1987, and 1988). These methods do not target smaller species such as the shiners and darters, which were collected historically. The older studies report species collected by seining, a method that targets smaller species and younger stages.

The fish community of Perkiomen Creek was described as typical of that found in similarly-sized lotic systems in southeastern Pennsylvania (PECO, 1984, p. 2.2-69). Most species were classified as indigenous and reproduced locally (PECO, 1984, p. 2.2-69). Collections of fish from 1970 through 1977 were comprised by 40 species plus hybrids (PECO, 1984, Table 2.2-53). The most abundant taxa in seine samples were minnows (mostly shiners) and young of larger species; electrofishing samples were dominated by redbreast sunfish, white sucker, smallmouth bass, pumpkinseed, carp, green sunfish (*Lepomis cyanellus*), and rock bass adults (PECO, 1984, pp. 2.2-70 and 71). American eel was the only migratory species found during the sampling period (PECO, 1984, p. 2.2-70). Species stocked during the sampling period include brook trout (*Salvelinus fontinalis*) (stocked in downstream tributaries) and muskellunge (*Esox masquinongy*) (one juvenile captured in 1977, indicating limited natural reproduction) (PECO, 1984, p. 2.2-70). None of the fish were commercially valuable or listed as threatened or endangered at the time (PECO, 1984, pp. 2.2-69 and 70). Bridle shiner (*Notropis bifrenatus*) has been collected from the Perkiomen Creek historically (i.e., up through 1977; AEC, 1973; PECO, 1984) and is currently a state listed endangered species. However, this species was not identified for Montgomery, Chester, or Bucks counties (PNHP, 2011a). Additionally, its abundance has declined throughout its range and is rarely found in the Delaware River drainage; no current (i.e., 1980 onward) records are known for bridle shiner in the three counties (PNHP, 2011b).

Fish surveys (electrofishing, creel surveys, etc.) of Perkiomen Creek were performed as part of the annual non-radiological environmental monitoring from the late 1970s into the 1980s (RMC, 1984, 1985, 1986, 1987, and 1988). Many species collected during these surveys were similar to previous studies. Notable exceptions were the capture of brown trout, chain pickerel (*Esox niger*), northern pike (*Esox lucius*), pike hybrids, and unidentified trout in the more recent years; none of which were collected during historic sampling. Electrofishing catches between 1981 and 1986 were all dominated by redbreast sunfish; other important species included white sucker, smallmouth bass, pumpkinseed, rock bass, and bluegill (*Lepomis macrochirus*) (RMC, 1984, pp. 5.2-2 and 3; RMC, 1985, p. 5.2-3; RMC, 1986, p. 5.2-1; RMC, 1987, p. 5.2-1; RMC, 1988, p. 5.2-1).

A recreational fishery historically existed in Perkiomen Creek for species of the pike family (Esocidae), sunfishes, smallmouth bass, and carp (NRC 1984, p. 4-48). Creel surveys performed at various times of the year in 1980, 1981, 1983, and 1985 indicated that fishing was concentrated near access points, the most popular of which were the dock in the park in Schwenksville, Ott's Dam and Park, the PA-113 bridge, near the Collegeville Dam, in Graterford, and in Collegeville (RMC, 1984, p. 5.3-4; RMC 1986, p. 5.3-3). Fishermen's catch were dominated by *Lepomis* sunfish, redbreast sunfish, smallmouth bass, and rock bass (RMC, 1984, p. 5.3-6; RMC, 1986, p. 5.3-1).

Brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) are currently stocked annually in Perkiomen Creek in Montgomery and Berks Counties by the PFBC (PFBC, 2010c and 2010d).

2.2.3.4 <u>East Branch Perkiomen Creek</u>

The East Branch Perkiomen Creek was studied extensively from 1972 through 1977 from its headwaters to its confluence with the Perkiomen Creek (NRC, 1984, p. 4-38). This waterbody is characterized by riffles, runs, a few shallow natural pools, and several manmade impoundments (NRC, 1984, p. 4-38). Historically, the middle and lower portions of East Branch Perkiomen Creek had degraded water quality (from approximately Sellersville, Pennsylvania downstream) (NRC, 1984, p. 4-38).

<u>Plankton and Macrophytes</u>

The periphyton community was studied in 1973 and 1974 using artificial substrates samplers. Results showed that diatoms were the dominant taxon and were most abundant during April through October (PECO, 1984, p. 2.2-79). Seasonal changes in community composition and productivity was similar to that found in the Schuylkill River and other temperate lotic systems (PECO, 1984, p. 2.2-79). The macrophyte community found in the East Branch Perkiomen Creek are similar to that described for the Perkiomen Creek (Section 2.2.3.3, above). Similar to Perkiomen Creek, zooplankton was not studied because studies in other small, temperate streams have shown that zooplankton is not dense and therefore of low potential impact (PECO, 1984, p. 2.2-53).

Benthic Macroinvertebrates

Macroinvertebrates in riffles in the East Branch Perkiomen Creek were collected in 1973, 1974, and 1976 using net samplers (NRC, 1984, p. 4-39; PECO, 1984, p. 2.2-53). Sample results indicated a diverse macroinvertebrate assemblage consisting of aquatic insects, planarians, annelids, and mollusks (NRC, 1984, p. 4-39; PECO, 1984, p. 2.2-54). Variation in the community along East Branch Perkiomen Creek was influenced by flow variability and water quality (PECO, 1984, p. 2.2-54).

The macrobenthic community was also studied from 1983 through 1986. At least 86 taxa were collected across all sampling stations each year (RMC, 1984, p. 4.2-4; RMC, 1985, p.4.2-1; RMC, 1986, p. 4.2-1; RMC, 1987, p. 4.2-1; RMC, 1988, p. 4.2-4). Throughout the sampling period, the benthic macroinvertebrate community remained similar, with oligochaete worms (Oligochaeta), crayfish (Decapoda), mayflies, stoneflies (Plecoptera), beetles, caddisflies, true flies, snails and clams (Bivalvia) being collected and midges, black flies, and *Stenelmis* (a riffle beetle) most abundant (RMC, 1985, p. 4.2-1; RMC, 1986, p. 4.2-1; RMC, 1987, p. 4.2-1). However, compared to surveys performed in the 1970s, two new genera of dragonflies (*Erythemis* and *Stylogomphus*) and one new caddisfly, *Setodes,* were found in 1983 and five new genera (*Ironoquia*, *Liodessus*, *Promenetus*, *Prostoia*, and *Tetragoneuria* [now *Epitheca*]) were collected in 1984 (RMC, 1984, p. 4.2-8; RMC, 1985, p. 4.2-2).

Ecological studies of the East Branch Perkiomen Creek have been performed annually as part of the post-operational Aquatic Biology Assessment for the Point Pleasant Water Diversion Project and for the LGS makeup water supply system demonstration project (see Section 3.1.2 for a detailed explanation of these projects). The most recent data available (i.e., collected from 2001 through 2009 are summarized here (NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, and 2010b). Benthic macroinvertebrates studies were conducted using a portable invertebrate box sampler (NAI, 2005, p. 6-2). Data from the 2001 and 2003 studies were similar to those collected previously, post-Diversion, especially since 1995 (NAI, 2005, p. 6-6). At least 41 taxa were collected across stations each year, and samples were dominated by midges, *Cheumatopsyche* (a caddisfly), *Stenelmis* (a riffle beetle), *Dugesia* (a flatworm), *Gammarus* (a scud), and *Chimarra* (a caddisfly) (NAI, 2005, pp.6-3 through 6-5; NAI, 2007, pp. 6-3 through 6-5; NAI 2008a, pp. 6-3 through 6-5; NAI 2008b, pp. 6-3 through 6-5; NAI, 2009, pp. 6-3 through 6-5; NAI 2010a, pp. 6-3 through 6-5). General conclusions from these studies (NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, 2010b, Executive Summaries) include:

- Benthic macroinvertebrate density was greater in the headwaters, with more rheophilic (fast-flowing water) taxa present;
- More pollution-sensitive species of benthos over time;
- Less variability in community composition along the stream gradient; and
- Occasional transfers of benthos between the Delaware River and Perkiomen Creek basins.

Ichthyoplankton

Larval fish in the East Branch Perkiomen Creek were studied in 1973 and 1974 using drift nets (PECO, 1984, p. 2.2-81). Results found the ichthyoplankton community was dominated by white sucker, yellow bullhead, sunfish, and minnows, although relative abundance varied between years (PECO, 1984, p. 2.2-81). Spawning of these species extended from April through August (PECO, 1984, p. 2.2-81).

Adult Fish

Table 2.2-5 of this report provides a list of fish species collected from East Branch Perkiomen Creek as reported for the study years. Data for other aquatic species are not repeated in this report. Note that although approximately one-quarter of the fish taxa historically found in the East Branch Perkiomen Creek were not reported in studies performed between 2001 and 2009, the majority of these species were only found in one or two early surveys, which tended to be more comprehensive in design and level of effort.

The fish community in East Branch Perkiomen Creek was studied comprehensively from June 1970 through December 1976. The community was found to consist of warm water species typical of small lotic systems in southeastern Pennsylvania (PECO, 1984, p. 2.2-80). Numerically important taxa included minnows, suckers (Catastomidae), catfish, pike, and sunfish (PECO, 1984, p. 2.2-80). Forty species plus hybrids were collected over the years of study; none were commercially valuable or listed as threatened or endangered at the time (PECO, 1984, p. 2.2-80). Bridle shiner, currently listed as state endangered, was collected historically from East Branch Perkiomen Creek, but is no longer found in the area (see Section 2.2.3.3). Brook trout were stocked occasionally in the East Branch, but did not support a naturally reproducing population (PECO, 1984, p. 2.2-80). One individual muskellunge was collected near the mouth of East Branch Perkiomen Creek and was assumed to have originated from Perkiomen Creek (i.e., the main stem) where this species had been stocked (PECO, 1984, p. 2.2-80). Brown trout and rainbow trout are currently stocked annually in the East Branch Perkiomen Creek in Montgomery and Bucks Counties by the PFBC (PFBC, 2010c and 2010e).

Seining in 1975 and 1976 for juveniles and small adults resulted in the collection of 30 fish species plus hybrids from lotic sites in East Branch Perkiomen Creek (PECO, 1984, p. 2.2-81). Dominant taxa included shiners, bluntnose minnow (*Pimephales notatus*), banded killifish, and tessellated darter (PECO, 1984, p. 2.2-81). However, the relative abundance of dominant taxa varied among sites, indicative of species zonation. This variability in abundance was thought to be attributable to downstream changes in habitat and water quality (PECO, 1984, p. 2.2-82).

Fishes larger than 50 millimeters (mm) fork length (FL) of pike, sucker, catfish, and sunfish families and goldfish and carp were collected from East Branch Perkiomen Creek via electrofishing in 1973 and 1975 (PECO, 1984, p. 2.2-82). White sucker, green sunfish, yellow bullhead (*Ameiurus natalis*), and redbreast sunfish were the dominant species by number and biomass. Other important species at certain locations or times included pumpkinseed, *Lepomis* sp. hybrid, creek chubsucker (*Erimyzon oblongus*), redfin pickerel (*Esox americanus*), chain pickerel (*E. niger*), brown bullhead, and smallmouth bass (PECO, 1984, p. 2.2-82). Species zonation was also evident in samples collected through electrofishing (PECO, 1984, p. 2.2-83).

Seining and electrofishing in East Branch Perkiomen Creek between 1981 and 1986 collected 28 or more species by seine and 18 or more species and hybrids by electrofishing (RMC 1984, p. 4.3-3 and 4; RMC, 1985, p. 4.3-1 and 4.4-2; RMC, 1986, pp. 4.3-1 and 4.4-1; RMC, 1987; p. 4.3-1; RMC, 1988; p. 4.3-1). Relative abundance of species caught in the seines varied somewhat among years, but the most abundant species, in general, were: shiners, bluntnose minnow, banded killifish, and smallmouth bass (RMC, 1984, p. 4.3-3 and 4; RMC, 1985, p. 4.3-1; RMC, 1986, p. 4.3-1; RMC, 1987, p. 4.3-9; RMC, 1988; p. 4.3-3). Electrofishing catches targeting large fish (i.e., larger than 50 millimeters fork length) in East Branch Perkiomen Creek were dominated by white sucker, green sunfish, smallmouth bass, redbreast sunfish, pumpkinseed, yellow bullhead (RMC, 1984, p. 4.4-3 and 4; RMC, 1985, p. 4.4-2; RMC, 1986, p. 4.4-1; RMC 1987, p. 4.3-1; RMC, 1988; p. 4.3-1).

Historically, East Branch Perkiomen Creek supported an important recreational fishery centered on catfish, the pike family, sunfishes, and smallmouth bass (NRC, 1984, p. 4-48). Creel surveys conducted in 1980, 1981, 1983, and 1985 along East Branch Perkiomen Creek found that the most fished areas were between Sellersville and Perkasie, especially at the Wawa Dam and Park (RMC, 1984, p. 4.6-5; RMC, 1986, p. 4.6-3). The catch was comprised almost entirely of species from the sunfish and catfish families, specifically *Lepomis* sunfish and smallmouth bass (RMC, 1984, p. 4.6-8; RMC, 1986, p. 4.6-1).

East Branch Perkiomen Creek was also seined and electrofished more recently (since 2001) in accordance with PADEP Permit No. E 09-77A to operate an encroachment (NAI, 2005, 2007, 2008a, 2008b, 2010a, and 2010b). During these surveys, at least 27 taxa were collected using seines and 22 taxa were captured via electrofishing (NAI, 2005, Tables 7-1 and 7-12; NAI, 2007, Table 7-1; NAI, 2008a, Table 7-1; NAI, 2008b, Table 7-1; NAI, 2009, Table 7-1; NAI, 2010a, Table 7-1). Seining was phased out over this time period, but in general, the collections were dominated by tessellated darter, white sucker, bluntnose minnow, green sunfish, smallmouth bass, and shiners (NAI, 2005, Tables 7-1 and 7-12; NAI, 2007, Table 7-1; NAI, 2008a, Table 7-1; NAI, 2008b, Table 7-1; NAI, 2009, Table 7-1; NAI, 2010a, Table 7-1; NAI, 2010b, Table 7-1). Data from the most recent reports prepared for that project support the following conclusions regarding how the fish community has responded to habitat modification associated with the water diversion system and other watershed changes over time:

- More pollution-sensitive species of fish have been collected over time;
- Less variability in community composition along the stream gradient;
- Local elimination or reduction of some species with populations in the headwaters, including redfin pickerel, creek chubsucker, golden shiner (*Notemigonus crysoleucas*), bluntnose minnow, and bridle shiner;
- Less inter-annual variability in species dominance;
- Upstream extension and increased abundance of species formerly representative of downstream reaches;
- Increased abundance and temporal persistence of particular downstream species; and
- Occasional intra-basin transfers of fish between the Delaware River and Perkiomen Creek.

2.2.3.5 Delaware River

Plankton and Macrophytes

Aquatic studies in the Delaware River near the Point Pleasant Pumping Station in 1972-1973 determined that habitats there consisted of riffles, rapids, runs, pools, and back eddies, with only one sizeable tributary in the area, Tohickon Creek (NRC, 1984, p. 4-36). Primary production was dominated by periphytic diatoms and filamentous algae. Water milfoil (*Myriophyllum* sp.) was common in back eddies and the most abundant macrophyte (NRC, 1984, p. 4-36).

A survey of aquatic plants in the Delaware River from Milford, PA upstream to Jervis, NY, which is located upstream of the Point Pleasant Pumping Station, was made in 1997 (DRBC, 1999). The study area is not located near the pumping station, but similar species could be expected to occur in that reach of the Delaware River if comparable habitat conditions exist. Results of the survey found that the most common rooted plants were *Elodea*, *Vallisneria*, and *Potamogeton*, which were also dominant in a 1989 study. Water stargrass (*Heteranthera dubia*) and *Cladophora* macroalgae were also found infrequently (DRBC, 1999).

A pilot study for implementing the periphyton monitoring network for the non-tidal Delaware River in 2005 found that the diatom community in the non-tidal portion of the River is generally characteristic of "high water quality and high biological integrity" (Limbeck and Smith, 2007). Samples collected from Washington Crossing, NJ (downstream of the Point Pleasant Pumping Station) and Upper Black Eddy, PA (upstream of the Point Pleasant Pumping Station) were comprised of 70 taxa of diatoms and were dominated by *Cocconeis placentula* var. *lineata* (Limbeck and Smith, 2007). *Navicula recens* was also highly abundant at the Washington Crossing, NJ site. Eight algal taxa were recorded from these locations, dominated by *Gloeocystis* sp. and *Leptolyngbya* sp. (Limbeck and Smith, 2007).

Benthic Macroinvertebrates

Macroinvertebrates were collected from riffle, run, and pool areas located approximately 2 kilometers (1.2 miles) upstream to 2.4 kilometers (1.5 miles) downstream of Point Pleasant during July and September 1972 using dip nets and hand removal. The benthic drift community was sampled in August 1972 and July to October 1973 using stationary fine mesh nets (NRC, 1984, p. 4-36). Sampling results indicated that all major orders of aquatic insects, annelid worms and leeches, mollusks, and crustaceans were present in the Delaware River. The benthic community was dominated by non-biting midges and amphipods (*Gammarus* sp.). The benthic drift community was comprised mainly of non-biting midges (NRC, 1984, p. 4-36).

Ichthyoplankton

Ichthyoplankton were collected from the Delaware River near the Point Pleasant Pumping Station as part of the annual non-radiological environmental monitoring from the late 1970s into the 1980s (RMC, 1984, 1985, and 1986). Thirty-five taxa were collected during these surveys. At least 20 taxa of fish eggs and larvae were collected each year and the community was dominated by herrings (Clupeidae), *Lepomis* sunfishes, carp and American shad, white suckers, quillback (*Carpiodes cyprinus*), channel catfish (RMC, 1986, p. 3.2-1; RMC, 1985, p. 3.2-2; RMC, 1984, pp. 3.2-5 and 3.2-6).

Adult Fish

Table 2.2-6 of this report provides a list of fish species collected from the Delaware River during the study years. Data for other aquatic species are not repeated in this report.

The Delaware River fish community in the vicinity of Point Pleasant was sampled from August 1972 to December 1973 using seines, fyke nets, and trap nets (NRC, 1984, p. 4-37). Forty-four species were collected; shiner and sunfishes numerically dominated the seine catches (NRC, 1984, p. 4-37). Sunfishes and catfishes were the most common taxa in the fyke and trap nets (NRC, 1984, p. 4-37). Four alewife (*Alosa pseudoharengus*) were collected in June 1973. Alewife represented the only anadromous species in samples (NRC, 1984, p. 4-37). Later studies conducted in 1979-80 found that American shad, alewife, and blueback herring (*Alosa aestivalis*) used the Delaware River in the vicinity of Point Pleasant as a nursery area (NRC, 1984, p. 4-37).

Historically, the Delaware River in the vicinity of Point Pleasant supported a recreational fishery for panfish and American shad (NRC, 1984, p. 4-47). The Delaware River currently supports a small commercial fishery (in New Jersey and Delaware) and a strong recreational fishery (NYSDEC, 2009).

No recent ecological studies have been performed in the Delaware River related to the operation of LGS. However, a creel study performed by Versar Inc. (2003) in 2002, which included the non-tidal portion of Delaware River, found that anglers caught 39 taxa, including herrings (*Alosa* spp.), catfish, shiners, sunfishes, and basses, among others. American shad and striped bass (*Morone saxatilis*) dominated the daytime catches in the non-tidal reaches; nighttime angling effort was comparatively lower and dominated by catfish and eel. Catch-and-release fishing was the norm (Versar Inc., 2003).

2.2.3.6 <u>Invasive Species</u>

Annual surveys of all four waterbodies have been performed to monitor for invasive species, specifically the exotic zebra mussel and the Asiatic clam.

Hydrilla (*Hydrilla verticillata*) is an invasive aquatic plant now established in the Schuylkill River in Philadelphia. This species, listed as a federal noxious weed in Pennsylvania, first colonized Pennsylvanian waters in the mid-1990s (Sea Grant Pennsylvania, 2011).

<u>Asiatic Clam</u>

The presence of the Asiatic clam in the Schuylkill River has been monitored since at least the 1980s. The Schuylkill River population remained downstream of LGS during the 1980s (RMC, 1984, pp. 7.0-4 and 5; RMC, 1985, p. 7.0-4; RMC, 1986, p. 7.0-1; RMC, 1987, p. 7.0-1; RMC, 1989, p. 4.0-2). However, by the early 1990s, this species was common upstream and downstream of LGS (PECO, 1993, p. 2) and these results were confirmed in subsequent sampling, including as recently as 2010 (NAI, 2010d).

Asiatic clam populations were monitored in the Perkiomen Creek in the 1980s; none were identified at sampling points surveyed between 1982 and 1988 (RMC, 1984, p. 7.0-5; RMC, 1985, p. 7.0-4; RMC, 1986, p. 7.0-1; RMC, 1987, p. 7.0-1; RMC, 1988, p. 7.0-1; RMC, 1989, p. 4.0-3). However, more recent surveys since the early 1990s near the Perkiomen Pumphouse at Graterford, PA found that this species was common (PECO, 1992, p. 2; PECO, 1993, p. 2; PECO, 1996, p. 2; PECO, 1997, p. 2; PECO, 1998, p. 1; PECO, 1999, p. 2; PECO, 2000, p. 1; Exelon Generation, 2001, p. 1-2; Exelon Generation, 2002, p. 1; Exelon Generation, 2003, p. 2; Exelon Generation, 2004, p. 2; Exelon Generation, 2005, p. 2; NAI, 2010d).

In the East Branch Perkiomen Creek, monitoring has indicated that the Asiatic clam was not present in the 1990s (RMC, 1984, p. 7.0-5; RMC, 1985, p. 7.0-4; RMC, 1986, p. 7.0-1; RMC, 1987, p. 7.0-1; RMC, 1988, p. 7.0-1; RMC, 1989, p. 4.0-3), but were “commonly observed” subsequently (PECO, 2000, p. 1; Exelon Generation, 2001, p. 1-2; Exelon Generation, 2002, p. 1; Exelon Generation, 2003, p. 2; Exelon Generation, 2004, p. 2; Exelon Generation, 2005, p. 2). By 2003, the Asiatic clam comprised five percent or more of the collection at the sampling location nearest the confluence with the Perkiomen Creek (NAI, 2008b, Table 6-13), and near the head of the Creek by 2006 (NAI, 2008b, Table 6-10). Intermediate sampling locations had lower concentrations of Asiatic clam (NAI, 2008b, Tables 6-11 and 6-12).

Sampling for the invasive Asiatic clam was conducted in August, September, and October 1982 along 35 points in the Delaware River from Point Pleasant downstream to Chester, Pennsylvania (NRC, 1984, p. 4-36). Asiatic clams were found from approximately Trenton, NJ downstream to the Benjamin Franklin Bridge (NRC, 1984, p. 4-37). Other bivalves such as fingernail clams (*Sphaerium* sp.) were collected near Point Pleasant, indicating that Asian clams could also exist in the area (NRC, 1984, p. 4-37). Later surveys of the Delaware River for this species found that the population existed downstream of Point Pleasant in 1985 and 1986 (RMC, 1986, p. 7.0-1; RMC, 1987, p. 7.0-1). However, by 1988, the population extended to six miles upstream of Easton, PA and clams were collected near the Point Pleasant Pumping Station intake (RMC, 1989, p. 4.0-2).

Zebra Mussel

Results of surveys for the invasive zebra mussel in the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek for the most recent years available (1989 through 2004, and 2010) indicated that zebra mussels had not invaded any of these aquatic systems.

Monitoring in the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek (including the diversion outfall structure and several locations along the water diversion system route) had not identified this species (PECO, 1991, p. 2; PECO, 1992, p. 1; PECO, 1993, p. 1; PECO, 1994, p. 1; PECO, 1995, p. 1; PECO, 1996, p. 2; PECO, 1997, p. 1; PECO, 1998, p. 1; PECO, 1999, p. 2; PECO, 2000, p. 1; Exelon Generation, 2001, p. 1-2; Exelon Generation, 2002, p. 1; Exelon Generation, 2003, p. 2; Exelon Generation, 2004, p. 2; Exelon Generation, 2005, p. 2; NAI, 2010d). This species has not been surveyed in the Delaware River near the Point Pleasant Pumping Station for LGS-related issues. The USGS (2009) reports that, as of 2009, this species has not been found in the Delaware River.

2.3 Groundwater Resources

2.3.1 Water Bearing Units

The LGS plant site is located on a topographic high, on the eastern bank of the Schuylkill River. The topography at the LGS plant site slopes steeply to the west and south toward the Schuylkill River and Possum Hollow Creek, respectively. Ground elevations at the LGS plant site range from less than 33.5 meters (110 feet) above mean sea level (amsl) at the Schuylkill River to approximately 85.3 meters (280 feet) amsl at the highest elevation near the cooling towers. The topography beneath and around the main structures, including the reactor and turbine enclosures, was altered during LGS construction, as a result of blasting used to excavate down to pre-existing bedrock surface.

Soils units in the region are typically thin or absent. Soils in the vicinity of LGS belong to the Reaville-Penn-Klinesville Association (USDA, 1967; Conestoga-Rovers, 2006). There are no glacial deposits capable of maintaining alluvial aquifers along the Schuylkill River or upland of the Schuylkill River in the vicinity of LGS (Pennsylvania Geologic Survey Map 59 *Glacial Deposits of Pennsylvania*). At LGS, there is a thin veneer of overburden soils that consists of various fill materials or weathered bedrock (silty clay), based on stratigraphic logs from well drilling activities (Conestoga-Rovers, 2006). These overburden materials are up to 3.7 meters (12 feet) thick and do not represent a water-bearing unit, based on the measurement of depth to groundwater at LGS (Conestoga-Rovers, 2006; AMO, 2007 and 2008).

The water-bearing unit (aquifer) in the vicinity of LGS consists of a thick Triassic-age sedimentary sequence known to include the Brunswick Formation and the Lockatong Formation

(Pennsylvania Geologic Survey Map 61, 1981, and detail Map 448 [Phoenixville Quadrangle] in the vicinity of LGS). The Brunswick Formation consists of reddish-brown shale, mudstone, and siltstone. Locally interbedded along the base of the Brunswick Formation, and laterally grading into the Brunswick Formation, are gray to black shale and siltstone of the older Lockatong Formation (Shultz, 1999; Longwill and Wood, 1965). The thickness of the Brunswick Formation is reported (Shultz, 1999) to be as much as 6,400.8 meters (21,000) feet in the region.

At LGS, the bedrock units of the Brunswick Formation have been observed to dip to the north / northwest at approximately 10 to 20 degrees (Conestoga-Rovers, 2006; Longwill and Wood, 1965, Plate 1). The Brunswick Formation has poor primary porosity. Instead, groundwater is stored and transmitted through a network of fractures and joints ('secondary porosity'), which are developed as vertical joint planes that occur at typical intersecting orientations of approximately N 30^o E and N 60^o W (Conestoga-Rovers, 2006; AEC, 1973).

The direction of groundwater flow beneath LGS follows its overall topography from the topographic high near the cooling towers toward the south and southwest and discharging to surface water of Possum Hollow Creek or the Schuylkill River (Conestoga-Rovers, 2006, Figure 5.5 through 5.7). Groundwater elevation measurements obtained in May through August 2006 (Figure 2.3-1) provides a composite view of the flow. These measurements indicate a homogeneous horizontal hydraulic gradient of approximately 0.021 meter per meter (0.07 foot per foot), based on a change in water table elevation of 42.7 meters (140 feet) across the 609.6-meter (2,000-foot) distance between the cooling towers and the Schuylkill River. Conestoga-Rovers (2006) suggested that the specific discharge from the saturated portion of the Brunswick Formation may be on the order of 0.02 cubic feet/day per square foot of aquifer section (based on a referenced hydraulic conductivity of 0.28 feet/day [Michalski, 1990]). This implies that along the approximately 1,219.2-meter (4,000-foot) long LGS plant site frontage with the Schuylkill River, groundwater discharges at a rate of approximately 227,100 liters (60,000 gallons) per day (assuming that groundwater from the upper 30.5 meters [100-feet] of the saturated bedrock unit discharges to the Schuylkill River).

2.3.2 Water Supply Wells

A search of the Pennsylvania Groundwater Information System (PaGWIS) conducted in March 2011 identified 34 water supply wells within a 1.6-kilometer (1-mile) radius from the center of LGS, consisting of 27 domestic water withdrawal wells, 6 industrial or commercial withdrawal wells, and 1 public supply withdrawal well (at a mobile home park). These wells are listed in Table 2.3-1 and their locations are shown in Figure 2.3-2. Of the 34 water supply wells, eight are located on the LGS plant site; however, only four of the eight are in service and, of these four, only the following two are used to support plant operation:

- PA Well ID 215319, known at LGS as Well 1 (or the "Alley Well"); and
- PA Well ID 28054, known at LGS as Well 3 (or the "Batch Plant Well").

Well 1 supplies water for potable use at LGS. The Well 1 pump yield is 189.2 liters per minute (50 gallons per minute) as makeup to a standpipe tank that maintains system head pressure. Well 3 provides a backup source of LGS fire emergency water, with the primary source supplied from the LGS cooling water system (refer to Section 3.1.2). The Well 3 pump yield is 246.0 liters per minute (65 gallons per minute) as makeup to a 189,250-liter (50,000-gallon) capacity fire emergency water storage tank. The Well 3 pump operates to replenish the storage tank during a fire emergency, in the event the backup supply is needed, or during standby when the tank level is low.

Both Well 1 and Well 3 are constructed as open borehole wells, and are reported to be approximately 94.5 meters (310 feet) and 178.3 meters (585 feet) deep, respectively (PaGWIS, 2010). The static depths to groundwater in Wells 1 and 3 are approximately 6.1 meters (20 feet) and 9.1 meters (30 feet) below grade, respectively (interpreted from Figures 5.5 through 5.9, Conestoga-Rovers, 2006). The pump in Well 1 was replaced in 2004 and positioned at a depth of approximately 89.6 meters (294 feet) (Conestoga Rovers, 2006). The pump in Well 3 also was replaced in 2004 and positioned at a depth of approximately 121.6 meters (399 feet) (Conestoga Rovers, 2006).

Water use records from 1997 through 2009 (Table 2.3-2) indicate that groundwater is withdrawn from Well 1 at an annual average rate ranging from 54.1 liters per minute (14.3 gallons per minute) in 2006 to 109.8 liters per minute (29.0 gallons per minute) in 1999, and from Well 3 at annual average rate ranging from 1.75 liters per minute (0.46 gallons per minute) in 2009 to 1.93 liters per minute (0.51 gallons per minute) in 2008.

The following additional water supply wells located on the LGS plant site are active, but are not required to support plant operation and their usage does not add significantly to total site withdrawals:

- PA Well ID 215330, known at LGS as the Training Center Well; and
- PA Well ID 166630, known at LGS as the Energy Information Center Well.

These wells supply water to their respective restroom facilities, and are not currently used for drinking water. Self-contained bottles with coolers are provided for drinking water at these facilities. The Training Center is in operation only shortly before and during the annual LGS refueling outage, for a total use of approximately one month per year. The rest of the year, the facility is unmanned and the well is essentially unused. Similarly, the Energy Information Center and its well are in operation occasionally for staff and visitors. The water withdrawal from these wells is very limited and is used only for non-potable, sanitary usage for the restrooms.

The active groundwater wells at the LGS plant site are located in the in the Schuylkill-Sprogels Run Sub-basin of the Southeastern Pennsylvania Ground Water Protected Area, as defined by the Delaware River Basin Commission (DRBC). DRBC Ground Water Protected Area Regulations (GWPAR) limit the total net annual groundwater withdrawal in the sub-basin, and the LGS wells have been allocated a total annual groundwater withdrawal of 65.9 million liters (17.4 million gallons) per year (approximately 124.9 liters per minute or 33 gallons per minute). The reported, annual average pumping rate for Well 1 and Well 3 combined has been less than 113.5 liters per minute (30 gallons per minute) for reporting years 1999 through 2009. Exelon Generation Company, LLC (Exelon Generation) estimates that the Training Center Well and the Energy Information Center Well combined add less than 13.9 liters per minute (1 gallon per minute) to the annual average pumping rate.

One of the identified offsite industrial/commercial wells is at an active quarry (Pottstown Trap Rock – Sanatoga Quarry, PA Well ID 167738), located approximately 1,112.5 meters (3,650 feet) north-northwest of the center of LGS. The well is reported to be 30.5-meters (100-feet) deep (PaGWIS, 2010). The quarry does not maintain a DRBC groundwater withdrawal permit, implying that the actual withdrawal rate from this well is less than 37,850 liters per day (10,000 gallons per day). At this withdrawal rate, the well is unlikely to deflect groundwater flow paths underneath LGS.

2.3.3 Groundwater Monitoring

In 2006, Exelon Generation implemented a program to proactively review the environmental status of its nuclear power generating stations, specifically to identify the potential for releases of tritium, strontium 90 (Sr-90), or station-related gamma-emitting radionuclides from all systems, structures, and components at the stations that are not designed for such a release. The investigation was part of an Exelon Generation fleet-wide program involving all Exelon Generation-owned nuclear generating stations, including LGS. The Exelon Generation program was designed as part of an industry-wide initiative, consistent with the guidance provided by the Nuclear Energy Institute (NEI, 2007a).

Exelon Generation retained Conestoga-Rovers and Associates (Conestoga-Rovers) to perform a hydrogeologic investigation at LGS. The objective of this investigation was to evaluate whether groundwater at or near LGS had been impacted by inadvertent releases of tritium, Sr-90, or LGS-related gamma-emitting radionuclides. Conestoga-Rovers developed and implemented a plan to characterize the geologic and hydrogeologic conditions beneath LGS including subsurface soil types, the presence or absence of confining layers, and the direction and rate of groundwater flow; characterize the groundwater/surface water interaction; evaluate groundwater quality at LGS including the vertical and horizontal extent, quantity, concentrations and potential sources of tritium and other radionuclides in the groundwater, if any; and define the probable sources of any radionuclides that could be released at LGS. To thoroughly quantify the potential for unmonitored releases of tritium, Sr-90, or LGS-related radionuclides to the environment from various systems, engineers performed an internal review of systems, structures, and components, as well as work practices, to determine which have the greatest potential for impacting shallow ground-water quality, should a release of radionuclides occur. Conestoga-Rovers used these data to develop a Site Conceptual Model to provide the bases for the continuing Radiological Groundwater Protection Program (RGPP).

A groundwater monitoring well network was designed and installed to include wells located: (1) in the vicinity and downgradient of LGS systems that "screened in" as a result of the engineering review; (2) at downgradient locations around the perimeter of LGS; and, (3) at upgradient locations, to verify that any radionuclides that may be found in groundwater are not migrating from offsite. Prior to and during the construction of LGS, 22 groundwater monitoring wells were installed (locations P1 through P19, and SP-20 through SP-22) into water bearing units of the Brunswick Formation, with total depths ranging between 18.3 meters (60 feet) and 36.6 meters (120 feet) below grade, and discrete 3.0-meter (10-foot) screens at the bottom of each borehole. Six of these monitoring wells met the criteria developed by Conestoga-Rovers for RGPP monitoring wells and are included in the RGPP well network: P3, P11, P14, P16, P17, and SP22. Nine additional wells were installed, MW-LR-1 through MW-LR-9, for a total of 15 monitoring wells, to complete the RGPP monitoring well network.

Monitoring under the RGPP was initiated in 2006 and performed at least semi-annually on each RGPP monitoring well. Monitoring includes sampling and analyses for tritium on each sample and once each calendar year for Sr-90 and LGS-related gamma-emitting radionuclides. The initial monitoring data, including hydrological characterizations, were reported in the Hydrogeologic Investigation Report completed for LGS (Conestoga-Rovers, 2006). This report was made available to state and federal regulators and the public. The report confirmed that releases of tritium, Sr-90, or LGS-related gamma-emitting radionuclides are not occurring from systems, structures, and components at LGS that are not designed for such a release. The results of the continuing monitoring program, including trending data, program modifications, reporting protocols, and other information are included as an Appendix to the annual LGS Radiological Environmental Operating Report (Exelon Generation, 2007, 2008b, 2009a, and 2010b) and confirm the 2006 report conclusions. Future radionuclide monitoring activities will be conducted at locations and frequencies (at least semi-annually) established in accordance with the RGPP (Exelon Generation, 2010b). Figure 2.3-3 shows the RGPP groundwater monitoring well network. Neither Sr-90 nor any LGS-related gamma-emitting radionuclides have been identified in any groundwater sample.

The reporting level for tritium in groundwater specified in the Exelon Generation Offsite Dose Calculation Manual (ODCM) is equal to the U.S. Environmental Protection Agency (EPA) drinking water standard of 20,000 picocuries per liter (pCi/L). In accordance with NEI guidance (NEI, 2007a) and the ODCM, the detection capability for analyzing tritium concentrations in groundwater samples is required to be 2,000 pCi/L. The Exelon Generation RGPP stipulates an even lower detection capability of 200 pCi/l for analyzing tritium concentrations in groundwater samples, so that tritium detected at or above this level can be addressed early. The RGPP also specifies alert and internal reporting values between 200 pCi/l and 2,000 pCi/L for Exelon Generation's own use in addressing tritium detections.

Tritium concentration data are reported in the annual LGS Radiological Environmental Operating Report. Tritium concentrations at some of the RGPP wells have occasionally triggered investigations and source elimination (Exelon Generation, 2007, 2008b, 2009a, and 2010b). However, sampling of the RGPP monitoring well network at LGS has not identified a tritium concentration greater than 2,000 pCi/L.

During the 2006 site investigation conducted by Conestoga-Rovers, tritium concentrations greater than 2,000 pCi/L were detected on two occasions (Conestoga-Rovers, 2006). A concentration of 4,360 ± 494 pCi/L was detected in Well P-12. However, the tritium concentration in that well is not representative of groundwater quality beneath LGS because the well is screened above the water table and is not in direct communication with the groundwater. Consequently, P-12 was not carried over after the 2006 site investigation as an RGPP monitoring well. Also, tritium was detected during the 2006 site investigation at a concentration of 2,020 ± 154 pCi/L in a sample collected by LGS personnel from the power block foundation sump, which accumulates water from the drain system around the power block. This water is not in communication with groundwater and, therefore, also is not reflective of groundwater quality beneath LGS. Tritium concentrations greater than 2,000 pCi/L have been detected in power block foundation sump samples on other occasions since 2006.

Overall, the 2006 Hydrogeologic Investigation Report (Conestoga-Rovers, 2006) and subsequent RGPP annual reports have concluded that there have been no releases of tritium, Sr-90, or LGS-related gamma-emitting radionuclides from systems, structures, or components at the stations to the groundwater that could leave the site. More specifically, neither Sr-90 nor LGS-related gamma emitters have been detected in samples of groundwater, and tritium is not migrating off the LGS plant site property at concentrations greater than 2,000 pCi/L, which is about one-tenth the USEPA drinking water standard.

Additional action to protect groundwater at the LGS plant site includes implementation of a Buried and Underground Piping and Tanks aging management program consistent with NEI Guideline for the Management of Buried Piping Integrity (NEI 09-14, January 2010).

2.4 Terrestrial Resources

This section describes terrestrial resources that may be affected by extended operation of LGS. As Section 2.1 explains, features of the LGS project include the LGS plant site, the LGS makeup water supply system (part of the LGS cooling water system), and the LGS transmission system. The land requirements for these features encompass terrestrial habitat areas.

2.4.1 Historical Information

The bases for the information provided in this section include:

- *Final Environmental Statement Related to the Proposed Limerick Generating Station Units 1 and 2* ["LGS Construction Phase FES"] (AEC, 1973);
- *Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2.* NUREG-0974. ["LGS Operating Phase FES"] (NRC, 1984); and
- *Environmental Report Operating License Stage* ["ER-OL"] (PECO, 1984).

Section 2.7.1 in the LGS Construction Phase FES contains information on the terrestrial biota of the LGS plant site and vicinity, including riparian areas, which existed prior to LGS construction. Table B.4 in that report lists common plant species likely to occur in successional area, wetland, or forest habitat at or in the vicinity of the LGS plant site. That table also notes which of those species likely to occur were actually found on the site prior to construction. Tables B.5, B.6, and B.7 in the LGS Construction Phase FES list plant species beyond those listed on Table B.4 that also were found prior to construction on the LGS plant site. Similarly, Tables B.8, B.9, B.10, B.11, and B.12 list mammals, reptiles and amphibians, aquatic birds, land birds, and perching birds, respectively, that were identified as both likely to occur and actually occurring prior to construction on the LGS plant site. This tabulated information is not repeated in this report.

Section 5.3 of the LGS Construction Phase FES concluded that bird mortalities due to collisions with the cooling towers should be relatively infrequent and few in number. This section also concluded that the effects of the removal of woodland (less than 4.0 hectares [less than 10 acres]) and alteration of brush and cropland (approximately 40.5 hectares [100 acres]) due to land development at the LGS plant site should only have a slight impact on the terrestrial biota off the site, since the areas are small relative to total habitats available in the site vicinity. Also, the deposition of chemicals from the cooling towers was expected to be many orders of magnitude less than natural deposition by rainfall.

After commencement of operations at LGS in 1984, annual, non-radiological environmental monitoring and reporting to the U.S. Nuclear Regulatory Commission (NRC) was performed in accordance with the Environmental Protection Plan (Non-Radiological), which was Appendix B to each unit's Facility Operating License. This continued until 2004, when NRC approved a license amendment to discontinue the program. However, no terrestrial monitoring was required as part of the Environmental Protection Plan.

Section 4.3.4.1 of the LGS Operating Phase FES noted that the ER-OL estimated that 32 percent of the site acreage located in Montgomery County had been disturbed during construction, and that areas not occupied by structures or needed for parking or roadways would be final graded and reseeded with perennial grasses. NRC staff expected plant and animal species along rural portions of the transmission line corridors to be similar to those in the site vicinity given a similar habitat mix of cultivated fields, forest-edge, and forest. In Section 5.5.1 of the LGS Operating Phase FES, NRC staff concluded that cooling tower drift would not adversely affect native vegetation or agricultural crops in the immediate vicinity of LGS.

Section 5.5.1 also concluded that the design of the transmission system would not cause harm to biota from induced shock, not result increased bird impactions on the lines (refer to Section 3.1.3 for avian management program used for the LGS transmission system), and not adversely affect biota from electric field effects. Furthermore, NRC concluded that the transmission line corridor vegetative management program (described in Section 3.1.3.2) should have minimal impact on nesting birds or on non-target biota from use of U.S. Environmental Protection Agency (EPA) approved herbicides. The NRC also analyzed the impacts to terrestrial wildlife due to spray pond operation and maintenance (described in Section 3.1.1.3), and concluded that the clay liner and chemical applications would deter waterfowl species from becoming established and that routine testing would not adversely impact terrestrial wildlife. Finally, NRC staff concluded that the design (mostly buried) of the LGS makeup water supply system supply pipelines (described in Section 3.1.2.1) and the grading and seeding of disturbed area after pipeline construction would not cause a detrimental environmental effect from maintaining the pipeline corridors.

With regard to threatened or endangered terrestrial species (described in Section 2.5), Section 4.3.5.1 of the LGS Operating Phase FES noted that no federally-listed fish, wildlife, or plant species were known to inhabit the LGS plant site vicinity, the transmission line routes, or the area along the LGS makeup water supply system route from the Delaware River. Investigations of the LGS transmission system corridors also had revealed no federally-listed threatened or endangered plant species.

Exelon Generation Company, LLC (Exelon Generation) has reviewed lists of current federally- and state-listed threatened or endangered species (see Table 2.5-1) against lists of species found to be at or in the vicinity of the LGS plant site, as identified in the LGS Construction Phase FES Appendix B tables, and found no matches.

2.4.2 Current Information

LGS license renewal will involve no new construction, refurbishment, ground disturbing activities, changes to conduct of operations, or changes to existing land-use conditions. Operation and maintenance activities during the terms of the renewed LGS licenses are only expected to occur in previously disturbed areas or existing ROWs. Hence, no new adverse impacts to terrestrial species and habitats are anticipated due to the LGS plant site, transmission system, or makeup water supply system from license renewal.

The LGS plant site is included in the Upper Schuylkill Conservation Landscape, which extends from just above Royersford Borough (in Montgomery County) to the Berks County Line (Rhoads and Block, 2008). It also is classified as being within the Eastern Broadleaf Forest (Oceanic) Province (Bailey et al., 1994).

The Schuylkill River is designated as a Pennsylvania Scenic River (DCNR, 2010).

In 2005, Exelon Corporation became a member of the Wildlife Habitat Council (WHC), a nonprofit group of corporations, conservation organizations, and individuals dedicated to restoring and enhancing wildlife habitat. The Wildlife Habitat Council's *Corporate Wildlife Habitat Certification/International Accreditation Program* recognizes commendable wildlife habitat management and environmental education programs at individual sites. To become certified, sites must demonstrate that programs have been active for at least one year with a management plan that lists goals, objectives and prescriptions and complete documentation of all programs.

Exelon Generation contracted with WHC to assist with a biodiversity assessment and a wildlife habitat management plan for the LGS plant site. In 2006, WHC issued a report summarizing its findings and recommendations (WHC, 2006). LGS subsequently formed an Environmental Stewardship Committee, composed of volunteers representing the major work groups at LGS, to work on selecting and implementing onsite environmental improvement projects, including wildlife habitat improvement, and for community outreach and education.

Table 14 of the 2006 WHC assessment report identified plant and animal species observed on the LGS plant site by visiting WHC biologists and LGS staff personnel. These species are listed below in Table 2.4-1. None of the observed species is a federally- or state-listed threatened or endangered species. Table 2.5-1 lists threatened and endangered species that could occur in Montgomery, Chester, or Bucks Counties based on a review of the Pennsylvania Natural Heritage Program web site for state-listed endangered and threatened species.

In 2010, building off the work started in 2005, LGS received WHC Corporate Wildlife Habitat Certification after preparing a Wildlife Management Plan (WMP) for use at the plant site (Exelon Generation, 2010c). Section 1.2.2 in the WMP describes the current terrestrial habitats on the LGS plant site. These include developed areas, agricultural fields, old field meadow, old field scrub/shrub, pioneer herbaceous, forest, palustrine wetlands, and open water. Based on historic data and recent field reconnaissance, Section 2.1 in the WMP lists plants and animals that have been observed at Exelon Generation-owned properties associated with the LGS plant site and makeup water supply system (refer to Section 2.1.2). The following plant and animal species are included on the list:

- The American Holly (*Ilex opaca*), which is state-listed as threatened, was observed on the LGS plant site in 1978; and
- The American bittern (*Botaurus lentiginosus*), Least bittern (*Ixobrychus exilis*), Great egret (*Casmerodius albus*), Black-crowned night heron (*Nycticorax nycticorax*), Yellow-crowned night heron (*Nyctanassa violacea*), Bald eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Peregrine falcon (*Falco peregrinus*), Yellow-bellied flycatcher (*Empidonax flaviventris*), and Blackpoll warbler (*Dendroica striata*), which are state-listed either as threatened or endangered and were observed during bird surveys conducted from 1972 to 1985.

Although reported in the WMP as having been observed on LGS-associated properties in the 1970s and 1980s, Exelon Generation is not aware that any of the species listed above has been recently present on or near the LGS plant site, makeup water supply system, or transmission lines.

Terrestrial-related projects completed under the LGS Environmental Stewardship Committee include:

- Erecting artificial avian and raptor nesting structures;
- Surveying the biodiversity of Possum Hollow Run;
- Installing a 91.1-meter (300-foot) long fence to reduce frog casualties; and
- Sponsoring of an outdoor classroom at Limerick Elementary School's internal courtyard, which has been enhanced with a butterfly garden and fish pond.

2.5 Threatened and Endangered Species and Essential Fish Habitat

The U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NOAA Fisheries Service) jointly designate federal status under the provisions of the *Endangered Species Act* of 1973 (ESA), as amended. Federally-listed threatened and endangered species, as listed in 50 CFR 17.11 (wildlife) and 50 CFR 17.12 (plants), are protected. The Pennsylvania Natural Heritage Program (PNHP) tracks the occurrence and location of native plant, animal, natural community and geologic resources, with a focus on species designated as threatened, endangered, or rare. PNHP is a partnership of the Pennsylvania Department of Conservation and Natural Resources (DCNR), the Pennsylvania Game Commission (PGC), and the Pennsylvania Fish and Boat Commission (PFBC). The FWS participates in the PNHP within its role as jurisdictional agency for federally-listed land and freshwater species. NOAA Fisheries Service exercises jurisdiction over marine and anadromous species.

A record of federally-listed threatened and endangered species that are known to occur in Pennsylvania and any county therein is available through the FWS via online queries (FWS, 2010). All species classified as threatened or endangered in the Commonwealth of Pennsylvania are listed in the Pennsylvania (PA) Code: 17 PA Code § 45.12,13 (plants); 58 PA Code § 75.1, 2 (fish, reptiles and amphibians, and invertebrates); and 58 PA Code § 133.21, 41 (birds and mammals). Records of state-listed species by county of occurrence are available through the PNHP via online queries (PNHP, 2011a). The counties of interest include those where project features are located (refer to Section 2.1). The LGS plant site, the LGS transmission system, and the LGS makeup water supply system are located in Montgomery, Chester, and Bucks Counties.

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) requires the identification and conservation of essential fish habitat (EFH). The regional fishery management councils, under the NOAA Fisheries Service, is responsible for describing EFH and specifying actions to minimize impacts to EFH in their respective regions.

Animal and plant species that are state- or federally-listed as endangered or threatened and recorded in the counties of interest are listed in Table 2.5-1. The species included in the table are those that meet at least one of the following conditions:

- Records maintained by the FWS (FWS, 2010) indicated that the species is known to occur in the counties of interest as defined above, and the species is:
    - Federally-listed as endangered or threatened,
    - A candidate for federal listing (i.e., petitioned species that are actively being considered for listing as endangered or threatened under the ESA, sometimes referred to as "species of special concern"), or
    - Proposed for federal listing (i.e., candidate species that were found by FWS or NOAA Fisheries Service to warrant listing as either threatened or endangered and were officially proposed as such in a *Federal Register* notice) (FWS, 2010); and
- Records maintained by the PNHP indicate that the species is known to occur in the counties of interest, and the species is state-listed as endangered or threatened (PNHP, 2011a).

Areas listed in 50 CFR 17.95 (for fish and wildlife) and 50 CFR 17.96 (for plants) have been determined by FWS to be Critical Habitat areas (i.e., specific geographic areas that are essential for the conservation of a federally-listed threatened or endangered species and may require special management and protection).

2.5.1 Federally Listed Species

Federally-listed endangered or threatened species occurring in one or more counties of interest include the following five species:

- Indiana bat (*Myotis sodalis*), federally-listed as endangered (FWS, 2010; PNHP, 2011a);
- Bog turtle (*Glyptemys muhlenbergii*), federally-listed as threatened (FWS 2010; PNHP, 2011a);
- Shortnose sturgeon (*Acipenser brevirostrum*), federally-listed as endangered (FWS, 2010; PNHP, 2011a)
- Dwarf wedgemussel (*Alasmidonta heterodon*), a small freshwater mussel, federally-listed as endangered (FWS, 2010, PNHP, 2011a); and
- Small-whorled pogonia (*Isotria medeoloides*), a perennial orchid, federally-listed as threatened (FWS, 2010; PNHP, 2011a).

Of the five species listed above, only the shortnose sturgeon is a marine species under the jurisdiction of the NOAA Fisheries Service.

No areas designated by the FWS as critical habitat for threatened or endangered species exist at the LGS plant site, the LGS makeup water supply system, or along the LGS transmission system corridors. Of the species listed above, only the Indiana bat has FWS-designated critical habitat areas, but none are located in Pennsylvania.

2.5.2 State Listed Species

State-listed endangered or threatened species in one or more counties of interest are listed in Table 2.5-1. They include the following:

- Three mammal species, including the federally-listed Indiana bat;
- Twelve bird species;
- Six reptile and amphibian species, including the federally-listed bog turtle;
- Five fish species, including the federally-listed shortnose sturgeon;
- One invertebrate species, the dwarf wedgemussel, which is also federally-listed; and
- 116 plant species, including the federally-listed small-whorled pogonia.

In addition, Pennsylvania, in 17 PA Code § 45.14, lists plant species that are classified as rare, but these species are not included in this report.

The bald eagle (*Haliaeetus leucocephalus*) and osprey (*Pandion haliaetus)* are no longer on the *Endangered Species Act* list of federally protected species, but remain protected by two other federal laws, including the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act (MBTA). The bald eagle is state-listed as a threatened species and is known to occur in Montgomery, Chester, and Bucks Counties. The osprey also is state-listed as a threatened species and is known to occur in Chester and Bucks Counties.

A search of PNHP's Pennsylvania Natural Diversity Inventory (PNDI) online database was conducted for areas involved with project features. At both the LGS plant site and the

Bradshaw Reservoir areas, the potential presence of state-listed-as-threatened, unnamed "Sensitive Species" under the jurisdiction of the PFBC was identified. In addition, the PNDI search for the Point Pleasant Pumphouse area identified (1) the potential presence of the lance-leaf loosestrife (*Lysmachia hybrida*), which is proposed for state–threatened status, and (2) the potential presence of one state-listed-as-threatened and one state-listed-as-endangered, unnamed "Sensitive Species" under the jurisdiction of the PFBC.

Appendix C includes copies of correspondence sent to and received from the FWS, PGC, DCNR, and PFBC in response to Exelon Generation's requests for information on listed threatened or endangered species. The letters to the PFBC and DCNR included requests for additional information regarding the PNDI search results, which were attached thereto. In general, the contacted agencies commented that, even though there may be species or resources of concern under agency of jurisdiction located in the vicinity of the project, the proposed license renewal of LGS is not likely to adversely impact these species, predicated on project involving no new construction, earth disturbance, or changes to existing land use.

2.5.3 Essential Fish Habitat

The Mid-Atlantic Fishery Management Council oversees 17 species of fish and shellfish (NEFSC, 2010); none of these marine species are found in the freshwater portions of the Delaware River, nor were they found in surveys of the river near the Point Pleasant Pumping Station (refer to Table 2.2-6) [NRC, 1984; RMC, 1984; RMC, 1985; RMC, 1986]. The Essential Fish Habitat Mapper v2.0 was also reviewed. No EFH is located in inland waterbodies; EFHs in the Delaware Estuary are found only as far upriver as Salem, NJ (NOAA, 2010).

2.5.4 Surveys of Listed Species

2.5.4.1 Aquatic

No ironcolor shiners (*Notropis chalybaeus*), banded sunfish (*Enneacanthus obesus*), or longear sunfish (*Lepomis megalotis*) have been found during fish surveys of the Schuylkill River, Perkiomen Creek, East Branch Perkiomen Creek, or Delaware River performed between 1970 and 2009 using various sampling gear (AEC, 1973; NRC, 1984; PECO, 1984; RMC, 1984; RMC, 1985; RMC, 1986; RMC, 1987; RMC, 1989; PECO, 1990; PECO, 1991; PECO, 1992; PECO, 1993; PECO, 1994; PECO, 1995; PECO, 1996; PECO, 1997; PECO, 1998; PECO, 1999; PECO, 2000; Exelon Generation, 2001; Exelon Generation, 2002; Exelon Generation, 2003; Exelon Generation, 2004; Exelon Generation, 2005; NAI, 2010a; NAI, 2010b; NAI, 2010c).

Ironcolor shiner is known from a tributary to the upper Delaware River, but its presence in the lower river has not been confirmed (Steiner, 2002, Ch. 11). Although banded sunfish is identified in Table 2.5-1 for Bucks County, this species is only known to be present in the lower Delaware River watershed (Steiner, 2002, Ch. 22). Based on 2007 data, the PNHP identified historic records (prior to 1980) of this species in Philadelphia and Bucks Counties, but current records were only found in Delaware County (PNHP, 2011c). PNHP data for eastern Pennsylvania indicate that historic records exist for longear sunfish in Bucks County, but no current (1980+) records occur in the LGS area (PNHP, 2011d).

Shortnose sturgeon (*Acipenser brevirostrum*) is both federally-listed and state-listed as endangered. The species historically occured in the Delaware River as far upriver as

Lambertville, NJ, but not as far as the Point Pleasant Pumping Station (NRC, 1984, p.4-51). Surveys were made in the Delaware River in the vicinity of the Point Pleasant Pumping Station for juvenile and adult fish in 1972-73 and for ichthyoplankton between 1982 and 1985. These surveys found no shortnose sturgeon (NRC, 1984; RMC, 1984; RMC, 1985; RMC, 1986). During the Delaware River Seine Survey made from 1980 to 2009 between the saltwater/freshwater interface and the fall line at Trenton, NJ, only one sturgeon was collected (NJDEP, 2010). A young-of-year shortnose sturgeon was captured in 2004 slightly downriver of the Commodore Barry Bridge (NJDEP, 2010). Note that Commodore Barry Bridge connects Chester, PA and Bridgeport, NJ, which are downriver of the Point Pleasant Pumping Station.

Atlantic sturgeon (*A. oxyrhynchus)*, which is state-listed as endangered, also utilizes the Delaware River for spawning. This species was found as far upriver as Bordentown, NJ, which is downriver from the Point Pleasant Pumping Station, during surveys between 1958 and 1980 (Brundage and Meadows, 1982). Similar to shortnose sturgeon, surveys performed for LGS did not identify Atlantic sturgeon (NRC, 1984; RMC, 1984; RMC, 1985; RMC, 1986). A survey was made of the Delaware River from the entrance of the bay upriver to Trenton, NJ in 2005 and 2006 (Simpson and Fox, undated). This netting and telemetry study collected and re-located individuals as far upriver as Trenton, NJ (Simpson and Fox, undated).

The species *Alasmidonta heterodon* (dwarf wedgemussel) was not identified during benthic surveys of the Schuylkill River, Perkiomen Creek, and East Branch Perkiomen Creek performed between 1970 and 2009 (AEC, 1973, Table B.1; PECO, 1984, Table 2.2-44; RMC, 1984, Tables 4.2-1 and 6.2-1; RMC, 1985, Tables 4.2-1 and 6.2-1; RMC, 1986, Tables 4.2-2 and 6.2-1; RMC, 1987, Tables 4.2-1 and 6.2-1; RMC, 1989, Table 3.2-1; NAI, 2010b, p. 9]. However, unidentified species of the genus *Alasmidonta* were found in the Schuylkill River during sampling between 1970 and 1976 and were termed rare (PECO, 1984, Table 2.2-13). It is uncertain if dwarf wedgemussel was present during that time.

No aquatic macrophytes listed in Table 2.5-1 were found during past surveys (PECO, 1984, Table 2.2-12; AEC, 1973, Table A.1).

2.5.4.2 Terrestrial

No observations of state- or federally-listed threatened or endangered terrestrial species at or in the vicinity of the LGS plant site have been documented in the following reports:

- The Annual Non-Radiological Environmental Operating Reports submitted to the NRC through 2005 in accordance with the LGS Environmental Protection Plan (PECO, 1999; PECO, 2000; Exelon Generation, 2001; Exelon Generation, 2002; Exelon Generation, 2003; Exelon Generation, 2004; Exelon Generation, 2005);
- LGS Non-Radiological Environmental Monitoring Reports, 1979-1988, reporting on cooling tower bird mortality (RMC, 1984; RMC, 1985; RMC, 1986; RMC, 1987); and
- Wildlife Habitat Council's Site Assessment and Wildlife Management Opportunities for Exelon Corporation's Limerick Generating Station (WHC, 2006).

However, as previously stated (see Section 2.4.2), the following state-listed species have been documented in species inventory tables contained in the LGS Wildlife Management Plan (WMP) (Exelon Generation, 2010c, Tables 1 and 2):

- The American Holly (*Ilex opaca*), which is state-listed as threatened, was observed on the LGS plant site in 1978; and
- The American bittern (*Botaurus lentiginosus*), Great egret (*Casmerodius albus*), Blackpoll warbler (*Dendroica striata*), Yellow-bellied flycatcher (*Empidonax flaviventris*), Peregrine falcon (*Falco peregrinus*), Bald eagle (*Haliaeetus leucocephalus*), Least bittern (*Ixobrychus exilis*), Yellow-crowned night heron (*Nyctanassa violacea*), Black-crowned night heron (*Nycticorax nycticorax*), and Osprey (*Pandion haliaetus*), which are state-listed either as threatened or endangered, were observed during bird surveys conducted during the period of 1972 to 1985.

Although reported in the WMP as having been observed on LGS-associated properties in the 1970s and 1980s, Exelon Generation is not aware that any of the species listed above recently has been present on or near the LGS plant site, makeup water supply system, or transmission lines.

Bald eagles have not been confirmed breeders within the Upper Schuylkill River conservation landscape of which the LGS plant site is a part (Rhoads and Block, 2008).

Osprey is a confirmed breeder within the Middle Perkiomen Creek corridor (Rhoads and Block, 2008).

The PECO Avian Management Program provides guidance for the actions of PECO employees and contractor personnel whenever bird nests and/or dead birds are encountered during field operations. Such guidance complies with applicable migratory bird regulations (both federal and state), including the MBTA and the ESA. Through 2010, no birds listed in Table 2.5-1 have been recorded as nesting or dead for the LGS transmission system.

2.5.5 Surveys of Other Species

A search of PNHP's Pennsylvania Natural Diversity Inventory (PNDI) online database identified the potential presence in two locations at the LGS plant site of Pizzini's cave amphipod (*Stygobromus pizzinii*), a Pennsylvania invertebrate of special concern (PNHP, 2011a). The PNDI search also identified the potential presence of the Tooth-cup (*Rotala ramosior*), a Pennsylvania rare plant. This cave amphipod, while not state-listed as threatened or endangered, is state-ranked as critically imperiled in Montgomery and Chester Counties because of extreme rarity or vulnerability to extirpation from the state. The previously discussed consultation letters submitted to the PFBC and DCNR included requests for further information regarding these PNDI results. The response from the PFBC mentions that globally rare amphipod and/or isopod species are known from the vicinity of the project sites; however, PFBC anticipates that the proposed activity is not anticipated to have any significant adverse impacts on these species since no new construction, earth disturbance, or changes to existing land uses are involved. Similarly, the response from DCNR indicates that while it knows of the presence of the Tooth-cup near the Limerick to Cromby and the Cromby to Plymouth Meeting 230-kV transmission line routes, DCNR has determined that no impact is likely to occur to the species since the project will not involve new construction, refurbishment, ground disturbance, changes to operations or existing land use conditions.

Stygonectes pizzinii, a synonym for *Stygobromus pizzinii*, or Pizzini's cave amphipod, was collected from the Schuylkill River between 1970 and 1976 (PECO, 1984, Table 2.2-13)]. Unidentified *Stygonectes* sp. were collected in the Perkiomen Creek and East Branch

Perkiomen Creek during the same time period (PECO, 1984, Table 2.2-44). Unidentified *Stygobromus* species were collected in 1983 from the East Branch Perkiomen Creek (RMC, 1984, Table 4.2-1) and from the Schuylkill River in 1985 and 1986 (RMC, 1986, Table 6.2-1; RMC, 1987, Table 6.2-1). Because individuals were not identified to species, it is uncertain whether any specimen collected in 1983, 1985 or 1987 was a Pizzini's cave amphipod. Other studies performed in the mid- to late-1980s and throughout the 2000s in the East Branch Perkiomen Creek failed to identify this amphipod genus or species (RMC, 1985, Table 4.2-1; RMC, 1987, Table 4.2-1; NAI, 2005, 2007, 2008a, 2008b, 2009, 2010a, 2010b). Field surveys of the benthic community in the Schuylkill River (1983, 1984, 1988, 2009) also did not find any individuals of Pizzini's cave amphipod (RMC, 1984, Table 6.2-1; RMC, 1985, Table 6.2-1; RMC, 1989, Table 3.2-1; NAI, 2010c).

2.6 Demography

2.6.1 Regional Demography

2.6.1.1 Population Sparseness and Proximity

The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) presents a population characterization method that is based on two factors: “sparseness” and “proximity” (NRC, 1996a). Sparseness measures population density and city size within 32.2 kilometers (20 miles) of a site and categorizes the demographic information as follows:

Demographic Categories Based on Sparseness		
Most sparse	1	Less than 40 persons per square mile and no community with 25,000 or more persons within 32.2 kilometers (20 miles)
	2	40 to 60 persons per square mile and no community with more than 25,000 or more persons within 32.2 kilometers (20 miles)
	3	60 to 120 persons per square mile or less than 60 persons per square mile with at least one community with 25,000 or more persons within 32.2 kilometers (20 miles)
Least sparse	4	Greater than or equal to 120 persons per square mile within 32.2 kilometers (20 miles)
Source: NRC (1996a)		

Proximity measures population density and city size within 80.4 kilometers (50 miles) and categorizes the information as follows:

Demographic Categories Based on Proximity		
Not in close proximity	1	No city with 100,000 or more persons and less than 50 persons per square mile within 80.4 kilometers (50 miles)
	2	No city with 100,000 or more persons and between 50 and 190 persons per square mile within 80.4 kilometers (50 miles)
	3	One or more cities with 100,000 or more persons and less than 190 persons per square mile within 80.4 kilometers (50 miles)
In close proximity	4	Greater than or equal to 190 persons per square mile within 80.4 kilometers (50 miles)
Source: NRC (1996a)		

The GEIS then uses the following matrix to rank the population category as low, medium, or high.

GEIS Sparseness and Proximity Matrix					
		Proximity			
		1	2	3	4
Sparseness	1	1.1	1.2	1.3	1.4
	2	2.1	2.2	2.3	2.4
	3	3.1	3.2	3.3	3.4
	4	4.1	4.2	4.3	4.4

Low Population Area		Medium Population Area		High Population Area

Source: NRC (1996a), pg. C-159

Exelon Generation Company, LLC (Exelon Generation) used 2010 data from the U.S. Census Bureau (USCB) with geographic information system software (ArcGIS®) to determine demographic characteristics in the vicinity of LGS. The calculations determined that approximately 1,365,850 people live within 32.2 kilometers (20 miles) of the LGS plant site, producing a population density of 420 persons per square kilometer (1,087 persons per square mile). Applying the GEIS sparseness measures results in the least sparse category, Category 4 (greater than or equal to 120 persons per square mile within 20 miles).

To calculate the proximity measure, Exelon Generation determined that approximately 8,311,616 people live within 80.4 kilometers (50 miles) of LGS, which equates to a population density of 409 persons per square kilometer (1,058 persons per square mile). Applying the GEIS proximity measures, the LGS region is classified as Category 4 (greater than or equal to 190 persons per square mile within 50 miles). Therefore, according to the GEIS sparseness and proximity matrix, the LGS region is in cell 4.4, with ranks of sparseness, Category 4, and proximity, Category 4, resulting in the conclusion that LGS is located in a high population area.

Note: People living in the following types of institutions/facilities on the date of the Census are counted as living at the institution/facility of residence rather than at any other former residence (USCB, 2010c):

- Correctional facilities (e.g., federal/state/local prisons, confinement/detention centers);
- Non-correctional facilities (e.g., adult/juvenile group homes, residential treatment centers, shelters);
- Long term medical facilities (e.g., psychiatric care facilities, nursing facilities); and
- Housing for students living away from their parental home (on- or off-campus).

2.6.1.2 Population Statistical Areas

All or parts of 22 counties and a number of Metropolitan Statistical Areas (MSAs) are located within 80.4 kilometers (50 miles) of LGS (see Figure 2.1.2 for a 50-mile vicinity map). LGS is within the Philadelphia-Camden-Wilmington Combined Statistical Area (CSA). The other MSAs in the area are: (1) Philadelphia, PA, (2) Lancaster, PA, (3) Reading, PA, and (4) York-Hanover, PA (USCB, 2003).

From 2000 to 2010, the population of the Philadelphia-Camden-Wilmington CSA increased from approximately 5,687,147 to approximately 5,965,343, an increase of 4.9 percent. LGS is primarily within Limerick Township, which is within Montgomery County. In 2010, the population of Limerick Township was 18,074.

The nearest major city is Philadelphia (64.4 kilometers or 40 miles southeast), with a 2010 population of 1,526,006 (USCB, 2010a).

2.6.1.3 Employee Residential Distribution

Table 2.6.1 shows the residential distribution of Exelon Generation employees stationed at LGS. The preponderance of employees resides in Montgomery County (41.3 percent), Berks County (30.3 percent), and Chester County (12.8 percent). Because most (about 84 percent) of LGS employees reside in these three counties, they are the counties with greatest potential to be affected by LGS license renewal in terms of land use, social services, and public facilities.

2.6.1.4 Population Projections in LGS Area

Data regarding past population statistics and future population forecasts for Montgomery County, Berks County, Chester County, Limerick Township and the Pottstown Metropolitan Region are provided in Section 2.8.1.

2.6.2 Minority and Low Income Populations

The U.S. Nuclear Regulatory Commission (NRC) performed environmental justice analyses for previous license renewal applications and concluded that a 80.4-kilometer (50-mile) radius could reasonably be expected to contain potential environmental impact sites and that the state is appropriate as the geographic area for comparative analysis (NRC, 2004). Exelon Generation used these standards for identifying the potentially affected minority and low-income populations for LGS license renewal.

Exelon Generation utilized data published by the USCB from the 2010 census. These data were analyzed using geographic information science software (ArcGIS®) to determine the environmental justice characteristics by census tract. All 1,978 census tracts within the 80.4-kilometer (50-mile) radius were analyzed.

Note: Exelon Generation followed the NRC guidelines for determining which census tracts are to be considered environmental justice areas based on minority populations and income levels. However, the Pennsylvania Department of Environmental Protection (PADEP) has lower thresholds than the NRC for considering a census tract as an environmental justice area as outlined in Environmental Justice Public Participation Policy (PADEP, 2004). Per PADEP guidance, if there is any census tract, entirely or in part, within this area of concern with a 30 percent or greater minority population or 20 percent or greater at or below the poverty level as defined by the USCB, the area of concern and the census tract together are considered an Environmental Justice Area.

2.6.2.1 <u>Minority Populations</u>

<u>U.S. Census Bureau Data</u>

The NRC Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues defines a “minority” population as: American Indian or Alaskan Native; Asian; Native Hawaiian or other Pacific Islander; Black Races, and Hispanic Ethnicity (NRC, 2004). Additionally, NRC’s guidance requires that other minority populations be considered in the following manner:

- All other single minorities are to be treated as one population and analyzed;
- Multi-racial populations are to be analyzed; and
- The aggregate of all minority populations are to be treated as one population and analyzed.

The guidance indicates that a minority population is large enough for consideration for environmental justice purposes if either of the following two conditions exists:

- The minority population in an individual census tract or environmental impact site exceeds 50 percent; or
- The minority population percentage of the environmental impact area is significantly greater (at least 20 percent) than the minority population percentage in the geographic area chosen for comparative analysis. (Note: NRC recommends using the overall state information where a given census tract is located as the basis for the comparative analysis.)

Exelon Generation reviewed USCB data for each census tract within an 80.4-kilometer (50-mile) radius to determine percentage of minorities in each census tract. Since the 80.4-kilometer (50-mile) radius includes census tracts located in four states, Exelon Generation reviewed data for Pennsylvania, New Jersey, Maryland, and Delaware. Each state was used as the geographic area for comparative analysis of the census tracts located in their respective states. These data are provided in greater detail in Table 2.6-3 and Table 2.6.4.

USCB data reviewed by Exelon Generation indicated the following percentages of individuals were considered minorities (aggregate for all races other than "white") as of the 2010 census:

- Pennsylvania – 18.0 percent
- New Jersey – 31.4 percent
- Maryland – 41.9 percent
- Delaware – 31.2 percent

Thus, in order to meet the requirements for an environmental justice area per NRC guidelines, tracts within their respective states must meet these minimum minority population percentages (aggregate for all races other than "white"):

- Pennsylvania – 21.6 percent
- New Jersey – 37.7 percent
- Maryland – 50.3 percent
- Delaware – 37.4 percent

Based on these guidelines, 685 of the 1,978 census tracts within an 80.4-kilometer (50-mile) radius exceed their respective state minority aggregate population percentages by 20 percent or more. Of these 685 census tracts, 415 census tracts have populations that are greater than 50 percent minority populations. The following is a brief summary of the number of census tracts, by state, within an 80.4-kilometer (50-mile) radius that meet the minimum NRC criteria to be considered an environmental justice area based on aggregate minority percentages.

- Pennsylvania – 529 census tracts (302 greater than 50 percent)
- New Jersey – 113 census tracts (81 greater than 50 percent)
- Maryland – 0 census tracts (0 greater than 50 percent)
- Delaware – 43 census tracts (32 greater than 50 percent)

Note: The above aggregate minority percentages do not include the total Hispanic population. This is due to the limitations inherent in USCB's methodology for categorizing those individuals of Hispanic descent. USCB presents the data for individuals of Hispanic descent in a manner that may double count individuals that have a multi-ethnic background. Thus, in order to prevent skewing of the data, Exelon Generation has not incorporated USCB data for Hispanics in the calculation of the aggregate minority numbers above. However, Exelon Generation has included Hispanic data when reviewing individual census tracts for environmental justice issues in the following sections as USCB presents the data for this purpose in such a way that the data is not skewed.

Broken down into specific groups, census data for Pennsylvania characterize the state population as follows (20 percent exceedance criteria in parentheses):

- 0.2 percent of the population as American Indian or Alaskan Native (0.24 percent)

- 2.7 percent Asian (3.24 percent);
- 0.0 percent Native Hawaiian or other Pacific Islander (0.0 percent)
- 10.8 percent Black races (12.96 percent)
- 2.4 percent all other single minorities (2.88 percent)
- 1.9 percent multi-racial (2.28 percent)
- 5.7 percent Hispanic ethnicity (6.84 percent)

The following is a summary of the number of census tracts in Pennsylvania that are considered environmental justice areas by ethnicity based upon 20 percent exceedance criteria:

- American Indian or Alaskan Native → 495 census tracts (0 tracts greater than 50 percent)
- Asian → 541 census tracts (2 tracts greater than 50 percent)
- Native Hawaiian or other Pacific Islander → 337 census tracts (0 tracts greater than 50 percent)
- Black races → 424 census tracts (191 tracts greater than 50 percent)
- All other single minorities → 337 census tracts (0 tracts greater than 50 percent)
- Multi-racial → 533 census tracts (0 tracts greater than 50 percent)
- Hispanic ethnicity → 368 census tracts (64 tracts greater than 50 percent)

Broken down into specific groups, census data for New Jersey characterize the state population as follows (20 percent exceedance criteria in parentheses):

- 0.3 percent of the population as American Indian or Alaskan Native (0.36 percent)
- 8.3 percent Asian (9.96 percent)
- 0.0 percent Native Hawaiian or other Pacific Islander (0.0 percent)
- 13.7 percent Black races (16.44 percent)
- 6.4 percent all other single minorities (7.68 percent)
- 2.7 percent multi-racial (3.24 percent)
- 17.7 percent Hispanic ethnicity (21.24 percent)

The following is a summary of the number of census tracts in New Jersey that are considered environmental justice areas by ethnicity based upon 20 percent exceedance criteria:

- American Indian or Alaskan Native → 92 census tracts (0 tracts greater than 50 percent)
- Asian → 44 census tracts (0 tracts greater than 50 percent)
- Native Hawaiian or other Pacific Islander → 115 census tracts (0 tracts greater than 50 percent)
- Black races → 143 census tracts (45 tracts greater than 50 percent)
- All other single minorities → 54 census tracts (0 tracts greater than 50 percent)
- Multi-racial → 114 census tracts (0 tracts greater than 50 percent)
- Hispanic ethnicity → 46 census tracts (14 tracts greater than 50 percent)

Broken down into specific groups, census data for Maryland characterize the state population as follows (20 percent exceedance criteria in parentheses):

- 0.4 percent of the population as American Indian or Alaskan Native (0.48 percent)
- 5.5 percent Asian (6.6 percent)
- 0.1 percent Native Hawaiian or other Pacific Islander (0.12 percent)

- 29.4 percent Black races (35.28 percent)
- 3.6 percent all other single minorities (4.32 percent)
- 2.9 percent multi-racial (3.48 percent)
- 8.2 percent Hispanic ethnicity (9.84 percent)

The following is a summary of the number of census tracts in Maryland that are considered environmental justice areas by ethnicity based upon 20 percent exceedance criteria:

- American Indian or Alaskan Native → 3 census tracts (0 tracts greater than 50 percent)
- Asian → 0 census tracts (0 tracts greater than 50 percent)
- Native Hawaiian or other Pacific Islander → 1 census tract (0 tracts greater than 50 percent)
- Black races → 0 census tracts (0 tracts greater than 50 percent)
- All other single minorities → 0 census tracts (0 tracts greater than 50 percent)
- Multi-racial → 3 census tracts (0 tracts greater than 50 percent)
- Hispanic ethnicity → 0 census tracts (0 tracts greater than 50 percent)

Broken down into specific groups, census data for Delaware characterize the state population as follows (20 percent exceedance criteria in parentheses):

- 0.5 percent of the population as American Indian or Alaskan Native (0.6 percent)
- 3.2 percent Asian (3.84 percent)
- 0.0 percent Native Hawaiian or other Pacific Islander (0.0 percent)
- 21.4 percent Black races (25.68 percent)
- 3.4 percent all other single minorities (4.08 percent)
- 2.7 percent multi-racial (3.24 percent)
- 8.2 percent Hispanic ethnicity (9.84 percent)

The following is a summary of the number of census tracts in Delaware that are considered environmental justice areas by ethnicity based upon 20 percent exceedance criteria:

- American Indian or Alaskan Native → 8 census tracts (0 tracts greater than 50 percent)
- Asian → 52 census tracts (0 tracts greater than 50 percent)
- Native Hawaiian or other Pacific Islander → 25 census tracts (0 tracts greater than 50 percent)
- Black races → 44 census tracts (19 tracts greater than 50 percent)
- All other single minorities → 44 census tracts (0 tracts greater than 50 percent)
- Multi-racial → 30 census tracts (0 tracts greater than 50 percent)
- Hispanic ethnicity → 42 census tracts (0 tracts greater than 50 percent)

Table 2.6-3 and Table 2.6-4 present the numbers of census tracts in each county in the 80.4-kilometer (50-mile) radius that exceed the NRC's environmental justice threshold for minority populations. Figures 2.6-1 to 2.6-8 display the minority census tracts within the 80.4-kilometer (50-mile) radius based on 20 percent exceedance of the state minority population percentages and census tracts that contain 50 percent minority populations.

PADEP Data

PADEP collected minority population data in 2004 based on 2000 census data (PADEP, 2005). These data, however, are organized by county rather than by census tract, which makes it difficult to compare USCB data to the 2004 PADEP data. However, Exelon Generation is providing a summary of the PADEP data for counties found within the 80.4-kilometer (50-mile) radius in Table 2.6-2. Please note that several counties are only partially located within the 80.4-kilometer (50-mile) radius. Of the county data provided in the table, the following Pennsylvania counties are located wholly within the boundaries of the 80.4-kilometer (50-mile) radius:

- Berks
- Bucks
- Chester
- Delaware
- Lehigh
- Montgomery
- Philadelphia

2.6.2.2 Low-Income Populations

NRC guidance defines low-income population based on statistical poverty thresholds (NRC, 2004) if either of the following two conditions is met:

- The low-income population in the census tract or the environmental impact site exceeds 50 percent; or
- The percentage of households below the poverty level in a census tract or an environmental impact area is significantly greater (typically at least 20 percent) than the low-income population percentage in the geographic area chosen for comparative analysis.

For recent poverty statistics, Exelon Generation compiled the U.S. Census 2005-2009 American Community Survey (ACS) 5-Year estimates. These data are population and housing characteristics-based on surveys collected from January 1, 2005 to December 31, 2009 (USCB, 2011). These data are provided in greater detail in the attached Table 2.6-5 and Table 2.6-6.

Note: Poverty data based on the 2010 census have not yet been published as of the date of this report. ACS data are the most up-to-date information available for poverty statistics.

Because the ACS data are estimates prior to the 2010 census, 2000 U.S. census tract geographic areas were used for the compilation of poverty data. Since census tract geographic boundaries changed between 2000 and 2010, tallies of census tracts in Table 2.6-5 and Table 2.6-6 cannot accurately be compared to tallies of minority populations (Table 2.6-3 and Table 2.6-4), which were compiled for 2010 census tract geographic areas.

ACS data were reviewed for each census tract within an 80.4-kilometer (50-mile) radius to determine percentage of individuals below the poverty line in each census tract. Since the 80.4-kilometer (50-mile) radius includes census tracts located in four states, Exelon Generation reviewed data for Pennsylvania, New Jersey, Maryland, and Delaware. Each state was used as the geographic area for comparative analysis of the census tracts located in their respective states.

ACS data reviewed by Exelon Generation indicate the following percentages of individuals at or below the poverty line as of 2009:

- Pennsylvania – 12.1 percent
- New Jersey – 8.8 percent
- Maryland – 8.2 percent
- Delaware – 10.5 percent

Thus, in order to meet the requirements for an environmental justice area per NRC guidelines, tracts within their respective states must meet the minimum population poverty percentages (20 percent exceedance of state percentage):

- Pennsylvania – 14.5 percent
- New Jersey – 10.6 percent
- Maryland – 9.8 percent
- Delaware – 12.6 percent

Based on these guidelines, 596 of the 1,931 census tracts within an 80.4-kilometer (50-mile) radius exceed their respective state poverty rates by 20 percent or more. Of these 596 census tracts, 55 census tracts have populations that are greater than 50 percent at or below the poverty line. The following is a brief summary of the number of census tracts, by state, within an 80.4-kilometer (50-mile) radius that meet the minimum NRC criteria to be considered an environmental justice area based on income levels:

- Pennsylvania → 429 census tracts (44 tracts greater than 50 percent)
- New Jersey → 119 census tracts (6 tracts greater than 50 percent)
- Maryland → 5 census tracts (0 tracts greater than 50 percent)
- Delaware → 43 census tracts (5 tracts greater than 50 percent)

Table 2.6-3 and Table 2.6-4 present the numbers of census tracts in each county in the 80.4-kilometer (50-mile) radius that exceed the NRC's environmental justice threshold for minority populations. Table 2.6-5 and Table 2.6-6 present the numbers of census tracts in each county in the 80.4-kilometer (50-mile) radius that exceed the NRC's environmental justice threshold for low-income population. Figure 2.6-9 and Figure 2.6-10 also offer a graphic description of the locations of the census tracts meeting the NRC's thresholds for environmental justice consideration based on low-income population. The first figure depicts census tracts where populations exceed the state poverty percentages by at least 20 percent, whereas the second figure depicts census tracts that have absolute poverty rates of at least 50 percent.

2.7 Taxes

Exelon Generation Company, LLC (Exelon Generation) pays real estate taxes directly to local taxing authorities for the property parcels associated with features of the LGS project that the company owns. Section 2.1 defines the project features and their locations. The taxing authorities include the counties, municipalities, and school districts in which these properties are located. Since the property parcels associated with LGS are located only in Montgomery, Chester, and Bucks counties, no tax discussion is applicable for Berks County.

Of the project features defined in Section 2.1, Exelon Generation is the sole owner of the LGS plant site and the following components of the LGS makeup water supply system: the

Perkiomen Pumphouse, the Bradshaw Reservoir; the Bradshaw Pumphouse; and the Bedminster Water Processing Facility. PECO, rather than Exelon Generation, owns or has rights to the LGS transmission system beyond the two onsite substations.

The discussion of taxes in this section is limited to the taxes paid by Exelon Generation, because it is assumed that taxes paid by PECO for the LGS transmission system would continue, whether or not the LGS operating licenses are renewed.

Table 2.7-1 shows the tax payments made by Exelon Generation for LGS from years 2006 - 2010. Table 2.7-2 lists the 2010 budgets for each of the LGS taxing authorities and the percentages of the 2010 budget represented by LGS tax payments. The budgets are funded through payments made to the local government jurisdictions either directly (e.g., property tax payments) or indirectly (e.g., state tax and revenue-sharing programs). In all cases, the LGS property tax payments represent a small percentage (generally 3.1 percent or less) of the budget for each of the taxing authorities.

Currently, Exelon Generation pays the majority of its annual real estate taxes to Limerick Township/Montgomery County and the Spring-Ford Area School District because most of the taxable Exelon Generation-owned LGS assets are located in Limerick Township. Limerick Township provides a portion of these taxes to Montgomery County to fund county services such as county operations, the judicial system, public safety, public works, cultural and recreational programs, human services, and conservation and development programs. Limerick Township property tax revenues fund various operations, including libraries, hospitals, roads, school districts, and fire departments. The Exelon Generation payments to Limerick Township and the Spring-Ford Area School District represent approximately 3.1 percent of the Township's budget and 2.2 percent of the School District's budget, respectively.

Real estate taxes paid by Exelon Generation to the following taxing authorities represent less than one percent of each of their respective budgets:

- Lower Pottsgrove Township/Montgomery County and the Pottsgrove School District;
- East Coventry Township/Chester County and the Owen J. Roberts School District;
- Plumstead Township/Bucks County and the Central Bucks School District; and
- Bedminster Township/Bucks County and the Pennridge School District.

2.8 Land Use Planning

This section provides information on local plans concerning land use and zoning that are relevant to population growth, housing, and changes in land use patterns. Land use issues related to the LGS plant site and the surrounding area are associated with county, regional, and local planning bodies. Refer to Section 2.1 for descriptions of the features and locations of LGS project components.

Due to (1) the location of the LGS plant site in two counties (Montgomery and Chester) and three townships (Limerick and Lower Pottsgrove in Montgomery County and East Coventry in Chester County); (2) most (greater than 84 percent) of LGS employees residing in Montgomery, Berks, and Chester counties; and (3) the proximity of LGS to the Borough of Pottstown, which is the nearest population center, information is provided herein related to the following land use planning entities:

- Montgomery County;
- Berks County;
- Chester County;
- Pottstown Metropolitan Regional Planning Committee; and
- Limerick Township

2.8.1 Background

U.S. Census Bureau (USCB) and Delaware Valley Regional Planning Commission (DVRPC) data regarding past population statistics and future population forecasts indicate that Montgomery County, Berks County, and Chester County have experienced growth over the last two decades (1990-2010) and are projected to continue growing through 2035.

Note: USCB population data are presented for 1990 through 2010. A combination of DVRPC and USCB population projection data are provided to show a comparison between what the local regional planning agency and the federal government project for future growth in Montgomery and Chester counties, including municipal populations. Berks County Planning Commission data are presented for population projections within Berks County. All data sources are provided in parentheses.

- Montgomery County Population Trend
    - 1990: 678,111 (USCB)
    - 2000: 750,097 (USCB)
    - 2010: 799,874 (USCB)
    - 2020 (est.): 854,994 (USCB)
    - 2025 (est.): 860,816 (DVRPC)
    - 2030 (est.): 888,265 (USCB)
    - 2035 (est.): 894,136 (DVRPC)

- Berks County Population Trend
    - 1990: 336,523 (USCB)
    - 2000: 373,638 (USCB)
    - 2010: 411,442 (USCB)
    - 2020 (est.): 421,304 (Berks County Data Book 12/11/07)
    - 2030 (est.): 446,582 (Berks County Data Book 12/11/07)

- Chester County Population Trend
    - 1990: 376,396 (USCB)
    - 2000: 433,501 (USCB)
    - 2010: 498,886 (USCB)
    - 2020 (est.): 604,385 (USCB)
    - 2025 (est.): 582,047 (DVRPC)
    - 2030 (est.): 692,054 (USCB)
    - 2035 (est.): 622,498 (DVRPC)

The Pottstown Metropolitan Region is comprised of several towns found within Chester County and Montgomery County that are in the immediate vicinity of the Borough of Pottstown. Minor portions of the LGS plant site are located within this region, but most of the site is located immediately adjacent to this region and plays a role in the economic vitality of the region. The following municipalities make up the Pottstown Metropolitan Region:

- Montgomery County
    - West Pottsgrove Township
    - Upper Pottsgrove Township
    - Lower Pottsgrove Township
    - Douglass Township
    - New Hanover Township
    - Pottstown Borough

- Chester County
    - East Coventry Township
    - North Coventry Township

The population trend for the Pottstown Metropolitan Region is as follows (DVRPC Municipal Data Navigator):

- 1990: 62,743
- 2000: 70,783
- 2010: 79,261
- 2025 (est.) 91,597
- 2035 (est.) 98,233

Additionally, Limerick Township has experienced a population increase since 1990. For example, based on USCB and DVRPC data, between the 1990 and 2010 census, Limerick Township grew its population by 170.1 percent. The rate of growth is not forecasted to continue at this level, but growth is expected to continue within Limerick Township:

- 1990: 6,691
- 2000: 13,534
- 2010: 18,074
- 2025 (est.): 21,802
- 2035 (est.): 24,000

2.8.2 Land Use and Planning Goals

Regional and local planning officials have shared goals of encouraging expansion and development in areas where dense development is already in existence and public facilities, such as water and sewer systems, have been planned, and discouraging incompatible land use mixes in agricultural or open spaces.

The planning for both counties is driven in part by the Pennsylvania Municipalities Planning Code Act of 1968 (Act), which promotes the preservation of natural and historic resources and prime agricultural land and encourages the revitalization of established urban centers through the use of Designated Growth Areas. The Act requires comprehensive planning on the part of counties. It is worth noting that, due to the autonomous nature of the local municipalities (townships, villages and boroughs) in Pennsylvania, a county has limited legislative scope to implement the comprehensive plans. As a result, partnerships and coalitions of governing bodies are needed to implement the plans. Montgomery County, Berks County, and Chester County implement their comprehensive plans through townships and boroughs ordinances as well as regional planning units.

2.8.2.1 Montgomery County

The goals of the Montgomery County Comprehensive Plan are to reduce sprawl, revitalize older areas, preserve open space, and provide new housing and employment opportunities while meeting market demand (MCPC, 2005a).

There are 62 municipalities within Montgomery County and all 62 municipalities in the county have officially adopted zoning ordinances, including zoning maps. In accordance with the Municipalities Planning Code, each municipality is required to submit all proposed zoning ordinance or map amendments to the county planning commission for review.

Regarding existing land use within Montgomery County, much of the county (over 54 percent) is already developed. According to Montgomery County data, the remaining 46 percent of the county consists of farmland, vacant land, woodlands, recreation land, and water with over 9 percent of the county permanently preserved as open land. Thus, approximately 36 percent of the county's open land is available for possible future development (MCPC, 2005a).

As of 2000, Montgomery County included a variety of land use types that was dependent upon historic rail and highway developments. No single area of Montgomery stands out as the center of any land use type; rather there are multiple centers for such land use types as urban towns, suburban areas, farmland, and countryside. These land use patterns have not, historically, been governed by county land use plans; rather, the county is divided into sixty-two municipalities each responsible for its own planning and zoning. Table 2.8-1, taken from the 2005 version of the Montgomery County Comprehensive Plan, shows the types of land uses in the county and proportions of each land use type. Based on this table, it is apparent that the three primary land use types found in Montgomery County as of 2000 are single family detached housing, agricultural or undeveloped land, and woodland.

The Montgomery County Planning Commission (MCPC) further outlines several focused development areas within the county. These two areas are Pottstown and the US-422 Corridor. The following descriptions are taken from MCPC documents (MCPC, 2005a):

> *Pottstown*: Pottstown has historically been home to large-scale manufacturing and industrial employers such as Bethlehem Steel and Mrs. Smith's Pie Company. While some of this industrial base has declined, Pottstown remains an important regional employment and educational center in the western portion of the county. Pottstown is also home to a sizeable downtown historic district. Over the next 25 years, with the opening of the Schuylkill Valley Metro[3], Pottstown will have more office buildings, a vibrant downtown with more specialty retail uses and residences, and significant educational and cultural facilities, while keeping its current industrial base. In addition, the Schuylkill River and trail[4] will play a more prominent role in the borough.
>
> *US-422 Corridor*: This rapidly suburbanizing corridor, which is really a combination of nodes located near interchanges in Limerick and Upper Providence, includes large pharmaceutical companies and other employers at certain interchanges and significant residential development and shopping

[3] As stated in Section 2.9.2, this project is not currently active due to lack of funding.
[4] Refer to Section 2.1.3 for the Schuylkill River Trail.

> centers at other interchanges. Over time, Upper Providence will get more service, retail, and residential uses to support the major employers while Limerick will see more office and industrial employment to complement its present uses.

Montgomery County has outlined several goals for future land development within the county. Due to the nature of municipal-based planning and zoning regulations, these goals are highly dependent upon municipalities for implementation. The primary goals for future development are:

- Almost all new development should be built in Designated Growth Areas and Existing Developed Areas;
- Development should preserve and protect environmentally-sensitive land, including floodplains, steep slopes, wetlands, and woodlands, except for development of flood-proofed buildings on brownfield sites in redeveloping areas; and
- All development should fit into its surroundings, matching positive characteristics of the neighborhood.

Development trend data for Montgomery County show that applications for new development reached an all-time high between 2000 and 2004. Since 2004, however, applications for development have been steadily decreasing. For example, in 2009 the MCPC received 484 applications for subdivision, land development, and zoning ordinance and map amendments. This was 28 percent less than in 2008. The total number of submissions has decreased for five straight years and is now the lowest it has been since 1970, when comparable county records began being recorded. The total acreage proposed for development has followed similar trends to the total number of applications submitted to Montgomery County. Total land acreage proposed for development in 2009 decreased by 28 percent from 2008 numbers, has decreased every year since 2004, and has reached historic 1970 lows. Conclusions reached by the MCPC in its “2009 Annual Summary: Subdivision, Land Development, and Zoning Activity” report state the following (MCPC, 2009):

> “The deepening declines in the last three years are the result of a staggering economy marked by high unemployment and severely tightening financial constrictions from creditors. Some prior plans, even if approved, lay dormant due to developers having either their own financial issues or just not being able to get necessary credit from lending institutions.”

2.8.2.2 <u>Berks County</u>

LGS features are not located in Berks County; however, approximately 30 percent of LGS employees reside in and commute from locations within Berks County. Thus, LGS has a direct economic impact on Berks County, especially the areas of the county in the nearest proximity to the LGS plant site. Berks County is 2,242 square kilometers (866 square miles) or approximately 224,182 hectares (553,967 acres) in size and made up of 74 municipalities (Berks County, 2003).

Within Berks County, the Berks County Planning Commission (BCPC) is responsible for developing and implementing the county’s comprehensive plan. Each municipality or group of municipalities also has their own municipal planning division through partnerships under the Joint Comprehensive Planning Program implemented by the BCPC in conjunction with the Berks County Community Development Office in 1992. This program allows for the full funding of comprehensive plans prepared by two or more cooperating municipalities within Berks County.

The goals of the Joint Comprehensive Planning Program, according to the county's comprehensive plan (Berks County, 2003) are as follows:

- Create a greater dialogue between the county and municipalities during the planning process;
- Improve the quality of local comprehensive plans; and
- Better implement the goals and objectives of the county's comprehensive plan.

By the end of 2006, over two-thirds of the County's municipalities had completed a plan under this program, with an additional nine municipalities in the process of completing a joint comprehensive plan or update. (Berks County, 2011).

According to 1999 land use data provided within the BCPC comprehensive plan (Berks County, 2003), Berks County is dominated by agricultural and woodland land use types. As of 1999, agriculture comprised 76,855 hectares (189,912 acres) of the total 224,182 hectares (553,967 acres), or 34.3 percent of total land area within the county. Woodland comprised 47,862 hectares (118,270 acres), or 21.3 percent of total land area within the county. Table 2.8-2 provides a summary of land uses in Berks County as of 1999.

Development trends within Berks County over the previous decade are similar to trends found within other counties in the region. Data provided within the Berks County Data Book (updated 12/11/2007) (BCPC, 2005) indicate an increase in new housing units within the county between 1997 (1,739 new housing units) and 2001 (2,787 new housing units). After 2002-2003 (2,200 new housing units), new housing units steadily declined through 2009 (1,112 new housing units). 2010 saw a 51.5 percent reduction in new housing units compared to 2009 units to 539 new housing units. 2010 represents the fewest number of new housing units within Berks County within the time period 1997-2010.

2.8.2.3 Chester County

Several LGS plant site property parcels and a portion of the exclusion area are located in Chester County. Also, approximately 13 percent of LGS employees reside in and commute from locations within Chester County. Thus, LGS has a direct economic impact on Chester County, especially the areas of the county in the immediate vicinity of the LGS plant site. Chester County is 1,972.8 square kilometers (762 square miles) or approximately 197,291 hectares (487,500 acres) in size and made up of 73 municipalities (CCPC, 2010a).

Within Chester County, the Chester County Planning Commission (CCPC) is responsible for developing and implementing the county's comprehensive plan. Each municipality also has its own municipal planning division. The county and individual municipalities coordinate their planning activities through a partnership known as the Vision Partnership Program and the overall planning guidelines found within their plan referred to as *Landscapes2* (CCPC, 2010b). According to the Chester County Comprehensive Policy Plan, the CCPC (2010b) implements this program in the following manner:

> "… by providing assistance to municipalities in refining their local planning programs. This assistance is primarily accomplished through Vision Partnership

Program (VPP) grants and community planning staff that directly assists municipalities on planning projects.

Through the Vision Partnership Program, municipalities receive professional planning services and financial assistance to help update their planning programs for consistency with *Landscapes2* as well as to achieve municipal planning goals. Municipalities may use VPP cash grants to retain the services of a professional planning consultant. In-kind grants may be used to retain Planning Commission staff for professional planning assistance."

According to 2005 land use records available through the DVRPC, land use in Chester County is dominated by agriculture land uses with 72,173.2 hectares (178,337.5 acres) of the total 196,575.4 hectares (485,731.3 acres), or 36.7 percent of total land area, located within the county used for agriculture (DVRPC, 2011). This represents roughly twice the area that is taken up by single-family land uses, which is the third highest user of land in the county. Table 2.8-3 provides a summary of land uses in Chester County as of 2005.

Development trends for Chester County are similar to those observed in Montgomery County. Mainly, 2009 saw sharp decreases in the number of planning and zoning applications submitted to the CCPC. These submittals represent proposed development in the immediate future for Chester County. The sharp decrease in submittals is likely due to a staggering economy and the difficulty that developers have been facing in finding financing for development projects. An improved economy coupled with the projected population increases would be expected to result in a rebound in development within the region through 2035 with economic cycles affecting short-term development trends. All future development is subject to review by local municipalities and Chester County for consistency with their comprehensive plans and zoning regulations.

According to the CCPC 2009 Annual Report, the CCPC received 239 plans for review in 2009 compared to 314 plans in 2008 (CCPC, 2009).

Some key indicators comparing development trends in 2008 and 2009 are listed below:

- 3,381 lots/units proposed in 2009 (8.87 percent decrease in number of lots/units proposed during 2009 over the previous year);
- 98 percent decrease in the number of sewage planning applications received in 2009 over the previous year;
- 3,053.1 hectares (7,544 acres) of land proposed for development in 2009;
- 19.3 kilometers (12 miles) of new road proposed for development;
- 0.90 hectares (2.23 acres) – the average area of proposed lot in 2009; and
- Of the 239 plans submitted for review, 97 percent were consistent with the county's comprehensive plan.

2.8.2.4 Pottstown Metropolitan Region

Land use planning within this region is governed by the Pottstown Metropolitan Region Intergovernmental Cooperative Implementation Agreement for Regional Planning (MCPC, 2005b). Each municipality provides two members to the governing body that reviews proposed land development and land use plans.

According to the Pottstown Metropolitan Regional Comprehensive Plan, (MCPC, 2005c) the goals of this agreement include:

- Protect the unique historical, cultural, and natural resources of the region.
- Promote the economic vitality and quality of life of the region's existing communities.
- Implement growth management techniques to provide for orderly and well-planned new development.
- Preserve open space and agriculture in the region.
- Develop transportation choices for better mobility in and through the region.
- Encourage walkable communities with a mix of uses and a range of housing options where appropriate.
- Promote new economic opportunities and jobs.
- Maintain and improve recreation options.
- Address the specific needs and unique conditions of each municipality.

The Pottstown Metropolitan Region originally developed during Pottstown's industrial era with surrounding villages and agrarian areas developing to support the population. Over time, more recent development trends have led to the suburbanization of the region. As of 2005, approximately 23 percent of the region's land has been developed for lower density housing. This has left approximately 39 percent of the land area as agriculture, open space, or undeveloped. Some of these lands are permanently preserved for agriculture or parkland, but large areas of prime developable land still exist in the region.

Table 2.8-4 provides a summary of land use types found within the Pottstown Metropolitan Region as of 2005.

The Pottstown Metropolitan Region is directly affected by the expansion of suburban sprawl emanating from the City of Philadelphia and its suburbs. In an effort to direct this growth to areas presently serviced by public infrastructure, redevelop existing urban areas, preserve open space, and limit suburban sprawl, the planning commission has designated specific areas within the region as designated growth areas. According to the region's comprehensive plan,

> "The designated growth areas provide sufficient, but not excessive, land area for new growth in order to encourage reinvestment in the existing developed centers. Outside of the designated growth areas, the primary objective is to preserve the rural landscape and natural resources thereby sustaining the environment and enhancing livability."

However, public sewer or water will not be provided to rural areas outside of designated growth areas in an effort to limit development in these areas.

The regional planning commission has divided the Pottstown Metropolitan Region into seven different land use categories. The future land use categories are as follows:

- Metropolitan Center
- Community Mixed Use Center
- Village Center
- Regional Retail

- Regional Commerce
- Suburban Residential
- Rural Resource Area

The comprehensive plan further defines allowable uses and development goals for each land use type, and also provides the process for review and approval of each land use type. The regional planning commission is in the process of developing a land use map for the region that will include designated areas for each of these land use types.

2.8.2.5 Limerick Township

Limerick Township, the primary location of the LGS plant site and one of 62 municipalities in Montgomery County, encompasses approximately 57.0 square kilometers (22 square miles).

The following excerpt is taken from the Limerick Township Comprehensive Plan (March 2009; Simone Collins Landscape Architecture, 2009):

> "In recent years, the township has largely been shaped by trends and developments from outside the township's limits including regional growth and infrastructure improvements. Montgomery County is one of Pennsylvania's wealthiest and fastest growing counties, and Limerick's location roughly in the center of the county has made rapid development somewhat inevitable. The opening of U.S. Route 422 in the mid-1980s provided fast and convenient access to Limerick and is the major reason the population more than doubled in the 1990s. Growth was further bolstered by the Limerick Township Municipal Authority, which has continued to support new development and expand its service area."

With the increase in population, creation of major roadway arterials such U.S. Highway (US-) 422, land uses within the township have changed a great deal since the 1980s. The township, which was historically a rural farming community, has evolved into a suburban community with residential subdivisions, commercial land uses, and retail development.

According to the Limerick Township Comprehensive Plan, most residential growth is dispersed across the southern two-thirds of the township (Simone Collins Landscape Architecture, 2009). Commercial uses are spreading along Limerick's arterial roadways. Ridge Pike in particular provides a significant amount of commercial land, as do the township's three interchanges on US-422. The Philadelphia Premium Outlets, for example, which opened in 2007, boasts 150 outlet stores at the Sanatoga Interchange.

Table 2.8-5 provides a summary of land use types found within Limerick Township as of 2007. Single-family residential development was the land use utilizing the greatest percentage of land area within the township. Open space was the second greatest user of township land. According to the township's comprehensive plan, much of the open space areas are no longer in active agriculture in anticipation of future development.

Limerick Township has developed several general goals and objectives to direct future land use within the township. Each of these goals has more specific criteria outlined within the comprehensive plan. According to the comprehensive plan, these general goals are as follows:

- Maintain and enhance economic vitality;
- Preserve and enhance natural and historic resources and stabilize previously damaged resources;
- Maintain and enhance all forms of transportation and create linkages to local and regional transportation infrastructure;
- Enhance the quality of life of township residents;
- Conserve resources and energy in all forms;
- Provide a wide variety of housing choices for township residents; and
- Promote the enhancement of the township's cultural resources and facilities.

These goals are further developed by inclusion in and development of Limerick Township's Zoning Ordinance, the Subdivision and Land Development Ordinance (SALDO), other township policies and programs, and the capital improvement program.

According to the township, the Future Land Use Plan (Simone Collins Landscape Architecture, 2009):

> "…prescribes changes in intensity and type of use and guides the character of development to promote growth in centers, conservation of natural resources in rural areas, and the enhancement of community facilities in developed parts of the township. Specific districts are delineated that are generally consistent with the existing boundaries of township zoning."

The details of the Future Land Use Plan, including proposed zoning changes, development districts, and administration of the Future Land Use Plan are laid out in great detail within Section 4: Growth Management Recommendations of the Limerick Township Comprehensive Plan (Simone Collins Landscape Architecture, 2009).

2.8.3 Social Services and Public Facilities

2.8.3.1 <u>Public Water Supply</u>

Because LGS is located in Limerick Township, Montgomery County and most (greater than 84 percent) of the LGS employees reside in Montgomery, Chester, and Berks Counties, the discussion of public water supply systems includes these three counties. Information on the public water systems serving these counties was obtained by querying the U.S. Environmental Protection Agency (EPA) Safe Drinking Water Information System (SDWIS) database (EPA, 2011a) and the Pennsylvania Department of Environmental Protection (PADEP) Drinking Water Reporting System (DWRS) database (PADEP, 2011a).

<u>Montgomery County</u>

Montgomery County is served by 39 community water systems serving a population of 1,220,427. The systems are owned by various entities, including municipalities, authorities, investors and the state government. In addition to the large public systems, there are small private systems provided for some mobile home parks.

The largest populations served are those receiving water from Aqua Pennsylvania, Inc. (820,000 persons served), Pennsylvania American Water Company - Norristown (91,000 persons), and the North Wales Water Authority (68,656 persons) (EPA, 2011a). The sources for the larger systems are primarily surface water (i.e., various creeks, streams and a reservoir), while the majority of the smaller systems are dependent upon groundwater sources. Surface water is the source for 77 percent of the water provided in the county.

County planners state that, of the seventeen major public water suppliers in the county, only three may experience a water supply deficiency without expanding their existing dependable water supply. None of the 17 water purveyors, however, will have a significant water supply deficit based upon the 2025 population that could not be easily satisfied by the development of just one additional source or use of an existing interconnection (MCPC, 2005a). Table 2.9-1 lists the largest municipal water suppliers (each serving greater than 10,000 people) in Montgomery County and provides data on production and capacity.

Berks County

From the year 2000 to 2009, Berks County's population grew by an estimated 9 percent, reflecting an increase in the demand for potable water. Water to match the increased demand was supplied by community water suppliers. Individual on-site wells meet the water supply needs of residents elsewhere in the county.

The Comprehensive Plan (Berks County, 2003) discusses the necessity of community facilities to provide for the basic, everyday needs of County residents, which includes water supply service, and that the level of service should take into account the existing development density and the future growth potential for a specific area. The Plan states:

> "The availability of public sewer and water systems allow local governments to plan for future residential, commercial, and industrial growth at densities that are economically feasible to support the systems. Guiding suburban and urban density development to those areas of the County that already have sewer and water infrastructure and/or are directly adjacent to existing infrastructure can help prevent development from occurring in areas that are not capable of economically supporting new infrastructure."

The Berks County Comprehensive Plan outlines some goals for the management of available water supplies. These include:

- Directing new development to areas that currently have public water and some level of excess capacity, or to areas that can expand for additional capacity;
- Protecting water quality by creating wellhead or similar source protection areas and prohibiting incompatible uses near surface water;
- Protecting water quantity through promoting water conservation, maintaining water lines, and placing conditions on water extraction for bottling and sale offsite;
- Increasing connection of on-site wells, serving on a single lot, to community supply systems;
- Encouraging consolidation of smaller water companies, to help secure funding, while discouraging new smaller water companies serving a small area; and
- Assigning county offices to lead efforts for a water system cooperative program.

Several municipalities own or hold easements/water rights to land throughout Berks County for the purpose of protecting their water supply. Table 2.9-2 lists the ten largest suppliers of water in Berks County and provides data on production and capacity. Surface water is the source of six of the 10 largest water suppliers in Berks County (EPA, 2011a).

Chester County

Chester County is served by 83 community water systems serving a population of 223,416. The systems are owned by various entities, including municipalities, authorities, and investors. In addition to the large public systems, there are small private systems provided for some mobile home parks, hospitals, retirement and nursing homes, schools, farms, and the like. The largest populations served are those receiving water from PA American Water Company (PA American) (44,000 persons served), PA American – Coatesville (35,600 persons), and the Aqua Pennsylvania, Inc. – West Chester (35,000 persons) (EPA, 2011a). The primary source for most of the larger systems is surface water (i.e., various creeks, streams and a reservoir), while the majority of the smaller systems are dependent upon groundwater sources. Surface water is the primary source for approximately 70 percent of the water provided in Chester County, including nine of its 10 largest water suppliers (EPA, 2011a).

The Chester County Comprehensive Policy Plan (CCPC, 2010b) outlines some policies for the management of available water supplies. These include:

- Encouraging coordination of water and wastewater planning efforts, based on projections of growth and demand, evaluation of existing local treatment and supply capability, and assessment of new water supply sources;
- Supporting infrastructure expansion and improvements and adopted regional and local plans that support future demands, avoid capacity shortfall, and provide safe and reliable utility services;
- Supporting planning efforts that evaluate projected water withdrawals to identify long term local and regional water supplies;
- Promoting integrated water supply, wastewater, and land use planning efforts in conjunction with affected municipalities, counties, and utility service providers; and
- Maintaining, upgrading, or expanding existing water facilities to support redevelopment and new development in designated growth areas

Table 2.9-3 lists the largest municipal water suppliers (each serving greater than 3,000 people) in Chester County and provides data on production and capacity.

2.8.3.2 Transportation

Because LGS is located primarily in Limerick Township, Montgomery County, and most (greater than 84 percent) of the LGS employees reside in Montgomery County, Berks County, and Chester County, the discussion of transportation is focused on these three counties.

Aviation

The Heritage Field Airport (formerly known as the Pottstown Limerick Airport), located about 2.4 kilometers (1.5 miles) northeast of the LGS plant site, serves local and transient general aviation and air taxi and charter service. Other airports in the vicinity used for similar purposes are the Pottstown Municipal Airport located in Pottstown about 8.0 kilometers (5 miles) northwest of the LGS plant site, and the Reading Regional Airport located near the City of Reading about 32.2 kilometers (20 miles) northwest of the LGS plant site. Larger airports in the general area include the Lehigh Valley International Airport located in Allentown, about 49.9 kilometers (31 miles) north of the LGS plant site, and the Philadelphia International Airport, located near Philadelphia, about 49.9 kilometers (31 miles) southeast of the LGS plant site.

The total number of commercial service/public airports and heliports in the vicinity of the LGS plant site is 11, including six in Montgomery County (includes one heliport), three in Berks County, and two in Chester County (PennDOT, 2011a).

Passenger Rail Service

The Southeastern Pennsylvania Transit Authority (SEPTA) provides light rail, bus, and trolley service in the region. In Montgomery County, the Norristown high speed line provides passenger rail service between the 69th Street Terminal in Philadelphia and Norristown. The Manayunk-Norristown regional rail line also provides passenger rail service between Center City Philadelphia and Norristown, in the eastern part of the county (Montgomery County, Undated). SEPTA also provides rail service in Chester County along the Paoli-Thorndale regional rail line that runs in an east-west direction between Thorndale and Center City Philadelphia (SEPTA, 2010). No SEPTA passenger rail service is offered within Berks County. Neither the Montgomery County nor the Chester County passenger rail lines operated by SEPTA provide a direct link to the area in close proximity to LGS to date.

In addition to SEPTA regional rail service, Amtrak offers a passenger rail service known as the Keystone Line between New York City and Harrisburg. This passenger rail service provides connections between these major cities, as well as Philadelphia, and points in both Chester County (Paoli, Exton, Downingtown, and Coatesville) and Montgomery County (Ardmore). However, this line does not service Berks County or the area in proximity to LGS (Amtrak, 2011).

The feasibility of restoring passenger rail service between communities along the US-422 corridor in Montgomery, Chester, and Berks counties and Center City Philadelphia (the “Schuylkill Valley Metro” concept) has been studied. However, the project is not currently active for lack of financing. An extension of SEPTA service from Norristown is being explored as a lower-cost rail option, and various innovative funding sources, including the possible conversion of US-422 to a toll road, are being investigated to determine whether rail service may still be viable in the US-422 corridor (Montgomery County, 2010).

Roadways

There is one entrance/exit for the LGS plant site, which can only be accessed via Evergreen Road, either directly from the Sanatoga exit of US-422 or indirectly from the Limerick Linfield exit of US-422 via several local roads. US-422 runs northwest from the Sanatoga exit through Pottstown Borough and the City of Reading, and then continues west through Berks County

Figures 2.1-2 and 2.1-3 show the routes of highways located in the vicinity of LGS.

Berks County is served by a radial system of arterial highways (Berks County, 2003). US-222 is the principal link between Reading and both Allentown and Lancaster, as well as a connection to the Pennsylvania Turnpike. PA 61 is the principal highway connection between eastern Pennsylvania and Reading. US-422 provides a direct link to the Delaware Valley, including Philadelphia, to the east. To the west, US-422 connects Reading to Lebanon, Harrisburg and the Capitol region. Berks County has no interstate highway link traversing the urban area;

however, Interstate Highway I-78 to the north and the Pennsylvania Turnpike to the south bound the County. PA 183 and PA 61 act as connectors to I-78, while I-176 and US-222 link the urban area with the Pennsylvania Turnpike.

Montgomery County is traversed by Interstate Highways I-76 (known as the “Schuylkill Expressway”), I-276 (the East-West Pennsylvania Turnpike), and I-476 (known as the “Northeast Extension of the Pennsylvania Turnpike” north of I-276 and as the “Blue Route” or “Mid-County Expressway” south of I-276). The Northeast Extension can be accessed approximately 24.1 kilometers (15 miles) east of the LGS plant site. I-76, I-276, and I-476 are about 24.1 kilometers (15 miles) south of LGS and can be accessed via US-422 (known as “the Pottstown Expressway” from Pottstown to these expressway/turnpike connections).

Access to LGS from Chester County is via US-422 as it runs in a southwest to northeast direction along the northeast corner of the county (CCPC, 2008). Other major roads servicing Chester County include I-78 running in an east-northwest direction through the center of the county and US-30 also running through the center of the county but in an east-southwest direction. US-1 is a major roadway traversing the southern section of the county in an east-southwest direction, as well.

Table 2.9-4 lists roadways in the vicinity of the LGS plant site and the annual average number of vehicles per day as determined by the Pennsylvania Department of Transportation (PennDOT).

In determining the significance levels of transportation impacts for license renewal, the U.S. Nuclear Regulatory Commission (NRC) uses the Transportation Research Board’s intersection level of service (ILOS) definitions (NRC, 1996a). ILOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists. Traffic congestion conditions are rated as A through F and, for signalized intersections, are designated as follows:

A -- Free flow of the traffic stream; users are unaffected by the presence of others.
B -- Stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished.
C -- Stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream.
D -- High-density, stable flow in which speed and freedom to maneuver are severely restricted; small increases in traffic will generally cause operational problems.
E -- Operating conditions at or near capacity level causing low but uniform speeds and extremely difficult maneuvering that is accomplished by forcing another vehicle to give way; small increases in flow or minor perturbations will cause breakdowns.
F -- Defines forced or breakdown flow that occurs wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. This situation causes the formation of queues characterized by stop-and-go waves and extreme instability.

PennDOT makes ILOS determinations for roadways involved in specific projects. There are no current PennDOT-generated ILOS determinations for the roadways listed in Table 2.9-4. However, ILOS data were collected for the Sanatoga Interchange Study (Simone Collins, 2008), which was commissioned by Lower Pottsgrove Township to evaluate proposed commercial development of an area north of the LGS plant site and northeast of Evergreen Road. These data are included in Table 2.9-5.

2.8.3.3 School Districts

This section evaluates the impact on school districts in the vicinity of LGS from 60 additional permanent workers, which Exelon Generation conservatively assumes that LGS would require to perform all license renewal surveillance, monitoring, inspections, testing, trending, and recordkeeping (SMITTR) activities (see Section 3.4). This number of workers is used to analyze the potential for impacts to school districts from enrollment of additional worker family members under the age of 18.

The analysis uses the following assumptions:

- The additional workers and their families would reside in surrounding areas in a similar distribution pattern as current LGS employees, as shown in Table 2.5-1;
- Every additional worker anticipated to take up residence in a given county will represent an individual household;
- The new individual household will be additive to (i.e., not replacing) existing households;
- The average household includes 0.64 people under the age of 18 (USCB, 2010b); and
- All new students would be attending public schools.

Because most (greater than 84 percent) of the LGS employees reside in Montgomery County, Berks County, and Chester County, the discussion of impacts on school districts is focused on these three counties. Data provided by each school district on the number of students enrolled in public schools within each of the three counties are available from the Pennsylvania Information Management System (PDE, 2011). Montgomery County has 22 school districts with a total enrollment of 108,341; Berks County has 18 school districts with a total enrollment of 70,345; and Chester County has 12 school districts with a total enrollment of 81,644.

Based on the assumptions used, the projected number of new enrollments would be 16 for Montgomery County, 12 for Berks County, and 5 for Chester County. These enrollments would be distributed among a number of the total 52 school districts and would limit the impact on any one district to few new enrollments. For each county, this represents a very small amount (< 0.1 percent) of the existing enrollment. Therefore, Exelon Generation concludes that the impact of 60 additional permanent workers on local school districts is small.

2.9 Meteorology and Air Quality

2.9.1 Regional Meteorology

The general climate in the LGS plant site region can be characterized as humid continental (PECO, 1984, Section 2.3.1.1). The winters are dominated by continental air masses. The summers are dominated by continental air masses alternating with maritime tropic air masses that can bring hot and humid conditions. Prevailing winter and summer winds favor the west to northwest and west to southwest, respectively. Low-pressure systems move through the area with the prevailing west winds generally producing a change in the weather system every three to four days. Occasional coastal storms from the Atlantic Ocean can bring heavy rains and, in extreme instances, flooding.

Climatology reporting locations generally representative of the LGS plant site are National Weather Service (NWS) stations at the Philadelphia International Airport, located about 49.9 kilometers (31 miles) to the southeast, and the Lehigh Valley International Airport, located in Allentown about 49.9 kilometers (31 miles) to the north. The LGS plant site is located about midway from the two stations not only in distance, but also in elevation (PECO, 1984, Section 2.3.1 and 2.3.2.).

Mean monthly temperatures at the LGS plant site range from about –1.1 ºC (30 ºF) to 23.9 ºC (75 ºF); temperatures rarely exceed 37.8 ºC (100 ºF) or drop below –17.8 ºC (0 ºF) (PECO, 1984, Section 2.3.1.1.3). Mean monthly relative humidity readings range from about 73 percent to 86 percent in mornings and about 50 percent to 62 percent in afternoons (PECO, 1984, Section 2.3.1.4). The LGS plant site receives a moderate amount of precipitation, which is well distributed throughout the year and slightly higher during the summer months. Mean annual total rainfall and snowfall/sleet are about 109.2 centimeters (43 inches) and 66.0 centimeters (26 inches), respectively (PECO, 1984, Section 2.3.1.1.5).

The LGS plant site is subject to occasional severe storm events (PECO, 1984, Section 2.3.1.2). Hurricanes or tropical storms rarely track through LGS, an inland plant site, and the effects of heavy rain from decaying hurricanes or tropical storms are a more serious consideration than strong winds. From 1963 to 1980, there were 14 hurricanes (H) and tropical storms (TS) that have affected the LGS plant site region (PECO, 1984, Question E451.5). A review of National Hurricane Center archives (NOAA, 2011) shows that, since 1995, nine similar events (i.e., H Floyd in 1999; TS Allison in 1999; H Isabel and TS Henri in 2003; H Frances, H Ivan, and H Jeanne in 2004; TS Barry in 2007; and TS Hanna in 2008) have occurred. Based on data from 1950 to 1981, tornadoes occur within a 80.4-kilometer (50-mile) radius of the LGS plant site at a mean frequency of about 1.16 per year with peak winds in excess of 160.9 kilometers (100 miles) per hour, although the probability of one striking within a one-degree latitude-longitude square surrounding LGS is estimated to be once every 9,179 years (PECO, 1984, Question E451.5). On average, the LGS plant site experiences about 27 to 32 thunderstorms per year, mostly occurring from April through September, with an estimated 26 lightning strikes occurring from those storms within 1.6 kilometers (1 mile) of the site (PECO, 1984, Section 2.3.1.2 and Question E451.5). Hailstorms are uncommon at the LGS plant site (one to two events per year on average, with a maximum of six in 1977) and are most likely to occur in the late spring (PECO, 1984, Section 2.3.1.2 and Question E451.5). Freezing rain and ice pellets may occur up to three to four times per year and seven to eight days per year, respectively, in the LGS plant site vicinity; however, glaze accumulations would be minimal, expected only once per year (PECO, 1984, Section 2.3.1.2 and Question E451.5). Peak winds from storms range from about 74.0 to 130.3 kilometers per hour (46 to 81 miles per hour) with peak gusts up to 144.8 kilometers per hour (90 mph per hour) (PECO, 1984, Section 2.3.1.2 and Question E451.5).

2.9.2 Local Meteorology

Exelon Generation Company, LLC (Exelon Generation) owns and operates weather stations at two meteorological towers installed near the LGS plant site to provide local meteorology (PECO, 1984, Section 2.3.2). The primary tower (Tower 1) is located on relatively high ground [base elevation of 76.2 meters (250 feet) above mean sea level (amsl)], approximately 914.4 meters (3,000 feet) north-northwest of plant center. The second tower (Tower 2) is located in the Schuylkill River valley (base elevation of 36.9 meters or 121 feet amsl), approximately 914.4 meters (3,000 feet) south-southwest of Tower 1. The positioning of the two towers allows for comparison of data in the valley with those on the hill. The parameters measured and recorded at three elevations from both towers include wind direction, wind speed, and temperatures. Additional onsite measurements at Tower 1 include horizontal and vertical wind direction fluctuations, relative humidity, barometric pressure, and precipitation.

Temperature and relative humidity measured at the LGS plant site show that on-site conditions tend to fall somewhere between the Philadelphia and Allentown NWS stations. However, precipitation measured locally at LGS tends to be significantly higher than that measured at both NWS stations. There are no geographical features in the LGS plant site vicinity that appear to cause significant local modifications of the regional synoptic scale weather systems, although some channeling effects in the river valley can occur (PECO, 1984, Sections 2.3.1.1.6 and 2.3.2.1.3.1).

An additional weather station at Exelon Generation's Peach Bottom Atomic Power Station, located approximately 77.2 kilometers (48 miles) southeast of the LGS plant site, provides a useful comparison for the LGS upper level wind sensors (PECO, 1984, Section 2.3.2.1.1.4).

No measurements of fogging or impaired visibility have been made at the LGS plant site. However, based on data from the two regional NWS stations, heavy fog (fog causing visibility to decrease to 0.4 kilometers or 0.25 miles, or less) occurs about 27 times per year and about one to four times per month (PECO, 1984, Section 2.3.2.1.6).

NRC staff concluded in the Final Environmental Statement - Construction Phase (FES-CP) (AEC, 1973) that the operation of the LGS cooling towers would:

- Not result in a fog problem at ground level;
- Result in very few instances of icing during an average year in the Limerick area; and
- Be very unlikely to cause precipitation through plume downwash.

2.9.3 Air Quality

Under the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for air quality based on public health and welfare, which specify maximum concentrations for six pollutants (referred to as "criteria" pollutants):

- Nitrogen dioxide at:
    - Annual [Arithmetic Average] of 53 parts per billion (ppb)
    - 1-hour average of 100 ppb (new January 22, 2010 standard);
- Sulfur dioxide at:
    - 140 ppb 24-hour average [not to be exceeded more than once per year]
    - Annual [Arithmetic Average] of 30 ppb
    - 1-hour average of 75 ppb (new June 2, 2010 standard)
- Carbon monoxide [not to be exceeded more than once per year] at:
    - 1-hour average of 35 parts per million (ppm)
    - 8-hour average of 9 ppm;
- Particulate matter at:
    - 24-hour average of 150 micrograms per cubic meter (ug/m^3) for "inhalable coarse particles" ranging in aerodynamic diameter of 2.5 to 10 microns (PM_{10})
    - 24-hour average of 35 ug/m^3 (lowered in 2006 from the 1977 standard of 65 ug/m^3) for "fine particles" with an aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$)
    - Annual arithmetic average of 15.0 ug/m^3 for ($PM_{2.5}$);

- Ozone at:
    - o 8-hour average of 0.075 ppm (lowered in 2008 from the 1997 standard of 0.08 ppm)
    - o 1-hour average of 0.12 ppm for no more than one day per calendar month (EPA revoked this standard in 2005 for those areas that have effective dates for their 8-hour designations); and
- Lead measured as Total Suspended Particles (TSP) at:
    - o 0.15 ug/m^3 [rolling 3-month average] (lowered in 2008 from the 1978 standard of 1.5 ug/m^3)
    - o 1.5 ug/m^3 [Quarterly Average]

It should be noted that many of the NAAQS include complex statistical requirements, such as the 8-hour ozone standard: "3-year average of the fourth highest daily maximum 8-hours average ozone concentration". These details have been left out here for clarity. The full standards are described and explained at the EPA website (EPA, 2010) and related federal code of regulations (40 CFR Part 50).

EPA designates areas with air quality that meets or is better than the NAAQS as attainment areas; areas with air quality that exceeds the NAAQS as non-attainment areas; and areas that were previously non-attainment areas but later re-designated as attainment areas as maintenance areas. These designations are made for each criteria pollutant and the degree of non-attainment is specified based on the level of NAAQS exceedance. States with non-attainment areas are required to develop a State Implementation Plan (SIP) for the air pollutants in non-attainment areas. States with maintenance areas are required to develop a maintenance plan as part of the SIP.

40 CFR Part 81 lists air quality attainment status for designated areas for air quality planning purposes. Section 81.339 pertains to designated areas within Pennsylvania. Montgomery County and Chester County, in which the LGS plant site is located, are both designated as attainment areas for nitrogen oxides, sulfur dioxide, carbon monoxide, PM_{10}, and lead. However, these counties and the regional planning areas within which they are located are classified as non-attainment for ozone and $PM_{2.5}$.

Both counties are included in the Philadelphia-Wilmington-Atlantic City (PA-DE-MD-NJ) area that EPA has designated a "moderate" non-attainment area for the 8-hour ozone NAAQS (Philadelphia Non-attainment Area) (FHWA, 2004). Since this area has an effective date for its 8-hour designations, the 1-hour average ozone standard was revoked in 2005 (EPA, 2011c). For the purposes of regulating stationary sources, the entire Commonwealth of Pennsylvania together with the State of New Jersey is considered a "moderate" ozone non-attainment area because both jurisdictions are in the Ozone Transport Region established under Section 184 of the Clean Air Act (CAA). Accordingly, under Section 172 of the CAA, Pennsylvania was required to submit a demonstration that its existing rules fulfill the CAA Reasonably Available Control Technology (RACT) 8-hour ozone standards. On August 29, 2007, the Pennsylvania Department of Environmental Protection (PADEP) submitted the attainment demonstration to EPA for the Pennsylvania portion of the moderate 8-hour ozone PA-DE-MD-NJ non-attainment area (PADEP, 2007).

Both counties also are included in the Philadelphia-Wilmington (PA-NJ-DE) area that EPA has designated as a non-attainment area for the 2006 24-hour and annual $PM_{2.5}$ NAAQS (FHWA, 2010). Accordingly, under Section 172 of the CAA, Pennsylvania was required to submit a demonstration that its existing rules fulfill the CAA RACT $PM_{2.5}$ standards. On April 12, 2010, PADEP submitted the attainment demonstration to EPA for the Pennsylvania portion of the $PM_{2.5}$ PA-NJ-DE non-attainment area (PADEP, 2010).

The CAA established 156 Mandatory Federal Class I areas where air quality and air quality related values, such as visibility, have special protection from regional haze and stationary source emission impacts. These areas are listed in 40 CFR Part 81. The closest of these Class I areas to LGS is the Brigantine Wilderness located on the south side of the Great Bay near Brigantine NJ, approximately 127 kilometers (78 miles) southeast of the LGS plant site. The second closest Class I area to LGS is the Shenandoah National Park, which is located in Virginia, approximately 442.5 kilometers (275 miles) southwest of the LGS plant site.

2.9.4 LGS Emissions

The sources of the emissions at LGS, as listed in its Title V Operating Permit (refer to Table 9.1-1), include eight emergency standby diesel generators and their diesel oil/day tanks, two cooling towers, one spray pond, three auxiliary boilers with one common fuel tank, a degreasing unit that uses cleaning solvents, and various waste oil sources. Emissions for the combustion sources are estimated based on fuel content, amount of fuel burned, hours of operation, and standard emission factors. Particulate matter emissions from the cooling towers and spray pond are estimated based on process factors including water circulation rate, drift, and evaporation rate, as well as measurements of the total dissolved solids concentration in the cooling tower and spray pond waters. Exelon Generation submits an annual statement to PADEP for emissions of pollutants resulting from operation of LGS, as required.

2.10 Historic and Archaeological Resources

2.10.1 Regional History in Brief

2.10.1.1 Prehistoric

Prehistory refers to the period of Native American occupation of Pennsylvania, prior to the beginning of written history. For purposes of study and discussion, the prehistoric era is divided into periods. The Paleoindian period extends from the beginning of human occupation of the region to approximately 8000 B.C. The Archaic period follows and ends at 1000 B.C. The Woodland period extends to European contact sometime around A.D. 1600.

The date of the first colonization of eastern North America is a matter of controversy, but was likely prior to 16,000 years ago. Paleoindians were hunters and gatherers who lived on a landscape consisting of open spruce forest with a grassy understory. Acorn and nut-bearing trees such as oak and hickory were present only in sheltered environments along streams. In addition to gathering a wide variety of plant foods, hunting of both large and small animals provided an important food source for Paleoindians. Because few Paleoindian sites have been found in Pennsylvania, much about this period remains unknown. Paleoindians likely lived in family groups and moved frequently to be close to resources such as plant foods, fishing locations, and raw material for making stone tools. Evidence indicates that Paleoindians traveled within large territories covering hundreds of miles. The Paleoindian occupation of Pennsylvania is characterized by spear points with flutes (or grooves) used for hafting, or tying the points to the shafts. Paleoindian tools were finely worked from high-quality stone such as jasper and chert. Common tools included knives for butchering and scrapers for hide working.

By the beginning of the Archaic period, oak, hickory, walnut, and hazelnut were abundant in the forests of Pennsylvania and provided an important source of food. Fruits and berries were also far more abundant than in the Paleoindian period. Archaic people continued the Paleoindian strategy of hunting and gathering, but do not appear to have traveled over such large territories. They continued to live in open camps and rock shelters, moving their camps depending on the abundance and seasonality of the foods they gathered. Population density grew throughout the period. The Archaic tool kit included scrapers, spokeshaves, drills, and knives, as well as mortars and pestles that increased the efficiency of plant-food processing. Point types included large forms with corner notches, some of which had serrated edges and date to circa 8000 to 6000 B.C., as well as forms with deeply notched, or bifurcate, bases dating to circa 6500 to 6000 B.C. Later points had stems or side notches, point styles that continued in use throughout most of prehistory.

During the Woodland period, the use of earthen pottery became widespread. Plant foods preserved in fire pits and roasting hearths indicate that hunting and gathering continued to provide a substantial portion of the diet. However, squash has also been found, indicating that at least some crops were cultivated early in the period. Population density continued to increase and by the time of European contact, people were living in large stockaded villages and growing crops such as corn, beans, and squash.

2.10.1.2 Historic

In 1681, William Penn received a charter from King Charles II for a tract of land extending from the Delaware River south and west to what was then Maryland. Penn laid out the city of Philadelphia, which grew to 600 houses by 1685. The town served as a port of entry for immigrants, initially Swedes and Dutch, followed later by English, German, and Scotch-Irish. The earliest historic settlement of the region expanded outward from Philadelphia along waterways that served as transportation corridors. The earliest colonists were farmers who settled in a dispersed pattern of farmsteads. Milling, distilling, and other processing industries were family-owned enterprises and were established along streams, which provided water power.

William Penn established Chester County, along with Bucks and Philadelphia Counties, in 1682. The original county seat was in Chester, but was moved to West Chester in 1789 when Chester became part of the newly formed Delaware County. Montgomery County was established in 1784 from outlying parts of Philadelphia County. The county court house and prison were built in Norristown in 1787; the first post office was opened in Pottstown in 1793.

The period between 1784 and 1870 marked a dramatic increase in the development of both political organization and infrastructure in the region. With settlers moving westward, more efficient means of transportation were required to link these new settlements to the centers of trade and government. Turnpikes, as well as canals and railroads, were built to accommodate the growing number of settlements and cut the costs of shipping agricultural products and manufactured goods over lengthening distances.

In 1815 the Pennsylvania legislature authorized the Schuylkill Navigation Company. The company constructed a canal system between Philadelphia and the anthracite coal fields of Schuylkill County. The Girard Canal, which extended from below Reading to Parker Ford, opened in 1824 and followed the west bank of the Schuylkill River through land that is now LGS plant site property (refer to Section 2.1). The canal company constructed two stone locks (Lock Nos. 54 and 55) and a two-story stone lockkeeper’s house on land owned by John Frick until his death in 1822 (O'Bannon, 1987). Between 1857 and 1937, a farming hamlet and commercial center arose around the lock. A store opened to serve both the farming community and the passengers and crews of the canal boats.

The Philadelphia and Reading Railroad, which passes through land that is now LGS plant site property along the east bank of the Schuylkill River, was one of the first railroads constructed in the United States. It was built primarily to haul coal. Completed in 1843, it became a profitable business. The railroad company reached its greatest power and success in the 1870s. After the Panic of 1893 the company reorganized and became a subsidiary of the Reading Company. It was an important and profitable railroad into the twentieth century, but in 1971 the Reading Company was forced to file for bankruptcy protection.

The Schuylkill Branch of the Pennsylvania Railroad was built along the western bank of the river in 1884 to compete with the Philadelphia and Reading Railroad. The Schuylkill Branch served primarily as a commuter line, but was largely abandoned in the 1950s as roadways were improved.

Historic settlement in the East Coventry Township, Chester County, portion of the LGS plant site property was centered near what is now the Fricks Locks Historic District, which became an agricultural hamlet and commercial center serving both the local community and the Girard Canal (O'Bannon, 1987). Although the name of this district differs in spelling among various documents and reports, it is listed in the National Register as Fricks Locks Historic District, which is considered its official name and is used in this document. It is referred to as the Fricks Lock district in the O'Bannon (1987) study, discussed below. The historic property also appears as Frick's Locks in some literature. The historic district should not be confused with the prehistoric archaeological site, 36CH103, which is named the Frick's Lock site and is located on the floodplain to the east of the historic district.

Commercial activities in the Fricks Locks Historic District began sometime before 1860 when the Frick family built a store to service canal boat crews. The agriculture complex grew and prospered in the late nineteenth century under the ownership of John Frick 's son Jacob until 1852 and grandson John until his death in 1896.

The Montgomery County portion of the LGS plant site property is located in Limerick and Lower Pottsgrove Townships, which was a rural area into the early twentieth century. The 1857 Kuhn and Shrope map shows scattered farmsteads in the area, which grew in number over the late nineteenth century (Kuhn and Shrope, 1857). By 1906, a small community had developed to the north of what is now the LGS plant site property at Sanatoga Station, along the Philadelphia and Reading Railroad in Lower Pottsgrove Township.

2.10.2 Historic and Archeological Analyses - Initial Construction and Operation

In 1972, Buchart-Horn, Inc., conducted an archaeological survey of the LGS plant site (roughly equivalent to today's Phase I investigation) (Holzinger and Humpreville, 1972). This study sought to identify any prehistoric Native American archaeological resources contained within the site (no attempt was made to document historic period resources). Four discrete areas of prehistoric occupation were identified, three of which were located on the western shores of the Schuylkill River, in the vicinity of Fricks Locks in Chester County. Parts of these areas are included in recorded sites designated 36CH38, 36CH103, and 36CH364. The other prehistoric artifact locus was situated on the eastern side of the Schuylkill, in Montgomery County, and is recorded as Site 36MG37. Local artifact collectors had previously identified all of these locations. Associated diagnostic tools dated those occupations to the Archaic, Early Woodland, and Middle Woodland culture periods.

The Final Environmental Statement (FES) for the LGS Construction Permit stage (FES-CP), summarized the 1972 Buchart-Horn report, included a letter from the Advisory Council on Historic Preservation (dated January 9, 1973) stating that the draft environmental statement was adequate with regard to cultural resources (AEC, 1973).

The Final Environmental Statement for the LGS Operating License stage (FES-OL) identified 35 properties listed on the National Register of Historic Places (National Register) that were within 15 kilometers (9.3 miles) of the site or within 2 kilometers (1.2 miles) of the transmission routes (NRC, 1984). The sites included three historic districts, four bridges, four mills, a store, two churches, a tavern, Washington's Headquarters, and 19 residences or farmsteads.

A letter from the Pennsylvania Historical and Museum Commission (PHMC), Bureau of Historic Preservation, which serves as the State Historic Preservation Office (SHPO), dated October 5, 1983 and included in the FES-OL, indicated that the operations of LGS would have no effect on significant historic or archaeological resources provided that archaeological surveys/mitigation were undertaken for the proposed transmission lines and provided that measures were taken to mitigate visual impacts to historic sites.

Consistent with the PHMC's 1983 letter, archaeological surveys were conducted during the mid- to late 1980s for five LGS transmission system lines: Lines 220-60, 220-61, 220-62, 220-63/64, and 5031 (refer to Section 2.1.3). The goals of these investigations were to locate, identify, and evaluate archaeological resources within the transmission line rights-of-way (ROW). If an archeological resource located within a ROW (1) was determined to be eligible for the National Register of Historic Places, (2) was not avoidable by the relocation of access roads and/or structure footings, and (3) was determined to have potential for providing significant information, a Phase III data recovery program was developed and implemented for the resource. All mitigative measures were reviewed and approved by the PHMC.

Line 220-60 extends along a 11.9-linear-kilometer (7.4-linear-mile) corridor on the eastern side of the Schuylkill River from the Limerick 220-kV Substation, located on the LGS plant site in Montgomery County, southeast to the Cromby Substation located at Exelon Generation Company, LLC's (Exelon Generation's) Cromby Generating Station in Chester County (Milner, 1984a). Eleven archaeological sites were investigated, seven in floodplain settings and four on uplands. However, none of the potentially significant sites extended into the areas of proposed transmission line structures. Hence, construction of Line 220-60 was found to have no effect on significant archaeological resources.

Line 220-61 extends for a distance of 13.7 linear kilometers (8.53 linear miles) on the west bank of the Schuylkill River from the Limerick 220-kV Substation south to the Cromby Generating Station (Milner, 1984b). Ten archaeological sites were investigated, five on floodplains and five in upland settings. Archaeological data recovery was completed to mitigate potential adverse effects at one significant prehistoric archaeological resource, the Frick's Lock Site (36CH103) (Kingsley et al., 1990). The remaining nine archaeological sites were determined to not extend into areas of proposed transmission line structures. Hence, construction of Line 220-61 was found to have no adverse effect on significant archaeological resources.

Line 220-62 extends from the Cromby Substation eastward to the North Wales Substation in Upper Gwynedd Township in Montgomery County for a distance of 25.7 linear kilometers (16 linear miles) (Milner, 1984c). Seventeen previously unrecorded sites were found, along with one isolated find. Sixteen sites were found in upland settings and one was found on a floodplain. Investigations revealed that no potentially significant sites were present within the areas of proposed transmission line structures. Therefore, construction of Line 220-62 was found to have no adverse effect on significant archaeological resources.

Line 220-63/64 extended 22.5 linear kilometers (14 linear miles) from the Cromby Substation in Chester County east to the Plymouth Meeting Substation in Montgomery County (Milner, 1985). The line has an intermediate connection at the Barbadoes Substation where it changes designation from 220-63 to 220-64. Fourteen archaeological sites and two lithic scatters were identified. Site 36MG156 was identified on the Schuylkill River floodplain and was considered eligible for the National Register. The significant data were recovered during the Phase I and II investigations and no further work was conducted. Data recovery was completed at the Indian Point Site (36CH53), a significant prehistoric site dating to the Early-Middle Woodland period (Kingsley et al., 1990). The remaining 12 sites were found not to extend into areas of proposed transmission line structures. Therefore, construction of Line 220-63/64 was found to have no adverse effect on significant archaeological resources.

Archaeological survey for Line 5031 covered 25.7 linear kilometers (16 linear miles), extending from the Limerick 500-kV Substation, on the LGS plant site immediately to the southeast of the main plant structures, to the Whitpain Substation in Whitpain Township (Milner, 1989). Approximately 4.8 kilometers (3 miles) of the ROW is shared with Line 220-62 and was surveyed as part of that archaeological project. Two archaeological sites were investigated, neither of which was considered eligible for the National Register. Hence, construction of Line 5031 was found to have no adverse effect on significant archaeological resources.

2.10.3 Other Historic and Archeological Analyses

In December 1986, John Milner Associates, Inc. completed an architectural and historical analysis of the Fricks Lock Historic District, located on the LGS plant site in East Coventry Township, Chester County (O'Bannon, 1987). This study identified a total of 20 historic buildings and six historic structures that contributed to the overall significance of this district. The buildings examined were all built between 1757 and 1937, and form part of a cohesive farming hamlet that documents the local evolution of rural domestic and agricultural architecture in this vicinity. Other structures identified within the district were directly related to this community's association with the Schuylkill Navigation Company's Girard Canal (circa 1820-1890), and include the infilled remains of Lock Numbers 54 and 55, as well as the former Lock Keeper's House. The report of this investigation concluded that the district met the criteria for listing in the National Register. Based on this conclusion, the "Fricks Locks Historic District" was listed under Criteria A and C in 2004. John Milner Associates, Inc., did no archaeological testing within the historic district, so eligibility under Criterion D was not determined.

In 2010, Kathleen M. Abplanalp, Ph.D., completed the *Historic and Architectural Survey of Frick's Lock Historic District* for Frens and Frens Architects on behalf of Exelon Generation. The purpose of the study was to evaluate the current integrity and historic significance of the architectural resources within the Fricks Locks Historic District and assess the continued viability of the NRHP listing. The study concluded that the current historic district boundaries appear appropriate (Abplanalp, 2010). In February 2011, Exelon Generation and East Coventry Township signed an agreement under which the historic structures that comprise Frick's Lock Village will be stabilized or rehabilitated.

2.10.4 Current Status

The PA Cultural Resources Geographic Information System (CRGIS) online database was accessed to identify resources listed or eligible for listing in the National Register (PHMC/PennDOT, 2011). The CRGIS indicated that 164 aboveground historic resources and 3 archaeological sites are listed on the National Register in Montgomery County and 380 aboveground historic resources and 6 archaeological sites are listed in Chester County. Of these 553 sites, 38 aboveground historic resources and no archaeological sites are within a 10.0-kilometer (6-mile) radius of LGS. These listed sites are shown in Table 2.11-1. In addition, the CRGIS identifies 63 aboveground historic resources and three archaeological sites that are eligible for listing in the National Register. These sites are shown in Tables 2.11-2 and 2.11-3, respectively. Figure 2.1-2 depicts the area around LGS bounded by the 10.0-kilometer (6-mile) radius.

Two historic resources are present within the boundaries of Exelon Generation-owned property related to the LGS plant site. Fricks Locks Historic District, in East Coventry Township, Chester County, is listed in the National Register under Criterion A for its significance in transportation history and under Criterion C for its architectural significance. The district encompasses approximately 7.3 hectares (18 acres).

The second resource within the LGS plant site property boundary is the Schuylkill Navigation Company (Girard) Canal, which crosses the property through the Fricks Locks Historic District. The canal has been determined eligible for listing in the National Register under Criteria A and C.

Exelon Generation has specific procedures, including a Cultural Resources Management Plan, for protecting cultural resources, including the Fricks Locks Historic District and the Schuylkill Navigation Company (Girard) Canal, from activities related to operation and maintenance of the LGS.

Site 36CH103 is within the ROW for Transmission Line 220-61 on the west bank of the Schuylkill River (see Section 2.11.2). The site is shown in CRGIS as having insufficient data for an eligibility determination. However, Phase III data recovery was completed there to mitigate potential effects of transmission line construction, as described above (Milner, 1984b; Kingsley et al., 1990), and construction of Line 220-61 was determined to have no adverse effects on significant archaeological resources.

2.11 Known or Reasonably Foreseeable Projects in Site Vicinity

This section provides information on known and reasonably foreseeable Federal and non-Federal projects and other actions in the vicinity of the LGS plant site that may contribute to the cumulative environmental impacts of license renewal and extended plant operation.

2.11.1 LGS Projects

As Section 3.2 describes, Exelon Generation Company, LLC (Exelon Generation) has no plans for refurbishment activities at LGS.

As Section 3.1.4 states, LGS operates a horizontal dry storage installation for spent nuclear fuel at the plant site in accordance with 10 CFR Part 72, Subpart K, “General License for Storage of Spent Fuel at Power Reactors.” The existing dry fuel storage facility has capacity for spent fuel to be generated throughout the existing LGS license terms (Exelon Generation, 2009b). Capacity expansion may be considered, if needed to support extended operation.

As Section 3.1.4 reports, LGS has no offsite disposal options and only limited onsite storage capacity for Class B/C low-level radioactive waste (LLRW). On May 31, 2011, NRC approved transport of such wastes to Exelon Generation's Peach Bottom Atomic Power Station (PBAPS) for temporary storage in an existing interim LLRW storage facility (LLRWSF)(ADAMS Accession No. ML110470320).

Exelon Generation has advised NRC of its plans to seek future approval for extended power uprates (EPU) at some nuclear power plants within its fleet, possibly including LGS Units 1 and 2 (Exelon Generation, 2009c). Extended power uprates usually require significant modifications to major pieces of non-nuclear equipment such as high-pressure turbines, condensate pumps and motors, main generators, and/or transformers, but no new construction on previously undisturbed land is anticipated to occur.

2.11.2 Projects in the Vicinity of Limerick Generating Station

2.11.2.1 EPA-Regulated Facilities

The "Envirofacts Warehouse" online database provided by the U.S. Environmental Protection Agency (EPA) lists a total of 466 EPA-regulated facilities within 9.7 to 12.9 kilometers (6 to 8 miles) of the LGS plant site. These facilities can be categorized as follows:

- 67 are registered point sources which produce and release air pollutants and are monitored by the AIRS Facility Subsystem (AFS);
- 2 sites are registered for cleanup as "brownfields" in the Assessment, Cleanup and Redevelopment Exchange System (ACRES) database;
- 6 sites are registered Superfund sites;
- 80 facilities are permitted to discharge wastewater into waterways or rivers;
- 350 facilities report hazardous waste management activities;
- 29 facilities are registered to store toxic chemicals on-site; and
- 5 facilities are regulated by the Toxic Substance Control Act, which allows the EPA to require reporting, record keeping and testing, and restrictions.

Detailed information concerning these facilities is available through the EPA "Envirofacts Warehouse" at www.epa.gov/enviro/.

2.11.2.2 Electricity Generating Capacity

Exelon Generation's Cromby Generating Station (Cromby) is a two-unit fossil fuel power plant located on the Schuylkill River, approximately 12.9 kilometers (8 miles) south of LGS. Cromby Unit 1 is a 144-megawatt (MW) coal-fired plant built in 1954; Unit 2 is a 201-MW unit built in 1955 and operates on natural gas or fuel oil. In December 2009, Exelon Generation announced its intent to permanently retire both Cromby units. Unit 1 retirement is scheduled for May 31, 2011 and Unit 2 retirement is scheduled for December 31, 2011 (Exelon Generation, 2010d).

Exelon Corporation also operates the Moser Generating Station, a 60 MW, 3-unit oil-fired peaking plant located in Lower Pottsgrove Township, approximately 3.2 kilometers (2 miles) west of the LGS plant site.

2.11.2.3 Other Notable EPA-Regulated Facilities

The Pottstown Borough Water Authority manages the Pottstown Water Treatment Plant, which is the source of water for the Pottstown area. The Pottstown Water Treatment Plant, located approximately 12.9 kilometers (8 miles) west of the LGS plant site, withdraws up to 18.9 million liters (5 million gallons) of water from the Schuylkill River daily. There are approximately 2,589 square kilometers (1,000 square miles) of land covering portions of 11 counties that drain into the river upstream of the intake (Pottstown Borough Water Authority, 2011).

Located approximately 4.0 kilometers (2.5 miles) west of LGS is the Occidental Chemical Corporation Remediation site, formerly known as the Firestone Tire and Rubber Manufacturing Facility. This Superfund site, which the Occidental Chemical Corporation is remediating under the oversight of the EPA, is comprised of nearly 101.2 hectares (250 acres) of land. Groundwater extraction and treatment activities are ongoing (EPA, 2011b).

An active quarry, Pottstown Trap Rock – Sanatoga Quarry, one of the Haines and Kibblehouse (H&K) Group family of companies, is located contiguous with the LGS plant site property boundary (H&K Group, 2011). The quarry is approximately 1,113 meters (3,650 feet) north-northwest of the center of LGS, directly adjacent to the Schuylkill River (see Figure 2.1-1). As stated in Section 2.3.2, the quarry does not maintain a DRBC groundwater withdrawal permit, implying that the actual groundwater withdrawal rate from dewatering is less than 37,850 liters per day (10,000 gallons per day).

Table 2.2-1 Schuylkill River Water Quality Measurements near LGS

Parameter	1975-1978 Min.-Avg.-Max.	2005 Sampling Result	2010 Sampling Result
Biochemical Oxygen Demand	0.7-2.1-5.9 mg/l	ND (2 mg/l)	ND (2 mg/l)
Chemical Oxygen Demand	Not measured	27 mg/l	ND (25 mg/l)
Total Organic Carbon	ND-3.3-20.7 mg/l	2.0 mg/l	4.5 mg/l
pH	7.36-7.69-8.24 su	7.26 su	7.43 su
Hardness	71.6-142.8-256.3 mg/l	119 mg/l	132 mg/l
Total Suspended Solids	ND-11-377 mg/l	3 mg/l	4 mg/l
Total Dissolved Solids	32-239-427 mg/l	186 mg/l	260.1 mg/l
Chloride	10.30-20.93-40.00 mg/l	Not measured	Not measured
Fluoride	ND-0.22-0.67 mg/l	ND (0.5 mg/l)	ND (0.5 mg/l)
Sulfate	35.1-78.5-209.7 mg/l	33 mg/l	29 mg/l
Sodium	5.98-13.78-31.47 mg/l	Not measured	Not measured
Potassium	1.71-2.60-4.34 mg/l	Not measured	Not measured
Calcium	20.11-35.15-70.10 mg/l	Not measured	Not measured
Magnesium	7.34-14.28-27.30 mg/l	10.1 mg/l	9.7 mg/l
Ammonia as N	ND-0.25-1.41 mg/l	ND (0.1 mg/l)	ND (0.1 mg/l)
Nitrate-Nitrite as N	1.17-2.54-3.84 mg/l	3 mg/l	2.85 mg/l
Phosphorus as P	0.17-0.40-1.08 mg/l	0.08 mg/l	0.08 mg/l
Arsenic	ND-0.001-0.004 mg/l	ND (0.001 mg/l)	ND (0.001 mg/l)
Beryllium	ND-ND-ND mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Boron	ND-0.14-0.27 mg/l	0.05 mg/l	ND (0.1 mg/l)
Cadmium	ND-0.001-0.012 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Chromium	0.001-0.005-0.043 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Copper	0.002-0.012-0.110 mg/l	ND (0.005 mg/l)	ND (0.01 mg/l)
Iron	0.090-0.340-13.560 mg/l	0.20 mg/l	0.26 mg/l
Lead	ND-0.003-0.348 mg/l	ND (0.005 mg/l)	ND (0.01 mg/l)
Manganese	0.050-0.242-1.380 mg/l	0.057 mg/l	0.068 mg/l
Nickel	ND-0.01-0.09 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Selenium	ND-ND-ND mg/l	ND (0.002 mg/l)	ND (0.002 mg/l)
Zinc	ND-0.034-0.194 mg/l	0.219 mg/l	0.069 mg/l
Mercury	ND-0.100-1.200 ug/l	ND (0.0002 mg/l)	ND (0.0002 mg/l)
Cobalt	ND-0.001-0.045 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)

Notes:
1. Min. = 4-year minimum; Avg. = 4-year average of seasonal median values; Max. = 4-year maximum
2. ND = Non-detectable at indicated (Method Detection Limit)
3. su = standard units
4. Sources of data are (a) the ER-OL (PECO, 1984, Tables 2.4-12) for 1975-1978 data, and (b) the 2005 and 2010 LGS NPDES permit renewal applications.
5. 2005 sampling result data are based on the average of two sampling events; 2010 sampling result data are based on single sampling events, except for Schuylkill River Total Dissolved Solids, which is based on the average of 19 sampling events.

Table 2.2-2 Perkiomen Creek Water Quality Measurements

Parameter	1975-1978 Range Min.-Avg.-Max.	2005 Sampling Result	2010 Sampling Result
Biochemical Oxygen Demand	ND-1.42-6.5 mg/l	1.5 mg/l	ND (2 mg/l)
Chemical Oxygen Demand	Not measured	ND (25 mg/l)	26 mg/l
Total Organic Carbon	ND-6.2-44.4 mg/l	3.9 mg/l	4.5 mg/l
pH	7.24-7.84-9.54 su	7.70 su	7.15 su
Hardness	48.8-85.4-129.3 mg/l	85 mg/l	92 mg/l
Total Suspended Solids	ND-7-717 mg/l	6 mg/l	6 mg/l
Total Dissolved Solids	61-161-466 mg/l	160 mg/l	204.2 mg/l
Chloride	8.86-22.38-50.30 mg/l	Not measured	Not measured
Fluoride	ND-0.17-0.55 mg/l	ND (0.5 mg/l)	ND (0.5 mg/l)
Sulfate	18.7-30.7-71.9 mg/l	21 mg/l	16 mg/l
Sodium	5.46-10.97-22.80 mg/l	Not measured	Not measured
Potassium	1.66-3.85-12.99 mg/l	Not measured	Not measured
Calcium	12.93-21.24-39.90 mg/l	Not measured	Not measured
Magnesium	5.05-8.28-14.80 mg/l	7.4 mg/l	7.2 mg/l
Ammonia as N	ND-0.05-0.89 mg/l	ND (0.1 mg/l)	ND (0.1 mg/l)
Nitrate-Nitrite as N	ND-1.76-3.19 mg/l	2 mg/l	1.38 mg/l
Phosphorus as P	0.07-0.24-1.17 mg/l	0.08 mg/l	0.22 mg/l
Arsenic	ND-ND-ND mg/l	ND (0.001 mg/l)	ND (0.001 mg/l)
Beryllium	ND-ND-ND mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Boron	ND-0.15-0.59 mg/l	0.1 mg/l	ND (0.1 mg/l)
Cadmium	ND-0.001-0.009 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Chromium	ND-0.002-0.014 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Copper	ND-0.007-0.122 mg/l	ND (0.005 mg/l)	ND (0.01 mg/l)
Iron	0.090-0.274-8.988 mg/l	0.32 mg/l	0.36 mg/l
Lead	ND-0.001-0.079 mg/l	ND (0.005 mg/l)	ND (0.01 mg/l)
Manganese	0.004-0.047-0.666 mg/l	0.018 mg/l	0.069 mg/l
Nickel	ND-0.01-0.05 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)
Selenium	ND-ND-ND mg/l	ND (0.002 mg/l)	ND (0.002 mg/l)
Zinc	ND-0.010-0.119 mg/l	ND (0.005 mg/l)	0.006 mg/l
Mercury	ND-0.001-0.905 ug/l	ND (0.0002 mg/l)	ND (0.0002 mg/l)
Cobalt	ND-0.001-0.003 mg/l	ND (0.005 mg/l)	ND (0.005 mg/l)

Notes:
1. Min. = 4-year minimum; Avg. = 4-year average of seasonal median values; Max. = 4-year maximum
2. ND = Non-detectable at indicated (Method Detection Limit)
3. su = standard units
4. Sources of data are (a) the ER-OL (PECO, 1984, Tables 2.4-12) for 1975-1978 data, and (b) the 2005 and 2010 LGS NPDES permit renewal applications.
5. 2005 sampling result data are based on the average of two sampling events; 2010 sampling result data are based on single sampling events except for Perkiomen Creek Total Dissolved Solids, which is based on average of five sampling events.

Table 2.2-3 Fish Species Collected from the Schuylkill River

Common Name	Scientific Name	Number of Reports Showing Species Present Before 2009 [a]	Species Reported Present in 2009 [b]
alewife	*Alosa pseudoharengus*	4	
American eel	*Anguilla rostrata*	8	X
American shad	*Alosa sapidissima*	3	
banded killifish	*Fundulus diaphanus*	8	
black crappie	*Pomoxis nigromaculatus*	9	X
blacknose dace	*Rhinichthys atratulus*	8	
bluegill	*Lepomis macrochirus*	10	X
bluntnose minnow	*Pimephales notatus*	7	X
bowfin	*Amia calva*	2	
brown bullhead	*Ameiurus nebulosus* (formerly *Ictalurus nebulosus*)	20	X
brown trout	*Salmo trutta*	1	
chain pickerel	*Esox niger*	2	
channel catfish	*Ictalurus punctatus*	19	X
comely shiner	*Notropis amoenus*	8	X
carp	*Cyprinus carpio*	22	X
common shiner	*Luxilus cornutus* (formerly *Notropis cornutus*)	19	X
creek chub	*Semotilus atromaculatus*	6	X
creek chubsucker	*Erimyzon oblongus*	7	
cutlips minnow	*Exoglossum maxillinqua*	7	
fallfish	*Semotilus corporalis*	8	
fathead minnow	*Pimephales promelas*	4	
flathead catfish	*Pylodictis olivaris*	0	X
golden shiner	*Notemigonus crysoleucas*	8	X
goldfish	*Carassius auratus*	19	
goldfish x carp hybrid	*C. auratus* x *C. carpio*	2	
green sunfish	*Lepomis cyanellus*	10	X
killifish species	*Fundulus* sp.	0	X
largemouth bass	*Micropterus salmoides*	20	X
longnose dace	*Rhinichthys cataractae*	4	
margined madtom	*Noturus insignis*	3	X
muskellunge	*Esox masquinongy*	3	
northern hogsucker	*Hypentelium nigricans*	0	X
pike hybrid	*Esox* sp.	3	
pumpkinseed	*Lepomis gibbosus*	18	X
quillback	*Carpoides cyprinus*	8	
rainbow trout	*Salmo gairdneri*	1	
redbreast sunfish	*Lepomis auritus*	19	X
redfin pickerel	*Esox americanus americanus*	2	

Table 2.2-3 Fish Species Collected from the Schuylkill River

Common Name	Scientific Name	Number of Reports Showing Species Present Before 2009 [a]	Species Reported Present in 2009 [b]
rock bass	*Ambloplites rupestris*	12	X
satinfin shiner	*Notropis analostanus*	1	
shiner sp.	Cyprinidae	1	
smallmouth bass	*Micropterus dolomieu* (formerly *M. dolomieui*)	19	X
spotfin shiner	*Cyprinella spiloptera* (formerly *Notropis spilopterus*)	19	X
spottail shiner	*Notropis hudsonius*	19	X
sunfish hybrid	*Lepomis* sp.	7	X
swallowtail shiner	*Notropis procne*	8	X
tessellated darter	*Etheostoma olmstedi*	8	X
trout (unidentified)	Salmonidae	1	
walleye	*Stizostedion vitreum vitreum*	2	
white catfish	*Ictalurus catus*	17	
white crappie	*Pomoxis annularis*	8	
white perch	*Morone americana*	1	
white sucker	*Catostomus commersoni*	19	X
yellow bullhead	*Ameiurus natalis* (formerly *Ictalurus natalis*)	20	X
yellow perch	*Perca flavescens*	6	

[a] Study Years/References: 1971/AEC (1973); 1970-1976/PECO (1984); 1979-1983/RMC (1984); 1984/RMC (1985); 1985/RMC (1986); 1986/RMC (1987); 1987/RMC (1988); 1988/RMC (1989); 1989/PECO (1990); 1990/PECO (1991); 1991/PECO (1992); 1992/PECO (1993); 1993/PECO (1994); 1994/PECO (1995); 1995/PECO (1996); 1996/PECO (1997); 1997/PECO (1998); 1998/PECO (1999); 1999/PECO (2000); 2000/Exelon Generation (2001); 2001/Exelon Generation (2002); 2002/Exelon Generation (2003); 2003/Exelon Generation (2004); 2004/Exelon Generation (2005)

[b] Study Years/References: 2009/NAI (2010c)

Table 2.2-4 Fish Species Collected from Perkiomen Creek

Common Name	Scientific Name	Number of Reports Showing Species Present From 1971 to 1986 [a]	Species Reported Present in 1987 [b]
American eel	*Anguilla rostrata*	6	X
banded killifish	*Fundulus diaphanus*	2	
black bullhead	*Ictalurus melas*	1	
black crappie	*Pomoxis nigromaculatus*	6	X
blacknose dace	*Rhinichthys atratulus*	2	
bluegill	*Lepomis macrochirus*	6	X
bluntnose minnow	*Pimephales notatus*	2	
bridle shiner	*Notropis bifrenatus*	2	
brook trout	*Salvelinus fontinalis*	1	
brown bullhead	*Ameiurus nebulosus* (formerly *Ictalurus nebulosus*)	6	X
brown trout	*Salmo trutta*	1	
carp	*Cyprinus carpio*	6	X
chain pickerel	*Esox niger*	1	X
channel catfish	*Ictalurus punctatus*	5	X
comely shiner	*Notropis amoenus*	2	
common shiner	*Luxilus cornutus* (formerly *Notropis cornutus*)	2	
creek chub	*Semotilus atromaculatus*	2	
creek chubsucker	*Erimyzon oblongus*	6	X
cutlips minnow	*Exoglossum maxillinqua*	2	
fallfish	*Semotilus corporalis*	6	X
fathead minnow	*Pimephales promelas*	2	
golden shiner	*Notemigonus crysoleucas*	6	X
goldfish	*Carassius auratus*	6	X
goldfish x carp hybrid	*C. auratus* x *C. carpio*	1	
green sunfish	*Lepomis cyanellus*	6	X
largemouth bass	*Micropterus salmoides*	6	X
longnose dace	*Rhinichthys cataractae*	2	
margined madtom	*Notorus insignis*	6	
minnow hybrid	Cyprinidae hybrid	5	X
mummichog	*Fundulus heteroclitus*	1	
muskellunge	*Esox masquinongy*	3	
northern pike	*Esox lucius*	1	
pike hybrid	*Esox* sp.	4	X
pumpkinseed	*Lepomis gibbosus*	6	X
redbreast sunfish	*Lepomis auritus*	6	X

Table 2.2-4 Fish Species Collected from Perkiomen Creek

Common Name	Scientific Name	Number of Reports Showing Species Present From 1971 to 1986 [a]	Species Reported Present in 1987 [b]
redfin pickerel	*Esox americanus americanus*	2	
rock bass	*Ambloplites rupestris*	6	X
satinfin shiner	*Notropis analostanus*	2	
shield darter	*Percina peltata*	2	
smallmouth bass	*Micropterus dolomieu* (formerly *M. dolomieui*)	6	X
spotfin shiner	*Cyprinella spiloptera* (formerly *Notropis spilopterus*)	2	
spottail shiner	*Notropis hudsonius*	2	
sunfish hybrid	*Lepomis* sp.	5	X
swallowtail shiner	*Notropis procne*	2	
tessellated darter	*Etheostoma olmstedi*	2	
trout (unidentified)	Salmonidae	1	
white catfish	*Ictalurus catus*	3	X
white crappie	*Pomoxis annularis*	6	X
white sucker	*Catostomus commersoni*	6	X
yellow bullhead	*Ameiurus natalis* (formerly *Ictalurus natalis*)	6	X
yellow perch	*Perca flavescens*	1	

[a] Study Years/References: 1971/AEC (1973); 1970-1977/PECO (1984); 1979-1983/RMC (1984); 1984/RMC (1985); 1985/RMC (1986); 1986/RMC (1987)

[b] Study Years/References: 1987/RMC (1988)

Table 2.2-5 Fish Species Collected from East Branch Perkiomen Creek

Common Name	Scientific Name	Number of Reports Showing Species Present From 1970 to 1987 [a]	Number of Reports Showing Species Present From 2001 to 2009 [b]
American eel	*Anguilla rostrata*	6	1
banded killifish	*Fundulus diaphanus*	6	7
black crappie	*Pomoxis nigromaculatus*	3	1
blacknose dace	*Rhinichthys atratulus*	6	7
bluegill	*Lepomis macrochirus*	6	7
bluntnose minnow	*Pimephales notatus*	6	7
bridle shiner	*Notropis bifrenatus*	5	0
brook trout	*Salvelinus fontinalis*	1	0
brown bullhead	*Ameiurus nebulosus* (formerly *Ictalurus nebulosus*)	6	3
brown trout	*Salmo trutta*	0	2
carp	*Cyprinus carpio*	6	2
chain pickerel	*Esox niger*	3	0
comely shiner	*Notropis amoenus*	6	6
common shiner	*Luxilus cornutus* (formerly *Notropis cornutus*)	6	7
creek chub	*Semotilus atromaculatus*	5	5
creek chubsucker	*Erimyzon oblongus*	6	2
cutlips minnow	*Exoglossum maxillinqua*	6	7
fallfish	*Semotilus corporalis*	6	6
fathead minnow	*Pimephales promelas*	4	5
golden shiner	*Notemigonus crysoleucas*	6	7
goldfish	*Carassius auratus*	6	0
goldfish x carp hybrid	*C. auratus* x *C. carpio*	2	0
green sunfish	*Lepomis cyanellus*	6	7
largemouth bass	*Micropterus salmoides*	6	6
longnose dace	*Rhinichthys cataractae*	6	7
margined madtom	*Notorus insignis*	4	7
minnow hybrid	Cyprinidae hybrid	4	0
mummichog	*Fundulus heteroclitus*	1	0
muskellunge	*Esox masquinongy*	2	0
pike hybrid	*Esox* sp.	1	0
pumpkinseed	*Lepomis gibbosus*	6	7
rainbow trout	*Salmo gairdneri*	1	6
redbreast sunfish	*Lepomis auritus*	6	7
redfin pickerel	*Esox americanus americanus*	6	1
rock bass	*Ambloplites rupestris*	6	7
satinfin shiner	*Notropis analostanus*	6	1
shield darter	*Percina peltata*	4	7
silvery minnow	*Hybognathus regius*	1	0

Table 2.2-5 Fish Species Collected from East Branch Perkiomen Creek

Common Name	Scientific Name	Number of Reports Showing Species Present From 1970 to 1987 [a]	Number of Reports Showing Species Present From 2001 to 2009 [b]
smallmouth bass	*Micropterus dolomieu* (formerly *M. dolomieui*)	6	7
spotfin shiner	*Cyprinella spiloptera* (formerly *Notropis spilopterus*)	6	7
spottail shiner	*Notropis hudsonius*	6	7
sunfish hybrid	*Lepomis* sp.	6	7
swallowtail shiner	*Notropis procne*	6	5
tessellated darter	*Etheostoma olmstedi*	6	7
walleye	*Stizostedion vitreum vitreum*	1	0
white catfish	*Ictalurus catus*	2	0
white crappie	*Pomoxis annularis*	3	1
white sucker	*Catostomus commersoni*	6	7
yellow bullhead	*Ameiurus natalis* (formerly *Ictalurus natalis*)	6	7
yellow perch	*Perca flavescens*	1	0

[a] Study Years/References: 1970-1976/PECO (1984); 1979-1983/RMC (1984); 1984/RMC (1985); 1985/RMC (1986); 1986/RMC (1987); 1987/RMC (1988)

[b] Study Years/References: 2001-2003/NAI (2005); 2004/NAI (2007); 2005/NAI (2008a); 2006/NAI (2008b); 2007/NAI (2009); 2008/NAI (2010a); 2009/NAI (2010b)

Table 2.2-6 Fish Species Collected from the Delaware River

Common Name	Scientific Name (Year of Study)	1972-1973	1982-1983	1984	1985
alewife	*Alosa pseudoharengus*	X			
American eel	*Anguilla rostrata*	X			
American shad	*Alosa sapidissima*		X	X	X
banded killifish	*Fundulus diaphanus*			X	
basses	*Micropterus* spp.	X			
blueback herring	*Alosa aestivalis*				
bluegill	*Lepomis macrochirus*	X			
brown bullhead	*Ameiurus nebulosus (*formerly *Ictalurus nebulosus)*		X		X
carp	*Cyprinus carpio*	X	X	X	X
channel catfish	*Ictalurus punctatus*		X	X	X
common shiner	*Luxilus cornutus (*formerly *Notropis cornutus)*		X		
crappies	*Pomoxis* spp.	X	X		
creek chubsucker	*Erimyzon oblongus*		X		
cutlips minnow	*Exoglossum maxillinqua*		X		
dace	*Rhinichthys* spp.	X			
freshwater catfishes	Ictaluridae	X	X	X	
gizzard shad	*Dorosoma cepedianum*				X
goldfish	*Carassius auratus*	X		X	
goldfish or carp (unidentified)	Cyprinidae		X	X	
herrings	Clupeidae		X	X	X
killifishes	Cyprinodontidae		X		
lamprey	Petromyzontidae		X	X	X
largemouth bass	*Micropterus salmoides*		X		
Lepomis sp.	*Lepomis* spp.		X	X	X
margined madtom	*Notorus insignis*		X		X
minnows and carps	Cyprinidae		X	X	X
pumpkinseed	*Lepomis gibbosus*	X			
quillback	*Carpoides cyprinus*		X	X	X
redbreast sunfish	*Lepomis auritus*	X			
rock bass	*Ambloplites rupestris*		X	X	X
satinfin shiner	*Notropis analostanus*	X			
shield darter	*Percina peltata*		X	X	X
shiner sp.	Cyprinidae	X	X		
smallmouth bass	*Micropterus dolomieu* (formerly *M. dolomieui)*		X	X	X
spotfin shiner	*Cyprinella spiloptera (*formerly *Notropis spilopterus)*	X	X		
spottail shiner	*Notropis hudsonius*		X		
suckers	Catostomidae		X	X	X

Table 2.2-6 Fish Species Collected from the Delaware River

	Year of Study	1972-1973	1982-1983	1984	1985
Common Name	**Scientific Name**				
sunfishes	Centrarchidae	X			
swallowtail shiner	*Notropis procne*	X	X		
tessellated darter	*Etheostoma olmstedi*		X	X	X
walleye	*Stizostedion vitreum vitreum*		X	X	X
white catfish	*Ictalurus catus*		X	X	X
white perch	*Morone americana*	X			X
white sucker	*Catostomus commersoni*	X	X	X	X
yellow bullhead	*Ameiurus natalis* (formerly *Ictalurus natalis*)		X		
yellow perch	*Perca flavescens*			X	

References: NRC (1984) - juveniles and adults; RMC (1984) - ichthyoplankton; RMC (1985) - ichthyoplankton; RMC (1986) - ichthyoplankton

Table 2.3-1 Water Well Locations within 1 Mile of LGS

Line #	PAGWIS ID	Owner	County	Municipality	Latitude	Longitude	Well Depth	Well Use	Water Use
1	12387	Lederer, Herman Jr.	Chester	East Coventry Twp.	40.2158	-75.5997	122	Withdrawal	Domestic
2	12425	C. Schukarft	Chester	East Coventry Twp.	40.2222	-75.6031	197	Withdrawal	Domestic
3	12459	J. Harris	Chester	East Coventry Twp.	40.2294	-75.6025	140	Withdrawal	Domestic
4	12532	Ryberg, Arlington	Chester	East Coventry Twp.	40.2275	-75.6006	--	Withdrawal	Domestic
5	12554	Kook	Chester	East Coventry Twp.	40.2272	-75.6006	120	Withdrawal	Domestic
6	12567	Luhnau, Rotrout	Chester	East Coventry Twp.	40.2119	-75.5872	--	Withdrawal	Domestic
7	101786	Smith Joseph	Chester	East Coventry Twp.	40.2256	-75.5997	175	Withdrawal	Domestic
8	101787	Smith Joseph	Chester	East Coventry Twp.	40.2256	-75.5997	125	Withdrawal	Domestic
9	101788	Smith Joseph	Chester	East Coventry Twp.	40.2256	-75.5997	175	Withdrawal	Domestic
10	101789	Smith Joseph	Chester	East Coventry Twp.	40.2256	-75.5997	125	Withdrawal	Domestic
11	101790	Smith Joseph	Chester	East Coventry Twp.	40.2275	-75.6006	200	Withdrawal	Domestic
12	101791	Smith Joseph	Chester	East Coventry Twp.	40.2275	-75.6006	150	Withdrawal	Domestic
13	101792	Smith Joseph	Chester	East Coventry Twp.	40.2275	-75.6006	175	Withdrawal	Domestic
14	106721	Garner Harold	Chester	East Coventry Twp.	40.2164	-75.5994	200	Withdrawal	Domestic
15	167513	Garner Victor	Montgomery	Lower Pottsgrove Twp.	40.2375	-75.5897	200	Withdrawal	Domestic
16	167637	Pre Designed St	Montgomery	Lower Pottsgrove Twp.	40.2344	-75.5900	300	Withdrawal	Domestic
17	167738	PTSTown Quarrys	Montgomery	Lower Pottsgrove Twp.	40.2356	-75.5917	100	Withdrawal	Industrial
18	28026	Philadelphia Electric Co (PECO)	Montgomery	Limerick Twp.	40.2228	-75.5861	198	Withdrawal	Industrial
19	28030	Philadelphia Electric Co (PECO)	Montgomery	Limerick Twp.	40.2242	-75.5856	310	Withdrawal	Industrial
20	28054	Philadelphia Electric Co (PECO)	Montgomery	Limerick Twp.	40.2281	-75.5814	585	Withdrawal	Industrial
21	166628	Luciano Leonard	Montgomery	Limerick Twp.	40.2225	-75.5736	97	Withdrawal	Domestic
22	166630	Peirson Jim	Montgomery	Limerick Twp.	40.2225	-75.5828	123	Withdrawal	Domestic
23	166634	Ketchell Rick	Montgomery	Limerick Twp.	40.2225	-75.5731	123	Withdrawal	Domestic
24	166635	Conti Construction	Montgomery	Limerick Twp.	40.2222	-75.5725	96	Withdrawal	Domestic
25	166658	S & A Homes	Montgomery	Limerick Twp.	40.2242	-75.5783	198	Withdrawal	Domestic
26	166666	Conti Construction	Montgomery	Limerick Twp.	40.2217	-75.5725	122	Withdrawal	Domestic
27	166672	S & A Homes	Montgomery	Limerick Twp.	40.2164	-75.5733	173	Withdrawal	Domestic
28	166695	Diesinger Ron	Montgomery	Limerick Twp.	40.2228	-75.5758	173	Withdrawal	Domestic
29	166803	Rotonda Robert	Montgomery	Limerick Twp.	40.2228	-75.5739	122	Withdrawal	Domestic
30	166906	Corp Bechtel	Montgomery	Limerick Twp.	40.2236	-75.5853	116	Withdrawal	Domestic
31	166907	Corp Bechtel	Montgomery	Limerick Twp.	40.2300	-75.5817	585	Withdrawal	Domestic

Table 2.3-1 Water Well Locations within 1 Mile of LGS

Line #	PAGWIS ID	Owner	County	Municipality	Latitude	Longitude	Well Depth	Well Use	Water Use
32	215235	Shaner's Mhp	Montgomery	Limerick Twp.	40.2367	-75.5792	--	Withdrawal	Public Supply
33	215319	PECO Limerick Generating Plant	Montgomery	Limerick Twp.	40.2247	-75.5847	310	Withdrawal	Commercial
34	215330	PECO Limerick Training Center	Montgomery	Limerick Twp.	40.2258	-75.5764	560	Withdrawal	Commercial

Source: DCNR (2011)

Table 2.3-2 Groundwater Use Data

Source: Annual water use reports for Sub Facility Reports WUDS ID 12923 (Well 1) and 12924 (Well 3)
PADEP (2011c) http://www.*pawaterplan.dep.state.pa.us/StateWaterPlan/WaterDataExportTool/WaterExportTool.aspx*

		1999-2009 Annual Withdrawal Reports (gallons)										
Well	Month	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Well 1	Jan	1,148,322	917,051	766,729	907,723	569,139	738,389	1,044,226	495,671	519,111	564,262	497,410
Well 1	Feb	940,466	935,216	698,189	846,754	620,786	595,870	1,076,532	510,482	542,953	634,038	525,351
Well 1	Mar	1,369,944	1,386,073	833,758	1,257,246	1,017,903	976,395	929,158	946,226	976,399	997,540	771,189
Well 1	Apr	1,779,813	1,743,334	1,317,621	782,765	889,544	1,037,762	552,669	464,974	505,131	732,152	772,779
Well 1	May	1,818,810	1,522,413	1,102,001	914,822	891,406	1,082,427	543,339	580,183	760,047	721,751	796,009
Well 1	Jun	1,592,761	1,295,322	1,049,115	804,398	853,920	1,040,257	604,803	653,571	757,585	823,700	872,714
Well 1	Jul	1,597,031	1,484,977	971,861	1,063,632	888,952	1,039,597	814,272	704,497	798,902	829,270	813,923
Well 1	Aug	1,275,666	1,263,426	965,865	894,740	841,774	955,728	1,017,321	808,229	807,583	718,765	742,731
Well 1	Sep	1,242,290	572,554	877,451	794,508	781,390	850,682	950,028	791,442	651,022	639,650	661,893
Well 1	Oct	777,406	599,632	1,001,904	715,719	878,229	1,052,216	982,111	647,480	666,998	572,381	586,121
Well 1	Nov	827,278	679,416	810,771	463,971	724,254	885,164	540,577	476,367	446,694	632,613	671,243
Well 1	Dec	852,242	709,590	671,449	393,579	751,975	968,632	464,131	454,233	448,578	814,404	554,185
Total		15,222,029	13,109,004	11,066,714	9,839,857	9,709,272	11,223,119	9,519,167	7,533,355	7,881,003	8,680,526	8,265,548
Well	Month	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Well 3	Jan										16,400	16,400
Well 3	Feb										16,400	16,400
Well 3	Mar										16,400	16,400
Well 3	Apr										90,050	63,050
Well 3	May										16,400	16,400
Well 3	Jun					Exempt					16,400	16,400
Well 3	Jul										16,400	16,400
Well 3	Aug										16,400	16,400
Well 3	Sep										16,400	16,400
Well 3	Oct										16,400	16,400
Well 3	Nov										16,400	16,400
Well 3	Dec										16,400	16,400
Total											270,450	243,450
Grand Total		15,222,029	13,109,004	11,066,714	9,839,857	9,709,272	11,223,119	9,519,167	7,533,355	7,881,003	8,950,976	8,508,998

Table 2.3-2 Groundwater Use Data

		1999-2009 Annual Withdrawal Reports (gpm)										
Well	Month	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Well 1	Jan	25.7	20.5	17.2	20.3	12.7	16.5	23.4	11.1	11.6	12.6	11.1
Well 1	Feb	23.3	22.4	17.3	21.0	15.4	14.3	26.7	12.7	13.5	15.2	12.6
Well 1	Mar	30.7	31.1	18.7	28.2	22.8	21.9	20.8	21.2	21.9	22.3	17.3
Well 1	Apr	41.2	40.4	30.5	18.1	20.6	24.0	12.8	10.8	11.7	16.9	17.9
Well 1	May	40.7	34.1	24.7	20.5	20.0	24.2	12.2	13.0	17.0	16.2	17.8
Well 1	Jun	36.9	30.0	24.3	18.6	19.8	24.1	14.0	15.1	17.5	19.1	20.2
Well 1	Jul	35.8	33.3	21.8	23.8	19.9	23.3	18.2	15.8	17.9	18.6	18.2
Well 1	Aug	28.6	28.3	21.6	20.0	18.9	21.4	22.8	18.1	18.1	16.1	16.6
Well 1	Sep	28.8	13.3	20.3	18.4	18.1	19.7	22.0	18.3	15.1	14.8	15.3
Well 1	Oct	17.4	13.4	22.4	16.0	19.7	23.6	22.0	14.5	14.9	12.8	13.1
Well 1	Nov	19.1	15.7	18.8	10.7	16.8	20.5	12.5	11.0	10.3	14.6	15.5
Well 1	Dec	19.1	15.9	15.0	8.8	16.8	21.7	10.4	10.2	10.0	18.2	12.4
Average (annual)		29.0	24.9	21.1	18.7	18.5	21.3	18.1	14.3	15.0	16.5	15.7
Well	Month	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Well 3	Jan										0.37	0.37
Well 3	Feb										0.41	0.41
Well 3	Mar										0.37	0.37
Well 3	Apr										2.08	1.46
Well 3	May										0.37	0.37
Well 3	Jun					Exempt					0.38	0.38
Well 3	Jul										0.37	0.37
Well 3	Aug										0.37	0.37
Well 3	Sep										0.38	0.38
Well 3	Oct										0.37	0.37
Well 3	Nov										0.38	0.38
Well 3	Dec										0.37	0.37
Average (annual)											0.51	0.46
Total Average (annual)		29.0	24.9	21.1	18.7	18.5	21.3	18.1	14.3	15.0	17.0	16.2

Table 2.4-1 Plants and Wildlife Identified at LGS

Type	Common Name	Scientific Name
Plants	Sugar maple	*Acer saccharum*
	Maple	*Acer* spp.
	Tree of heaven	Ailanthus altissima
	Indian hemp	*Apocynum cannabinum*
	Burdock	*Arctium minus*
	Creeper vine	*Campsis radicans*
	Catalpa	*Catalpa speciosa*
	Chicory	*Cichorium intybus*
	Thistle	*Cirsium* spp.
	Crown vetch	*Coronilla varia*
	Wild carrot	*Delphinium* spp.
	Lovegrass	*Eragrostis curvula*
	Daisy fleabane	*Erigeron annuus*
	Wild strawberry	*Fragaria virginiana*
	Daylily	*Hemerocallis hybrida*
	Jewelweed	*Impatiens biflora*
	Mile-a-minute	*Ipomoea cairica*
	Black walnut	*Juglans nigra*
	Creeping cedar	*Juniperus horizontalis*
	Eastern red cedar	*Juniperus virginiana*
	Everlasting pea	*Lathyrus grandiflours*
	Laspodeza	*Lespodeza* spp.
	Tuliptree	*Liriodendron tulipifera*
	Japanese honeysuckle	*Lonicera japonica*
	Japanese stiltgrass	*Microstegium vimineum*
	Beard tongue	*Pestemon* spp.
	Common reed	*Phragmites australis*
	American pokeweed	*Phytolacca Americana*
	Oaks	*Quercus* spp.
	Prairie Coneflower	*Ratibida pinnata*
	Smooth sumac	*Rhus glabra*
	Staghorn sumac	*Rhus typhia*
	Wineberry	*Rubus phoenicolasius*
	Rasberry	*Rubus* spp.
	Black-eyed Susan	*Rudbeckia hirta*
	Curled dock	*Rumex crispus*
	Foxtail	*Setaria faberi*
	Lilac	*Syringa vulgaris*
	Common dandelion	*Taraxacum officinale*
	Yew	*Taxus baccata*
	Poison ivy	*Dtoxicodendron radicans*
	White clover	*Trifolium repens*

Table 2.4-1 Plants and Wildlife Identified at LGS

Type	Common Name	Scientific Name
	Common mullein	*Verbascum thapsus*
Mammals	Opossum	*Didelphis virginiana*
	White-tailed deer	*Odocoileus virginianus*
	Raccoon	*Procyon lotor*
	Gray squirrel	*Sciurus Carolinensis*
	Eastern cottontail rabbit	*Sylvilagus floridanus*
	Red fox	*Vulpes vulpes*
Birds	Canada goose	*Branta Canadensis*
	Red tailed hawk	*Buteo jamaicensis*
	Northern cardinal	*Cardinalis cardinalis*
	Turkey vulture	*Cathartes aura*
	Killdeer	*Charadrius vociferous*
	Barn swallow	*Hirundo rustica*
	Purple martin	*Progne subis*
	Eastern bluebird	*Sialis sialis*
	European starling	*Sturnus vulgaris*
	Tree swallow	*Tachycineta bicolor*
Insects	Clouded sulphur	*Coias philodice*
	Darner	*Family Aeshnidae*
	Viceroy	*Limenitis archippus*
	Southern dogface	*Phoebis sennae*
	Pearl crescent	*Phyciodes tharos*
	Cabbage white	*Pieris brassicae*

Source: WHC (2006)

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Mammals				
Cryptotis parva	Least Shrew	--	Endangered	Chester
Myotis leibii	Eastern Small-footed Myotis	--	Threatened	Bucks
Myotis sodalis	Indiana Bat	Endangered	Endangered	Montgomery, Chester, Bucks
Birds				
Asio flammeus	Short-eared Owl	--	Endangered	Chester
Bartramia longicauda	Upland Sandpiper	--	Threatened	Montgomery, Chester, Bucks
Botaurus lentiginosus	American Bittern	--	Endangered	Chester
Cistothorus platensis	Sedge Wren	--	Endangered	Bucks, Chester
Falco peregrinus	Peregrine Falcon	--	Endangered	Bucks
Haliaeetus leucocephalus	Bald Eagle	--	Threatened	Montgomery, Chester, Bucks
Ixobrychus exilis	Least Bittern	--	Endangered	Chester
Nycticorax nycticorax	Black-crowned Night-heron	--	Endangered	Chester
Nyctanassa violacea	Yellow-crowned Night-heron	--	Endangered	Montgomery
Pandion haliaetus	Osprey	--	Threatened	Chester, Bucks
Rallus elegans	King Rail	--	Endangered	Chester
Spiza americana	Dickcissel	--	Endangered	Chester
Reptiles and Amphibians				
Glyptemys muhlenbergii	Bog Turtle	Threatened	Endangered	Montgomery, Chester, Bucks
Opheodrys aestivus	Rough Green Snake	--	Endangered	Chester
Pseudacris triseriata kalmi	New Jersey Chorus Frog	--	Endangered	Montgomery, Bucks
Pseudemys rubriventris	Redbelly Turtle	--	Threatened	Montgomery, Chester, Bucks
Rana sphenocephala	Coastal Plain Leopard Frog	--	Endangered	Chester, Bucks
Scaphiopus holbrookii	Eastern Spadefoot	--	Endangered	Bucks
Fish				
Acipenser brevirostrum	Shortnose Sturgeon	Endangered	Endangered	Bucks
Acipenser oxyrinchus	Atlantic Sturgeon	Candidate	Endangered	Bucks
Enneacanthus obesus	Banded Sunfish	--	Endangered	Bucks

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Lepomis megalotis	Longear Sunfish	--	Endangered	Bucks
Notropis chalybaeus	Ironcolor Shiner	--	Endangered	Montgomery, Bucks
Invertebrates				
Alasmidonta heterodon	Dwarf Wedgemussel	Endangered	Endangered	Montgomery, Chester, Bucks
Plants				
Agalinis auriculata	Eared False-foxglove	--	Endangered	Montgomery, Chester, Bucks
Ammanian coccinea	Scarlet Ammannia	--	Endangered	Bucks
Arabis missouriensis	Missouri Rock-cress	--	Endangered	Montgomery
Arethusa bulbosa	Swamp-pink	--	Endangered	Chester
Aristida purpurascens	Arrow-feathered Three Awned	--	Threatened	Chester, Bucks
Arnica acaulis	Leopard's-bane	--	Endangered	Chester
Asplenium bradleyi	Bradley's Spleenwort	--	Threatened	Chester
Bidens bidentoides	Swamp Beggar-ticks	--	Threatened	Bucks
Bouteloua curtipendula	Tall Gramma	--	Threatened	Chester
Carex alata	Broad-winged Sedge	--	Threatened	Bucks
Carex bicknellii	Bicknell's Sedge	--	Endangered	Chester, Bucks
Carex bullata	Bull Sedge	--	Endangered	Chester, Bucks
Carex crinita var. *brevicrinis*	Short Hair Sedge	--	Endangered	Chester, Bucks
Carex polymorpha	Variable Sedge	--	Endangered	Chester
Carex prairea	Prairie Sedge	--	Threatened	Bucks
Carex sterilis	Sterile Sedge	--	Threatened	Montgomery, Bucks
Carex tetanica	A Sedge	--	Threatened	Chester, Bucks
Carex typhina	Cattail Sedge	--	Endangered	Montgomery, Chester, Bucks
Cerastium arvense var. villosissimum	Serpentine Chickweed	--	Endangered	Chester
Chasmanthium laxum	Slender Sea-oats	--	Endangered	Bucks
Chrysopsis mariana	Maryland Golden-aster	--	Threatened	Chester, Bucks
Cirsium horridulum	Horrible Thistle	--	Endangered	Chester
Clematis viorna	Vase-vine Leather-flower	--	Endangered	Chester

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Cyperus diandrus	Umbrella Flatsedge	--	Endangered	Chester, Bucks
Cyperus refractus	Reflexed Flatsedge	--	Endangered	Montgomery, Bucks
Cyperus retrorsus	Retrorse Flatsedge	--	Endangered	Bucks
Dodecatheon radicatum	Jeweled Shooting-star	--	Threatened	Montgomery
Echinochloa walteri	Walter’s Barnyard-grass	--	Endangered	Bucks
Eleocharis obtuse var. *peasei*	Wright’s Spike-rush	--	Endangered	Bucks
Eleocharis parvula	Little-spike Spike-rush	--	Endangered	Bucks
Eleocharis quadrangulata	Four-angled Spike-rush	--	Endangered	Bucks
Elephantopus carolinianus	Elephant’s foot	--	Endangered	Chester
Ellisia nyctelea	Ellisia	--	Threatened	Montgomery, Chester, Bucks
Epilobium strictum	Downy Willow-herb	--	Endangered	Montgomery, Bucks
Eriophorum gracile	Slender Cotton-grass	--	Endangered	Montgomery, Bucks
Eriophorum tenellum	Rough Cotton-grass	--	Endangered	Chester
Eriophorum viridicarinatum	Thin-leaved Cotton-grass	--	Threatened	Bucks
Euphorbia ipecacuanhae	Wild Ipecac	--	Endangered	Bucks
Euphorbia purpurea	Glade Spurge	--	Endangered	Chester
Eurybia spectabilis	Low Showy Aster	--	Endangered	Bucks
Euthamia tenuifolia	Grass-leaved Goldenrod	--	Threatened	Montgomery, Bucks
Festuca paradoxa	Cluster Fescue	--	Endangered	Chester
Fimbristylis annua	Annual Fimbry	--	Threatened	Chester
Gaylussacia dumosa	Dwarf Huckleberry	--	Endangered	Montgomery, Chester
Glyceria obtusa	Blunt Manna-grass	--	Endangered	Montgomery
Helianthemum bicknellii	Bicknell's Hoary Rockrose	--	Endangered	Chester, Bucks
Heteranthera multiflora	Multi-flowered Mud-plantain	--	Endangered	Bucks
Hypericum majus	Larger Canadian St. John's-wort	--	Threatened	Chester
Ilex opaca	American Holly	--	Threatened	Chester, Bucks
Iris prismatica	Slender Blue Iris	--	Endangered	Montgomery, Chester, Bucks
Iris verna	Dwarf Iris	--	Endangered	Bucks

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Isotria medeoloides	Small-whorled Pogonia	Threatened	Endangered	Chester
Juncus dichotomus	Forked Rush	--	Endangered	Montgomery, Chester, Bucks
Juncus scirpoides	Scirpus-like Rush	--	Endangered	Montgomery, Chester, Bucks
Juncus torreyi	Torrey's Rush	--	Threatened	Chester
Linum intercursum	Sandplain Wild Flax	--	Endangered	Montgomery, Chester, Bucks
Listera australis	Southern Twayblade	--	Endangered	Chester
Listera cordata	Heart-leaved Twayblade		Endangered	Bucks
Lobelia kalmii	Brook Lobelia	--	Endangered	Montgomery
Lobelia puberula	Downy Lobelia	--	Endangered	Chester
Lycopodiella alopecuroides	Foxtail Clubmoss	--	Endangered	Bucks
Lycopodiella appressa	Southern Bog Clubmoss	--	Threatened	Bucks
Lycopus rubellus	Bugleweed	--	Endangered	Bucks
Lyonia mariana	Stagger-bush	--	Endangered	Montgomery, Chester, Bucks
Magnolia tripetala	Umbrella Magnolia	--	Threatened	Chester, Bucks
Magnolia virginiana	Sweet bay magnolia	--	Threatened	Montgomery, Chester, Bucks
Myriophyllum farwellii	Farwell's Water-milfoil	--	Endangered	Bucks
Myriophyllum heterophyllum	Broad-leaved Water-milfoil	--	Endangered	Bucks
Nymphoides cordata	Floating-heart	--	Threatened	Bucks
Panicum amarum var. *amarulum*	Southern Sea-beach Panic-grass	--	Threatened	Bucks
Panicum scoparium	Velvety Panic-grass	--	Endangered	Chester, Bucks
Parnassia glauca	Carolina Grass-of-parnassus		Endangered	Bucks
Phemeranthus teretifolius	Round-leaved Fame-flower	--	Threatened	Chester
Phyllanthus caroliniensis	Carolina Leaf-flower	--	Endangered	Chester
Poa autumnalis	Autumn Bluegrass	--	Endangered	Chester, Bucks
Poa paludigena	Bog Bluegrass	--	Threatened	Chester
Polygala cruciata	Cross-leaved Milkwort	--	Endangered	Montgomery, Chester, Bucks
Polygala curtissii	Curtis's Milkwort	--	Endangered	Chester
Polygala incarnata	Pink Milkwort	--	Endangered	Chester
Polystichum braunii	Braun's Holly Fern	--	Endangered	Bucks

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Populus balsamifera	Balsam Poplar	--	Endangered	Montgomery
Potamogeton pulcher	Spotted Pondweed	--	Endangered	Bucks
Potentilla paradoxa	Bushy Cinquefoil	--	Endangered	Montgomery
Prunus maritima	Beach Plum	--	Endangered	Montgomery, Bucks
Ptelea trifoliata	Common Hop-tree	--	Threatened	Bucks
Ptilimnium capillaceum	Mock Bishop-weed	--	Endangered	Bucks
Pycnanthemum torrei	Torrey’s Mountain-mint	--	Endangered	Bucks
Quercus falcata	Southern Red Oak	--	Endangered	Montgomery, Chester, Bucks
Quercus phellos	Willow Oak	--	Endangered	Chester, Bucks
Ranunculus fascicularis	Tufted Buttercup	--	Endangered	Montgomery, Chester
Rhamnus lanceolata	Lance-leaved Buckthorn	--	Endangered	Chester
Rhexia mariana	Maryland Meadow-beauty	--	Endangered	Chester, Bucks
Rhynchospora capillacea	Capillary Beaked-rush	--	Endangered	Bucks
Sagittaria calycina var. *spongiosa*	Long-lobed Arrow-head	--	Endangered	Bucks
Scaphiopus holbrookii	Eastern Spadefoot	--	Endangered	Bucks
Schoenoplectus smithii	Smith’s Bulrush	--	Endangered	Bucks
Scleria minor	Minor Nutrush	--	Endangered	Chester
Scleria muehlenbergii	Reticulated Nutrush	--	Endangered	Chester
Scleria pauciflora	Few Flowered Nutrush	--	Threatened	Montgomery, Chester, Bucks
Sedum rosea	Roseroot Stonecrop	--	Endangered	Bucks
Sericocarpus linifolius	Narrow-leaved White-topped Aster	--	Endangered	Montgomery, Chester, Bucks
Sisyrinchium atlanticum	Eastern Blue-eyed Grass	--	Endangered	Chester, Bucks
Sparganium androcladum	Branching Bur-reed	--	Endangered	Bucks
Spiranthes romanzoffiana	Hooded Ladies'-tresses	--	Endangered	Montgomery
Spiranthes vernalis	Spring Ladies'-tresses	--	Endangered	Montgomery, Chester
Sporobolus heterolepis	Prairie Dropseed	--	Endangered	Chester
Symphyotrichum depauperatum	Serpentine Aster	--	Threatened	Chester
Symphyotrichum novi-belgii	New York Aster	--	Threatened	Montgomery, Bucks

Table 2.5-1 Threatened and Endangered Species that could occur in Montgomery, Chester, and Bucks Counties

Scientific Name	Common Name	Federal Status	State Status	Counties with Recorded Location
Triphora trianthophora	Nodding Pogonia	--	Endangered	Montgomery, Chester, Bucks
Triplasis purpurea	Purple Sandgrass	--	Endangered	Bucks
Trollius laxus	Spreading Globeflower	--	Endangered	Bucks
Utricularia intermedia	Flat-leaved Bladderwort	--	Threatened	Bucks
Utricularia radiata	Small Swollen Bladderwort	--	Endangered	Bucks
Vernonia glauca	Tawny Ironweed	--	Endangered	Montgomery, Chester
Viburnum nudum	Possum-haw	--	Endangered	Montgomery, Chester, Bucks
Viola brittoniana	Coast Violet	--	Endangered	Bucks

Note: “--" in the Federal Status column signifies that the species is not a federally-listed species.

Sources: FWS (2010); PNHP (2011a)

Table 2.6-1 Residential Distribution of Limerick Generating Station Employees

State	County of Residence	Number of Employees	Percent of Total
Pennsylvania	Montgomery	339	41.3
	Berks	249	30.3
	Chester	105	12.8
	Lehigh	13	1.6
	Bucks	18	2.2
	Lancaster	18	2.2
	Delaware	35	4.3
	Philadelphia	10	1.2
	Lebanon	4	0.5
	Schuylkill	4	0.5
	Carbon	5	0.6
	Northampton	3	0.4
	Dauphin	1	0.1
	Luzerne	3	0.4
	York	1	0.1
Delaware	New Castle	5	0.6
New Jersey	Burlington	1	0.1
	Camden	3	0.4
	Gloucester	2	0.2
	Union	1	0.1
West Virginia	Hampshire	1	0.1
	TOTAL	821	100.0

Source: Exelon Generation human resource files (current as of 2010) – excludes contract personnel

Table 2.6-2 Pennsylvania Minority Population Data

County	Race Alone	Pop2004	Population Percentage
Berks County	White	363,076	92.7
	Black	18,041	4.6
	American Indian or Alaska Native	924	0.2
	Asian	4,604	1.2
	Native Hawaiian or Pacific Islander	487	0.1
	Two or More Races	4,508	1.2
	TOTAL MINORITY PCT		**7.3**
Bucks County	White	571,354	92.5
	Black	21,436	3.5
	American Indian or Alaska Native	981	0.2
	Asian	18,068	2.9
	Native Hawaiian or Pacific Islander	204	0.0
	Two or More Races	5,515	0.9
	TOTAL MINORITY PCT		**7.5**
Carbon County	White	59,949	98.0
	Black	611	1.0
	American Indian or Alaska Native	84	0.1
	Asian	235	0.4
	Native Hawaiian or Pacific Islander	16	0.0
	Two or More Races	299	0.5
	TOTAL MINORITY PCT		**2.0**
Chester County	White	419,000	90.0
	Black	28,803	6.2
	American Indian or Alaska Native	764	0.2
	Asian	12,813	2.8
	Native Hawaiian or Pacific Islander	212	0.0
	Two or More Races	4,203	0.9
	TOTAL MINORITY PCT		**10.0**
Delaware County	White	430,728	77.6
	Black	95,607	17.2
	American Indian or Alaska Native	663	0.1
	Asian	22,145	4.0
	Native Hawaiian or Pacific Islander	118	0.0
	Two or More Races	5,779	1.0
	TOTAL MINORITY PCT		**22.4**
Lancaster County	White	456,348	93.6
	Black	16,435	3.4
	American Indian or Alaska Native	859	0.2
	Asian	7,861	1.6
	Native Hawaiian or Pacific Islander	282	0.1
	Two or More Races	5,547	1.1
	TOTAL MINORITY PCT		**6.4**

Table 2.6-2 Pennsylvania Minority Population Data

County	Race Alone	Pop2004	Population Percentage
Lebanon County	White	119,998	96.4
	Black	2,201	1.8
	American Indian or Alaska Native	228	0.2
	Asian	1,168	0.9
	Native Hawaiian or Pacific Islander	47	0.0
	Two or More Races	847	0.7
	TOTAL MINORITY PCT		**3.6**
Lehigh County	White	295,982	90.8
	Black	15,600	4.8
	American Indian or Alaska Native	968	0.3
	Asian	8,499	2.6
	Native Hawaiian or Pacific Islander	250	0.1
	Two or More Races	4,751	1.5
	TOTAL MINORITY PCT		**9.2**
Monroe County	White	137,310	86.4
	Black	15,660	9.9
	American Indian or Alaska Native	485	0.3
	Asian	2,719	1.7
	Native Hawaiian or Pacific Islander	189	0.1
	Two or More Races	2,562	1.6
	TOTAL MINORITY PCT		**13.6**
Montgomery County	White	663,959	85.8
	Black	62,664	8.1
	American Indian or Alaska Native	1,044	0.1
	Asian	38,035	4.9
	Native Hawaiian or Pacific Islander	256	0.0
	Two or More Races	8,071	1.0
	TOTAL MINORITY PCT		**14.2**
Northampton County	White	263,852	93.4
	Black	9,973	3.5
	American Indian or Alaska Native	609	0.2
	Asian	5,126	1.8
	Native Hawaiian or Pacific Islander	268	0.1
	Two or More Races	2,726	1.0
	TOTAL MINORITY PCT		**6.6**
Philadelphia County	White	703,229	47.8
	Black	664,804	45.2
	American Indian or Alaska Native	4,845	0.3
	Asian	75,900	5.2
	Native Hawaiian or Pacific Islander	1,240	0.1
	Two or More Races	20,133	1.4
	TOTAL MINORITY PCT		**52.2**
Schuylkill County	White	142,551	96.5

Table 2.6-2 Pennsylvania Minority Population Data

County	Race Alone	Pop2004	Population Percentage
	Black	3,746	2.5
	American Indian or Alaska Native	153	0.1
	Asian	770	0.5
	Native Hawaiian or Pacific Islander	0	0.0
	Two or More Races	450	0.3
	TOTAL MINORITY PCT		**3.5**
York County	White	376,076	93.6
	Black	16,405	4.1
	American Indian or Alaska Native	874	0.2
	Asian	3,945	1.0
	Native Hawaiian or Pacific Islander	199	0.0
	Two or More Races	4,114	1.0
	TOTAL MINORITY PCT		**6.4**

Source: PADEP (2005)

Table 2.6-3 Count of Tracts with Percent of Minority Populations Exceeding 20 Percent of State Percentage

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic
Delaware	New Castle	126	44	8	52	25	44	30	43	42
Maryland	Cecil	18	0	2	0	1	0	3	0	0
	Harford	3	0	1	0	0	0	0	0	0
New Jersey	Burlington	99	36	15	9	24	3	37	26	1
	Camden	126	54	39	19	30	28	35	43	25
	Cumberland	1	0	1	0	0	0	0	0	0
	Gloucester	61	9	3	0	16	1	10	3	0
	Hunterdon	25	0	1	0	7	1	0	0	1
	Mercer	70	36	24	10	31	18	23	35	17
	Salem	23	8	8	0	2	3	7	6	2
	Somerset	5	0	0	6	2	0	0	0	0
	Warren	15	0	1	0	3	0	2	0	0
Pennsylvania	Berks	90	16	37	5	23	42	35	28	45
	Bucks	143	9	32	53	26	20	29	16	21
	Carbon	11	0	2	0	3	0	1	0	1
	Chester	116	10	27	41	26	25	27	21	29
	Delaware	144	55	31	63	22	14	52	52	13
	Lancaster	93	12	30	19	25	28	29	17	31
	Lebanon	28	0	9	0	4	9	7	4	9
	Lehigh	76	13	32	18	21	38	34	24	41
	Monroe	8	0	3	0	2	2	2	0	4
	Montgomery	211	39	36	134	53	20	54	59	21
	Northampton	68	9	18	17	15	19	21	13	28

Table 2.6-3 Count of Tracts with Percent of Minority Populations Exceeding 20 Percent of State Percentage

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic
Pennsylvania	Philadelphia	384	260	229	191	113	119	240	294	124
	Schuylkill	31	1	8	0	4	1	2	1	1
	York	3	0	1	0	0	0	0	0	0

Source: USCB (2010a) Census Data

Table 2.6-4 Count of Tracts with Percent of Minority Populations Exceeding 50 Percent

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic
Delaware	New Castle	126	19	0	0	0	0	0	32	0
Maryland	Cecil	18	0	0	0	0	0	0	0	0
	Harford	3	0	0	0	0	0	0	0	0
New Jersey	Burlington	99	13	0	0	0	0	0	13	0
	Camden	126	13	0	0	0	0	0	32	8
	Cumberland	1	0	0	0	0	0	0	0	0
	Gloucester	61	0	0	0	0	0	0	0	0
	Hunterdon	25	0	0	0	0	0	0	0	0
	Mercer	70	17	0	0	0	0	0	31	6
	Salem	23	2	0	0	0	0	0	5	0
	Somerset	5	0	0	0	0	0	0	0	0
	Warren	15	0	0	0	0	0	0	0	0
Pennsylvania	Berks	90	0	0	0	0	0	0	18	20
	Bucks	143	0	0	0	0	0	0	0	0
	Carbon	11	0	0	0	0	0	0	0	0
	Chester	116	2	0	0	0	0	0	4	1
	Delaware	144	29	0	1	0	0	0	34	0
	Lancaster	93	0	0	0	0	0	0	5	4
	Lebanon	28	0	0	0	0	0	0	0	1
	Lehigh	76	0	0	0	0	0	0	11	11
	Monroe	8	0	0	0	0	0	0	0	0
	Montgomery	211	4	0	0	0	0	0	12	0
	Northampton	68	0	0	0	0	0	0	0	3

Table 2.6-4 Count of Tracts with Percent of Minority Populations Exceeding 50 Percent

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic
Pennsylvania	Philadelphia	384	156	0	1	0	0	0	218	24
	Schuylkill	31	0	0	0	0	0	0	0	0
	York	3	0	0	0	0	0	0	0	0

Source: USCB (2010a) Census Data

Table 2.6-5 Count of Tracts with Population in Poverty Exceeding 20 Percent of State Percentage

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic	All Races
Delaware	New Castle	122	45	8	15	0	23	25	54	48	43
Maryland	Cecil	15	4	1	2	0	1	4	4	4	5
	Harford	3	1	0	0	0	0	0	0	1	0
New Jersey	Burlington	96	22	3	3	0	18	16	19	24	15
	Camden	138	45	10	23	1	37	35	53	48	48
	Cumberland	1	1	0	0	0	1	0	1	1	1
	Gloucester	57	22	1	5	0	17	11	24	22	16
	Hunterdon	25	8	0	2	0	3	3	5	4	1
	Mercer	67	26	6	7	2	19	13	29	32	27
	Salem	23	12	1	2	1	5	5	12	8	8
	Somerset	5	0	0	1	0	0	0	0	0	0
	Warren	15	3	0	2	0	2	3	5	3	3
Pennsylvania	Berks	82	37	6	5	1	34	28	47	46	27
	Bucks	136	32	4	14	0	11	16	29	22	6
	Carbon	10	1	1	0	0	5	2	5	7	2
	Chester	113	32	5	9	1	24	18	42	36	17
	Delaware	147	60	5	26	0	21	34	67	41	34
	Lancaster	89	32	3	15	3	31	27	42	38	23
	Lebanon	27	4	1	2	0	11	6	12	14	4
	Lehigh	68	29	6	6	0	31	21	38	37	26
	Monroe	6	1	1	1	0	1	2	4	4	0
	Montgomery	210	40	2	40	0	24	39	53	28	17

Table 2.6-5 Count of Tracts with Population in Poverty Exceeding 20 Percent of State Percentage

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic	All Races
Pennsylvania	Northampton	62	17	4	6	1	21	16	26	22	14
	Philadelphia	381	249	31	118	5	128	137	266	184	251
	Schuylkill	31	7	1	4	0	4	14	17	10	8
	York	2	1	0	0	0	1	1	1	2	0

Source: 2005-2009 American Community Survey (ACS) 5-Year Estimates (USCB, 2011)

Table 2.6-6 Count of Tracts with Population in Poverty Exceeding 50 Percent

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic	All Races
Delaware	New Castle	122	7	6	4	0	12	11	4	13	5
Maryland	Cecil	15	1	0	1	0	0	2	0	0	0
	Harford	3	0	0	0	0	0	0	0	0	0
New Jersey	Burlington	96	2	3	0	0	6	7	0	3	0
	Camden	138	10	8	9	1	13	17	8	12	5
	Cumberland	1	0	0	0	0	1	0	0	1	0
	Gloucester	57	1	1	2	0	8	5	3	5	0
	Hunterdon	25	3	0	0	0	2	2	0	0	0
	Mercer	67	4	5	1	2	7	5	3	7	1
	Salem	23	1	1	2	1	3	2	0	3	0
	Somerset	5	0	0	0	0	0	0	0	0	0
	Warren	15	1	0	0	0	0	0	0	0	0
Pennsylvania	Berks	82	15	6	0	1	14	17	9	13	6
	Bucks	136	6	4	4	0	4	7	2	4	0
	Carbon	10	0	1	0	0	5	1	4	5	0
	Chester	113	10	1	3	1	5	6	4	5	1
	Delaware	147	6	5	6	0	13	20	4	17	3
	Lancaster	89	15	2	8	3	11	14	5	6	0
	Lebanon	27	1	1	0	0	4	4	1	3	0
	Lehigh	68	9	3	1	0	14	8	5	7	3
	Monroe	6	0	1	0	0	1	2	0	0	0
	Montgomery	210	9	2	10	0	16	15	1	9	0

Table 2.6-6 Count of Tracts with Population in Poverty Exceeding 50 Percent

State	County	Total Tracts	Black	American Indian	Asian	Hawaiian Pacific Islander	Other	Multi-Race	Aggregate of Races (all but White)	Hispanic	All Races
Pennsylvania	Northampton	62	5	3	0	1	6	6	4	5	0
	Philadelphia	381	48	26	47	5	70	65	41	74	31
	Schuylkill	31	4	0	3	0	3	9	8	3	0
	York	2	1	0	0	0	0	0	1	1	0

Source: 2005-2009 American Community Survey (ACS) 5-Year Estimates (USCB, 2011)

Table 2.7-1 LGS Property Tax Payments, 2006 – 2010

Taxing Authority	CY2006	CY2007	CY2008	CY2009	CY2010
Montgomery County					
Limerick Township	$368,376	$402,404	$479,143	$495,044	$466,315
Spring-Ford Area School District	$2,340,454	$2,184,627	$2,193,537	$2,429,533	$2,271,282
Lower Pottsgrove Township	$1,802	$1,849	$1,797	$1,817	$1,804
Pottsgrove School District	$10,482	$10,943	$11,479	$11,988	$12,271
Chester County					
Chester County	$6,207	$6,383	$6,383	$6,654	$6,654
East Coventry Township	$2,517	$2,517	$5,319	$5,034	$5,035
Owen J Roberts School District	$39,052	$40,210	$41,770	$42,794	$43,919
Bucks County					
Plumstead Township	$6,481	$6,481	$6,481	$6,481	$7,372
Central Bucks School District	$21,373	$22,178	$23,148	$24,048	$24,971
Bedminster Township	$5,097	$4,920	$4,920	$4,920	$4,920
Pennridge School District	$17,461	$18,664	$19,484	$19,977	$20,557
Totals	$2,819,292	$2,701,176	$2,793,461	$3,047,660	$2,865,100

Note: Montgomery County numbers include Payments in Lieu of Taxes (PILOT)

CY = Calendar Year

Source: Exelon Corporation

Table 2.7-2 Payment as a Percentage of Taxing Authority 2010 Adopted Budget		
Taxing Authority	**2010 Adopted Budget ($M)**[1]	**LGS Property Tax Payment as Percentage of Budget**[2]
Montgomery County		
Montgomery County – Through Limerick Township	$407.7	<0.1%
Limerick Township	$ 14.5	3.1%
Spring-Ford Area School District	$125.5	2.2%
Montgomery County – Through Lower Pottsgrove Township	$403.9	<0.1%
Lower Pottsgrove Township	$ 5.4	<0.1%
Pottsgrove School District	$ 56.8	<0.1%
Chester County		
Chester County	$420.7	<0.1%
East Coventry Township	$ 3.2	<0.1%
Owen J Roberts School District	$103.0	<0.1%
Bucks County		
Bucks County – Through Plumstead Township	$460.1	<0.1%
Plumstead Township	$ 4.3	0.17%
Central Bucks School District	$283.2	<0.1%
Bucks County – Through Bedminster Township	$460.1	<0.1%
Bedminster Township	$ 2.0	0.2%
Pennridge School District	$111.4	<0.1%

[1] Municipal budget is for calendar year; school district budget is for school year 2010-2011.
[2] Percentages are based on 2010 LGS property tax payments shown in Table 2.7-1.

Sources:

Montgomery County (2009); Limerick Township (Undated); Spring-Ford Area School District (2010); Sanatoga Post (2010) – source for Lower Pottsgrove Township budget; Lower Pottsgrove Township (2008); Pottsgrove School District (2010)

Chester County (2009b); East Coventry Township (Undated); Owen J Roberts School District (2010)

Bucks County (2010); Plumstead Township (Undated); Central Bucks School District (2010); Bedminster Township (Undated); Pennridge School District (2010)

Table 2.8-1 Montgomery County Land Use – 2000		
Land Use Type	**Total Acreage**	**Percent of Total County Land**
Single Family Detached	78,449	25.0%
Single Family Detached Low Density	22,424	7.2%
Single Family Attached	6,804	2.2%
Multifamily	3,246	1.0%
Mobile Home Park	523	0.2%
Retail	5,203	1.7%
Office	4,613	1.5%
Mixed Use	1,836	0.6%
Industrial	9,775	3.1%
Institutional	11,394	3.7%
Utilities	1,563	0.5%
Transportation	20,783	6.7%
Mining	947	0.3%
Recreation and Parkland Fields	15,848	5.1%
Woodland	61,602	19.8%
Agricultural or Undeveloped Land	63,579	20.4%
Water	3,568	1.1%
Total Acres	311,758	100.0%

Source: MCPC (2005a)

Table 2.8-2 Berks County Land Use – 1999		
Land Use Type	**Total Acreage**	**Percent of Total County Land**
Single Family Residential	80,051	14.5
Multifamily Residential	2,546	0.4
Commercial	10,803	1.9
Commercial Recreation	4,644	0.8
Industrial	17,714	3.2
Public/Non-Profit	68,231	12.3
Agriculture	189,912	34.3
Rural	30,348	5.4
Woodland	118,270	21.3
Water Body	5,777	1.0
Road and Railroad Right-of-Way	25,671	4.6
Total Acres	553,967	100.0%

Source: Berks County (2003)

Table 2.8-3 Chester County Land Use – 2005

Land Use Type	Total Acreage	Percent of Total County Land
Single Family	87,637.6	18.0
Multifamily	4,127.7	0.8
Industrial	2,796.9	0.6
Transportation	38,980.3	8.0
Utility	2,259.1	0.5
Commercial	8,307.8	1.7
Community Services	4,488.2	0.9
Mining	1,046.7	0.2
Recreation	8,740.3	1.8
Agriculture	178,337.5	36.7
Wooded	128,931.2	26.5
Vacant	15,300.8	3.2
Water	4,777.2	1.1
Total Acres	485,731	100.0%

Source: DVRPC (2011)

Table 2.8-4 Pottstown Metropolitan Region Land Use – 2005

Land Use Type	Total Acreage	Percent of Total Region Land
Multifamily	282	0.5
Single Family Attached	95	0.2
Twin/Duplex	459	0.9
Mobile Home Park	307	0.6
Single Family Detached	13,751	26.1
Country Residence	3,813	7.2
Mixed Use	456	0.9
Retail	875	1.7
Office	452	0.9
Industrial	758	1.4
Institutional	1,404	2.7
Utilities	626	1.2
Undeveloped	6,727	12.8
Public Open Space	1,140	2.2
Private Open Space	822	1.6
Agriculture	11,770	22.3
Roads/Water	8,919	16.8
Total Acres	52,746	100.0%

Source: MCPC (2005c)

Table 2.8-5 Limerick Township Land Use – 2007		
Land Use Type	**Total Acreage**	**Percent of Total Township Land**
Commercial	1,010.1	7.5%
Industrial	370.4	2.8%
Institutional	264.1	1.9%
Single Family	4,668.4	34.1%
Multifamily	221.5	1.6%
Open Space	1,209.4	8.5%
Recreation	789.9	5.7%
State Game Lands	438.9	3.3%
Undeveloped	3,808.8	27.9%
Utility	689.9	5.1%
No Data	190.9	1.6%
Total Acres	13,662	100.0%

Source: Simone Collins Landscape Architecture (2009)

Table 2.9-1 Ten Largest Montgomery County Water Suppliers

Water Supplier	Average Production (GPD)	Maximum Production (GPD)	Design Capacity (GPD)	Storage Capacity (G)
Aqua Pennsylvania Main System	87,600,000	118,000,000	125,000,000	137,795,000
North Penn Water Authority	10,000,000	13,000,000	24,000.000	10,500,000
Pennsylvania American Water-Norristown	9,576,000	11,598,000	16,900,000	10,500,000
North Wales Water Authority	7,400,000	NR	13,300,000	18,800,000
Pottstown Borough Water Authority	6,000,000	7,000,000	12,000,000	13,200,000
Ambler Borough Water Department	2,000,000	3,100,000	2,200,000	2,000,000
Horsham Water and Sewer Authority	1,900,000	3,000,000	3,000,000	3,300,000
Aqua Pennsylvania Hatboro	1,500,000	1,737,500	3,000,000	960,000
Audubon Water Company	917,000	1,250,000	3,000,000	1,338,000
Collegeville Trappe Joint PWD	638,000	1,143,500	1,634,000	1,178,500

Notes:
GPD = gallons per day
G = gallons
Largest by Population Served

Source: EPA (2011a), PADEP (2011a)

Table 2.9-2 Ten Largest Berks County Water Suppliers

Water Supplier	Average Production (GPD)	Maximum Production (GPD)	Design Capacity (GPD)	Storage Capacity (G)
Reading Area Water Authority	14,000,000	16,585,000	40,000,000	76,269,000
Paw Penn District	2,500,000	3,250,000	3,745,000	3,720,000
Western Berks Water Authority	3,500,000	5,500,000	8,000,000	8,250,000
Paw Glen Alsace Division	1,425,799	19,159,300	28,134,000	4,270,000
Muhlenberg Township Municipal Authority	4,100,000	5,321,000	8,480,000	4,825,000
Shillington Municipal Authority	1,200,000	1,600,000	2,300,000	1,000,000
Mt Penn Municipal Water Authority	740,000	1,084,000	4,000,000	2,264,000
Kutztown Borough Water	892,762	1,490,000	1,188,000	1,750
Wyomissing Borough Water System	1,500,000	1,800,000	2,000,000	0
Boyertown Municipal Authority	860,000	1,100,000	2,000,000	2,315,000

Notes:
GPD = gallons per day
G = gallons
Largest by Population Served

Source: EPA (2011a), PADEP (2011a)

Table 2.9-3 Ten Largest Chester County Water Suppliers

Water Supplier	Average Production (GPD)	Maximum Production (GPD)	Design Capacity (GPD)	Storage Capacity (G)
PA American Water Company Main System	2,500,000	3,000,000	5,750,000	9,150,000
PA American Coatesville	3,780,000	4,422,000	8,000,000	12,370,000
Aqua PA West Chester	5,000,000	6,000,000	8,000,000	12,700,000
Aqua PA Uwchlan	2,010,000	2,714,000	3,180,000	4,696,000
Phoenixville Water Department	2,500,000	3,500,000	10,300,000	10,300,000
Downingtown Water Authority	1,121,929	1,482,000	2,500,000	4,500,000
Aqua PA Spring Run	750,000	Not listed	900,000	2,763,000
Kennett Square Municipal Water Works	582,000	727,000	792,000	1,420,000
Oxford Borough Authority	360,000	463,000	431,000	2,250,000
Aqua PA Beversrede	185,750	228,131	350,000	1,000,000

Notes:
GPD = gallons per day
G = gallons
Largest by Population Served

Source: EPA (2011a), PADEP (2011a)

Table 2.9-4 Roadway Information

	Roadway and Location	Federal Functional Class	Annual Average Daily Traffic (AADT)
Montgomery County	US-422 east of Sanatoga Interchange	Other Freeways and Expressways	49,000
	Linfield Road / South Pleasantview Road between Evergreen Road and Ridge Pike	Local Road	2,500 / 1,300
	Linfield Road between Linfield and US-422	Minor Arterials	6,600
	Limerick Center Road / Sanatoga Road between Evergreen Road and Limerick Road	Urban Collector / Local Road	1,900 / 1,800
	Main Street from Linfield Road / Linfield Trappe Road to US-422 Limerick-Linfield Interchange	Local Road	5,000 / 6,600
	Evergreen Road	Local Road	3,000
Berks County	PA-82/PA-345 from PA-724 Birdsboro to US-422	Minor Arterials	8,300
	PA 662 north of US-422 from Douglassville	Minor Arterials	8,800
	PA-724 through Berks	Minor Arterials	5,800
	US-422 east of Douglassville / US-422 west of Douglassville	Other Principal Arterial Highways	36,000 / 27,000
Chester County	US-422 west of Armand Hammer Interchange	Other Freeways and Expressways	53,000
	PA-100 to PA-724	Other Freeways and Expressways	14,000
	PA-724 west of PA-100 / PA-724 east of PA-100	Minor Arterials	7,000 / 8,900 to 13,000
	Linfield Road (bridge) to Main street	Minor Arterials	5,700
	PA-100 south of US-422	Principal Arteries and Highways	20,000

Sources:
2009 Traffic Volume Map, Montgomery County, Pennsylvania, Published February 2011 (PennDOT, 2011b)
2009 Traffic Volume Map, Chester County, Pennsylvania, Published December 2010 (PennDOT, 2010a)
2009 Traffic Volume Map, Berks County, Pennsylvania, Published December 2010 (PennDOT, 2010b)
Federal Functional Class Map Montgomery County (PennDOT, 2009a)
Federal Functional Class Map Chester County PennDOT, 2009b)
Federal Functional Class Map Berks County PennDOT, 2009c)

Table 2.9-5 Highway Levels of Service Existing Conditions, Sanatoga Interchange Study

Intersection	Approach	Weekday P.M. Peak Hour	Saturday Midday Peak Hour
High Street & Park Road	Eastbound	B	A
	Westbound	A	A
	Northbound	E	E
	Southbound	F	F
High Street & Rupert Road	Eastbound	B	C
	Westbound	B	B
	Northbound	C	C
	Southbound	D	D
	ILOS[1]	C	*C*
Evergreen Road & Route 422 WB Off-Ramp	Eastbound	C	C
	Westbound	C	C
	Northbound	B	B
	Southbound	C	D
	ILOS	*C*	*C*
Evergreen Road & Route 422 WB On- Ramp	Northbound	B	C
Evergreen Road & Route 422 EB Ramps	Westbound	C	C
	Northbound	B	B
	Southbound	A	A
	ILOS	*B*	*B*
Evergreen Road & Lightcap Road	Eastbound	A	A
	Westbound	A	A
	Northbound	C	D
	ILOS	*A*	*A*

[1] ILOS = (Overall) intersection level of service (for signalized intersections)
Source: Simone Collins Landscape Architecture (2008) Sanatoga Interchange Study, Chapter 2, Page 12. Prepared for Lower Pottsgrove Township, Montgomery County, Pennsylvania.

Key:
A -- Free flow of the traffic stream; users are unaffected by the presence of others.
B -- Stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished.
C -- Stable flow that marks the beginning of the range of flow in which the operation of individual users is significantly affected by interactions with the traffic stream.
D -- High-density, stable flow in which speed and freedom to maneuver are severely restricted; small increases in traffic will generally cause operational problems.
E -- Operating conditions at or near capacity level causing low but uniform speeds and extremely difficult maneuvering that is accomplished by forcing another vehicle to give way; small increases in flow or minor perturbations will cause breakdowns.
F -- Defines forced or breakdown flow that occurs wherever the amount of traffic approaching a point exceeds the amount which can traverse the point. This situation causes the formation of queues characterized by stop-and-go waves and extreme instability.

Table 2.11-1 Historic Above-Ground Resources within a 6-mile Radius of LGS that are Listed in the National Register of Historic Places

Site Name	Location	PHMC Key #
Fricks Locks Historic District	Fricks Locks Road, End, 1/4 Mile East of Saratoga Road, East Coventry Twp., Chester Co.	116261
Hare's Hill Road Bridge	East Pikeland Twp., Chester Co.	001553
Kimberton Historic District (Boundary Increase)	Hares Hill Road, Prizer Road, and Kimberton Road, East Pikeland Twp., Chester Co.	001562
Kimberton Village Historic District	Intersection of Kimberton Road & Hares Hill Road, East Pikeland Twp., Chester Co.	104837
Prizer's Mill Complex	Mill Lane, East Pikeland Twp., Chester Co.	001580
Rapp's Covered Bridge	Rapp's Dam Road, East Pikeland Twp., Chester Co.	000375
Hall's Bridge	East Vincent Twp., Chester Co.	001551
Kennedy Covered Bridge	Seven Stars Road, East Vincent Twp., Chester Co.	050742
Parker's Ford	Old Schuylkill Road, East Vincent Twp., Chester Co.	079670
River Bend Farm	Sanatoga Road, East Vincent Twp. Chester Co. (Not in East Vincent Twp.)	050884
Vincent Forge Mansion	Cook's Glen Road, East Vincent Twp., Chester Co.	082618
Pottstown Landing Historic District	Main Street, North Coventry Twp., Chester Co.	104047
Coventryville Historic District	Route 23, South Coventry, Warwick, and East Nantmeal Twps., Chester Co.	001531
French Creek Farm	Kimberton Road, West Vincent Twp., Chester Co.	095688
Simon Meredith House	Pughtown Road, South Coventry Twp., Chester Co.	050889
Stephen Meredith House	South Coventry Twp.	079484
Nathan Michener House	Ridge Road, South Coventry Twp., Chester Co.	001574
S.R. 7015	West Vincent Twp., Chester Co.	132272
William and Mordecai Evans House	206 Main Street, Limerick Twp., Montgomery Co.	079687
Isaac Hunsberger House	545 West Ridge Pike, Limerick Twp., Montgomery Co.	087972
Sanatoga Union Sunday School	2341 East High Street, Lower Pottsgrove Twp., Montgomery Co.	084422

Table 2.11-1 Historic Above-Ground Resources within a 6-mile Radius of LGS that are Listed in the National Register of Historic Places

Site Name	Location	PHMC Key #
Sunnybrook Park & Ballroom; Sunnybrook Convention Center: Colonial Restaurant; Sunnybrook	99 Sunnybrook Road, Lower Pottsgrove Twp., Montgomery Co.	140507
Long Meadow Farm – Plank House and Barn	New Hanover Twp., Montgomery Twp.	000561
High Street Historic District; Hill Historic District	631-1329 High Street, Pottstown Borough, Montgomery Co.	096230
Jefferson School	Pottstown Borough, Montgomery Co.	118680
John Potts House; Pottsgrove Mansion	High Street, Pottstown Borough, Montgomery Co.	000565
Old Pottstown Historic District	Manatawny Creek, Beech Street, Adams Street, Apple Street, and Hanover Street, Pottstown Borough, Montgomery Co.	064416
Old Pottstown Historic District Boundary Increase	High & South Hanover Streets, Pottstown Borough, Montgomery Co.	077112
Pottstown Roller Mill	Pottstown Borough, Montgomery Co.	000566
Reading Railroad: Station (Pottstown)	High Street, Pottstown Borough, Montgomery Co.	064347
William Grubb Mansion	1304 East High Street, Pottstown Borough, Montgomery Co.	096664
Continental Stove Works; Buckwalter Stove Company	1st Street, Royersford Borough, Montgomery Co.	082496
Augustus Lutheran Church	Trappe Borough, Montgomery Co.	000789 (NHL)
Henry Melchior Muhlenberg house	201 West Main Street, Trappe Borough, Montgomery Co.	079790
Henry Antes House	Upper Frederick Twp., Montgomery Co.	000788 (NHL)
Bridge in Upper Frederick Twp.	L.R. 46007, Crossing Swamp Creek, Upper Frederick Twp., Montgomery Co.	000217
John Englehardt Homestead	Keyser Road, 1 mile South of Obelisk, Upper Frederick Twp., Montgomery Co.	000533
Sunrise Mill	Neiffer Road, at Swamp Creek Road, Upper Frederick Twp., Montgomery Co.	000575

NHL = National Historic Landmark

Source: PA Cultural Resources Geographic Information System (CRGIS) online database (PHMC/PennDOT, 2011)

Table 2.11-2 Historic Above-Ground Resources within a 6-mile Radius of LGS Determined Eligible for Listing in the National Register of Historic Places

Site Name	Location	PHMC Key #
John Mattis Farm	250 Kolb Road, East Coventry Twp. Chester Co.	121479
Bridge	S.R. 7015, East Coventry Twp., Chester Co.	132046
Schuylkill Navigation Company Canal	East Coventry Twp., Chester Co.	140714
Daniel H. Kulp House	131 Mack Road, East Coventry Twp., Chester Co.	141504
Queen Anne House	East Rapp's Dam Road, East Pikeland Twp., Chester Co.	022358
Bernard Property	Hares Hill Road, East Pikeland Twp., Chester Co.	105434
Pennhurst State Hospital & Home	East Vincent Twp., Chester Co.	064464
Pennhurst State Hospital	East Vincent Twp., Chester Co.	064464
Jonathon Rogers or Jacob Beaver House	West Seven Stars Road, East Vincent Twp., Chester Co.	079511
Egress Acres	East Vincent Twp., Chester Co.	097182
William Yeager Farm	Hoffecker Road, East Vincent Twp., Chester Co.	097300
Frank Titanic Property	Bertolet School Road, East Vincent Twp., Chester Co.	097518
Samuel Rosen Farm	Ellis Wood Road, East Vincent Twp., Chester Co.	097621
Camp Sankanac	66 Bertolet School Road, East Vincent Twp., Chester Co.	101617
Bridge	S.R. 7015 Crossing Pigeon Creek, East Coventry Twp., Chester Co.	132046
S.R. 7015	East Vincent Twp., Chester Co.	132082
Isaac Schlichter House & Barn	Stony Run Road, East Vincent Twp., Chester Co.	105032
Parsonage, Falkner Swamp Reformed Church	117 Cross Road, New Hanover Twp., Montgomery Co.	079899
Elliott Farm	North side of Fagleysville Road/Wagner Road, New Hanover Twp., Montgomery Co.	105340
Ira Gruber Estate	Schuylkill Road, North Coventry Twp., Chester Co.	022543
Farmers Hall	Church Street, North Coventry Twp., Chester Co.	079383
Walters Tract Subdivision	1338 West Schuylkill Road, North Coventry Twp., Chester Co.	105024

Table 2.11-2 Historic Above-Ground Resources within a 6-mile Radius of LGS Determined Eligible for Listing in the National Register of Historic Places

Site Name	Location	PHMC Key #
S.R. 0724	Laurel Locks Farm, North Coventry Twp., Chester Co.	127053
Kenilworth Historic District	Schuylkill Road, North Coventry Twp., Chester Co.	140712
Schuylkill Navigation Company Canal	North Coventry Twp., Chester Co.	140714
Spring City Historic District	Spring City Borough, Chester Co.	000042
Textile Mill	Spring City Borough, Chester Co.	105474
Gilbert Farm	1447 Grosser Road, Douglass Twp., Montgomery Twp.	085684
Georg Michael Kuntz Homestead	Limerick Twp., Montgomery Co.	079713
Williams Evans House	61 South Reed Road, Limerick Twp., Montgomery Co.	085618
Hood Mansion	Sanatoga Road, Limerick Twp., Montgomery Co.	096337
Property A	Limerick Twp., Montgomery Co.	097192
Linfield Road House	Linfield Road, Limerick Twp., Montgomery Co.	097304
Limerick Historic District	Ridge Pike at U.S. 422, Limerick Twp., Montgomery Co.	097846
Fruitville Road Stone Arch Bridge	Fruitville Road, Limerick Twp., Montgomery Co.	121481
(Not named in CRGIS record)	52 Keen Road, Limerick Twp., Montgomery Co.	140444
Old Perkiomen Copper Mine	Bounded Roughly by Swamp Creek, Mine Run, and Perkiomen Creek, Lower Frederick Twp., Montgomery Co.	111282
Saylor Property	1559 North Pleasant View Road, Lower Pottsgrove Twp., Montgomery Co.	121767
Jacobs Aircraft Engine Company Property	351-375 Armand Hammer Boulevard, Lower Pottsgrove Twp., Montgomery Co.	124550
The Hill School	High St. Pottstown Borough, Montgomery Co.	050663
Henry Potts House	720 High Street, Pottstown Borough Montgomery Co.	086593
Glasgow Village	1300 Glasgow Street, Pottstown Borough, Montgomery Co.	091053
Charlotte Street Historic District	220-878 Charlotte Street, Pottstown Borough, Montgomery Co.	102254

Table 2.11-2 Historic Above-Ground Resources within a 6-mile Radius of LGS Determined Eligible for Listing in the National Register of Historic Places

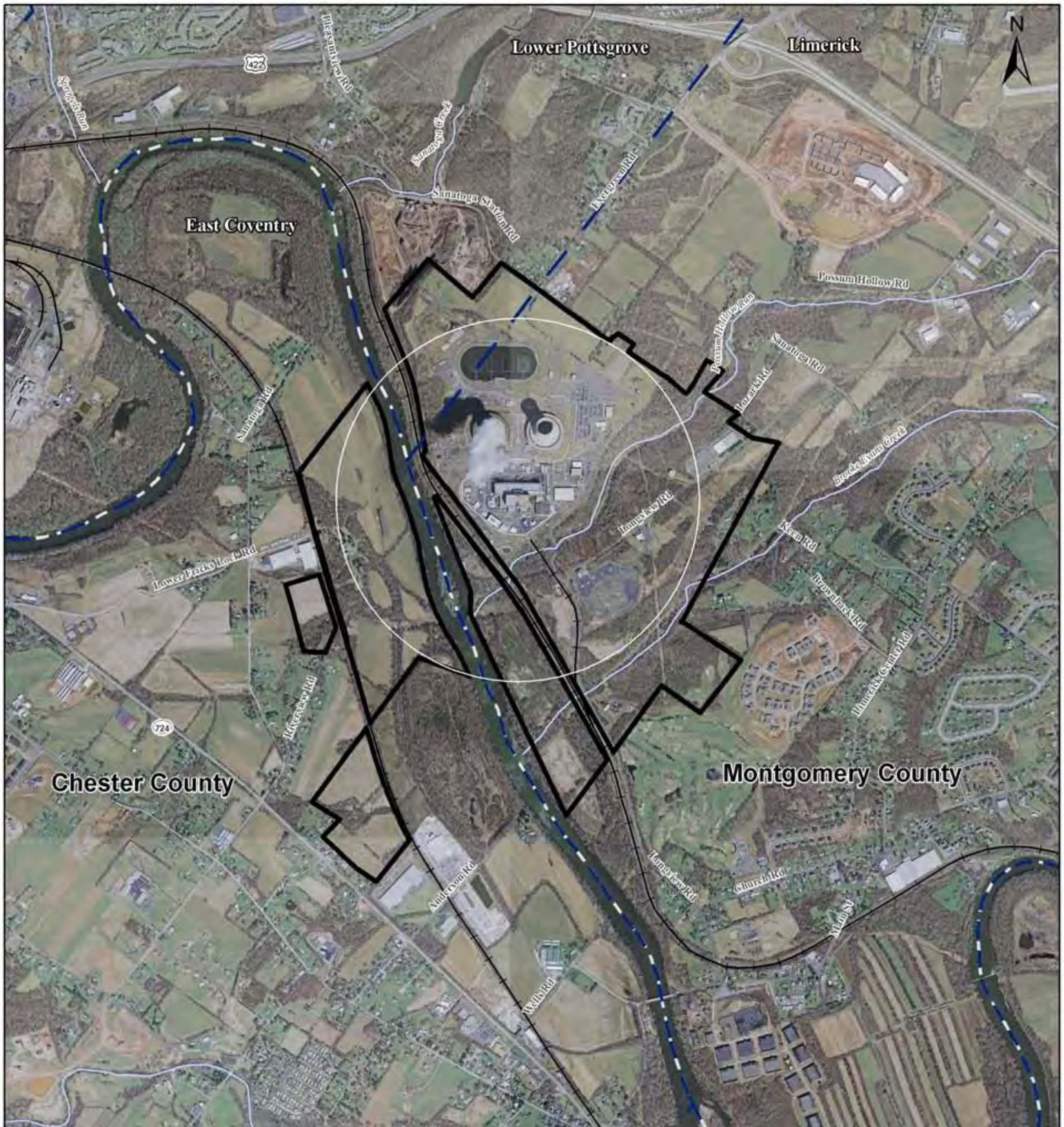
Site Name	Location	PHMC Key #
W.W. Rupert Elementary School	Pottstown Borough, Montgomery Co.	115932
Pottstown Conservation District	Pottstown Borough, Montgomery Co.	119061
Pottstown Industrial Historic District	Queen Street, Moser Street, and Susquehanna River, Pottstown Borough, Montgomery Co.	121485
S.R. 7046	Pottstown Borough, Montgomery Co.	136796
W.L. Latshaw House (Meridan Youth Services)	134 North 4th Avenue, Royersford Borough, Montgomery Co.	085452
Diamond Glass Co.	200-280 First Avenue, Royersford Borough, Montgomery Co.	141672
Lamb Tavern	724 Main Street, Trappe Borough, Montgomery Co.	079653
Dewees Tavern & Dwelling	301-307 Main Street, Trappe Borough, Montgomery Co.	079622
Village of Trappe Historic District	151-724 Main Street, 18-24 East 3rd Avenue, 20-60 West 5th Avenue, 15-71 West 7th Avenue, Trappe Borough, Montgomery Co.	106251
Senator Lewis Royer Farm	96 East 3rd Street, Trappe Borough, Montgomery Co.	106257
Jan Neuss Log House	Colonial Road, Upper Frederick Twp., Montgomery Co.	079781
Bertolet's Mennonite Meeting House	Colonial Road, 1 mile West of Route 73, Upper Frederick Twp., Montgomery Co.	096922
(Not named in CRGIS record)	2nd Avenue, Upper Providence Twp., Montgomery Co.	000216
Vanderslice/Custer Farm; Guy F. & Eleanor Wagner	357 Greenwood Avenue, Upper Providence Twp., Montgomery Co.	103213
Hildebidle Property; Mourar Property	1637 Yeager Rd. Upper Providence Twp., Montgomery Co.	104182
S.R. 7046	Upper Providence Twp., Montgomery Co.	136891
Gudebrod Brothers Silk Company	Old Reading Pike, West Pottsgrove Twp., Montgomery Co.	091862
Hoffman's Store	236 High St., Pottstown Borough, Montgomery Co.	79730
Riegner, John, House	2481 Romig Road, New Hanover Twp., Montgomery Co.	141482

Source: PA Cultural Resources Geographic Information System (CRGIS) online database (PHMC/PennDOT, 2011)

Table 2.11-3 Archaeological Sites within a 6-mile Radius of LGS that have been Determined Eligible for Listing in the National Register of Historic Places

Site Name	Location	PHMC Site #
Hartenstine Heritage Site 2	Limerick Twp., Montgomery Co.	36MG0345
Hartenstine Heritage Site 3B	Limerick Twp., Montgomery Co.	36MG0347
Potts-Saylor Mill Race	Pottstown Borough, Montgomery Co.	36MG0277

Source: PA Cultural Resources Geographic Information System (CRGIS) online database (PHMC/PennDOT, 2011)



0 875 1,750 3,500 Feet

Reference:
DVRPC 2005 Aerial Imagery
ESRI 2009 Streets and Roads

NAD 1983 State Plane Pennsylvania South
Projection: Lambert Conformal Conic
Linear Unit: Foot US

Total Exelon Generation-owned property: 645 acres.

PA NJ MD DE

Legend

- Exelon Generation Property Boundary
- 2500 Ft Radius Exclusion Area
- Conrail Line
- County Boundary
- Municipal Boundary

Figure 2.1-1 LGS Plant Site Boundary
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

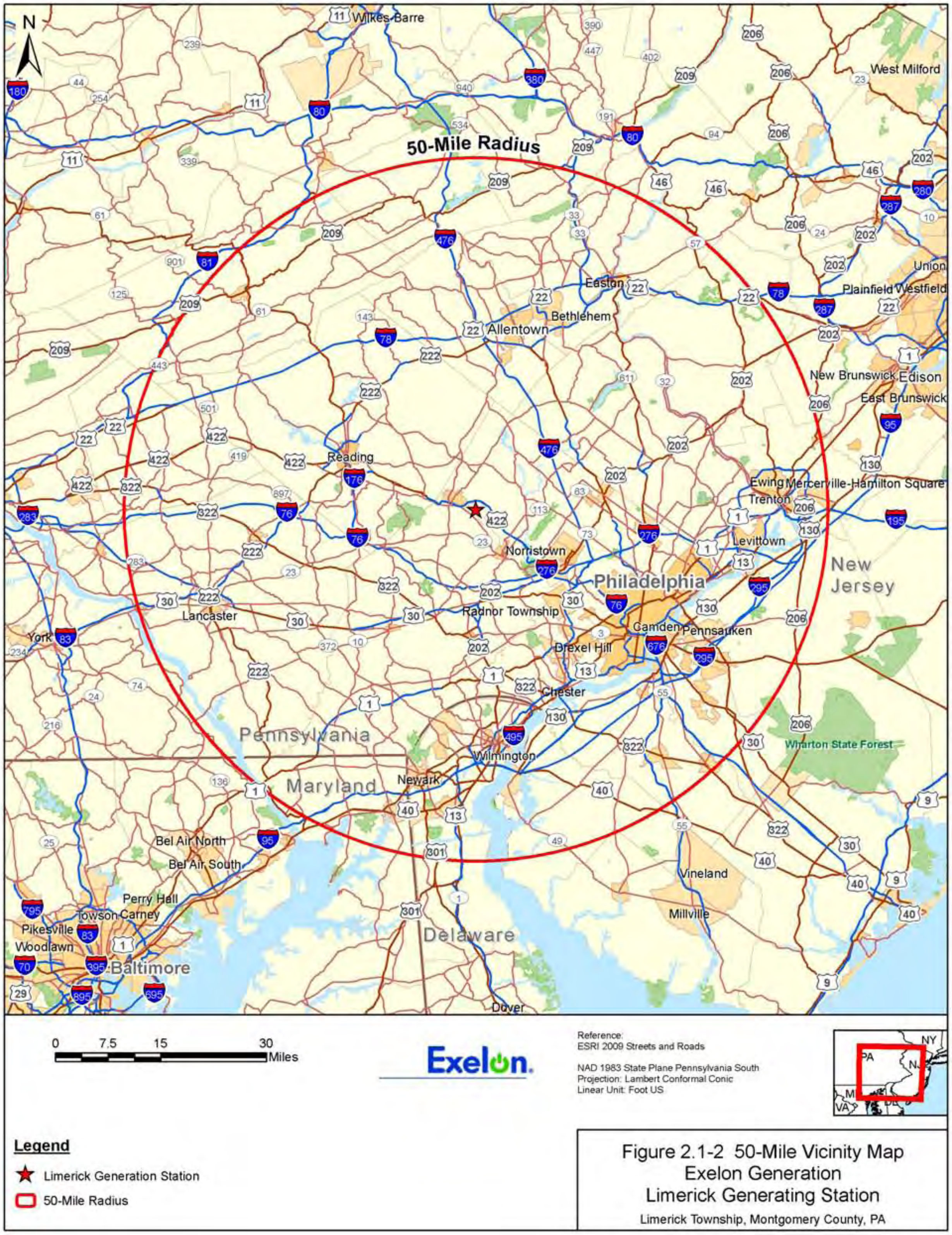


Figure 2.1-2 50-Mile Vicinity Map
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

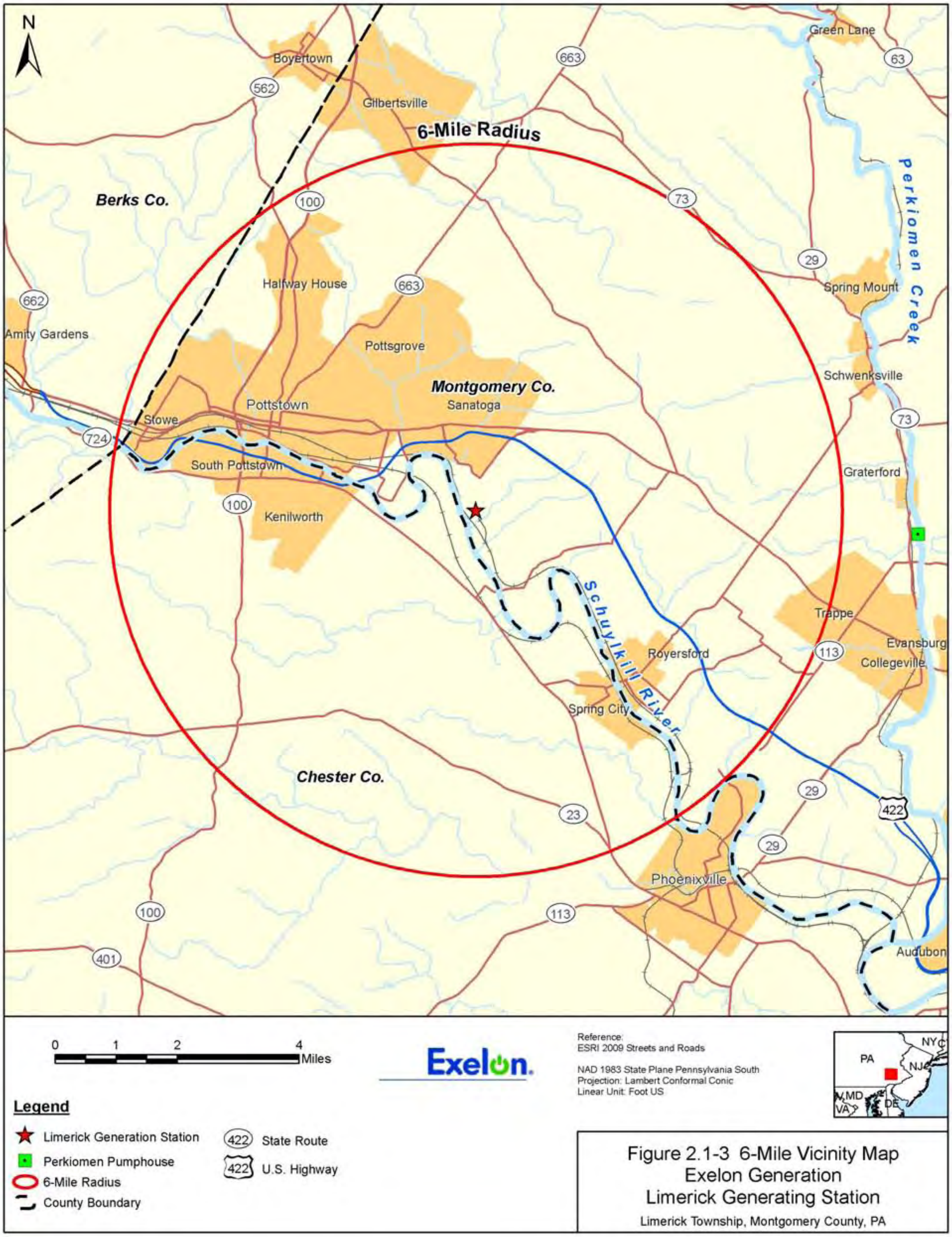


Figure 2.1-3 6-Mile Vicinity Map
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

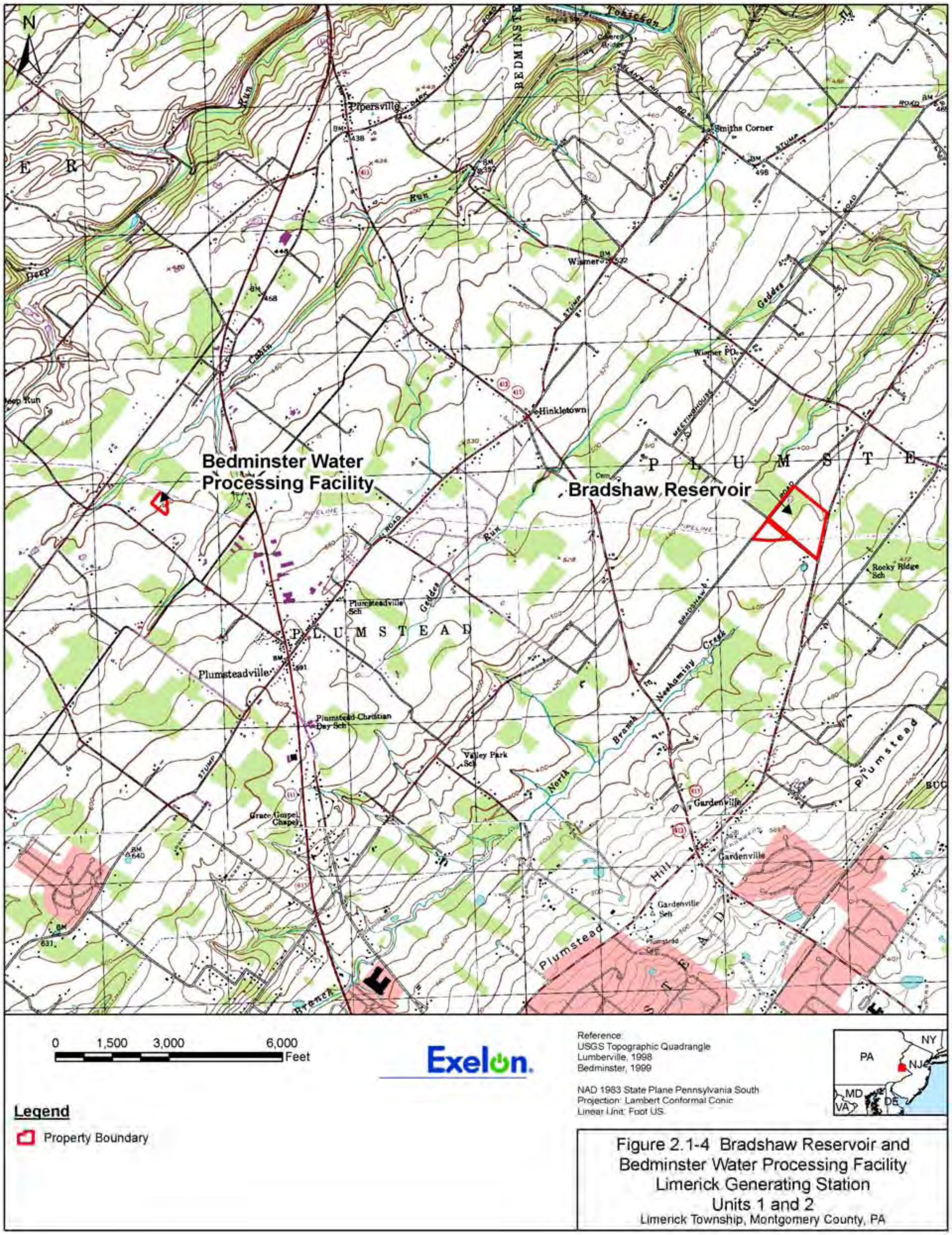


Figure 2.1-4 Bradshaw Reservoir and Bedminster Water Processing Facility
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

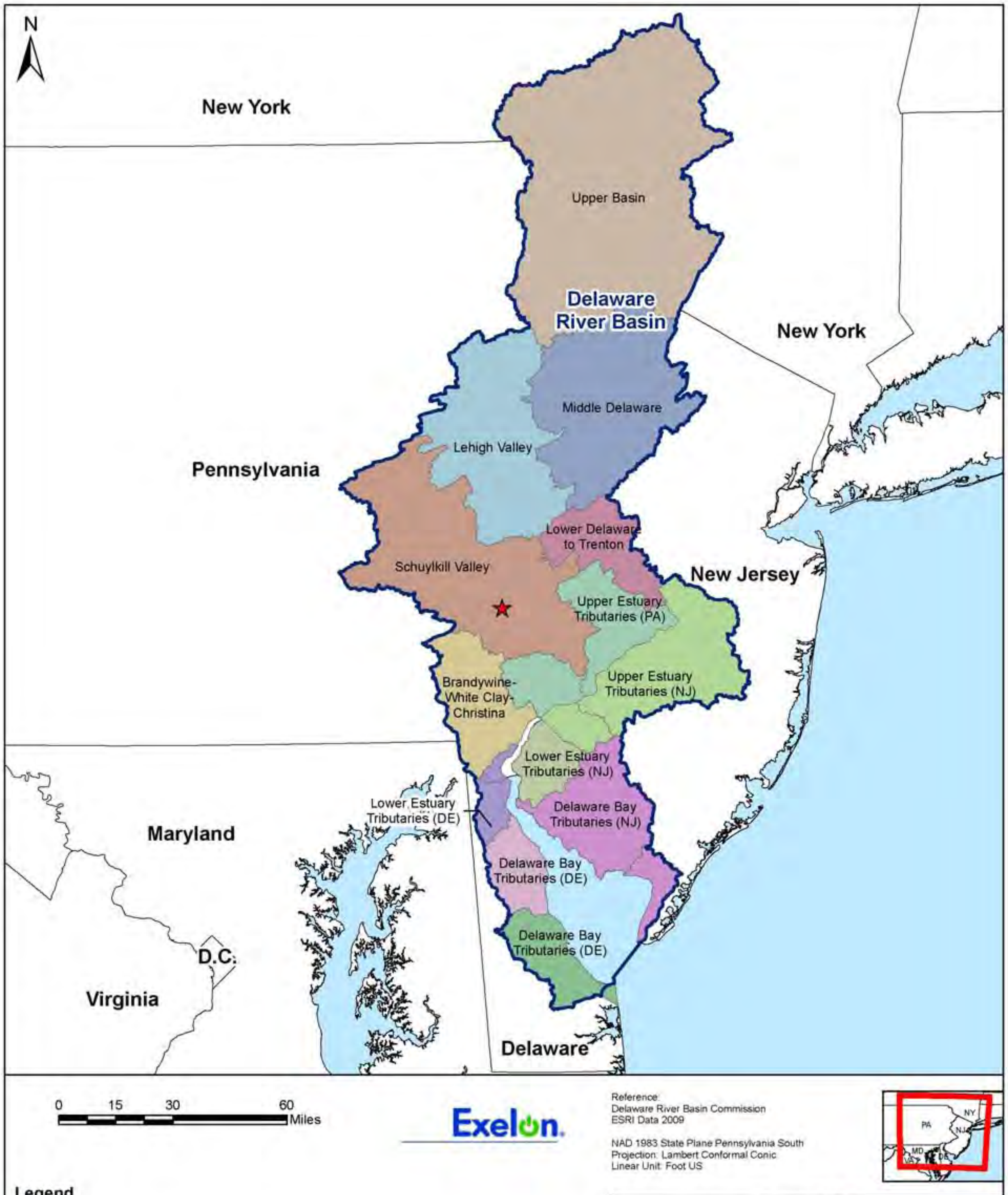


Figure 2.1-5
Delaware River Basin
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

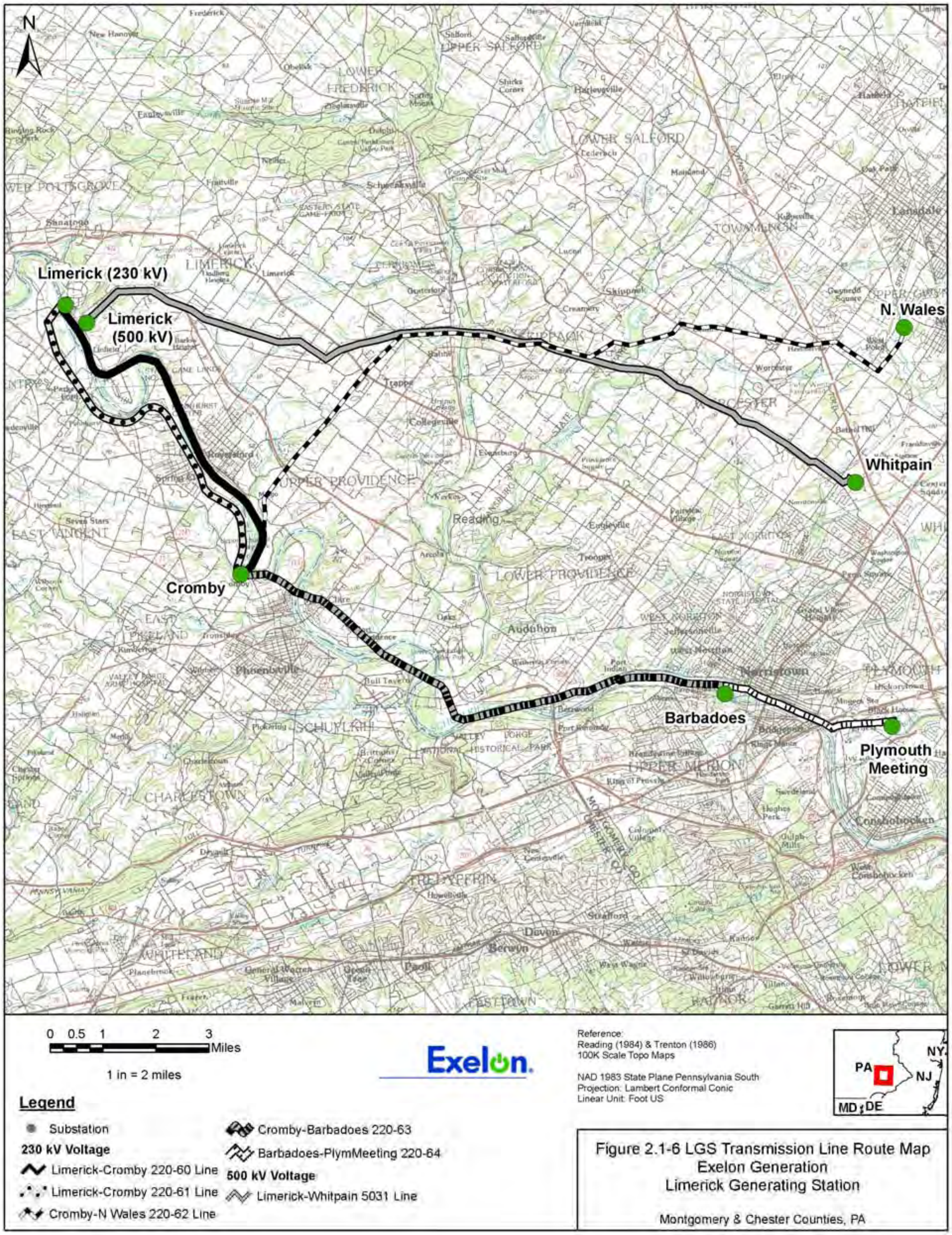


Figure 2.1-6 LGS Transmission Line Route Map
Exelon Generation
Limerick Generating Station

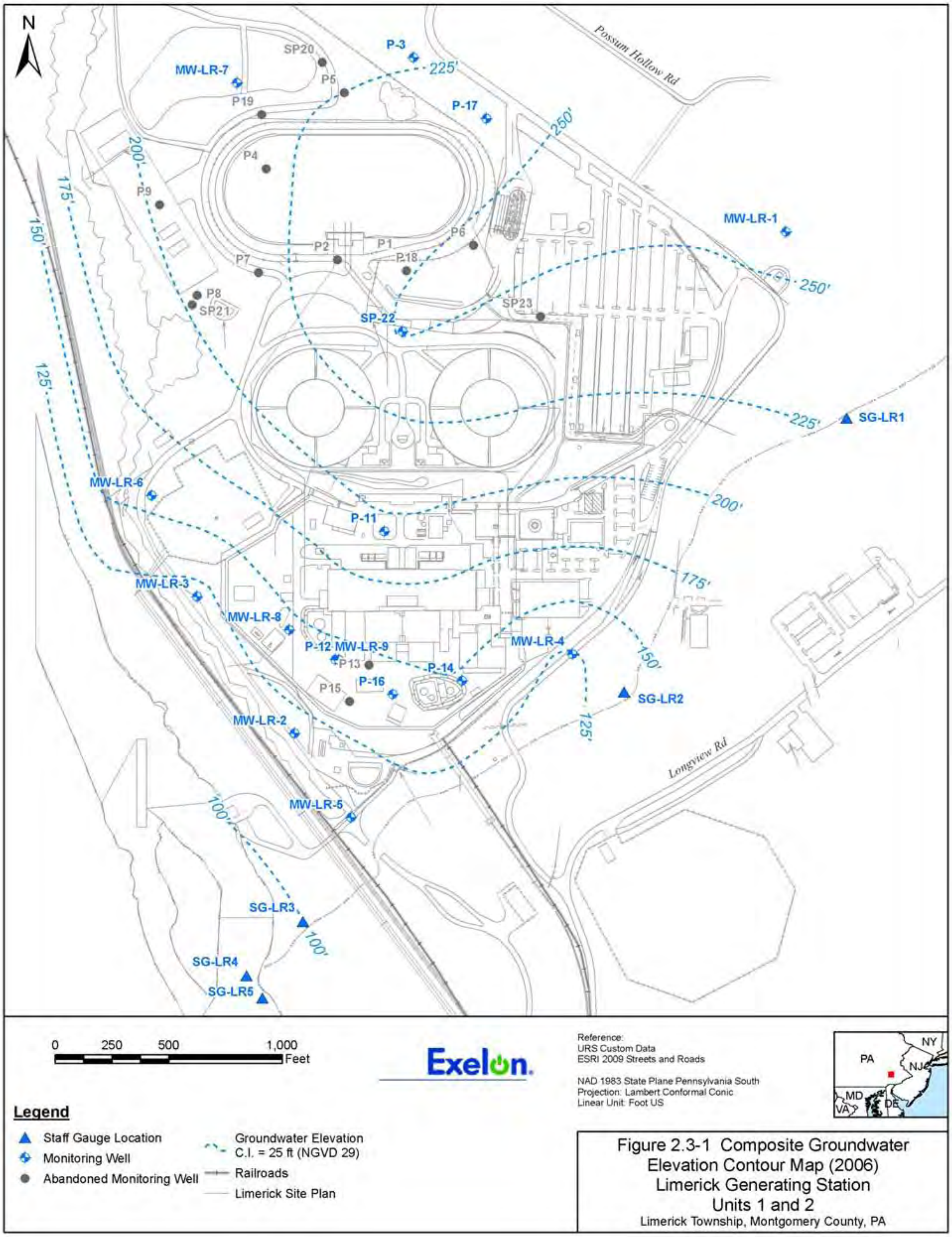


Figure 2.3-1 Composite Groundwater Elevation Contour Map (2006)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

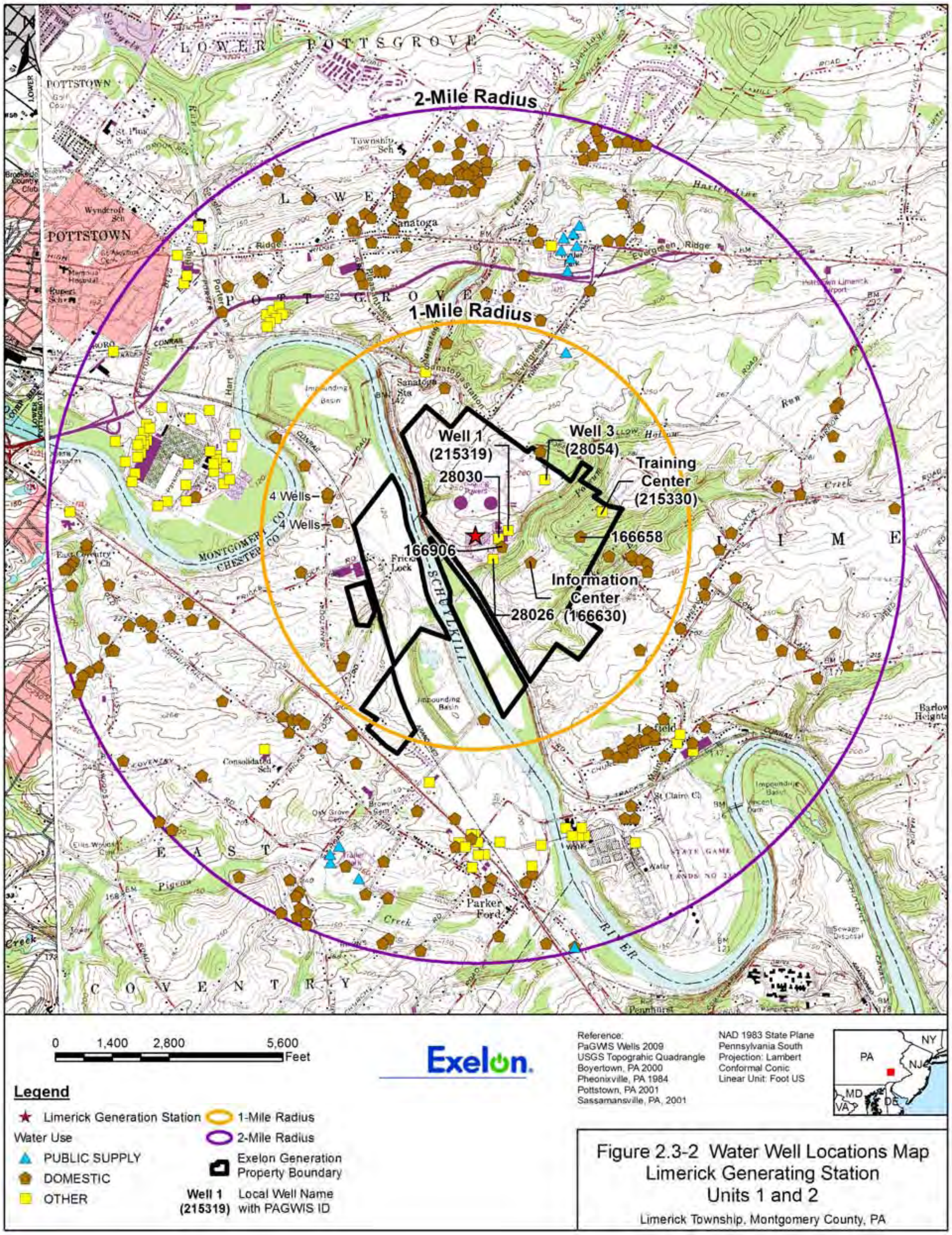


Figure 2.3-2 Water Well Locations Map
Limerick Generating Station
Units 1 and 2

Limerick Township, Montgomery County, PA

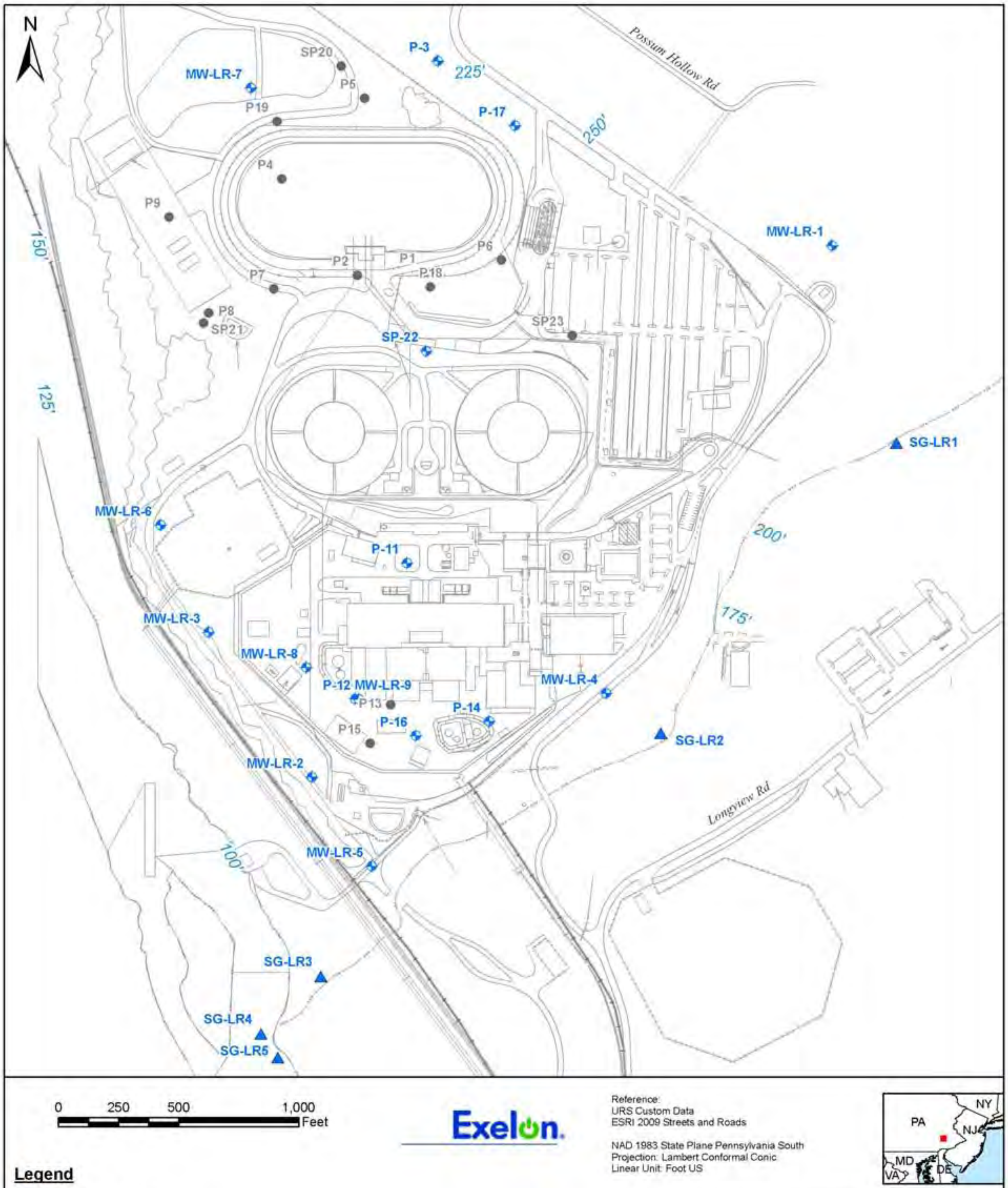
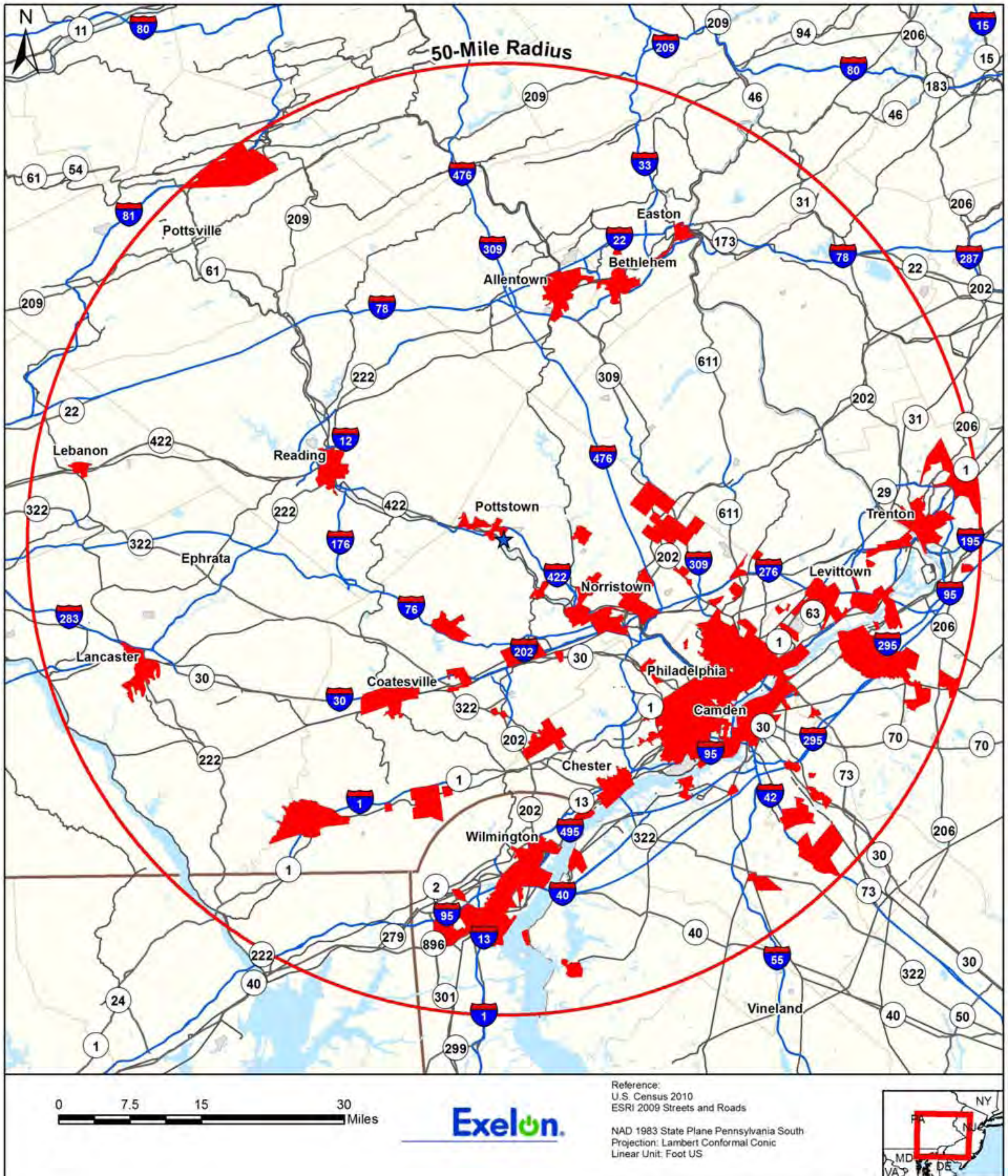


Figure 2.3-3 RGPP Monitoring Locations
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA



Legend

Aggregate Races Minority Greater Than 20% State Percentage

Figure 2.6-1 Aggregate Races Minority Populations (>20%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

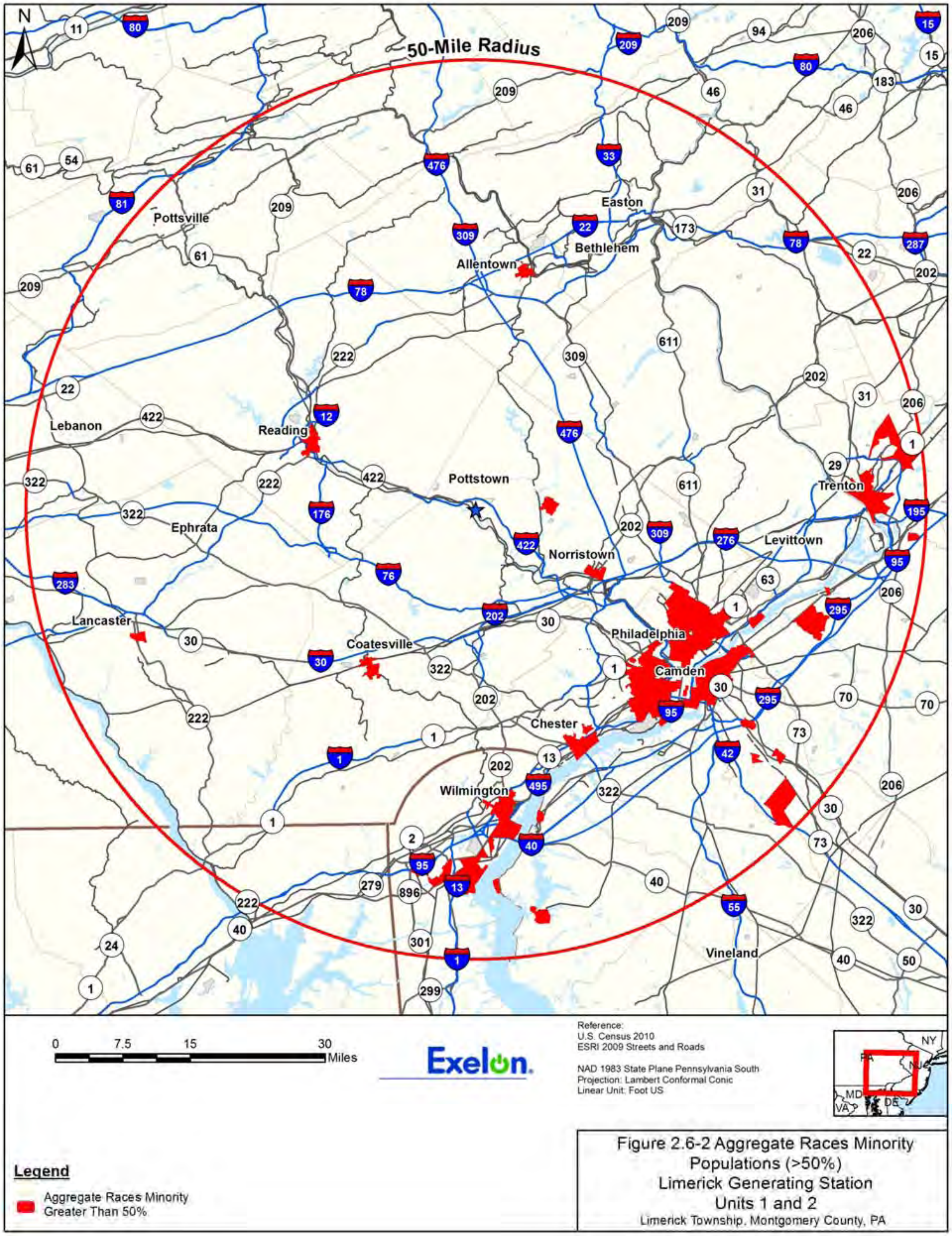


Figure 2.6-2 Aggregate Races Minority Populations (>50%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

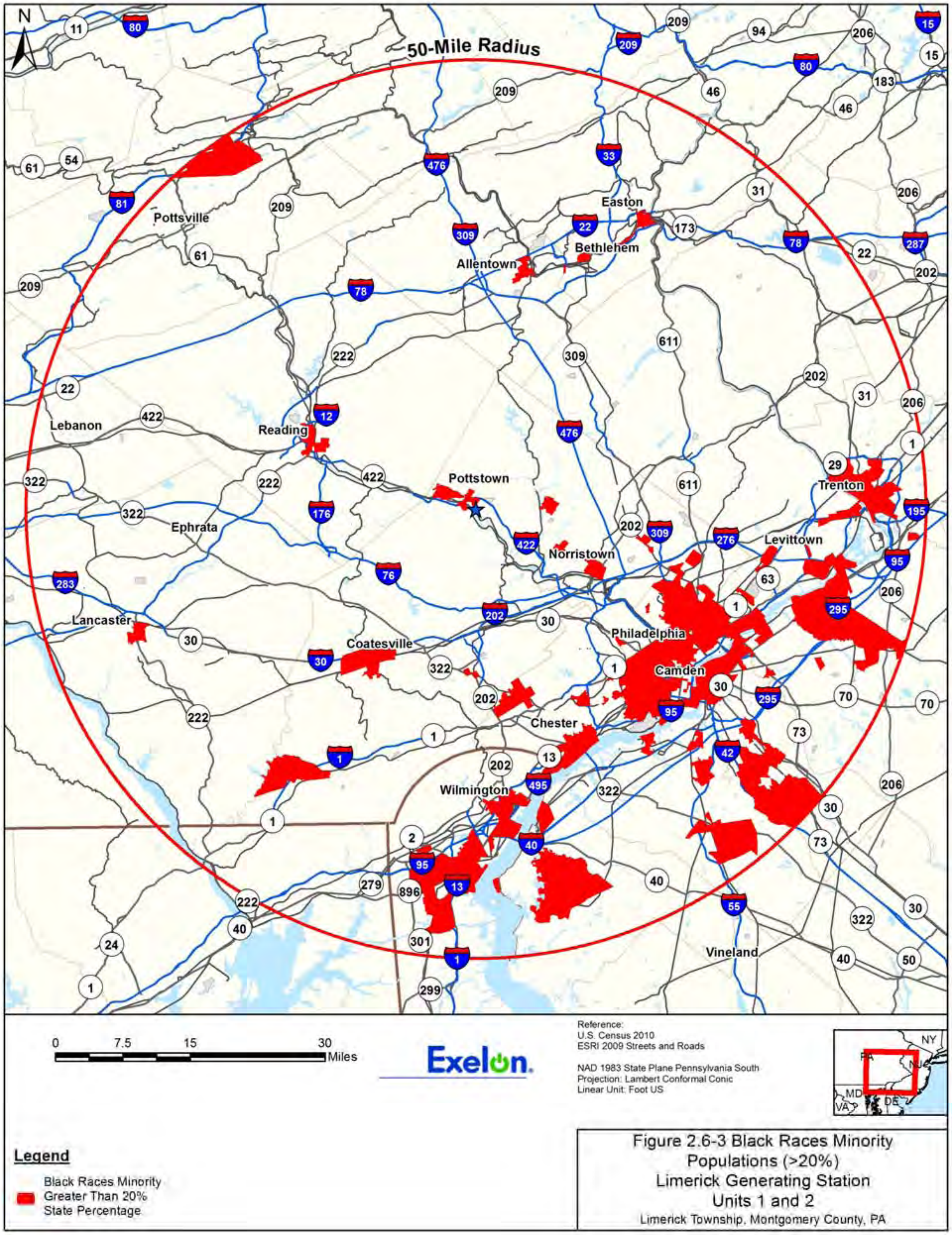


Figure 2.6-3 Black Races Minority Populations (>20%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

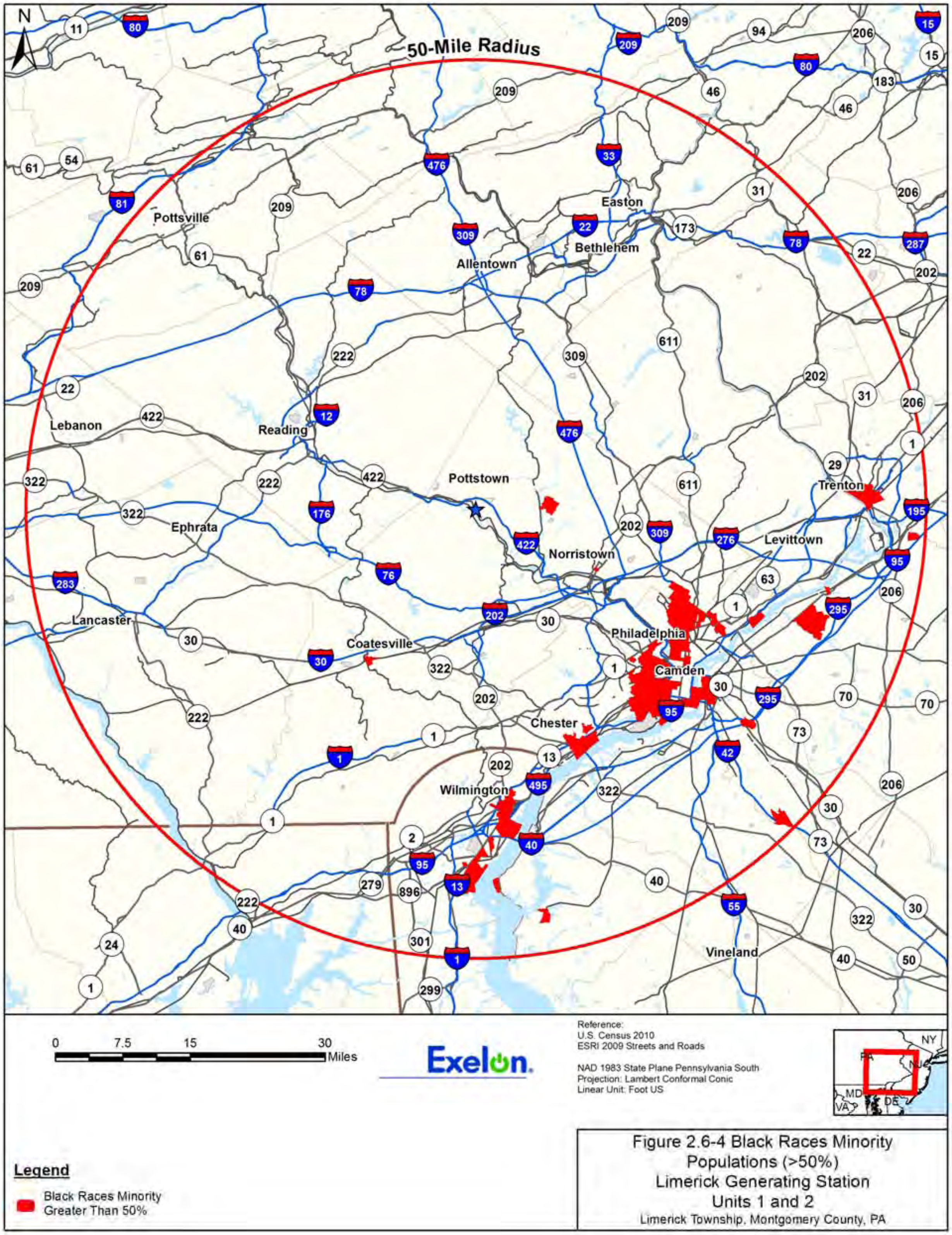


Figure 2.6-4 Black Races Minority Populations (>50%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

Legend

Black Races Minority Greater Than 50%

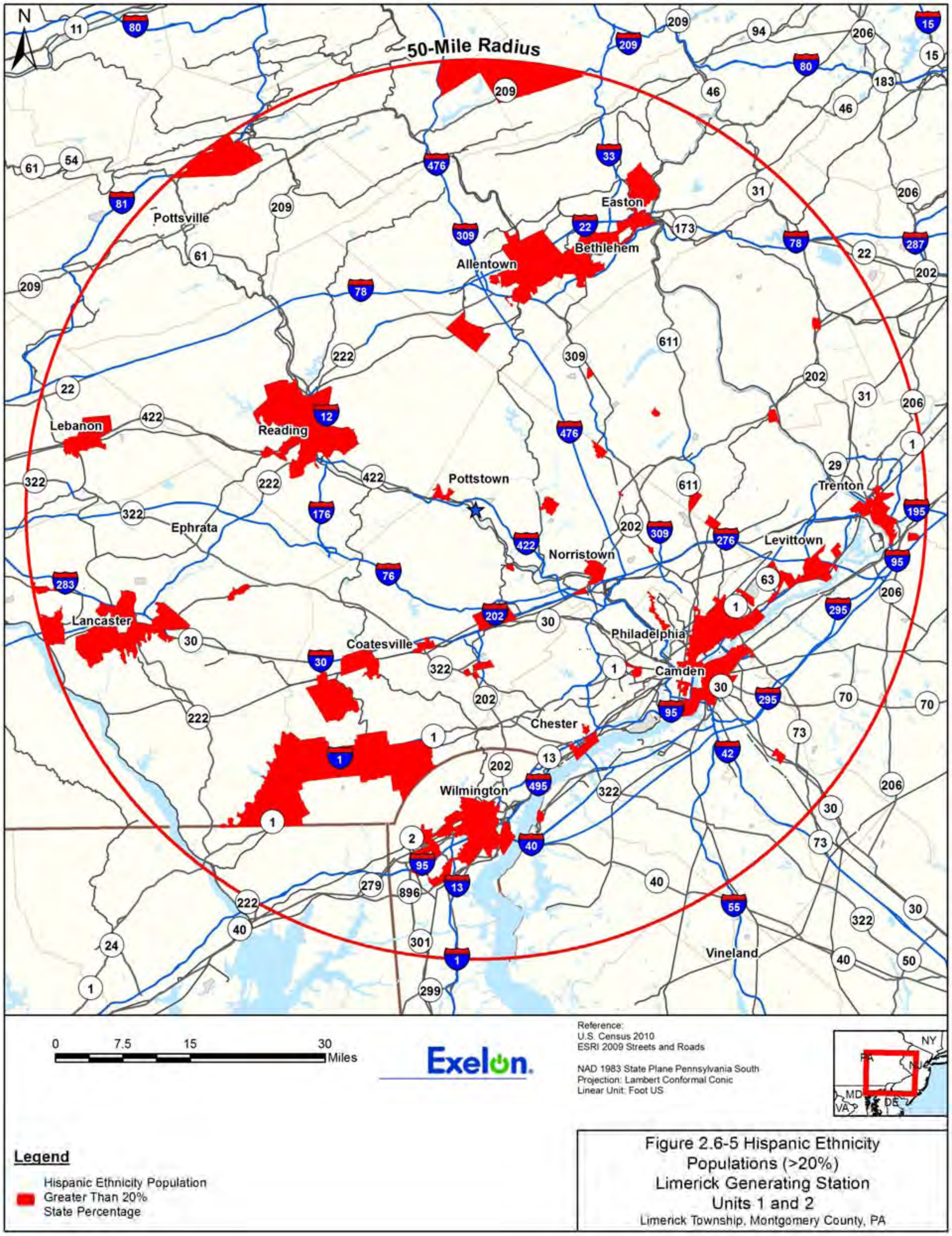


Figure 2.6-5 Hispanic Ethnicity Populations (>20%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

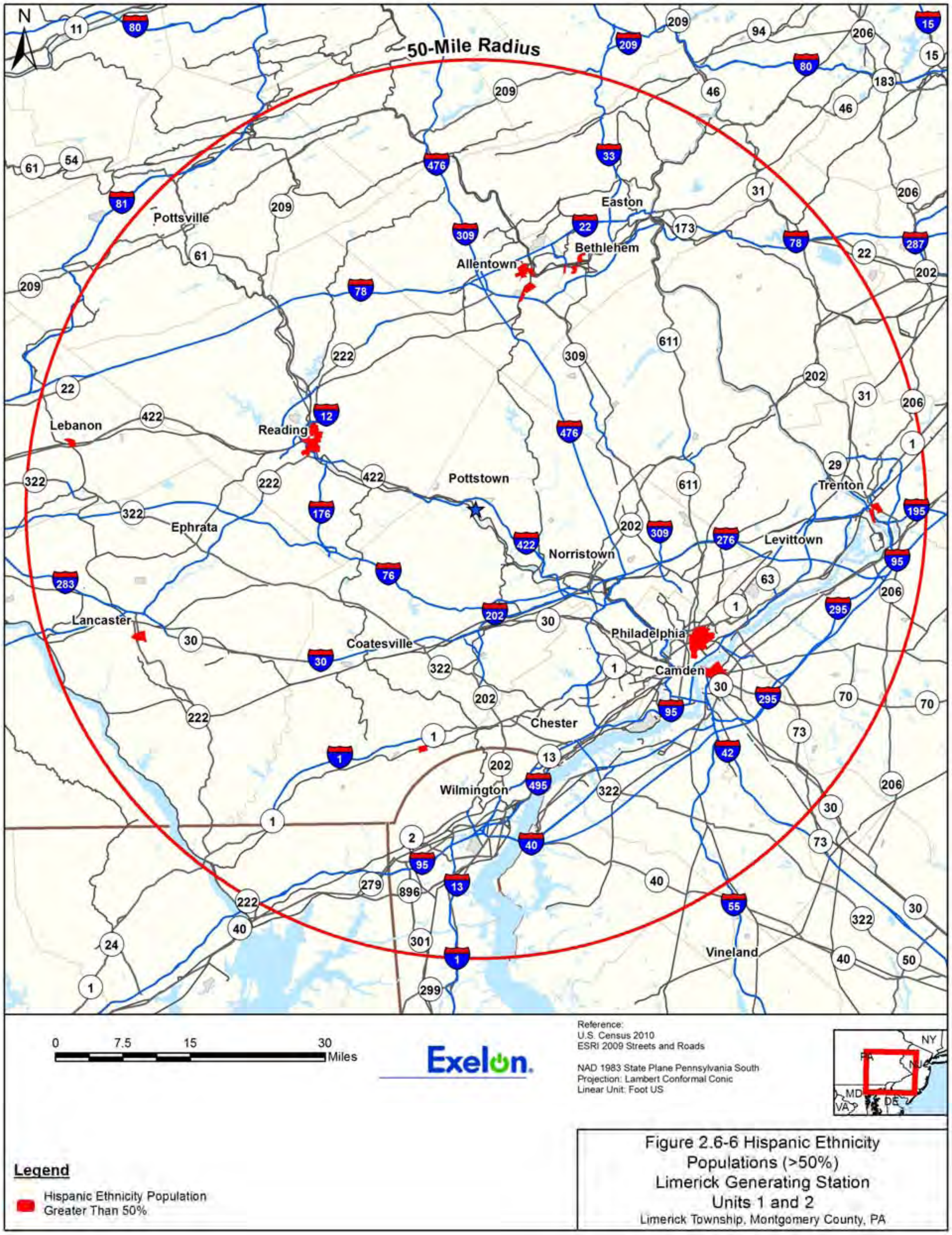


Figure 2.6-6 Hispanic Ethnicity Populations (>50%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

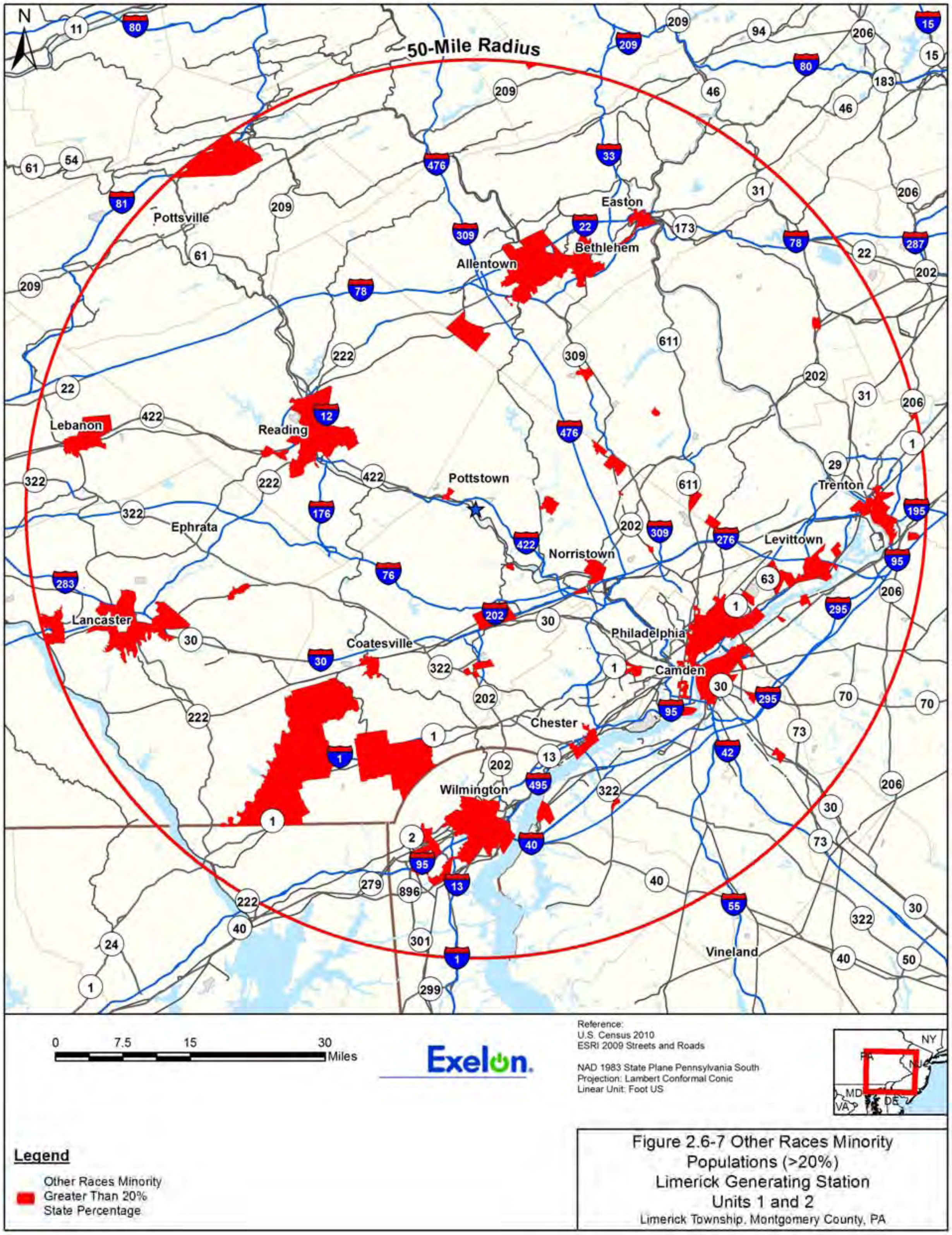


Figure 2.6-7 Other Races Minority Populations (>20%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

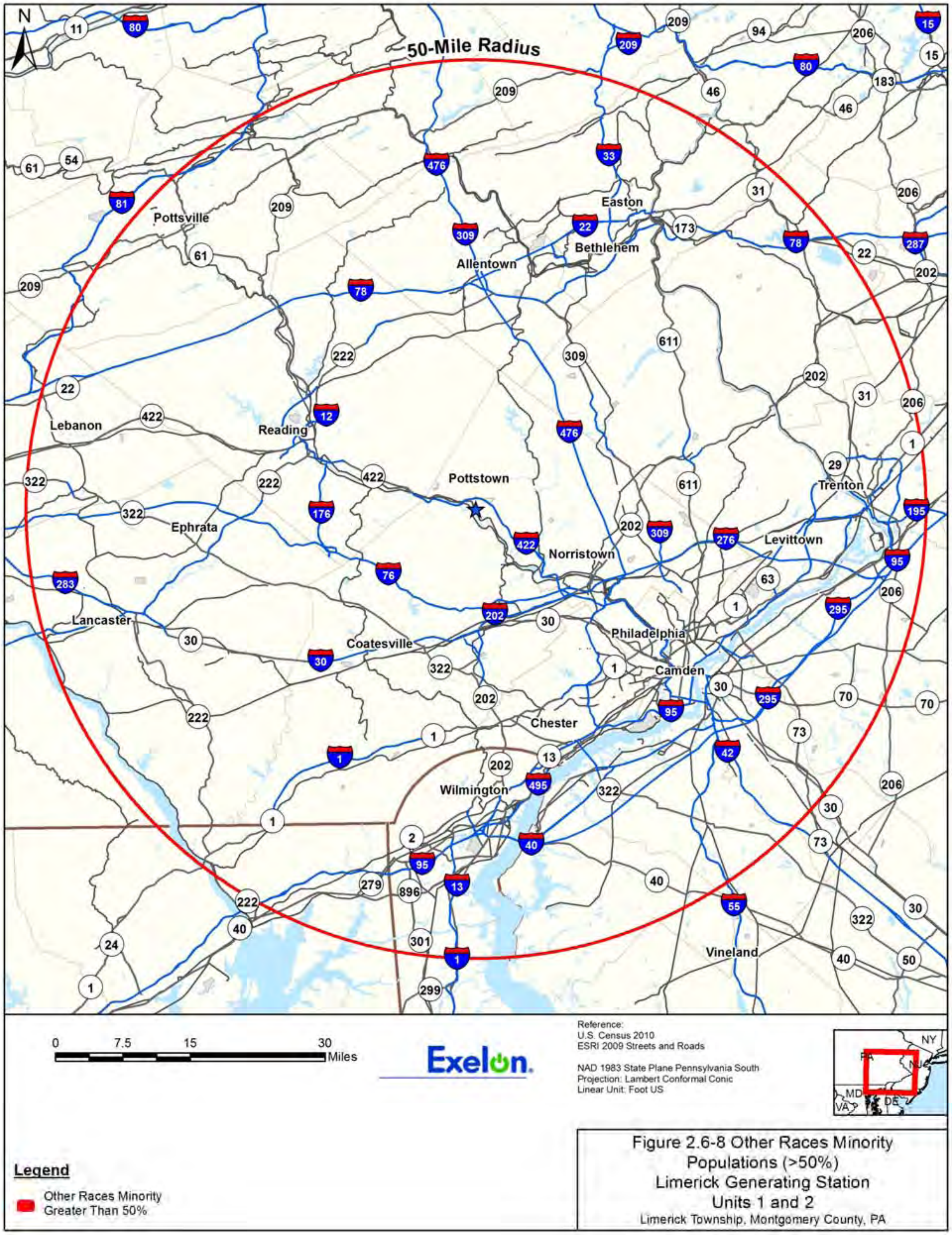


Figure 2.6-8 Other Races Minority Populations (>50%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

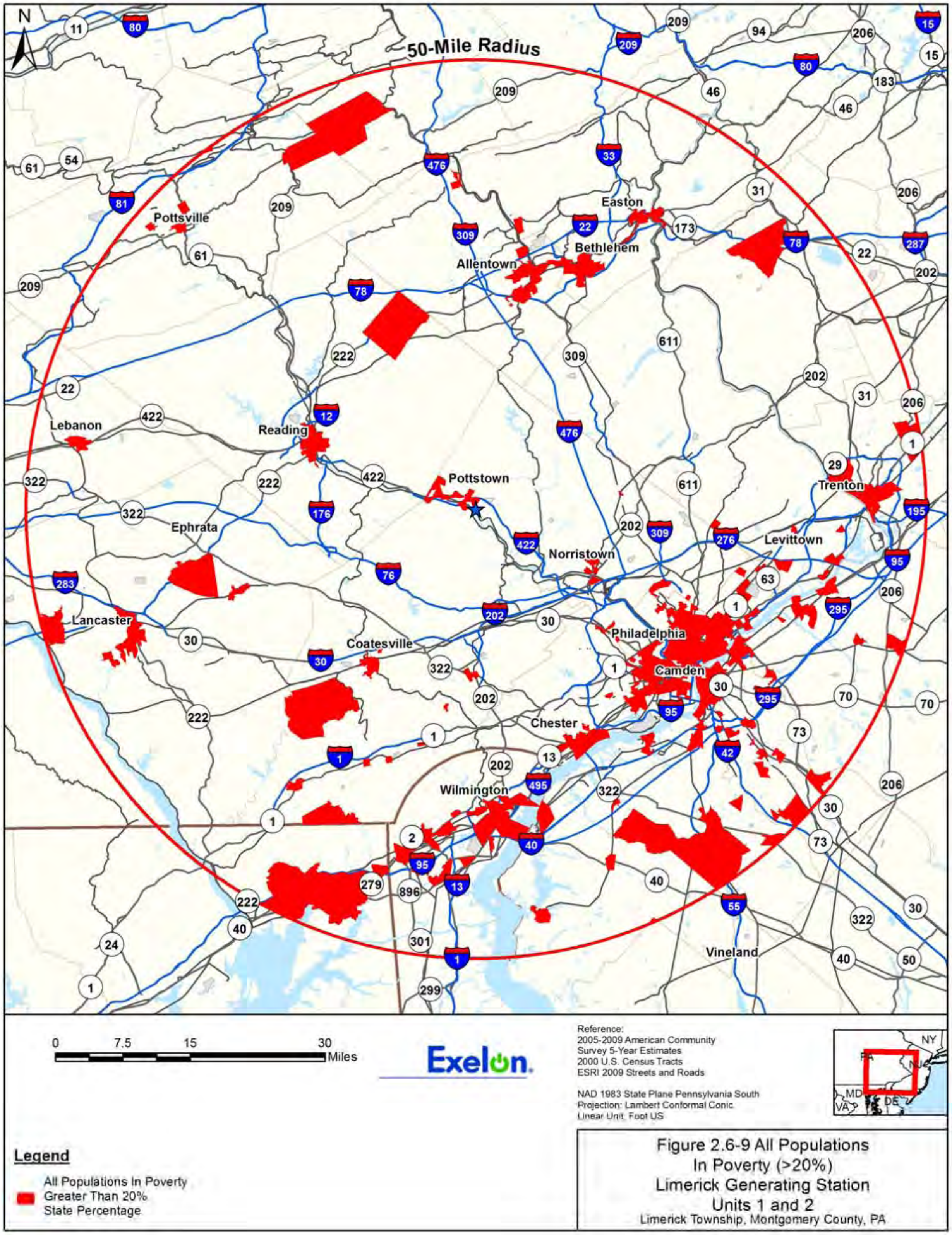


Figure 2.6-9 All Populations In Poverty (>20%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

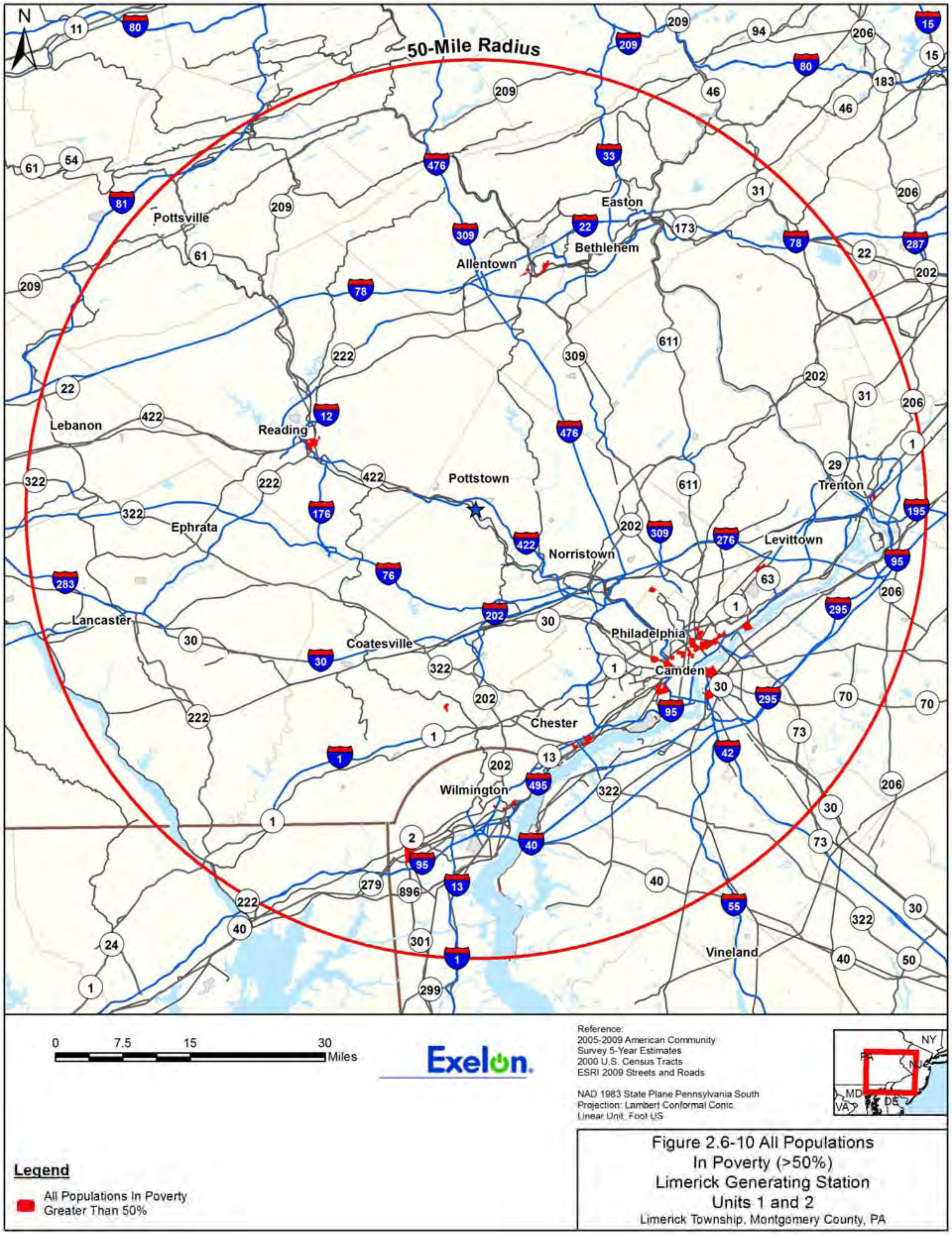


Figure 2.6-10 All Populations In Poverty (>50%)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

3.0 THE PROPOSED ACTION

NRC

“The report must contain a description of the proposed action, including the applicant’s plans to modify the facility or its administrative control procedures…. This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment….” 10 CFR 51.53(c)(2)

Exelon Generation Company, LLC (Exelon Generation) proposes that the U.S. Nuclear Regulatory Commission (NRC) renew the operating licenses for Limerick Generating Station, Units 1 and 2 (LGS) for an additional 20 years. Renewal would give Exelon Generation and the Commonwealth of Pennsylvania the option of relying on LGS to meet future electricity needs. Section 3.1 discusses the plant in general. Sections 3.2 through 3.4 address potential changes that could occur as a result of license renewal.

3.1 General Plant Information

General information about LGS is available in several documents. In 1984, NRC published the Final Environmental Statement (FES) related to the operation of LGS (NRC, 1984). The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC, 1996a) describes LGS features and, in accordance with NRC requirements, Exelon Generation maintains the Updated Final Safety Analysis Report (UFSAR) for LGS (Exelon Generation, 2008a). Exelon Generation has referred to each of these, as well as certain additional documents, while preparing this environmental report for license renewal. Information provided below for plant systems is based primarily on information available in the referenced sections of the UFSAR.

Refer to Section 2.1 for definitions of the LGS plant site, the LGS cooling water system, and the LGS transmission system, and to Figure 2.1 for a delineation of the LGS plant site boundaries.

Refer to Figure 3.1-1 and Figure 3.1-2 for the general layout and an aerial photograph, respectively, of the LGS plant site.

LGS features that are used by both Limerick units are termed “common.”

The following sections provide additional information on the LGS reactor, containment, and spray pond systems; cooling and other water systems; transmission system; and waste management and effluent control systems.

3.1.1 Reactor, Containment, and Spray Pond Systems

3.1.1.1 Reactor System

The nuclear reactor system for each Limerick unit includes a single-cycle, forced circulation, General Electric boiling-water reactor (GE BWR) producing steam for direct use in the steam turbine (Exelon Generation, 2008a, Section 1.2.4.1). Originally, each reactor at LGS was licensed to operate at a rated core thermal power of 3,293 megawatts thermal (MWt) at 100 percent steam flow. Subsequent to issuing the original operating licenses, LGS Units 1 and 2 were reevaluated with regard to Stretch Power Uprates (SPU) and rerated to 3,458 MWt each. Measurement Uncertainty Recapture (MUR) uprates, approved April 8, 2011 (NRC, 2011), increased the licensed rated core thermal power for each unit to 3,515 MWt. The corresponding approximate annual average net electrical generation per unit is 1,170 megawatts electrical (MWe).

The reactor vessel contains the core and other components including steam separators and dryers, jet pumps, the control rod guide tubes, distribution lines for the feedwater and core spray, in-core instrumentation, and supporting structures. The main connections to the reactor vessel include the steam lines, coolant recirculation lines, feedwater lines, control rod drives (CRD), nuclear instrumentation housings, and emergency core cooling system (ECCS) lines.

The reactor core includes an array of fuel rods that creates heat from a controlled nuclear reaction that occurs when control rods are withdrawn. Fuel enrichment and average peak rod burnup conditions are no more than 5 percent uranium-235 and 62,000 megawatt-days per metric ton of uranium (MWd/MTU), respectively.

The core is fed by demineralized water that enters at its lower portion. The water absorbs heat as it flows upward around the fuel rods and forms steam. The steam-water mixture leaving the top of the core is dried by steam separators and dryers located in the upper portion of the reactor vessel. The steam is then directed to the main turbine through four main steam lines where it turns the turbine generator to produce electricity. The unused steam is exhausted to the main condensers, where it transfers heat to the cooling water system and is condensed into water. The condensed water is purified in the condensate demineralizer system and then fed back to the reactor vessel to complete the circuit.

The reactor recirculation system consists of two recirculation pump loops external to the reactor vessel. These loops provide the piping path for the driving flow of water to the reactor vessel jet pumps that provide a continuous internal circulation path for the major portion of the core coolant flow.

3.1.1.2 Containment System

The containment consists of dual barriers: the primary containment and the secondary containment (Exelon Generation, 2008a, Section 1.2.4.2). The primary containment surrounds the reactor vessel and also houses the reactor coolant recirculation pumps and piping loops. The secondary containment is the structure that encloses the reactor, and its primary containment, and spent fuel storage pool areas.

The primary containment is a steel-lined reinforced concrete pressure-suppression system of the over-and-under configuration. The purpose of the primary containment system is to limit releases of radioactive material to the environment in the event of a nuclear accident so that the offsite doses are below the values stated in 10 CFR 50.67.

The primary containment design employs the drywell/pressure-suppression features of the BWR/Mark II containment concept. If a failure should occur, reactor vessel water and steam would be released into the air space of the drywell. The resulting increase in drywell pressure would force the air/water/steam mixture to be vented into the suppression pool. The steam would be condensed in the pool to limit the pressure increase inside the primary containment.

Cooling systems remove heat from the reactor core, the drywell, and from the suppression pool, thus providing continuous cooling of the primary containment under such accident conditions. The release of radioactive materials to the environment, then, is minimized through systems provided to maintain the primary containment integrity and through isolation valves that are actuated to close off potential leakage of radioactive materials through the process lines that are connected to the primary containment structure.

Leakage from the primary containment system is contained within the secondary containment system. The secondary containment system is designed to minimize the release of airborne radioactive materials, and to provide for the controlled, filtered release of the secondary containment atmosphere under accident conditions.

3.1.1.3 Spray Pond

In the event that the normal cooling water sources (refer to Section 3.1.2) are unavailable, a spray pond is provided on the LGS plant site as an emergency cooling water system to ensure that an adequate source of cooling water is available at all times for reactor shutdown and cooldown, and accident mitigation (Exelon Generation, 2008a, Sections 2.4.8.1 and 9.2.6).

The spray pond is located about 152.4 meters (500 feet) north of the cooling towers and is common to both Limerick units. The spray pond pump structure is located on the pond perimeter and contains the pumps used to supply water for the removal of heat during emergencies and removal of reactor residual heat. The pumps take water from the spray pond and circulate the water through coolers and heat exchangers; the warmed water is then returned to the spray pond either through the nozzles of the spray network or through winter bypass lines. The spray nozzles direct the warmed water upward for heat transfer to the atmosphere. Interconnections are provided to allow use of a cooling tower as a heat sink if conditions permit. Makeup water is supplied to the spray pond from the LGS cooling water system to replace evaporative losses and discharges from the pond to the Schuylkill River via the cooling tower blowdown line (refer to Section 3.1.2).

The spray pond area, located in a restricted-access area of the LGS plant site and surrounded by security fences, occupies approximately 7.0 hectares (17.2 acres) (4.0 hectares or 9.9 acres water surface area plus 3.0 hectares or 7.3 acres of surrounding area). Due to its size and its connection with the Schuylkill River and Perkiomen Creek via the LGS common makeup water system (refer to Section 3.1.2), the pond may attract wildlife or aquatic life. However, because of its safety-related functions, the spray pond is managed through barrier fencing, chemical addition, and dredging to discourage or prevent use by wildlife and aquatic life. Sedimentation on the spray pond compacted clay liner is monitored and removed, when required, to maintain the storage volume above minimum requirements.

3.1.2 Water Systems

The LGS water systems that interface with the environment include the cooling water system and the groundwater supply system. The LGS cooling water system consists of the LGS makeup water supply system (common to both Limerick units), the circulating water systems (one per Limerick unit), and the cooling tower blowdown system (also common to both Limerick units) (Exelon Generation, 2008a, Sections 1.2.4.6, 1.2.4.7, 9.2, and 10.4.5).

The cooling water system functions to supply cooling water to remove waste heat from the steam exiting the turbines of Limerick Units 1 and 2 and dissipate it to the environment. The circulating water system for each unit consists of one cooling tower, three main condensers, four 25-percent-capacity circulating water pumps, and associated piping, valves, controls, and instrumentation.

Makeup water, obtained from the LGS makeup water supply system (described in Section 2.1.2), is supplied to both circulating water systems to replace water lost due to (1) evaporation and drift from the cooling towers (“consumptive use”) and (2) blowdown from the cooling towers (“non-consumptive use”). Since LGS uses a closed-cycle cooling system, most (i.e., about 75 percent at design conditions) of the makeup water is used consumptively to replace cooling tower evaporative losses. The non-consumptively used portion of the makeup water is for controlling chemistry parameters in the circulating water by limiting the buildup of dissolved solids. This portion is returned to the Schuylkill River as blowdown. Blowdown from each cooling tower basin is combined with other plant wastewaters, monitored, and discharged to the Schuylkill River through a common permitted outfall.

Makeup water for both consumptive use and non-consumptive use at LGS is normally withdrawn from the Schuylkill River through an intake pumphouse (Schuylkill Pumphouse) that serves both LGS units. However, LGS also relies on other water sources and an auxiliary intake pumphouse on the Perkiomen Creek (Perkiomen Pumphouse) to make up for its consumptive use during periods of Schuylkill River low flow. The Perkiomen Creek is the secondary source for consumptively used water when use of the normal source (the Schuylkill River) is restricted due to low flow.

The Schuylkill Pumphouse is situated on the LGS plant site along the eastern bank of the Schuylkill River opposite the northern end of the mid-channel island (Limerick Island). The structure houses five pumps that take suction from the Schuylkill River: three river water pumps for consumptive cooling water makeup and two blowdown (non-consumptive) makeup water pumps.

The Perkiomen Pumphouse (also referred to as the “Perkiomen auxiliary intake pumphouse”) is located approximately 27.4 meters (90 feet) inland from the Perkiomen Creek western bank. The structure contains three intake pumps (two operating and one spare) sized to supply the consumptive cooling water needs for both LGS units, plus one small auxiliary pump to maintain Perkiomen Storage Tank level when the makeup system is not in use or in the winter to agitate the tank water to provide freeze protection. A buried pipeline conveys the water from the pumphouse over a distance of almost 13 kilometers (8 miles) to the storage tank located at the LGS plant site.

The common blowdown system discharges cooling tower blowdown through a pipeline common to both units directly to the Schuylkill River through a submerged discharge diffuser structure located about 213.4 meters (700 feet) downstream of the Schuylkill Pumphouse.

The groundwater supply system includes two wells that are utilized at the main plant site, one for supplying domestic water and the other serving as a backup supply of fire emergency water. Two additional small wells are located near the main plant site. These wells are operated only occasionally for brief periods to supply water for domestic use to the Limerick Energy Information Center and the Limerick Training Center.

The following subsections provide additional information on the LGS water systems that interface with the environment.

3.1.2.1 Surface Water Withdrawals, Use, and Discharges

Both the Delaware River Basin Commission (DRBC) and the Pennsylvania Department of Environmental Protection (PADEP) have regulations in place to limit environmental impacts associated with the operation of the LGS cooling water system.

The DRBC regulates LGS water withdrawals and water use, and also places limitations on blowdown discharges from LGS, in accordance with DRBC’s regulations. Exelon Generation has docket approval from the DRBC (Docket No. D-69-210, as revised) for the following withdrawals and discharges:

1. A maximum daily water withdrawal for two-unit electric generation of up to 212.7 million liters per day [56.2 million gallons per day (MGD)] via the Schuylkill River intake and/or the Perkiomen Creek intake, consisting of:
    a. Withdrawal for consumptive use of up to 159.0 million liters per day (42 MGD) average; and
    b. Withdrawal for non-consumptive use of up to 53.7 million liters per day (14.2 MGD); and

2. The discharge of up to 53.7 million liters per day (14.2 MGD) of blowdown to the Schuylkill River.

LGS procedures are used to control operations in accordance with the DRBC docket that governs LGS water usage and water diversion. These procedures are consistent with the DRBC-approved Operating and Monitoring Plan for the LGS makeup water supply system. Exelon Generation expects to continue using approved procedures for operating in accordance with DRBC requirements during the period of extended operation.

A schematic of the LGS makeup water supply system is provided as Figure 3.1-3.

The rules for makeup water supply to LGS are summarized below. These rules are based on a combination of the operating and monitoring plan that was in effect prior to 2003 and plan modifications temporarily allowed by DRBC to conduct a water supply demonstration project since 2003. The demonstration project is discussed below. Exelon Generation has requested, via an application to DRBC, a new docket revision that ends the demonstration project and allows the temporary modifications emplaced to implement the project to be incorporated into the operating and monitoring plan for future operations of the LGS makeup water supply system. DRBC approval of the request is pending as of the date of this report's publication.

LGS may withdraw water from the Schuylkill River for non-consumptive use without restriction. Due to the potential for adverse water conditions in the Schuylkill River, the DRBC has imposed mitigative restrictions and requirements on the operation of the LGS makeup water supply system for consumptive use makeup to protect water quality, including in-stream and downstream uses. These restrictions and requirements are triggered when the river flow is below 15.8 cubic meters per second (560 cubic feet per second or cfs) for two-unit operation or 15.0 cubic meters per second (530 cfs) for one-unit operation, measured upstream at the USGS Pottstown Gage Station (No. 01472000) and adjusted for ongoing releases from DRBC-sponsored projects upstream of the gage station. If a triggering condition occurs in the Schuylkill River, LGS uses one or a combination of the following DRBC-approved alternative water sources to supply its consumptive use makeup:

- The Schuylkill River, provided that either (1) low flow conditions do not exist in the river or (2) consistent with the provisions of the temporary demonstration projects, the river flow upstream of LGS is augmented using releases of stored water from either the Still Creek Reservoir (under non-emergency conditions and subject to its yield curve) or the Wadesville Mine Pool, or both, at a rate equal to the withdrawal rate plus an allowance for in-transit losses;

- The Perkiomen Creek (the secondary water source), via the Perkiomen auxiliary intake pumphouse, provided that the creek flow meets one of the following conditions:

- o The natural Perkiomen Creek flow is at least 5.9 cubic meters per second (210 cfs) for two-unit operation or 5.1 cubic meters per second (180 cfs) for one-unit operation), measured at the USGS Graterford Gage Station (No. 01473000); or
- o The natural Perkiomen Creek flow is less than the DRBC-prescribed minimum amount specified in the preceding bullet, but the following mitigating conditions are met:
  - The stream flow upstream of the auxiliary intake pumphouse is augmented through a diversion of water from the Delaware River to the East Branch Perkiomen Creek via the Bradshaw Reservoir; and
  - The natural flow of the Delaware River of at least 84.9 cubic meters per second (3,000 cfs), measured at the USGS Trenton Gage Station (No. 01463500); or
- o The natural flows of the Perkiomen Creek and the Delaware River are both less than the DRBC-prescribed minimum amounts specified in the preceding bullets (typically during declared drought conditions), but compensatory releases of water stored on behalf of LGS are made from the Merrill Creek Reservoir.[5]

The water supply demonstration project being conducted by Exelon Generation since 2003, with DRBC concurrence and oversight, tests the feasibility and effects of using the Wadesville Mine Pool and Still Creek Reservoir as an alternative consumptive use makeup water supply sources. Prior to the demonstration project, the only available alternative makeup water supply sources were those available via the Perkiomen Pumphouse. By adding two more water sources (the Wadesville Mine Pool and, under non-emergency conditions, the Still Creek Reservoir) for augmenting flow in the Schuylkill River, the demonstration project has substantially increased operational flexibility for the LGS makeup water supply system in the event of river low flow conditions.

In 2005, the demonstration was expanded to also allow water withdrawal from the Schuylkill River for consumptive use makeup at LGS at times when the ambient water temperature in the river is at or above 15 ºC (59 ºF). Prior to the demonstration project, when the Schuylkill River ambient temperature was at or above 15 ºC (59 ºF), the DRBC prohibited consumptive use makeup water withdrawal from the river, making it necessary to instead withdraw this water from Perkiomen Creek via the Perkiomen Pumphouse.

The demonstration is authorized under Docket No. D-69-210 Revision Nos. CP-11 and CP-12, and DRBC resolutions authorizing extension of demonstration through 2011, or until approval of the new docket revision (Revision No. CP-13), whichever comes first.

In summary, if the demonstration project is made permanent by DRBC, the DRBC docket and the operating and monitoring plan for the LGS makeup water supply system will be modified such that the amount of time that makeup water can be withdrawn via the Schuylkill Pumphouse would increase and the amount of time that makeup water must be withdrawn via the Perkiomen Pumphouse would decrease. A consequence of reducing the amount of time during which makeup water must be withdrawn from Perkiomen Creek is a reduction in the amount of time during which augmentation of the Perkiomen Creek flow by diverting water from the Delaware River may be necessary. In December 2010, DRBC adopted a resolution extending

[5] As previously stated (Section 2.1.2), Exelon Generation is a member of the Merrill Creek Owners Group. The Merrill Creek Reservoir, located in Washington Township, Warren County, New Jersey, stores water that can be used for consumptive use makeup during low flow conditions in the Delaware River at designated electric generating facilities, including LGS, which are on or connected to the Delaware River.

the demonstration project through December 2011 to provide additional time to develop and complete a public process on the proposed docket modification. Exelon Generation anticipates that DRBC will approve the requested docket modification such that its provisions will be effective during the period of extended operation resulting from renewal of the NRC operating license for LGS.

The diversion of water from the Delaware River is accomplished through a series of pumping stations, the Bradshaw Reservoir, and transmission mains. The withdrawal from the Delaware River is through the Point Pleasant Pumping Station, currently owned and operated by Forest Park Water, a municipal water purveyor jointly owned by North Wales and North Penn Water Authorities. The pumping station is used to transfer water from the Delaware River to the Bradshaw Reservoir as necessary to maintain adequate reservoir operational volume and reserve storage. The reservoir is an upland man-made structure owned and operated by Exelon Generation. The facility includes the Bradshaw Pumphouse, also owned and operated by Exelon Generation, used to transfer water when required from the Bradshaw Reservoir to the East Branch Perkiomen Creek via a transmission main. Exelon Generation also owns and operates the Bedminster Water Processing (Treatment) Facility, located along the transmission main, to seasonally inject ozone into the main to provide disinfection of the water for fecal coliform before the water is discharged to the East Branch Perkiomen Creek, in accordance with National Pollutant Discharge Elimination System (NPDES) Permit PA0052221.

Overall, diverting water from the Delaware River into the LGS makeup water supply system is more costly to Exelon Generation than the other DRBC-approved options described above. Hence, cost savings for Exelon Generation are achieved by reducing the amount of time during which this option must be used. Exelon Generation has committed to share any such cost savings through yearly contributions to a Restoration and Monitoring Fund (RMF). The RMF is operated by a third party who allocates the funds to projects intended to improve water quality in the Schuylkill River watershed and, thereby, help sustain the river's designated water uses.

In the event that the Delaware River diversion system is unavailable at a time when conditions in the Schuylkill River have triggered mitigative restrictions and requirements under the DRBC docket, Exelon Generation has arranged for emergency releases from the Still Creek Reservoir to augment Schuylkill River flow under a contract with its owner and operator, the Tamaqua Area Water Authority (TAWA). The contract with TAWA covers both maintaining a reserve volume in the reservoir for emergency releases and, as previously mentioned regarding the demonstration project, making releases under non-emergency conditions from the reservoir's operating volume subject to the yield curve.

PADEP regulates the following activities associated with the LGS cooling water system under its NPDES permitting program:

- Discharges from LGS of industrial wastewater;
- Discharges from the Bradshaw Reservoir of water diverted from the Delaware River;
- Discharges of storm water from the LGS plant site;
- Thermal discharges from LGS as required by Section 316(a) of the Clean Water Act (CWA); and
- Design and operation of the LGS cooling system intake structures as required by CWA Section 316(b).

Federal Clean Water Act Section 401 requires an applicant seeking a federal license for an activity that may result in a discharge to navigable waters to provide the licensing agency with a certification by the state where the discharge would originate indicating that applicable state water quality standards will not be violated as a result of the discharge (33 USC 1341). The Pennsylvania Department of Environmental Resources (now PADEP) issued a Section 401 State Water Quality Management Permit on July 16, 1976 for LGS prior to its initial operation. The permit transmittal letter states that the facilities, if operated properly, will meet the water quality standards for the Schuylkill River.

Exelon Generation holds NPDES permits from the PADEP for industrial wastewater discharges (includes cooling water system blowdown) and storm water discharges from the LGS plant site to the Schuylkill River (No. PA0051926) and for discharges from the Bradshaw Reservoir to the East Branch Perkiomen Creek (No. PA0052221). CWA Section 316(a) and Section 316(b) requirements also are addressed in NPDES Permit No. PA0051926. NPDES Permit No. PA0051926, which expired March 31, 2011, is administratively continued pending PADEP action on a timely permit renewal application submitted September 28, 2010. NPDES Permit No. PA0052221 expires on June 30, 2014. Copies of these permits and the notice of timely filing of a renewal application for NPDES Permit No. PA0051926 are provided in Appendix B.

Sanitary wastewater from LGS is discharged through an existing approved connection to the Limerick Township Sewer Department, which maintains the sewer system within Limerick Township. The department includes a King Road Plant, which has a total treatment capacity of 1,700,000 gallons but is currently running at 1,000,000 gallons per day, and a Possum Hollow Plant, which has a total treatment capacity of 700,000 gallons but is currently running at 200,000 gallons per day (Limerick Township, 2011).

3.1.2.2 <u>Circulating Water and Cooling Tower Blowdown Systems</u>

The circulating water system flow circuit starts in the cooling tower basins, where cooled water flows by gravity through large diameter pipelines and through the main condensers for heat removal. The heated water then flows to the inlets of the circulating water pumps, which discharge the heated water through pipeline headers back to the cooling towers for heat dissipation. The per unit design flow of four pumps operating in parallel is 1,710,730 liters per minute (452,000 gallons per minute or gpm).

The cooling towers are over 152.4-meter- (500-foot-) high hyperbolic natural-draft structures employing a cross-flow principle of heat transfer. The heated water is discharged to the cooling towers at an elevation of 21.3 meters (70 feet) above ground level and flows down through fill material to the basins. The fill material is designed to provide extensive surface area to increase the contact between the heated water and the air-cooling medium. Each basin has water-holding capacity of 27,347.5 cubic meters (966,000 cubic feet) plus 22.9 centimeters (9 inches) of height as freeboard. The buoyant heated water vapor rises naturally through the hyperbolic shaped portion of the cooling tower and discharges into the atmosphere.

During freezing weather, valves are provided to route heated water directly to the basins during system startup for icing control and to prevent ice from accumulating in the cooling tower fill. During power operations warm circulating system water can be diverted through the cooling tower deicing slot valves as needed to eliminate ice buildup on the outer fill structure areas.

Sulfuric acid is injected into the cooling tower basins on an intermittent basis to control pH and to prevent scaling on the condenser tubes. In addition, inhibitors are injected to control mild steel, copper, and heat exchanger corrosion, manganese deposition, siltation/sedimentation, biofouling, foaming, and scale formation on heat transfer surfaces.

Makeup water is provided to the circulating water systems from the Schuylkill River and/or the Perkiomen Creek through the common LGS makeup water supply system. The Schuylkill Pumphouse and the Perkiomen Pumphouse and their supply lines to the cooling tower basins are further described below.

Schuylkill River water used in the circulating water system enters the front and sides of the Schuylkill Pumphouse through trash bars with 8.9-centimeter (3.5-inch) vertical bar spacing, which allows for free passage of fish swimming near the face of the bar racks. A floating trash dock with skirt is installed in front of the trash rack to divert most surface debris and some organisms before they reach the trash racks. The water then passes through four traveling screens with 0.635-centimeter (0.25-inch) square mesh openings into the pump station. The three consumptive use makeup water pumps are rated at 42,768 liters per minute (11,300 gpm) each. The two blowdown (non-consumptive use) makeup water pumps are rated at 15,139 liters per minute (4,000 gpm) each. Any combination of pumps may be used to meet the total makeup water demand up to the 212.7 million liters per day (56.2 MGD) limit. The Schuylkill Pumphouse is designed to limit the velocity of the water approaching the traveling screens to a maximum of 0.229 meters per second (0.75 feet per second). The pumphouse supplies water to the cooling tower basins via a 91.4-centimeter (36-inch) diameter main pipeline. The main pipeline then divides into two 76.2-centimeter (30-inch) supply lines to the cooling tower basins where the makeup water mixes with the circulating water. The main pipeline also has two 15.2-centimeter (6-inch) diameter branch lines, one that supplies water to a raw water clarifier in the process water treatment system and the other that supplies makeup water to the spray pond.

Perkiomen Creek water used in the circulating water system enters the Perkiomen Pumphouse through 15 submerged stationary “wedge-wire” screens, placed at midstream in the Perkiomen Creek. Shallow weirs located in the creek just below the Perkiomen Pumphouse maintain a pool level above the submerged screens. The screens are cylindrical, approximately 1.8 meters (6 feet long) and 0.6 meters (2 feet) in diameter, with a slot size of 2 mm. The average through-slot velocity is less than 0.12 meters per second (0.4 feet per second), and the maximum through-slot velocity is less than 0.15 meters per second (0.5 feet per second). The water then passes into three pipelines connected to the pumphouse. The pumphouse contains three 50-percent capacity make-up water pumps rated at 55,258 liters per minute (14,600 gpm) each and one auxiliary makeup water pump rated at 1,476 liters per minute (390 gpm). Unless conditions have triggered the mitigative restrictions and requirements in the DRBC docket, the consumptive use makeup water pumps do not operate. The auxiliary pump operates intermittently to maintain the makeup water storage tank near full level.

The cooling tower blowdown system consists of weirs that allows continuous overflow from both cooling tower basins during normal cooling tower basin operation. Blowdown can be discontinued by reducing the makeup flow, thereby allowing water level in the basin to fall below the weir elevation. Each cooling tower basin is provided with a 81.3-centimeter (32-inch) diameter blowdown line. These lines are then combined into one 91.4-centimeter (36-inch) diameter blowdown pipeline. The pipeline also serves as the conduit for other plant wastewaters. The combined flow is measured and then discharged to the Schuylkill River through Outfall 001 via a submerged multi-port discharge diffuser (see Figure 3.1-4), in accordance with the LGS NPDES permit. The diffuser is encased in a concrete channel stabilization structure on the east side of the river and consists of a 71.1-centimeter (28-inch) diameter pipe with a total of 283 nozzles installed on 15.2-centimeter (6-inch) centers, each nozzle having a 3.175-centimeter (1.25-inch) diameter opening. The stabilization structure extends to the west side of the river.

3.1.2.3 Other Water Systems

The other water systems described in this section are those that directly interface with the LGS normal or emergency cooling water system. These systems include service water (SW) systems provided for normal operation, emergencies and the removal of reactor residual heat, and the clarified water system.

The normal SW system for each Limerick unit is a non-safety-related single-loop cooling system utilizing three 50-percent capacity pumps operating in parallel (one pump is on standby status) that take suction from the associated unit's cooling tower basin. The normal SW pumps, located in the circulating water pump structure, circulate cooling water from the cooling tower basins through various heat exchangers. The warmed water is then returned to the cooling towers and cooled. Although each unit has its own normal SW system, interconnections are provided so that either system can cool equipment common to both units. The components cooled by the normal SW system during normal plant operation are associated with:

- The spent fuel pool cooling system;
- The emergency service water system;
- Non-essential reactor auxiliary systems located in the reactor and radwaste enclosures;
- Turbine auxiliary systems located in the turbine enclosure; and
- Chilled water systems located in the drywell and control enclosure.

At certain times during a refueling outage, the normal SW system also supports decay heat removal.

The emergency SW system (ESW system) is a safety-related system, designed to reliably supply cooling water to emergency equipment during loss of offsite power and reactor loss-of-coolant accident conditions. This system consists of two independent loops, with each loop supplying corresponding safety-related equipment for each unit. The system is common to Limerick Units 1 and 2 and consists of two independent loops (A and B), with two 50-percent system capacity (100-percent loop capacity) pumps per loop. The pumps take suction from the spray pond and supply emergency service water to the safety-related equipment. The warmed water is returned to the spray pond and cooled via the spray network, or returned via the winter bypass lines. During normal plant operation, all the equipment supplied by the ESW system, with the exception of the standby diesel generators, are supplied by the normal SW system.

The residual heat removal SW system (RHRSW system) is the other safety-related system that is connected to the spray pond. The RHRSW system is designed to supply cooling water to the residual heat removal heat exchangers of both units. The system is common to the two reactor units, and consists of two loops. The two RHRSW system return loops are cross connected for flexibility. Each loop services one RHR heat exchanger in each unit, and provides sufficient cooling for safe shutdown, cooling, and accident mitigation of both units. Each loop has two pumps located in the spray pond pump structure. One pump supplies 50 percent flow to one RHR heat exchanger. During two-unit operation, there are four heat exchangers (two per unit), and therefore, two of the four pumps are required for safe shutdown and accident mitigation. The RHRSW pumps take suction from the spray pond and supply RHRSW to the heat exchangers. The warmed water is returned to the spray pond and cooled via the spray network, or returned via the winter bypass lines.

The clarified water system receives makeup water from the normal cooling water intake system and provides filtered, clarified river water for use as component lubricating water and as the input stream for the treatment system that produces demineralized water, which in turn is used for reactor-related and other plant systems or components that require a supply of demineralized-grade water for non-consumptive applications.

3.1.2.4 Groundwater Withdrawals, Use, and Discharge

Two active groundwater supply wells are installed at the main plant area of the LGS plant site (Exelon Generation, 2008a, Section 2.4.13). The Well 1 (the "Alley" Well) pump yield is 189.2 liters per minute (50 gpm) supplied for potable use at LGS. The Well 3 (the "Batch Plant" Well) pump yield is 146.0 liters per minute (65 gpm) for a backup supply of fire emergency water. Figure 3.1-1 shows the locations of these two wells.

The Alley Well supplies water to a standpipe tank that maintains head pressure on the potable water system ring header. Discharge of sanitary wastewater from potable use is routed to the local municipal authority's sewage treatment plant.

Exelon Generation has a public water supply permit from PADEP and a PADEP-certified operator to operate the well and the facilities provided for water treatment and storage for distribution. Treatment is provided for disinfection, corrosion control for lead and copper, and filtration for arsenic reduction.

The Batch Plant Well operates infrequently to supply make up to a tank that stores water used in the event of a fire emergency. This system is a backup to the normal supply of fire protection water from the cooling water system.

Two additional active groundwater wells are located on the LGS plant site, but away from the main plant structures, and their usage is intermittent and limited to domestic purposes. One groundwater well supplies water to restroom facilities at the Limerick Training Center. The well is currently not used for potable water. The other groundwater well supplies water to the restroom facilities at the Limerick Energy Information Center. Water from this well also is currently not used for potable water. Self-contained bottles with coolers are provided for drinking water at both the Training Center and the Energy Information Center.

3.1.3 Transmission System

The electric power systems of Limerick Units 1 and 2 generate and transmit electric power into the PJM power network using the LGS transmission system (Exelon Generation, 2008a, Sections 1.2.4.4, 8.2, and 10.2). Each Limerick unit is provided with an independent substation, which is 230 kilovolts (kV) for Unit 1 and 500 kV for Unit 2. The two substations, interconnected by an autotransformer and transmission line, ultimately feed into the PJM interconnection through 230-kV and 500-kV transmission systems owned by PECO, the energy delivery subsidiary of Exelon Corporation serving southeastern Pennsylvania. Two independent offsite sources deliver auxiliary power to LGS for startup and for operating the safety-related systems.

The main generator for each unit is an 1,800-revolutions per minute (rpm), 3-phase, 60-Hertz (Hz) synchronous unit rated at 1,265 megavolt-amperes (MVA). Each generator is connected directly to the turbine shaft and is equipped with an excitation system coupled directly to the generator shaft. Voltage from the generators is stepped up from 22 kV to 230 kV on Unit 1 from 22 kV to 500 kV on Unit 2 by the unit main transformers. Overhead lines then supply the electricity from the main transformers to the 230-kV and 500-kV switchyards at their respective substations.

Four 230-kV transmission lines were constructed to connect Limerick Unit 1 to the electric grid and one 500-kV transmission line was constructed to connect Limerick Unit 2 to the electric grid. The identification of the substations and lines, and a description of the line routes and rights-of-way (ROWs) are provided in Section 2.1.3. Maps showing the routes of the five transmission lines are provided as Figures 3.1-5 through Figure 3.1-8.

As discussed below, Exelon Generation and PECO, respectively, have programs and processes in place to manage vegetation on LGS plant site areas and the ROWs associated with the LGS transmission system. Exelon Generation expects that it, as well as PECO, will continue to use these or similar processes during the period of extended operation.

3.1.3.1 <u>Exelon Generation Vegetation Management Program</u>

At the LGS plant site, Exelon Generation follows an Exelon Corporation, Energy Delivery Division procedure for grounds maintenance. This procedure applies to any site property, including areas under or near transmission lines and substation areas, which require some element of landscaping, grass mowing, weed control, clean-up, debris removal, snow removal/ hard surface de-icing, or any other activity relating to grounds maintenance.

Exelon Generation is responsible for vegetation management of LGS plant site areas. The type and level of ongoing ground maintenance activites are identified after receiving feedback from business unit representatives and LGS plant site stakeholders. Vegetation management activities are generally limited to grass mowing, removal of litter and debris, and herbicide application. The procedure states that only approved herbicides may be used, which must be applied in strict accordance with manufacturer instructions and applicable regulations; and that these herbicides must be applied either by a certified applicator or an operator working under a licensed applicator who is present during application of the products.

3.1.3.2 <u>PECO Vegetation Management Program</u>

As an Exelon Corporation-owned company, PECO follows the corporate Energy Delivery Division procedure that governs the vegetation management program for transmission line ROWs. This vegetation management program is intended to prevent trees and other vegetation from causing interruptions in the transmission of electricity. The program comprises preventative and corrective maintenance processes, and everyday work processes coupled with mitigation and QA/QC processes. The program is guided by the principles of integrated vegetation management, environmentally sensitive management techniques, public outreach, partnership building, and cost management. PECO partners with external agencies to manage ROWs in a manner that promotes biodiversity and reduces long-term impacts.

Where there is ample ROW width, PECO employs a “Wire Zone-Border Zone” management procedure. Woody species, especially those that sprout prolifically, are not permitted in the wire zone, which is the zone directly below the conductors and an appropriate distance out from the outermost conductors. In the border zone, adjacent to the wire zone on each side, low growing species are allowed to grow. Taller vegetation is allowed to grow only outside the border zone along the ROW edge. For ROWs with multiple transmission lines, the entire ROW may be treated as a “Wire Zone” to prevent vegetation from interfering with the distribution lines at the edge of the ROW. By managing the vegetation in zones of varying vegetation heights, the diversity of habitat provided for wildlife is greatly enhanced, as is the diversity of plant species.

Under the vegetation management program, an annual work plan is developed that contains details of lines to be inspected as part of the annual inspection, and lines that may require preventative maintenance or other activities. The work planner applies principles described in ANSI A300, Part 7, IVM - Best Management Practices handbook to plan work and develop a maintenance activity plan prior to the year of execution. To implement the work plan, vegetation management procedures and protocols are followed for performing preventive maintenance and corrective maintenance.

Vegetation Management Preventive Maintenance Process

The purpose of the Vegetation Management Preventative Maintenance Program is to prevent vegetation from encroaching onto the LGS transmission system ROWs to such an extent that it causes a service interruption or impedes access. An integrated vegetation management (IVM) approach is used and is based on a five–year cycle plan. Integrated vegetation management is a system of managing plant communities in which managers identify compatible and incompatible vegetation, evaluate control methods, and evaluate, select, and implement the most appropriate controls to achieve specific objectives. The choice of controls is based on the anticipated effectiveness, environmental impact, site characteristics, safety, security, economics, and other relevant factors.

For areas along the ROW corridor that require routine scheduled vegetation management, activities typically include tree removal, tree trimming, ROW access mowing, and tree growth regulator and herbicide applications. Floor vegetation maintenance guidelines consist of removal of or applying herbicides to all vegetation with the potential to impact reliability or impede access to the facilities. Procedures for application of herbicides are similar to those used by Exelon Generation, as described previously.

Guidelines used when planning ROW preventive maintenance activities include utilizing principles of the IVM approach; removing woody vegetation from the floor of the ROW that does not comply with required clearances from the transmission lines; encouraging the development of native, compatible, early successional vegetation; and, where possible, discouragement of exotic, invasive vegetation. Exceptions to these guidelines include:

- Allowing trees located in deep ravines or under abnormally high conductors to remain provided that clearance requirements are still met;
- Not retaining landscape plants that mature up to a height of 4.6 meters (15 feet) under abnormally low conductors;
- Protection of river and steam crossing using:
    - Selective pruning of incompatible vegetation to gradually establish a compatible plant community; and
    - Buffers at crossings, surface water supply reservoirs, and drinking water wells and springs, retaining as much compatible vegetation as possible;

- Allowing tree nurseries provided that they do not exceed an established allowable height, are not planted under or around towers, and do not block vehicle access routes;
- When pre-existing vegetation management agreements are in place that may differ from standard practice; or
- When vegetation management rights are limited due to easements.

Vegetation Management Corrective Maintenance Process

The purpose of the Vegetation Management Corrective Maintenance Program is to help prevent vegetation caused interruptions to LGS transmission network operability between preventative cycle maintenance dates. A complete ground inspection of all aerial transmission lines takes place annually. The inspector identifies, categorizes, and arranges correction of vegetation issues within the ROW or granted easements that will likely cause an interruption to the transmission system. Of immediate concern would be an issue classified at the highest category level for any location where vegetation appears to be closer to the conductor than the minimum air insulation distance at the time of inspection, which is likely to cause an immediate interruption to the transmission system. All trees identified as hazardous with the potential to impact reliability of the transmission system are promptly removed.

Mitigation Process

In the event that vegetation management maintenance work that is initiated by the preventive or corrective maintenance processes to maintain critical clearances is precluded or halted by an external constraint, PECO may employ a mitigation process. This process is designed to provide a framework for actions to mitigate those situations and allow the work to be performed, thus avoiding possible interruptions in the transmission of electricity generated at LGS.

3.1.3.3 PECO Avian Management Program

PECO follows its procedure that governs the avian management program for PECO transmission line ROWs. This avian management program is intended to provide guidance for PECO, contractor, and subcontractor employees for:

- The procedures to be followed whenever bird nests and/or dead birds are encountered during field operations; and
- Compliance with applicable federal and state bird regulations, which include the Migratory Bird Treaty Act, the Endangered Species Act, and the Bald and Golden Eagle Protection Act.

The program provides guidelines for assessing nest usage, nest removal, and reporting and documenting bird mortality/injury incidents.

3.1.4 Waste Management and Effluent Control Systems

Existing radioactive and non-radioactive waste management and effluent control systems currently in place and in operation at LGS are summarized in this section. Exelon Generation expects to continue to utilize these systems during the period of extended operation at LGS.

3.1.4.1 Radioactive Wastes

This section discusses the sources of radioactive gaseous, liquid, and solid wastes generated at LGS, and the systems used to manage these wastes (Exelon Generation, 2008a, Section 1.2.4.8). The solid waste types include low-level radioactive wastes (LLRW), spent nuclear fuel (SNF), and low-level mixed wastes (LLMW). LLMW are discarded materials that meet the definition of hazardous waste, as established under the Resource Conservation and Recovery Act (RCRA), and also contain radioactive material subject to regulation under the Atomic Energy Act.

In general, the sources of radioactive gaseous, liquid, and solid wastes generated at LGS are radioisotope byproducts associated with nuclear fission, reactor coolant activation, and non-coolant material activation (e.g., coolant impurities and irradiated material corrosion products) that contact plant structures and systems. The facilities provided at LGS for the management of these generated wastes are designed so that the discharge of radioactive effluents and offsite shipment of radioactive materials for disposal are made in accordance with applicable regulations.

Exelon Generation anticipates that LGS will continue to generate quantities of LLRW and SNF during the period of extended operation at rates similar to those documented during current ongoing and past LGS operations. Exelon Generation anticipates that minimal LLMW, if any, will be generated during the period of extended operation. Exelon Generation will continue to use the systems in place at LGS, as further described below, to manage these type wastes when they are generated.

Existing LGS waste management systems, including the proposed use of excess storage capacity at Exelon Generation's Peach Bottom Atomic Power Station (see discussion below under Solid Waste Management System), are sufficient to accommodate LLRW, SNF, and LLMW at generation levels anticipated to occur during the period of extended operation.

As stated in UFSAR Section 1.2.4.8 (Exelon Generation, 2008a):

> "The radioactive waste management systems are designed to confine the release of plant-produced radioactive material [*added*: including water containing tritium] to well within the limits specified in 10 CFR Part 20 and 10 CFR Part 50, Appendix I. Various methods are used to achieve this end (e.g., collection, filtration, holdup for decay, dilution, and concentration). The pre-1994 10 CFR Part 20, Appendix B limits were used for the original licensing basis of LGS. Current liquid effluent releases are limited by LGS Technical Specifications to ten-times the Effluent Concentration Limit (ECL) specified for each isotope named in post-1994 10 CFR Part 20, Appendix B, Table 2, Column 2. Current gaseous and liquid effluent releases are controlled by the Radioactive Effluent Controls Program defined by the LGS Technical Specifications."

The Offsite Dose Calculation Manual (ODCM) contains the methodology and parameters used in the calculation of offsite doses resulting from gaseous and liquid effluents in association with the LGS Radiological Environmental Monitoring Program (REMP). An assessment of each year's REMP data collected since 1984 is provided in an Annual Radiological Environmental Operating Report. Exelon Generation prepares and submits this report annually to the NRC by April of the year following data collection. A review of the reports submitted over the last ten years (from 2002 to 2011) indicates that no adverse radiological impacts on the environment have been reported.

Gaseous Waste Management System

The gaseous waste management system consists of two subsystems: the offgas system, which collects and delays release of noncondensable radioactive gases removed via air ejectors from the main condensers; and ventilation systems, which process airborne radioactive releases from other plant sources (Exelon Generation, 2008a, Section 11.3). The offgases from the main condensers are the greatest source of radioactive gaseous waste. The treatment of these gases reduces the released activity to well below permissible levels.

The condenser offgases consist of radioactive activation and fission product gases, radiolytic hydrogen and oxygen, and condenser air in-leakage. The offgas system uses catalytic recombination of hydrogen and oxygen (to form water) for volume reduction and for control of hydrogen concentration below flammable limits. The system also filters and delays the radioactive gases (activation and fission product gases and radiolytic hydrogen and oxygen) to reduce radioactivity levels before releasing the gases to the environment. The gases leaving the condenser air ejector enter the recombiner where they are converted to a steam vapor. The water vapor (steam and recombined hydrogen and oxygen) is condensed and the remaining noncondensable gas (consisting mostly of air with traces of activation and fission gases) is cooled and flows through a holdup pipe. The gas leaving the holdup pipe is cooled (to remove additional water) and reheated (to reduce the relative humidity), and then flows through a series of charcoal adsorber/delay beds, where krypton and xenon decay, and through a HEPA after-filter. The offgas stream is directed to the turbine enclosure vent stack where it is diluted with air and monitored before release through the north stack.

The other sources of radioactive gases are from the reactor enclosures (including the common refueling area), the turbine enclosures, and the radwaste enclosure/chemistry lab expansion. These structures are each equipped with air supply and exhaust systems and, for use during post-accident conditions, filtration units for treatment prior to release. The sources are each monitored by radiation detectors after treatment and prior to planned and controlled discharge. Discharge is through the north stack, except for the refueling area and reactor enclosure ventilation exhausts, which are discharged through the south stack.

The containment systems are equipped with two additional treatment systems that provide increased filtration and delay of airborne radioactivity prior to release: the Standby Gas Treatment System (SGTS) and the Reactor Enclosure Recirculation System (RERS). These systems are initiated upon detected high-high radiation levels in the containments or refueling area. The SGTS also is used before a shutdown requiring containment entry to purge airborne radioactivity and continued purging through a monitored release point while maintenance activities are performed inside primary containment.

Other release points provided for radioactive gases are from the “hot” maintenance shop filtered exhaust system and the auxiliary boiler, which may be used for burning waste oil with some amount of radioactive particulate content as allowed by 10 CFR 20.2004, but is not currently used (Exelon Generation, 2008a, Sections 9.4.8 and 9.4.9). This method was last used in 2004 and, although permitted, there are presently no plans to continue using this method at LGS.

The regulations in 10 CFR 50.36 require that the quantities of principal radionuclides in effluents from nuclear power plants be reported. Regulatory Guide 1.21, Rev. 2 (NRC, 2008) indicates that principal radionuclides are those having either a significant activity or a significant dose contribution. In addition, Regulatory Guide 1.21, Rev. 2 states that licensees should evaluate whether carbon-14 (C-14), a naturally occurring isotope, is a principal radionuclide for gaseous releases from their facilities. The latter guidance was added to Regulatory Guide 1.21 in 2009 because reductions in radioactive effluents from commercial nuclear power plants through ALARA (as low as reasonably achievable) programs had converged with improvements in analytical methods for measuring C-14 such that C-14 may have become a new principal radionuclide at some plants. LGS has reported C-14 emissions in its 2010 annual radioactive effluent release report.

Liquid Waste Management System

The radioactive liquid waste management system collects, treats, stores, and disposes of radioactive liquid wastes (Exelon Generation, 2008a, Section 11.2). These wastes are collected in sumps and drain tanks at various locations throughout each Limerick unit and then transferred to the appropriate collection tanks in the common radwaste enclosure according to their classification (i.e., equipment drain, floor drain, chemical drain, or laundry drain waste). The liquid wastes are processed and either returned to the condensate system for re-use in the plant, packaged for offsite shipment, or discharged from the plant after mixing with cooling tower blowdown as described below.

Collected equipment drainage is processed through a precoat filter and a mixed resin bed demineralizer and is then collected in one of two sample tanks. The water in the sample tanks is normally transferred to the condensate tank for re-use, but may be recirculated for additional treatment or routed for discharge.

Collected floor drainage (typically having a higher conductivity than equipment drainage) also is processed through a precoat filter and a mixed resin bed demineralizer and is then collected in a sample tank. The water in the sample tank is normally discharged from the plant, but may be recirculated for additional treatment or routed to the equipment drain subsystem for re-use in the condensate system provided that the water meets plant water quality specifications for re-use.

Collected chemical drainage (laboratory wastes, decontamination solutions and other corrosive wastes) is chemically neutralized, if required, and then transferred to the floor drain subsystem for further processing.

Collected laundry drainage (from personnel decontamination facilities) is processed through a laundry filter, and is then collected in a sample tank.

The radioactivity removed from collected liquids is concentrated in filters and ion exchange resins, which are then sent to the solid waste management system for processing and packaging, interim storage, and eventual shipment to a licensed waste disposal facility. The processed liquid waste that is not recycled in the plant is discharged into the cooling tower blowdown line on a batch basis. The mixing of the effluent with the blowdown flow, which occurs within the LGS plant site boundary, maintains the radionuclide concentrations at the release point in the Schuylkill River below 10 CFR Part 20 limits.

Solid Waste Management System

The solid waste management system collects, monitors, processes, packages, and provides temporary storage facilities for radioactive solid wastes originating from nuclear systems equipment (e.g., spent control rod blades and in-core ion chambers) and from plant processes (e.g., filter residue, spent resins, paper, air filters, rags; used clothing, tools, and parts that cannot be effectively decontaminated; and solid laboratory wastes) for offsite shipment and permanent disposal (Exelon Generation, 2008a, Section 11.4). The LGS Process Control Program establishes the procedural process and boundary conditions for solid waste management, and parameters to provide reasonable assurance that the processed waste will meet acceptance criteria for onsite storage and offsite disposal.

These wastes are classified for purposes of near-surface disposal, in accordance with 10 CFR 61.55, by calculating the concentrations of long-lived radionuclides, short-lived radionuclides, or a combination of both. The waste classification with the least stringent disposal requirements is Class A, followed by Class B and Class C. Greater-than-Class C (GTCC) waste is generally not acceptable for near-surface disposal. At LGS, GTCC wastes consist of a relatively small quantity of irradiated metal reactor internals that were activated by neutrons during reactor operations, producing high concentrations of radionuclides. These reactor internals are stored for radioactive decay in the spent fuel storage pools. Following decay, they may be processed using remote handling equipment and be put into an approved container for shipment, storage, or disposal, as available for their then-determined waste classification.

LGS also generates “Green-is-Clean” (GIC) waste, which is waste collected from the Radiological Controlled Area (RCA), packaged separately from LLRW, and shipped offsite to a processing facility in Tennessee.

Dry wastes, mostly Class A LLRW, are collected in containers positioned throughout the plant. The radioactivity level of much of this waste is low enough to allow manual handling. Compressible dry wastes are packaged into strong, tight containers, and non-compressible dry wastes are also packaged in these or other suitable containers that meet disposal site requirements. Filled containers are sealed, moved to designated controlled-access areas for temporary storage, and allowed to accumulate until it is economical to transport them for offsite processing and/or final disposal.

Wet wastes are collected, dewatered, packaged, and stored in shielded compartments prior to offsite shipment for disposal. Input to the system is solids from condensate filters/demineralizers, and may also be spent bead and powdered resins backwashed from the Reactor Water Cleanup (RWCU) system and the floor drain, equipment drain and fuel pool cleanup systems. Generally, wet wastes are Class A LLRW for disposal purposes and Low Specific Activity (LSA) materials, as defined in 10 CFR Part 71, for transportation purposes. One exception is waste produced by the RWCU system, which normally exceeds both LSA and Class A criteria, mostly due to cobalt-60 (Co-60) levels.

After dewatering, wet wastes that cannot be reused and that meet neither the criteria for Class A LLRW nor the criteria for LSA material are packaged in High Integrity Containers (HICs) in preparation for offsite shipment and disposal. The HICs containing such wastes are then temporarily stored in the High Level Storage Area (HLSA), located in the Radwaste Enclosure. HICs stored in the HLSA are managed in accordance with instructions contained in applicable Exelon Generation corporate procedures.

Exelon Generation operates an onsite Radwaste Storage Pad (RSP) for interim storage of radioactive waste containers that are transferred from the HLSA and other plant areas. The RSP is located at the LGS plant site, west of the spray pond, and is managed in accordance with an LGS site-specific procedure. The pad includes two separate storage areas: (1) a fenced-in area holding an array of up to 18 sea vans, six for storing dry waste packaged in boxes and 12 for storing contaminated reusable material; and (2) another area that is surrounded on all sides by approximately 3.7-meter (12-foot) high, 0.9-meter (3-foot) thick concrete shell, gravel-filled shield walls. The waste container types allowed in the latter area include sea vans for holding dry waste packaged in boxes, and containers for holding Class A wastes that are placed within concrete vaults, known as “Secure Environmental Containers” (SECs). Excluded from storage at the RSP are Class B/C wastes (due to their high curie content), LLMW, SNF, GTCC waste, liquid or gaseous wastes, and non-LGS-generated waste. Based on guidance contained in NRC Generic Letter 81-38, the procedure limits the length of interim storage of any given container placed at the RSP to five years. The curie content and placement of the vaults and sea vans within the RSP is strictly controlled to minimize offsite dose. A pre-fire protection plan/strategy is in effect and is implemented for this storage area.

Class A LLRW generated at LGS is currently disposed of offsite at the *EnergySolutions,* LLC LLRW Disposal Facility in Clive, Utah. As mentioned previously, LGS also ships GIC waste to the Duratech facility in Tennessee. If any of the GIC waste is found to be radioactively contaminated, that portion will be repackaged and shipped to the *EnergySolutions* facility for disposal. LGS stages sea vans behind the Radwaste Enclosure for separately accumulating boxed Class A dry waste and GIC wastes. When a sea van is full, it is scheduled for shipment, and once shipped, it is replaced with an empty sea van. Class A LLRW generated at LGS during the license renewal period will continue to be packaged and shipped off-site to a disposal facility licensed to receive such waste.

Since 1974, Exelon Generation has collected data on the volumes and activity of Class A LLRW shipped off-site each year for disposal and submits the data by April of the following year to the NRC in an Annual Radioactive Effluent Release Report.

The *EnergySolutions,* LLC Clive, Utah facility is not licensed to receive Class B or Class C LLRW. Prior to July 1, 2008, Class B and Class C (Class B/C) LLRW from LGS was transported, for disposal to the *EnergySolutions,* LLC Barnwell Disposal Facility in South Carolina. On July 1, 2008, the Barnwell facility, which is located within the Atlantic Interstate Low-Level Radioactive Waste Management Compact (“Atlantic Compact”), ceased accepting Class B/C LLRW shipments from out-of-compact generators—an action authorized by the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPAA). Because Pennsylvania is not a member of the Atlantic Compact, this action has precluded subsequent shipments of LLRW from LGS to the Barnwell Facility. Since there also are no other Class B/C LLRW disposal facilities in the U.S. that are accessible to Pennsylvania generators, Class B/C LLRW generated at LGS after July 1, 2008 has temporarily been stored on-site.

For storage of Class B/C waste onsite, LGS currently has designated three large vaults and 11 small vaults as the HLSA in the Radwaste Enclosure. The HLSA is the only area at LGS authorized for temporary storage of Class B/C waste. As of 2008, after the Barnwell disposal facility became unavailable, LGS had two 3.83 cubic meter (135.4 cubic feet) RWCU containers in the HLSA and expected to generate two smaller 2.07 cubic meter (73.3 cubic feet) containers of Class B/C wastes per year, based on past and projected generation rates for this waste stream.

On May 31, 2011, NRC approved transport and temporary storage of Class B/C wastes at Exelon Generation’s Peach Bottom Atomic Power Station (PBAPS), which has an existing interim LLRW storage facility (LLRWSF) that was constructed in the 1980s (ADAMS Accession No. ML110470320). Class B/C LLRW will be packaged at LGS for shipment and storage in grapple-compatible containers. Exelon Generation has evaluated the proposed container type to ensure that container integrity will be maintained for the duration of an "extended storage period" (defined as 80 years) at the PBAPS LLRWSF. The containers also have been evaluated to ensure that they will not rupture when subjected to handling for transportation to PBAPS from LGS, or to a future disposal site from PBAPS. All containers will comply with U.S. Department of Transportation requirements set forth in Title 49 of the Code of Federal Regulations, as applicable, as well as with NRC regulations (10 CFR Part 71) and the PBAPS Waste Acceptance Criteria (WAC).

The PBAPS LLRWSF has the capacity to hold 520 containers of Class B/C LLRW in 35 separate cells (Exelon Generation, 2010a). Assuming that LGS generates on average two containers of Class B/C waste per year during operation and PBAPS generates a similar quantity, over the next 40 years approximately 160 containers of Class B/C waste will be generated which represents approximately 31 percent of the total available Class B/C storage capacity. Therefore, the available capacity of the PBAPS LLRWSF is expected to be sufficient to hold the Class B/C waste from both LGS and PBAPS until the end of their periods of extended operation with additional capacity remaining to hold Class B/C waste for decommissioning of both Stations. The extended operating license for Limerick Unit 1 would expire in 2044 and the extended operating license for Limerick Unit 2 would expire in 2049. The extended operating licenses for the PBAPS units would expire prior to those for the Limerick units.

Low-Level Mixed Wastes

In 2001, the U.S. Environmental Protection Agency (EPA) created a conditional exemption for LLMW storage, treatment, transportation, and disposal (66 FR 27266-27297; May 16, 2001); the exemption was adopted by Pennsylvania without modification or exception.

The storage and treatment conditional exemption exempts LLMW from the regulatory definition of hazardous waste provided that eligibility criteria are met and maintained. These criteria include management of the waste under a single NRC license, submittal of a notification letter to PADEP claiming an exemption, and the use of trained personnel, chemically compatible containers that meet NRC requirements, physical separation from incompatible chemicals, compliance inspections, and an emergency response plan.

The transportation and disposal conditional exemption also exempts LLMW from the regulatory definition of hazardous waste provided that eligibility criteria are met and maintained. These criteria include meeting land disposal restriction (LDR) treatment standards (40 CFR Part 268), manifesting and transporting in accordance with NRC regulations (10 CFR Part 20 and 10 CFR Part 71), use of appropriate containers (carbon steel drum, HIC, or equivalent), and disposal at an NRC regulated and licensed disposal facility under the current Waste Acceptance Criteria (WAC) specified by the mixed waste disposal facility designated to receive those containers.

LLMW generated at LGS is managed in accordance with guidance contained in an existing Exelon Generation procedure. Currently, no LLMW is stored at LGS. From 2001-2010, there were two occasions when LLMW was generated at LGS. In 2002, 63.5 kilograms (140 pounds) of contaminated lead paint sludges generated at LGS was shipped offsite to Perma-Fix of Florida, a wholly owned subsidiary of Perma-Fix Environmental Services, Inc. The Perma-Fix of Florida facility is licensed and permitted to treat a variety of characteristic and listed mixed waste, soils, liquids, sludges, and debris to LDR standards. The treated waste was then shipped for disposal to the *EnergySolutions,* LLC Barnwell Disposal Facility in South Carolina, which was the licensed LLRW disposal facility (LLRWDF) used by Exelon Generation until July 1, 2008. In 2009, 43.1 kilograms (95 pounds) of contaminated instrument components containing lead and mercury generated at LGS were shipped for disposal at the *EnergySolutions, LLC* disposal facility near Clive, Utah, which is the licensed Class A LLRWDF currently used by Exelon Generation.

If necessary, Exelon Generation is prepared to store on-site, in compliance with the RCRA storage and treatment conditional exemption, LLMW generated at LGS during the period of extended operation. Exelon Generation also is prepared to arrange for transportation to and disposal of LLMW, in compliance with the RCRA transportation and disposal conditional exemption to a licensed LLRWDF for Class A wastes.

Spent Nuclear Fuel

The Limerick Unit 1 and Unit 2 spent fuel pools provide storage space for irradiated fuel assemblies removed from the reactors during refueling outages. The spent fuel pools are licensed for a maximum fuel storage capacity of 4,117 fuel assemblies each (Exelon Generation, 2008a, Section 9.1.2.2.2.2). With these capacities, loss of full core offload capability was estimated to occur in 2013 (NRC, 1994).

Accordingly, Exelon Generation has gained a general license for an Independent Spent Fuel Storage Installation ("ISFSI") at LGS (see Figure 3.1-1 for its location). The general license allows LGS, as a reactor licensee under 10 CFR Part 50, to store spent fuel from both units at LGS at an ISFSI, provided that such storage occurs in pre-approved casks in accordance with the requirements of 10 CFR Part 72, subpart K (General License for Storage of Spent Fuel at Power Reactor Sites). In 2008, the first dry storage cask (known as a "Horizontal Storage Module" or HSM) was placed on the LGS ISFSI pad.

The ISFSI will be operated, monitored, inspected, and maintained throughout the life of LGS in accordance with the existing general license, and requirements contained in the current Health Physics Program and Radiological Environmental Monitoring Program (REMP), the Nuclear Radiological Emergency Plan Annex, Maintenance Plan, and other controlling plans and procedures.

Area radiation monitors installed in the Reactor Enclosure area will continue to be used to monitor dose contributions from ISFSI cask loading operations in the Reactor Enclosure as well as movement of spent fuel to the ISFSI, and dose contributions from the loaded HSMs.

Low-Level Radioactive Waste Minimization

Safety, good housekeeping, and preventive maintenance are high priorities at LGS. Periodic housekeeping walkdowns are conducted by housekeeping area coordinators, which include inspections of material storage areas, loading and unloading areas, waste handling areas, and equipment.

Waste minimization is an important aspect of managing radioactive wastes, spill prevention, and the spread of contamination. Waste minimization policies establish guidelines for reducing the quantity and/or hazard potential of chemical wastes, processed wastes, waste lubricants, spent laboratory reagents, wastes associated with medical treatment and procedures, and mixed (both radioactively contaminated and RCRA hazardous) wastes.

In accordance with Exelon Generation's corporate policies and procedures, LGS implements programs to minimize generation of dry active waste (DAW) and radioactive waste liquids through implementation of good waste minimization practices, trending of performance indicators on a regular basis, and self-assessment.

DAW consists of radioactively contaminated materials such as paper, plastic, maslin, rubber, incidental metal, small sections of wires and cables, and other miscellaneous materials that are destined for disposal. DAW generation is minimized by controlling the types and amounts of materials that enter radiologically controlled areas (RCAs).

Radioactive liquid wastes consist of aqueous liquid effluents containing radioactive material and spent liquid effluent processing media that is slurried for waste collection. Generation of radioactive liquid wastes is minimized by managing the leakage rate into radwaste collection systems and by dewatering of spent processing media.

3.1.4.2 Nonradioactive Wastes

Exelon Generation expects that LGS operations will continue to generate quantities of non-radioactive wastes during the period of extended operation at rates similar to those documented during current and past operations. These wastes are managed in accordance with applicable regulations that are reflected in guidelines contained in Exelon Generation corporate procedures.

These guidance documents are intended to ensure that the waste forms discussed below are properly collected, characterized, packaged, labeled, stored, and transported to permitted/authorized offsite facilities. Wastes that meet the RCRA definition of hazardous waste would require treatment to meet LDR treatment standards. Also, Exelon Generation corporate procedures establish standards for minimizing wastes and specify recycling protocols and priorities.

The term "hazardous wastes" refers to regulated wastes that meet EPA's definition for solid waste and possess the characteristics of ignitability, corrosivity, reactivity, or toxicity (as defined by RCRA), or are specifically included on an EPA list of hazardous wastes. PADEP is authorized by the EPA to administer the RCRA hazardous waste program. Based on past and current generation rates, LGS is classified as a Small Quantity Generator of hazardous wastes, generating between 100 kg and 1,000 kg of hazardous waste per month. LGS hazardous waste and non-hazardous waste (defined below) quantities are reported annually to PADEP.

The term "non-hazardous wastes" refers to wastes that are not classified as hazardous waste, but still are subject to regulation in Pennsylvania. Non-hazardous wastes that have been or could be generated at LGS include:

- Residual waste (includes discarded solid, liquid, semi-solid, or contained gaseous waste materials resulting from industrial operations, waste treatment system sludges, and discarded laboratory chemicals);
- Universal waste (includes discarded batteries, pesticides, thermostats, lamps, and mercury-containing devices);

- Infectious waste (includes discarded human blood and blood products/residues, needles, specimens and their containers);
- Regulated asbestos-containing material (RACM) waste (friable and certain non-friable asbestos-containing materials); and
- Municipal waste (cafeteria and office wastes, and certain construction/demolition debris that do not fall under residual waste).

Based on past and current generation rates, LGS is classified as a Large Quantity Generator of residual wastes (greater than 1,000 kg generated per month) and a Small Quantity Handler of universal wastes (less than 5,000 kg accumulated at any time). LGS currently contracts with Philips Services, Inc. (Hatfield, Pennsylvania) for the processing and disposal of these wastes.

Small amounts of infectious wastes are generated at LGS, in conjunction with operation of the on-site health facility/on-site nurse station activities. Approximately 3 to 4 shipments per year of such wastes are sent offsite currently to the Stericycle, Inc. facility in Morgantown, Pennsylvania.

Waste oil/used oil refers to any natural or synthetic oil that has been used at LGS and is contaminated by impurities, but is not classified as hazardous waste. These used oils also may be mixed with fuels/fuel products, recovered from wastewater treatment systems, or oil contaminated with polychlorinated biphenyls (PCBs) at levels less than 50 parts per million (ppm). LGS currently contracts with Eldridge, Inc. (West Chester, Pennsylvania) and Lewis Environmental, Inc. (Royersford, Pennsylvania) for processing waste oil/used oil for beneficial reuse or disposal. Waste oil/used oil with some amount of radioactive particulate content may also be burned onsite in the auxiliary boiler for energy recovery as allowed under 10 CFR 20.2004. This method was last used in 2004 and, although permitted, there are presently no plans to continue using this method at LGS.

Exelon Generation has implemented a Preparedness, Prevention, and Contingency (PPC) Plan in compliance with PADEP requirements, and a separate Spill Prevention Control and Countermeasure (SPCC) Plan for LGS in compliance with 40 CFR 112, “Oil Pollution Prevention.”

LGS does not anticipate that generation rates of non-hazardous wastes will change significantly during the period of extended operation and anticipates that suitable off-site treatment /disposal facilities will continue to be available.

3.2 Refurbishment Activities

NRC

"The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures as described in accordance with § 54.21...This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)

"The environmental report must contain analyses of …refurbishment activities, if any, associated with license renewal…" 10 CFR 51.53(c)(3)(ii)

"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40-year license term will be from one of two broad categories…(2) major refurbishment or replacement actions, which usually occur fairly infrequently and possibly only once in the life of the plant for any given item...." (NRC, 1996a; Section 2.6.3.1)

Exelon Generation has no plans for refurbishment or replacement activities to support renewal of the LGS operating licenses. Exelon Generation has addressed refurbishment activities in this Environmental Report in accordance with NRC regulations and complementary information in the GEIS for nuclear plant license renewal (NRC, 1996a). NRC requirements for the renewal of operating licenses for nuclear power plants include the preparation of an integrated plant assessment (IPA) (10 CFR 54.21). The IPA must identify and list systems, structures, and components subject to an aging management review. Items that are subject to aging and might require refurbishment include, for example, the reactor vessel piping, supports, and pump casings (see 10 CFR 54.21 for details), as well as items that are not subject to periodic replacement.

The IPA conducted by Exelon Generation under 10 CFR Part 54 has not projected the need for any major refurbishment or replacement activities to maintain the functionality of important systems, structures, and components during the period of extended operation. Exelon Generation has included the IPA as Section 2 in the LGS License Renewal Application.

3.3 Programs and Activities for Managing the Effects of Aging

NRC

"…The report must contain a description of … the applicant's plans to modify the facility or its administrative control procedures…. This report must describe in detail the modifications directly affecting the environment or affecting plant effluents that affect the environment…." 10 CFR 51.53(c)(2)

"…The incremental aging management activities carried out to allow operation of a nuclear power plant beyond the original 40 year license term will be from one of two broad categories: (1) SMITTR actions, most of which are repeated at regular intervals …." NRC (1996a) (SMITTR is defined in NRC (1996a) as surveillance, monitoring, inspections, testing, trending, and recordkeeping.)

In accordance with 10 CFR 54.21, programs and inspections for managing aging effects at LGS are described in the LGS License Renewal Application, Appendix B, Aging Management Programs and Activities. Other than implementation of these programs and inspections, there are no planned modifications of LGS administrative control procedures associated with license renewal.

3.4 Employment

3.4.1 Current Work Force

Exelon Generation employs approximately 821 full time employees at LGS. Approximately 84 percent of the employees live in Montgomery, Berks and Chester Counties, Pennsylvania. The remaining LGS employees living in Pennsylvania are distributed across 12 counties, with numbers ranging from 1 to 35 employees per county. Less than two percent of LGS employees live outside of Pennsylvania (see Table 2.6-1).

The Limerick units are on 24-month refueling cycles. During refueling outages, site employment increases above the permanent work force by as many as 1,400 workers for approximately 20 to 30 days. This number of outage workers falls outside of the range (200 to 900 workers per reactor unit) reported in the GEIS for additional maintenance workers (GEIS Section 2.3.8.1), but occurs for a relatively short period of time (approximately three weeks).

3.4.2 Refurbishment Increment

As stated in Section 3.2, the IPA for LGS projects no refurbishment activities that are necessary for license renewal. Therefore, Exelon Generation has not estimated a workforce associated with refurbishment activities.

3.4.3 License Renewal Increment

Performing the license renewal activities described in Section 3.3 would necessitate increasing the LGS staff workload by some increment. The size of this increment would be a function of the schedule within which Exelon Generation must accomplish the work and the amount of work involved. The analysis of license renewal employment increment focuses on programs and activities for managing the effects of aging.

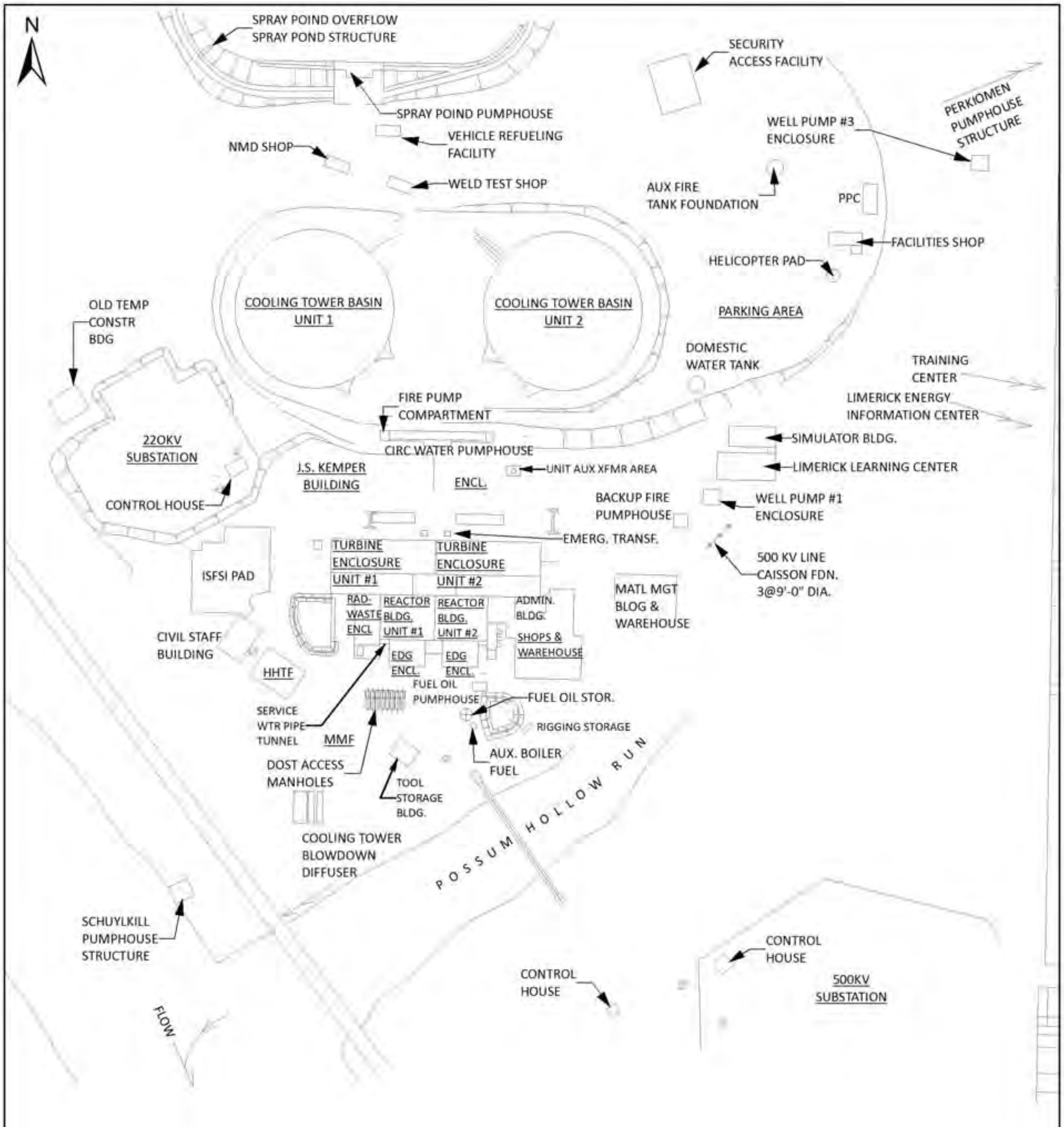
The GEIS (in Sections 2.4 and 2.6.2.7) assumes that NRC would renew a nuclear power plant license for a 20-year period beyond the term of its initial license, and that NRC would issue the renewal approximately 10 years before the initial license expires. In other words, the renewed license would be in effect for approximately 30 years. The GEIS further assumes that the utility would initiate surveillance, monitoring, inspections, testing, trending, and recordkeeping (SMITTR) activities at the time of issuance of the new license and would conduct license renewal SMITTR activities throughout the remaining 30-year life of the plant (GEIS Section 2.6.2.2), sometimes during full-power operation (GEIS Section 2.6.4.2), but mostly during normal refueling and the 5- and 10-year inservice inspection and refueling outages (GEIS Section 2.6.2.9).

Exelon Generation has determined that the GEIS scheduling assumptions are reasonably representative of LGS incremental, license renewal workload scheduling. Many LGS license renewal SMITTR activities would have to be performed during outages.

Although some LGS license renewal SMITTR activities would be one-time efforts, others would be recurring periodic activities that would continue for the life of the plant. The GEIS estimates that the most additional personnel needed to perform license renewal SMITTR activities would typically be between 60 and 110 persons, during the three- to four-month duration of a 10-year in-service inspection and refueling outage. Having established this upper value for what would be a single event in 20 years for each unit, the GEIS uses these numbers as the expected number of additional permanent workers needed per unit attributable to license renewal (GEIS Section 2.6.3.2).

The GEIS (in Section 4.7) uses this approach in order to "...provide a realistic upper bound to potential population-driven impacts…." Exelon Generation expects that its existing capability for temporarily supplementing the workforce for routine activities, such as outages, will most likely enable Exelon Generation to perform the increased SMITTR workload without adding workers to the LGS staff. However, for purposes of analysis in this environmental report, Exelon Generation conservatively assumes that LGS would require 60 additional permanent workers to perform all license renewal SMITTR activities and that all 60 employees would migrate into the 80.4-kilometer (50-mile) radius. Adding 60 full-time employees to the plant work force for the period of extended operation would have the indirect effect of creating additional jobs.

Considering the size of the 80.4-kilometer (50-mile) radius population (7,860,510 as stated in Section 2.6.1) and the fact that most indirect jobs would be service-related, Exelon Generation assumes that the majority of indirect workers would already be residing within the 80.4-kilometer (50-mile) radius.



Exelon.

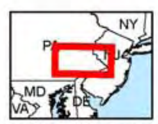
Reference:
Bechtel, San Francisco

Figure 3.1-1 LGS Plant Site Layout
Limerick Generating Station
Units 1 and 2

Limerick Township, Montgomery County, PA

Exelon.

Reference: Imagery provided by Exelon



Key Map Not To Scale

Figure 3.1-2 LGS Plant Site Aerial Photo
Exelon Generation
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

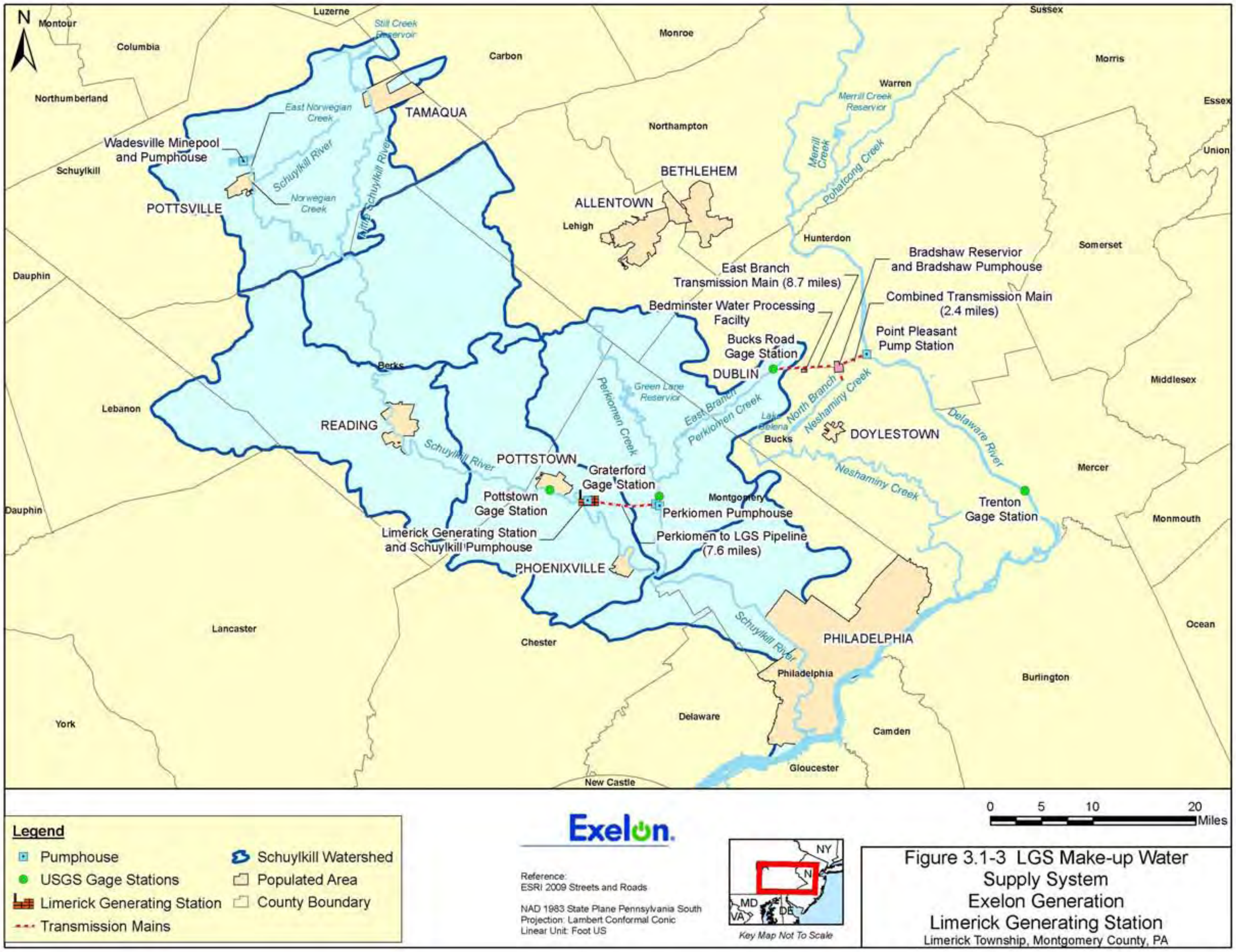


Figure 3.1-3 LGS Make-up Water Supply System
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

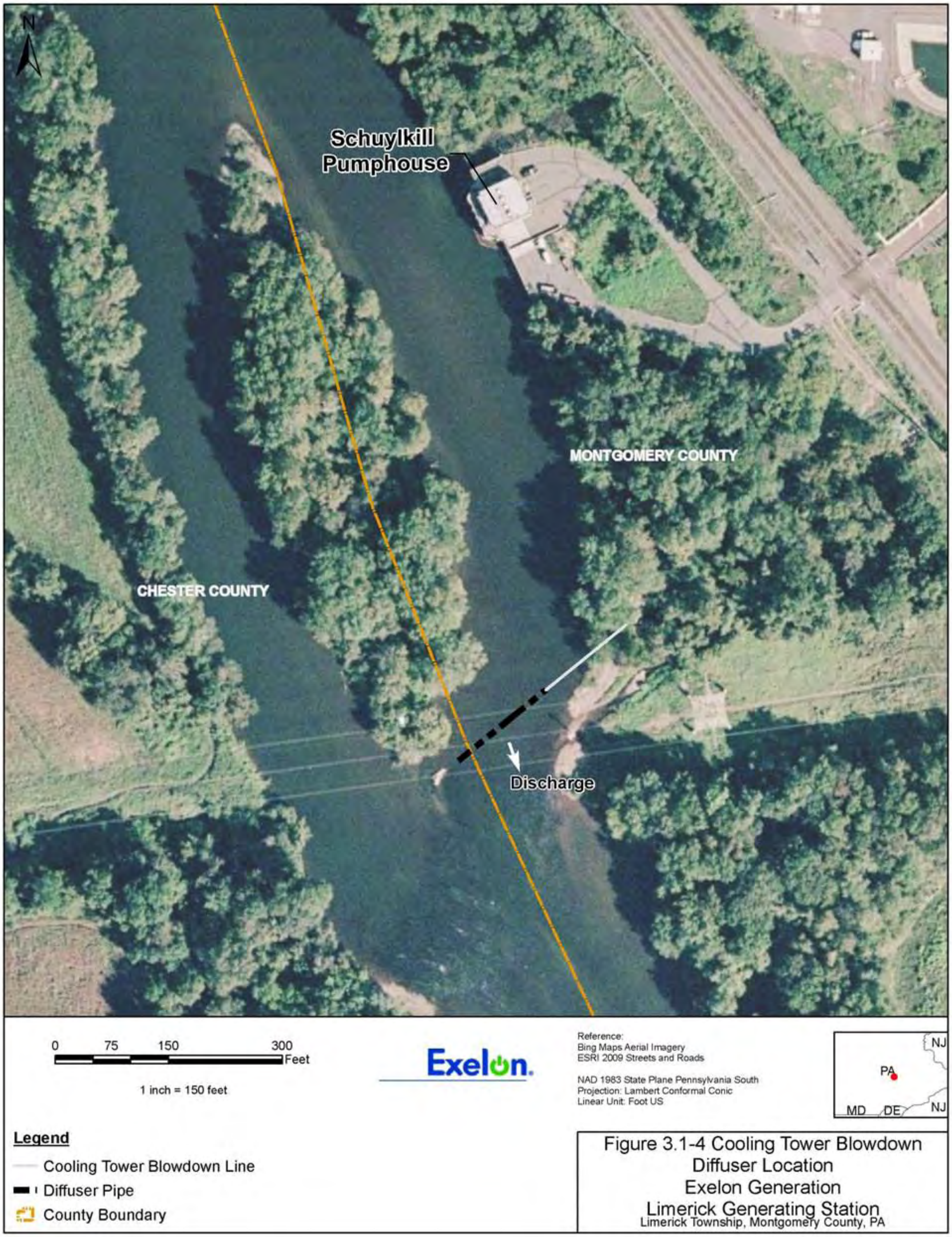


Figure 3.1-4 Cooling Tower Blowdown Diffuser Location
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

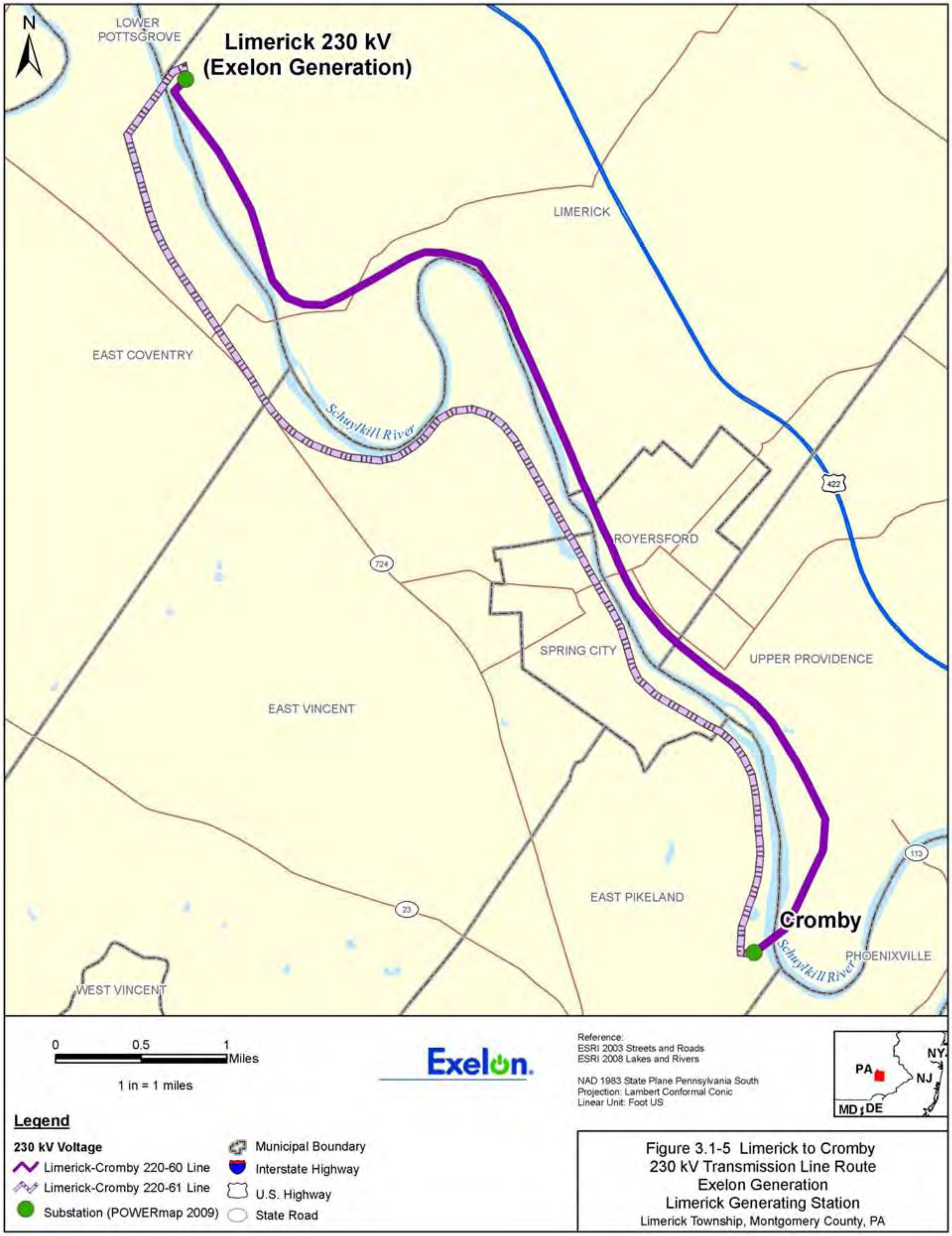


Figure 3.1-5 Limerick to Cromby
230 kV Transmission Line Route
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

Figure 3.1-6 Cromby to North Wales
230 kV Transmission Line
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

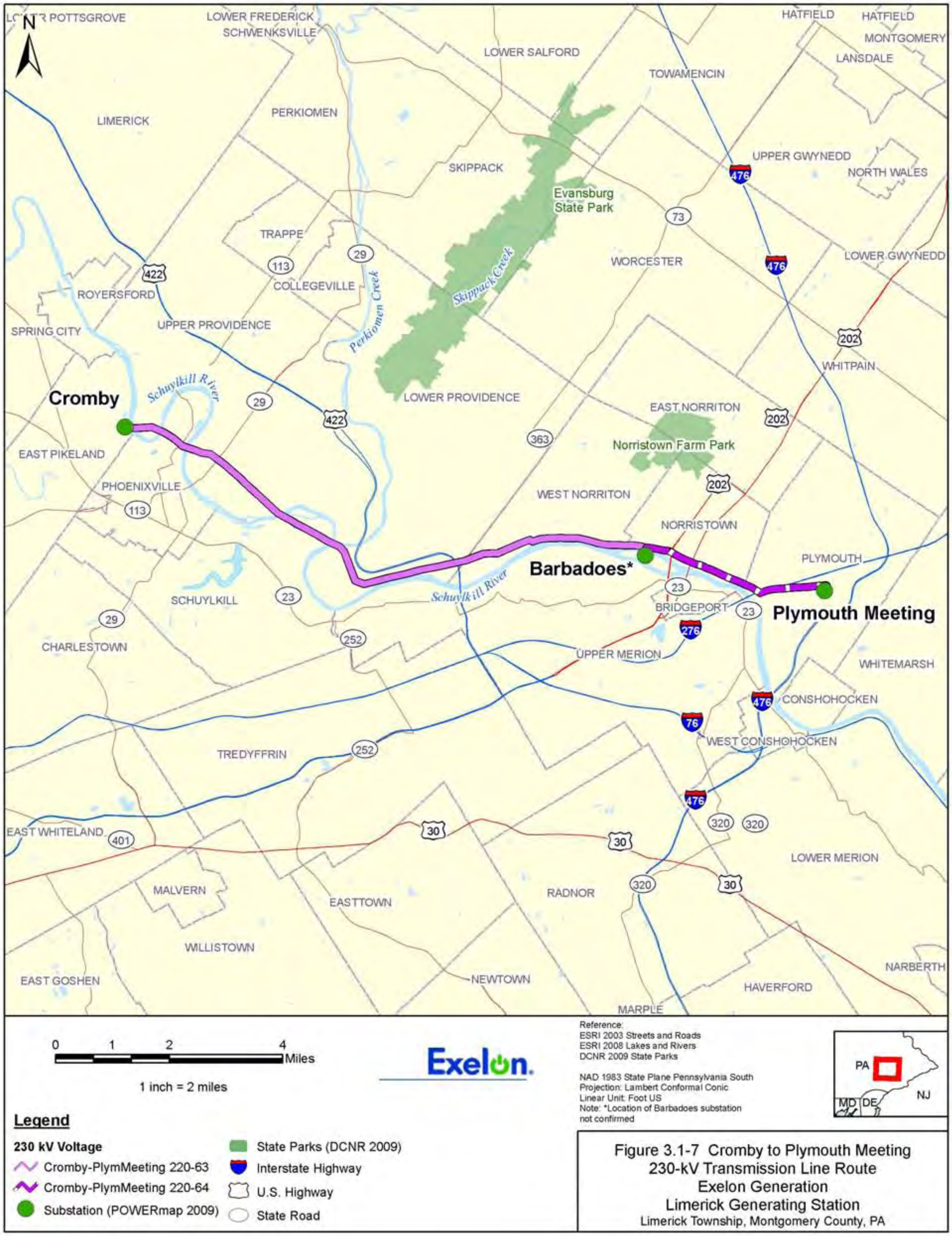


Figure 3.1-7 Cromby to Plymouth Meeting 230-kV Transmission Line Route
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

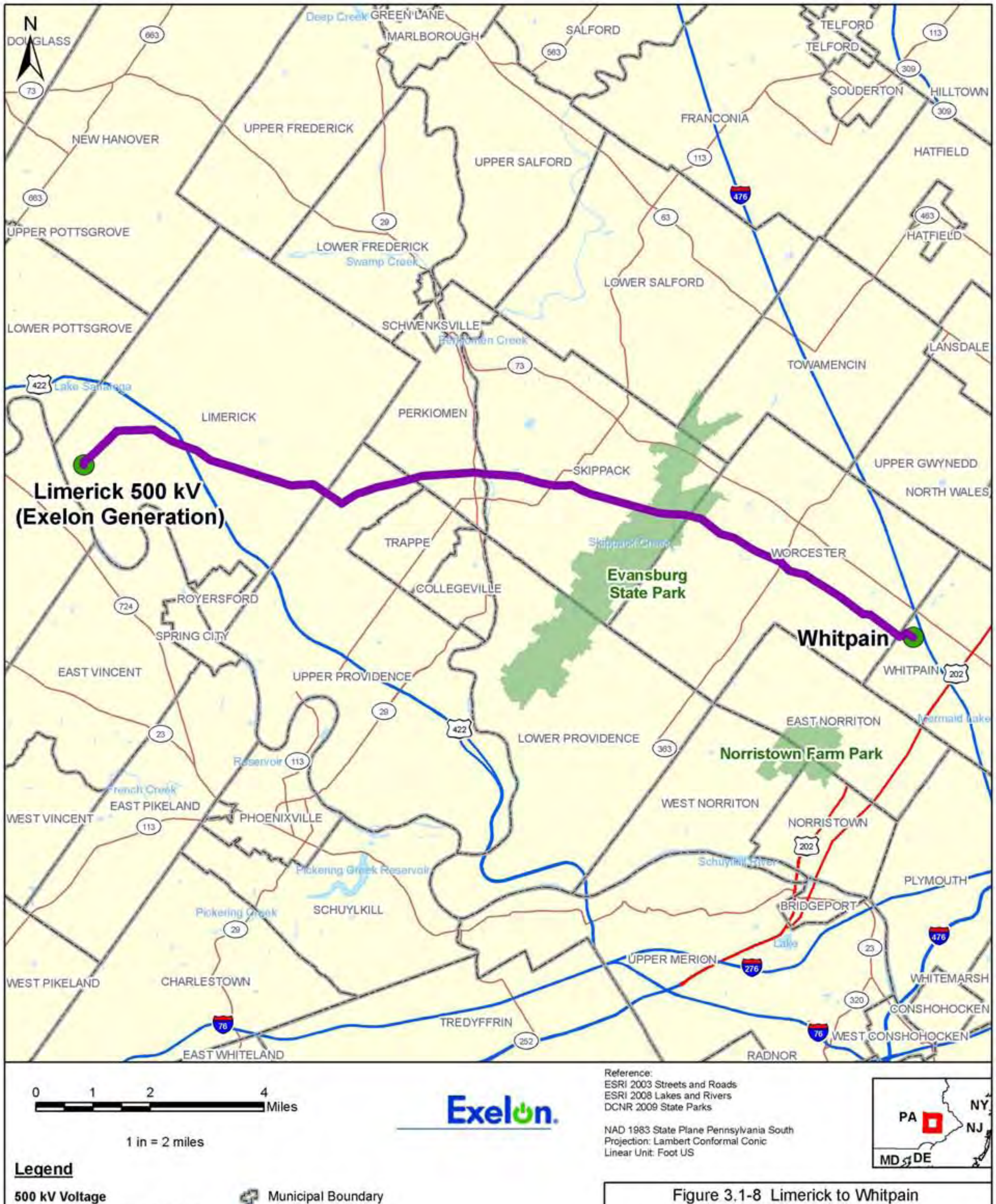


Figure 3.1-8 Limerick to Whitpain
500 kV Transmission Line Route
Exelon Generation
Limerick Generating Station
Limerick Township, Montgomery County, PA

4.0 ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTION AND MITIGATION ACTIONS

NRC

The report must contain a consideration of alternatives for reducing impacts…for all Category 2 license renewal issues….” 10 CFR 51.53(c)(3)(iii)

“The environmental report must include an analysis that considers…the environmental effects of the proposed action…and alternatives available for reducing or avoiding adverse environmental effects.” 10 CFR 51.45(c) as adopted by 10 CFR 51.53(c)(2)

The environmental report shall discuss the “…impact of the proposed action on the Environment. Impacts shall be discussed in proportion to their significance….” 10 CFR 51.45(b)(1) as adopted by 10 CFR 51.53(c)(2)

“The information submitted…should not be confined to information supporting the proposed action but should also include adverse information.” 10 CFR 51.45(e) as adopted by 10 CFR 51.53(c)(2)

Section 4.0 presents an assessment of the environmental consequences associated with the renewal of the Limerick Generating Station, Units 1 and 2 (LGS) operating licenses. The U.S. Nuclear Regulatory Commission (NRC) has identified and analyzed 92 environmental issues that it considers to be associated with nuclear power plant license renewal and has designated the issues as Category 1, Category 2, or NA (not applicable). NRC designated an issue as Category 1 if, based on the result of its analysis, the following criteria were met:

- The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic;

- A single significance level (i.e., small, moderate, or large) has been assigned to the impacts that would occur at any plant, regardless of which plant is being evaluated (except for collective offsite radiological impacts from the fuel cycle and from high-level waste and spent-fuel disposal); and

- Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant specific mitigation measures are likely to be not sufficiently beneficial to warrant implementation.

If the NRC analysis concluded that one or more of the Category 1 criteria could not be met, NRC designated the issue as Category 2. NRC requires plant-specific analyses for Category 2 issues.

Finally, NRC designated two issues as NA, signifying that the categorization and impact definitions do not apply to these issues.

NRC rules do not require analyses of Category 1 issues that NRC resolved using generic findings [10 Code of Federal Regulations (CFR) 51] as described in the Generic Environmental

Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC, 1996a). Absent any new and significant information, an applicant may reference the generic findings or GEIS analyses for Category 1 issues. Of the 90 total categorized issues, NRC designated 69 as Category 1 and 21 as Category 2.

Appendix A of this report lists the 92 issues and identifies the environmental report section that addresses each issue.

CATEGORY 1 AND NA LICENSE RENEWAL ISSUES

NRC

"The environmental report for the operating license renewal stage is not required to contain analyses of the environmental impacts of the license renewal issues identified as Category 1 issues in Appendix B to subpart A of this part." 10 CFR 51.53(c)(3)(i)

"…[A]bsent new and significant information, the analyses for certain impacts codified by this rulemaking need only be incorporated by reference in an applicant's environmental report for license renewal…." (NRC, 1996a, pg. 28483)

Category 1 License Renewal Issues

Exelon Generation Company, LLC (Exelon) has determined that 8 of the 69 Category 1 issues do not apply to Limerick because they are specific to design features, operational features, or natural conditions that are not found at the facility. Furthermore, Exelon Generation has determined that 7 additional Category 1 issues do not apply to Limerick because they are limited to refurbishment activities, which are not expected to take place at Limerick during the license renewal term. Appendix Table A-1 lists the 69 Category 1 issues, indicates whether or not each issue is applicable to Limerick and, if inapplicable, provides Exelon Generation's basis for this determination. Appendix Table A-1 also includes references to supporting analyses in the GEIS where appropriate.

For the 54 Category 1 issues that are applicable to Limerick, Exelon Generation has reviewed the NRC findings at Table B-1 in Appendix B to 10 CFR Part 51 and has not identified any new and significant information that would make the NRC findings, with respect to those Category 1 issues, inapplicable to LGS. Therefore, Exelon Generation adopts by reference the NRC findings for the 54 applicable Category 1 issues.

"NA" License Renewal Issues

NRC determined that its categorization and impact-finding definitions did not apply to Issues 60 and 92; however, Exelon Generation included these issues in Appendix Table A-1. NRC noted that applicants currently do not need to submit information on Issue 60, chronic effects from electromagnetic fields (10 CFR Part 51). For Issue 92, environmental justice, NRC does not require information from applicants, but noted that it will be addressed in individual license renewal reviews (10 CFR Part 51). Exelon Generation has included environmental justice demographic information in Section 2.6.2.

<u>CATEGORY 2 LICENSE RENEWAL ISSUES</u>

NRC

"The environmental report must contain analyses of the environmental impacts of the proposed action, including the impacts of refurbishment activities, if any, associated with license renewal and the impacts of operation during the renewal term, for those issues identified as Category 2 issues in Appendix B to subpart A of this part." 10 CFR 51.53(c)(3)(ii)

"The report must contain a consideration of alternatives for reducing adverse impacts, as required by § 51.45(c), for all Category 2 license renewal issues…." 10 CFR 51.53(c)(3)(iii)

NRC designated 21 issues as Category 2. Exelon Generation has determined that 6 of the 21 Category 2 issues do not apply to LGS because they are specific to design features, operational features, or natural conditions that are not found at the facility. Furthermore, Exelon Generation has determined that four additional Category 2 issues do not apply to LGS because they are limited to refurbishment activities, which are not expected to take place at LGS during the license renewal term. Appendix Table A-1 lists the 21 Category 2 issues, indicates whether or not each issue is applicable to LGS and, if inapplicable, provides Exelon Generation's basis for this determination. Appendix Table A-1 also includes references to supporting analyses in the GEIS where appropriate.

Sections 4.1 through 4.20 (Section 4.17 addresses two issues related to off-site land use) address the Category 2 issues. If an issue does not apply to LGS, the associated section explains the basis for inapplicability. For the 11 Category 2 issues that Exelon Generation has determined to be applicable to LGS, the appropriate sections contain the required analyses beginning with a statement of the issue. These analyses include conclusions regarding the significance of the impacts relative to the renewal of the operating licenses for LGS and, if applicable, discuss potential mitigative alternatives to the extent required.

Exelon Generation has identified the significance of the impacts associated with each issue as either small, moderate, or large, consistent with the criteria that NRC established in 10 CFR Part 51, Appendix B, Table B-1, Footnote 3, as follows:

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.

MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.

LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

In accordance with National Environmental Policy Act practice, Exelon Generation considered ongoing and potential additional mitigation in proportion to the significance of the impact to be addressed (i.e., impacts that are SMALL receive less mitigative consideration than impacts that are LARGE) (NRC, 1996a, Section 4).

4.1 Water Use Conflicts

NRC

"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than 3.15×10^{12} ft^3 / year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on the flow of the river and related impacts on instream and riparian ecological communities must be provided. The applicant shall also provide an assessment of the impacts of the withdrawal of water from the river on alluvial aquifers during low flow." 10 CFR 51.53(c)(3)(ii)(A)

"…The issue has been a concern at nuclear power plants with cooling ponds and at plants with cooling towers. Impacts on instream and riparian communities near these plants could be of moderate significance in some situations…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 13

The NRC made surface water use conflicts a Category 2 issue because consultations with regulatory agencies indicate that water use conflicts are already a concern at two closed-cycle plants and may be a problem in the future at other plants. In the GEIS, NRC notes two factors that may cause water use and availability issues to become important for some nuclear power plants that use cooling towers. First, some plants equipped with cooling towers are located on small rivers that are susceptible to droughts or competing water uses. Second, consumptive water loss associated with closed-cycle cooling systems may represent a substantial proportion of the flows in small rivers. In the GEIS, NRC referenced LGS as an example of a plant with a closed-cycle cooling system that is subject to water availability constraints because of in-stream-flow requirements in a small river, controversy over water use related to intrabasin transfer, competing water uses, and water-related agreements between utilities (GEIS Section 4.3.2.1). Accordingly, this issue applies to LGS.

LGS withdraws makeup water from the Schuylkill River, which meets the NRC's definition of a small river. As discussed in Section 2.2.1, the average annual mean stream flow of the Schuylkill River at the USGS Pottstown gage station is 56.51 cubic meters per second (1,996.2 cubic feet per second [cfs]) or 1.78×10^8 cubic meters per year (6.3×10^{10} cubic feet per year). The Schuylkill River near LGS meets the NRC definition of a small river since its annual flow rate is less than 9×10^{10} cubic meters per year (3.15×10^{12} cubic feet per year).

As discussed in Section 3.1.2, LGS is designed with a closed-cycle cooling tower-based heat dissipation system. Cooling water lost to cooling tower evaporation is replaced by make-up water pumped from the Schuylkill River at a Delaware River Basin Commission (DRBC) approved maximum daily rate of 212.7 million liters per day [42 million gallons per day (MGD)]. This equates to 1.84 cubic meters per second (65.0 cfs), and represents up to 3.3 percent of average river flow. However, during low flow periods, the consumptive water loss associated with the LGS closed-cycle cooling systems can represent a more substantial proportion of the flows in the Schuylkill River. For this reason, when the Schuylkill River flow measured at the Pottstown gage decreases to 15.0 cubic meters per second (530 cfs) (for one unit in operation) or 15.8 cubic meters per second (560 cfs) (for two-unit operation), withdrawal of Schuylkill River water for consumptive cooling use at LGS is restricted. Accordingly, Exelon Generation must use alternate water supplies to mitigate consumptive usage of Schuylkill River water during low flow periods and, thereby, avoid potential conflicts with other uses of the river water.

Until recently, during low flow conditions in the Schuylkill River, LGS mitigated consumptive use by withdrawing makeup water from the Perkiomen Creek, which in turn was required to be augmented with an intrabasin transfer of water from the Delaware River into the East Branch Perkiomen Creek (known as the "water diversion system") if natural flow rate in the Perkiomen Creek also was low. In addition, Exelon Generation has a water-related agreement with other utilities to augment Delaware River flow during declared drought periods using water released from storage in the Merrill Creek Reservoir, which was constructed specifically for this purpose. The water diversion system and the Merrill Creek Reservoir agreement were intended to avoid water use conflicts with other uses of Perkiomen Creek and Delaware River waters.

In 2002, Exelon Generation was approved by DRBC to demonstrate, starting in 2003, the use of two new upstream water sources to directly augment Schuylkill River flow during low flow conditions so that permitted withdrawals from the Schuylkill River at LGS for consumptive use makeup may continue. The two new water sources are the Wadesville Mine Pool and the Still Creek Reservoir. The latter source was previously approved only for emergency releases when the water diversion system was unavailable, but its use has now been expanded, subject to adherence with the reservoir's yield curve, for the demonstration. Concerns over pumping mine pool water and releasing the water untreated to the Schuylkill River headwaters, due to the association with acid mine drainage, were addressed through a rigorous monitoring program conducted over the eight-year demonstration (2003-2010) period, which allowed for an adequate range of seasonal high and low river flow conditions. The monitoring program included water quality and biological monitoring at strategic locations, weekly and annual reporting, and stakeholder involvement to demonstrate whether adverse effects on water use occur.

In 2004, the DRBC approved an expansion of the demonstration, starting in 2005, to demonstrate use the Schuylkill River for consumptive use makeup at LGS when the river ambient temperature reached and remained above 15 ºC (59 ºF), which was a condition that previously would have necessitated use of the water diversion system. Concerns raised over eliminating the temperature restriction, the original intent of which was to avoid low dissolved oxygen levels downstream of LGS, were addressed through additions to the monitoring program conducted over the six-year (2005-2010) demonstration period.

The DRBC has approved a resolution extending the demonstration through 2011 to allow more time for DRBC to evaluate Exelon Generation's application for permanent implementation of the water management operating plan changes associated with the demonstration. If DRBC approves the requested changes for permanent implementation, via a new docket revision, all of these developments are expected to result in less reliance on the water diversion system during times of low flow or high temperature of the Schuylkill River.

4.1.1 Assessment of Impacts of LGS License Renewal as Related to Water Use Conflicts

The assessment of the impact of LGS operation during the period of extended operation on river flow and related ecological communities is based on consideration of:

- The controls in place to minimize water use conflicts and potential impacts from wastewater discharges; and,
- The extent of effect, if any, that LGS operation has had on river flow and designated uses of the river, including related ecological communities, as an indicator of possible future impacts.

4.1.1.1 Regulatory Controls

The controls over water use and wastewater discharges that are intended to minimize water use conflicts in the Delaware River Basin and impacts from wastewater discharges to state waters have been in place since the NRC issued the LGS FES; moreover, these or similar controls are expected to continue throughout the period of extended operation. Refer to Section 2.2.2 for a summary of regulatory controls that govern water use and wastewater discharges associated with the operation of LGS.

4.1.1.2 Impacts of LGS Operation

LGS is included in the DRBC Comprehensive Plan, and DRBC issued the docket approving the construction and operation of the facility. The docket is intended to protect the designated uses of Schuylkill River water, which include: industrial water supplies (after reasonable treatment); maintenance of resident fish and other aquatic life, passage of anadromous fish, and wildlife; secondary contact recreation; and navigation.

The DRBC docket for LGS specifies the approved allocation of water for consumptive and non-consumptive cooling use and places conditions/limitations on water use and discharge, as described above and in Section 2.2.2. The maximum LGS consumptive use is limited to 3.3 percent of Schuylkill River flow under average flow conditions. Furthermore, DRBC has authorized the demonstrations described above with monitoring designed to detect environmental impacts.

The demonstration of new upstream water sources to directly augment Schuylkill River flow during low flow conditions has been conducted over a wide range of ambient conditions and has included intensive aquatic monitoring, weekly and annual reporting, and stakeholder involvement. Based on the results observed during the period from 2003 to 2010, DRBC is considering an Exelon Generation application requesting that the LGS docket be modified to allow permanent implementation of the demonstration project by incorporating an LGS water management operating plan, including authorization for consumptive use withdrawals from the Schuylkill River when either or both new augmentation sources are used or when the river ambient temperature reaches and remains above 15 ºC (59 ºF).

Exelon Generation holds National Pollutant Discharge Elimination System (NPDES) permits for water discharges from LGS and the Bradshaw Reservoir. These are subject to renewal every five years, at which time the Pennsylvania Department of Environmental Protection (PADEP) has the opportunity to modify discharge limits based on regulatory developments and stream conditions. Additionally, PADEP can modify an NPDES permit when appropriate.

4.1.1.3 Conclusion

Both the DRBC and PADEP have controls in place to mitigate water usage conflicts and control the discharge of pollutants associated with LGS operations. Such controls, which are specified in the DRBC docket and NPDES permits, are subject to periodic review and public comment during the renewal processes.

Current operations at LGS are in compliance with applicable requirements, and any foreseeable projects that could affect water use or discharge at LGS would be subject to prior DRBC and PADEP reviews. The maximum LGS consumptive use is limited to 3.3 percent of Schuylkill River flow under average flow conditions. Based on these considerations, Exelon Generation believes that impacts on instream and riparian ecological communities relating to water use conflicts from LGS operation during the period of extended operation would be SMALL and would not warrant additional mitigation.

Impact to alluvial water bearing material (aquifers) caused by LGS makeup water withdrawal is addressed in Section 4.6.

4.2 Entrainment of Fish and Shellfish in Early Life Stages

NRC

"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations…or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…entrainment." 10 CFR 51.53(c)(3)(ii)(B)

"...The impacts of entrainment are small in early life stages at many plants but may be moderate or even large at a few plants with once-through and cooling-pond cooling systems. Further, ongoing efforts in the vicinity of these plants to restore fish populations may increase the numbers of fish susceptible to intake effects during the license renewal period, such that entrainment studies conducted in support of the original license may no longer be valid..." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 25

This Category 2 issue of entrainment of fish and shellfish in early life stages does not apply to LGS because condenser cooling at the units does not utilize a once-through cooling water system or a cooling pond heat dissipation system. As Section 3.1.2 describes, LGS uses a closed cycle cooling system with cooling towers, withdraws make-up water from the Schuylkill River and/or Perkiomen Creek, and discharges cooling tower blowdown to the Schuylkill River.

4.3 Impingement of Fish and Shellfish

NRC

"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act 316(b) determinations…or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from…impingement…." 10 CFR 51.53(c)(3)(ii)(B)

"…The impacts of impingement are small at many plants but may be moderate or even large at a few plants with once-through and cooling pond cooling systems…." 10 CFR 51, Subpart A, Appendix B, Table B 1, Issue 26

The issue of impingement of fish and shellfish does not apply to LGS because condenser cooling at the units does not utilize a once-through cooling water system or a cooling pond heat dissipation system. As Section 3.1.2 describes, LGS uses a closed cycle cooling system with cooling towers, withdraws make-up water from the Schuylkill River and/or Perkiomen Creek, and discharges cooling tower blowdown to the Schuylkill River.

4.4 Heat Shock

NRC

"If the applicant's plant utilizes once-through cooling or cooling pond heat dissipation systems, the applicant shall provide a copy of current Clean Water Act… 316(a) variance in accordance with 40 CFR Part 125, or equivalent State permits and supporting documentation. If the applicant cannot provide these documents, it shall assess the impact of the proposed action on fish and shellfish resources resulting from heat shock …." 10 CFR 51.53(c)(3)(ii)(B)

"…Because of continuing concerns about heat shock and the possible need to modify thermal discharges in response to changing environmental conditions, the impacts may be of moderate or large significance at some plants…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 27

The issue of heat shock does not apply to LGS because condenser cooling at the units does not utilize a once-through cooling water system or a cooling pond heat dissipation system. As Section 3.1.2 describes, LGS uses a closed cycle cooling system with cooling towers, withdraws make-up water from the Schuylkill River and/or Perkiomen Creek, and discharges cooling tower blowdown to the Schuylkill River.

4.5 Groundwater Use Conflicts (Plants Using Greater than 100 GPM of Groundwater)

NRC

"If the applicant's plant…pumps more than 100 gallons (total onsite) of groundwater per minute, an assessment of the impact of the proposed action on groundwater use must be provided." 10 CFR 51.53(c)(3)(ii)(C)

"Plants that use more than 100 gpm may cause groundwater use conflicts with nearby groundwater users." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 33

NRC made groundwater use conflicts a Category 2 issue because, at a withdrawal rate of more than 378.5 liters per minute (100 gallons per minute), a cone of depression could extend offsite, which could deplete the groundwater supply available to offsite users, an impact that could warrant mitigation. Information to be ascertained includes: (1) whether the LGS groundwater withdrawal rate exceeds 378.5 liters per minute (100 gallons per minute or gpm) and if yes, (2) what the drawdown at offsite locations would be and (3) what the impact on neighboring wells would be.

As discussed in Section 3.1.2, the combined pump yields of the two LGS groundwater supply wells is 435.3 liters per minute (115 gpm). However, as detailed in Section 2.3, the actual water use records filed with the PADEP between 1999 and 2009 indicate that the true annual average rate of water withdrawal for both LGS groundwater wells combined ranged between 54.1 and 109.8 liters per minute (14.3 and 29.0 gpm). The *NRC Regulatory Guide 4.2S1 (Supplement 1 to Regulatory Guide 4.2)* provides further guidance for this issue by stating that *"if the applicant can provide withdrawal records or other evidence that the plant does not pump more than an* ***annual average*** *[emphasis added] of 100 gpm (6 L/s) of groundwater, the ER should note this fact, and no additional information is needed on this issue*."

Because this issue of groundwater use conflicts is concerned with annual average pumping records, the issue does not apply to LGS, which has demonstrated an actual, onsite, annual average groundwater pumping rate of less than 435.3 liters per minute (100 gpm).

4.6 Groundwater Use Conflicts (Plants Using Cooling Towers Withdrawing Makeup Water from a Small River)

NRC

"If the applicant's plant utilizes cooling towers or cooling ponds and withdraws make-up water from a river whose annual flow rate is less than $3.15{\times}10^{12}$ ft^3 / year...[t]he applicant shall also provide an assessment of the impacts of the withdrawal of water from the river on alluvial aquifers during low flow." 10 CFR 51.53(3)(ii)(A)

"…Water use conflicts may result from surface water withdrawals from small water bodies during low flow conditions which may affect aquifer recharge, especially if other groundwater or upstream surface water users come on line before the time of license renewal…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 34

NRC made this groundwater use conflict a Category 2 issue because surface water withdrawals from small rivers could adversely impact recharge to alluvial aquifers. This is a particular concern during low-flow conditions and could create a cumulative impact due to other upstream consumptive uses. Cooling towers and cooling ponds lose water by evaporation, which is necessary to cool the heated water before it is discharged to the environment.

The issue of potential groundwater use conflicts applies because the LGS withdraws makeup water from the Schuylkill River, which meets the NRC's definition of a small river. As discussed in Section 2.2.1, the average annual mean stream flow of the Schuylkill River at the USGS Pottstown gage station is 56.51 cubic meters per second (1,996.2 cfs) or $1.78\text{x}10^8$ cubic meters per year ($6.3\text{x}10^{10}$ cubic feet per year). The Schuylkill River near LGS meets the NRC definition of a small river since its annual flow rate is less than $9{\times}10^{10}$ cubic meters per year ($3.15{\times}10^{12}$ cubic feet per year).

As discussed in Section 3.1.2, LGS is designed with a closed-cycle cooling tower-based heat dissipation system. Cooling water lost to cooling tower evaporation is replaced by make-up water pumped at a DRBC-approved maximum daily rate of 212.7 million liters per day [65 cfs or 42 million gallons per day (MGD)]. This represents 3.3 percent of average annual mean stream flow in the Schuylkill River. When the Schuylkill River flow measured at the Pottstown gage decreases to 15.0 cubic meters per second (530 cfs) (for one unit in operation) or 15.8 cubic meters per second (560 cubic cfs) (for two-unit operation), pumping of the river for consumptive use at LGS becomes restricted[6]. With river flow at 15.8 cubic meters per second (560 cubic cfs), consumption of river water at 65 cfs would represent 11.6 percent of river flow. The additional withdrawal authorized by the DRBC for non-consumptive use of 53.7 million liters per day [22 cfs (14.2 mgd)] would represent an additional 3.9 percent of river flow, but this water is returned to the river a relatively short distance (about 213.4 meters (700 feet) downstream of the withdrawal point.

[6] In comparison, the 7-day average low flow occurring once in a ten-year period ($Q_{7\text{-}10}$) is 312 cfs, based on the same period of record.

This section is concerned with the effect of water withdrawals from the Schuylkill River on the recharge to water-bearing units (aquifer) during periods of low flow. More specifically, it discusses the effects on near-surface alluvial aquifers.

As discussed in Section 2.3, the water-bearing unit (aquifer) in the vicinity of the LGS consists of a thick Triassic-age sedimentary sequence known to include the Brunswick Formation and the Lockatong. The Brunswick Formation consists of reddish-brown shale, mudstone, and siltstone. Locally interbedded along the base of the Brunswick Formation, and laterally grading into the Brunswick Formation, are gray to black shale and siltstone of the older Lockatong Formation. The thickness of the Brunswick Formation is reported to be as much as 6,400.8 meters (21,000 feet) in the region. The Brunswick Formation has poor primary porosity. Instead, groundwater is stored and transmitted through a network of fractures and joints ('secondary porosity'), which are developed as vertical joint planes.

The direction of groundwater flow beneath LGS follows its overall topography from the topographic high near the cooling towers toward the south and southwest, discharging to surface water of the Possum Hollow Creek or the Schuylkill River.

The ability of a river to recharge water into near-surface alluvial aquifers depends principally on two factors: (i) the presence of alluvial or other high-permeability deposits within the flood plain of the river, and (ii) the hydraulic head gradient between groundwater and surface water (i.e., whether the river is a net-gaining or a net-losing stream).

Glacial deposits (e.g., till, glacial drift, outwash deposits, valley fill) are not present within the lower reaches of the Schuylkill River in Berks and Montgomery Counties (including the vicinity of the LGS) (PABTGS, 1997). Instead, the Schuylkill River watershed in lower Berks and Montgomery Counties is underlain by a fractured, water-bearing unit. Although the bedrock aquifer is typically capped by thin deposits of regolith (weathered bedrock, clayey soils) and/or localized alluvial deposits in river valleys, these deposits are neither thick nor permeable enough to provide sustained yields of groundwater to wells (USGS, 2002). Instead, the regolith permits infiltration of precipitation into its pore space, which then slowly releases water to the underlying fractured bedrock. Therefore, because highly permeable or extensive alluvial or glacial deposits in the vicinity of the LGS and along the lower Schuylkill watershed are absent, variations in the stream flow of the Schuylkill River do not have an effect on long-term groundwater availability.

The groundwater flow regime in the vicinity of LGS is largely controlled by local topography, where the depth to groundwater is a subdued replica of the land surface, with water levels shallowest in the valleys (representing discharge areas) and deepest on hill tops (representing recharge areas) (USGS, 2002). As such, groundwater recharges the stream base flow from areas of high hydraulic head to areas of lower hydraulic head along stream and springs. The observed groundwater and surface water head measurements at the LGS are typical for this flow regime, whereby the Schuylkill River represents a gaining stream throughout the year (i.e., groundwater is flowing out to the river, and not the other way). For example, during the observed years (2006 and 2007) groundwater heads in monitoring wells closest to the Schuylkill River ranged from 33.5 to 35.4 meters (110 to 116 feet) above mean sea level (amsl), with the Schuylkill River stage being less than 32.0 meters (105 feet) amsl, indicating that the Schuylkill River is a gaining stream. Conestoga-Rovers (2006) suggested that the specific discharge from the saturated portion of the Brunswick Formation may be on the order of 0.02 cubic feet per day (0.15 gallons per day) per square foot of aquifer. This implies that, along the approximately

1,219.2-meter (4,000-foot) long LGS plant site frontage on the Schuylkill River, groundwater discharges at a rate of approximately 227,1 liters per day (60,000 gallons per day).

Figure 4.6-1 shows DRBC-permitted water supply wells in the vicinity of the LGS and along the Schuylkill River. The closest significant withdrawal of groundwater occurs at Well #4 (DRBC Well ID 9342), which is located approximately 3.7 kilometers (2 miles) downstream of the LGS, on the south bank of the river. This well is completed in the Brunswick Formation to a depth of 152.4 meters (500 feet). It is, therefore, not affected by surface water flow in the Schuylkill River. Similarly, other domestic and public water supply wells in the vicinity of the LGS are completed in the Brunswick Formation to significant depths, and the groundwater captured by these supply wells is primarily derived from regional (upland) recharge. Thus, any withdrawal of water from the Schuylkill River for use at the LGS has no impacts on groundwater availability or recharge to alluvial aquifers, and cannot impact other groundwater users in the area.

Therefore, the impacts of withdrawing makeup water from the Schuylkill River on the underlying water bearing unit (fractured bedrock aquifer) are SMALL and additional mitigation measures are not warranted.

4.7 Groundwater Use Conflicts (Plants Using Ranney Wells)

NRC

“If the applicant’s plant uses Ranney wells…an assessment of the impact of the proposed action on groundwater use must be provided.” 10 CFR 51.53(c)(3)(ii)(C)

“…Ranney wells can result in potential groundwater depression beyond the site boundary. Impacts of large groundwater withdrawal for cooling tower makeup at nuclear power plants using Ranney wells must be evaluated at the time of application for license renewal.…” 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 35

The issue of groundwater use conflicts does not apply to LGS because the plant does not use Ranney wells. As Section 3.1.2 describes, LGS withdraws groundwater using only conventional-type wells.

4.8 Degradation of Groundwater Quality

NRC

“If the applicant’s plant is located at an inland site and utilizes cooling ponds, an assessment of the impact of the proposed action on groundwater quality must be provided.” 10 CFR 51.53(c)(3)(ii)(D)

“…Sites with closed-cycle cooling ponds may degrade groundwater quality. For plants located inland, the quality of the ground water in the vicinity of the ponds must be shown to be adequate to allow continuation of current uses….” 10 CFR 51, Subpart A, Appendix B, Table B 1, Issue 39

The issue of groundwater quality degradation does not apply to LGS because the plant does not use cooling ponds. As Section 3.1 describes, LGS uses a closed cycle cooling system with cooling towers, withdraws make-up water from the Schuylkill River and/or Perkiomen Creek, and discharges cooling tower blowdown to the Schuylkill River.

4.9 Impacts of Refurbishment on Terrestrial Resources

NRC

The environmental report must contain an assessment of "…the impact of refurbishment and other license-renewal-related construction activities on important plant and animal habitats…." 10 CFR 51.53(c)(3)(ii)(E)

"…Refurbishment impacts are insignificant if no loss of important plant and animal habitat occurs. However, it cannot be known whether important plant and animal communities may be affected until the specific proposal is presented with the license renewal application…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 40

"…If no important resource would be affected, the impacts would be considered minor and of small significance. If important resources could be affected by refurbishment activities, the impacts would be potentially significant…." (NRC 1996a, Section 3.6, pg. 3-6)

The issue of terrestrial resource impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.10 Threatened or Endangered Species

NRC

“Additionally, the applicant shall assess the impact of the proposed action on threatened or endangered species in accordance with the Endangered Species Act.” 10 CFR 51.53(c)(3)(ii)(E)

“Generally, plant refurbishment and continued operation are not expected to adversely affect threatened or endangered species. However, consultation with appropriate agencies would be needed at the time of license renewal to determine whether threatened or endangered species are present and whether they would be adversely affected.” 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 49

NRC made impacts to threatened and endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any identified species could be affected by refurbishment activities or continued plant operations through the renewal period. In addition, compliance with the Endangered Species Act requires consultation with the appropriate federal agency (NRC, 1996a, Sections 3.9 and 4.1).

4.10.1 Threatened or Endangered Species – Refurbishment

NRC made impacts to threatened or endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any identified species could be affected by refurbishment activities or continued plant operations through the renewal period. In addition, compliance with the Endangered Species Act requires consultation with the appropriate federal agency (NRC, 1996a, Sections 3.9 and 4.1).

The issue of threatened or endangered species impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.10.2 Threatened or Endangered Species – License Renewal Term

NRC made impacts to threatened or endangered species a Category 2 issue because the status of many species is being reviewed, and site-specific assessment is required to determine whether any identified species could be affected by refurbishment activities or continued plant operations through the renewal period. In addition, compliance with the Endangered Species Act requires consultation with the appropriate federal agency (NRC, 1996a, Sections 3.9 and 4.1).

Section 2.2 of this Environmental Report describes the aquatic communities of the Schuylkill River and approved alternate water sources. Section 2.4 describes important terrestrial habitats at LGS and along the associated transmission corridors. Section 2.5 discusses threatened or endangered species that may occur in the vicinity of LGS or its associated transmission corridors. Animal and plant species that are state- or federally-listed as endangered or threatened and recorded in the counties of interest are listed in Table 2.5-1.

The LGS plant site, the LGS transmission system, and the LGS makeup water supply system are located in Montgomery, Chester, and Bucks Counties (counties of interest). As discussed in Section 2.5, federally-listed endangered or threatened species occurring in one or more counties of interest include the Indiana bat, bog turtle, shortnose sturgeon, dwarf wedgemussel and small-whorled pogonia. State-listed endangered or threatened species in one or more counties of interest are listed in Table 2.5-1. They include three mammal species, twelve bird species, six reptile and amphibian species, and 116 plant species.

The Mid-Atlantic Fishery Management Council oversees 17 species of fish and shellfish; none of these marine species are found in the Schuylkill River or the Perkiomen Creek, or the freshwater portions of the Delaware River. No Essential Fish Habitat (EFH) is located in inland water bodies; EFH in the Delaware Estuary are found only as far upriver as Salem, NJ.

Bald eagles have not been confirmed breeders within the Upper Schuylkill River conservation landscape of which LGS is a part. Osprey is a confirmed breeder within the Middle Perkiomen Creek corridor.

Even though state records indicate that certain species listed as threatened or endangered are known to be present in the counties of interest, Exelon Generation has not encountered any of these threatened or endangered species during surveys and reviews that have been conducted at the LGS plant site and the LGS makeup water supply system. Also, PECO has not reported encountering them along the LGS transmission system corridors. Hence, Exelon Generation believes that operation of LGS does not adversely affect any listed species or its habitat (see Section 2.5). Vegetation management practices at the plant site and along the transmission corridors are developed and implemented in conjunction with appropriate regulatory agencies to minimize potential impacts on threatened or endangered species. Furthermore, LGS operations and PECO transmission line maintenance practices are not expected to change significantly during the period of extended operations. Therefore, no adverse impacts to threatened or endangered terrestrial species are anticipated during the period of extended operation.

Exelon Generation contacted the Pennsylvania Department of Conservation and Natural Resources, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, and the U.S. Fish and Wildlife Service requesting information on any listed species or species of concern for which potential conflicts could exist, with particular emphasis on species that might be adversely affected by continued operation over the license renewal period. Agency responses are provided in Appendix C. All four agencies indicated that license renewal is unlikely to affect any listed species.

Because Exelon Generation has no plan to alter operations after license renewal, has committed to comply with applicable regulatory requirements, and resource agencies have evidenced no serious concerns about license renewal impacts on protected species, Exelon Generation concludes that impacts to threatened or endangered species from license renewal would be insignificant (SMALL) and do not warrant mitigation.

4.11 Air Quality During Refurbishment (Non-Attainment of Maintenance Areas)

NRC

"If the applicant's plant is located in or near a nonattainment or maintenance area, an assessment of vehicle exhaust emissions anticipated at the time of peak refurbishment workforce must be provided in accordance with the Clean Air Act as amended." 10 CFR 51.53(c)(3)(ii)(F)

"…Air quality impacts from plant refurbishment associated with license renewal are expected to be small. However, vehicle exhaust emissions could be cause for concern at locations in or near nonattainment or maintenance areas. The significance of the potential impact cannot be determined without considering the compliance status of each site and the numbers of workers expected to be employed during the outage…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 50

The issue of air quality impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.12 Microbiological Organisms

NRC

"If the applicant's plant uses a cooling pond, lake, or canal or discharges into a river having an annual average flow rate of less than 3.15×10^{12} ft^3/year (9×10^{10} m^3/year), an assessment of the impact of the proposed action on public health from thermophilic organisms in the affected water must be provided." 10 CFR 51.53(c)(3)(ii)(G)

"These organisms are not expected to be a problem at most operating plants except possibly at plants using cooling ponds, lakes, or canals that discharge to small rivers. Without site-specific data, it is not possible to predict the effects generically." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 57

Due to the lack of sufficient data from facilities using cooling ponds, lakes, or canals or discharging to small rivers, NRC designated impacts on public health from thermophilic organisms a Category 2 issue. Information to be determined is: (1) whether the plant discharges to a small river, and (2) whether discharge characteristics (particularly temperature) are favorable to the survival of thermophilic organisms.

The issue is applicable to LGS because the LGS discharges water to the Schuylkill River, which meets the NRC's definition of a small river. As discussed in Section 2.2.1, the Schuylkill River flow is 56.51 cubic meters per second (1,996.2 cfs) or $1.78\text{x}10^8$ cubic meters per year ($6.3\text{x}10^{10}$ cubic feet per year). The Schuylkill River near LGS meets the NRC definition of a small river since its annual flow rate is less than 9×10^{10} cubic meters per year (3.15×10^{12} cubic feet per year). The issue is also relevant because the Schuylkill River in the vicinity of LGS is used by the public for boating and fishing recreational purposes (secondary contact), although not for swimming (primary contact).

Organisms of concern include the enteric pathogens *Salmonella* sp. and *Shigella* sp., as well as *Pseudomonas aeriginosa*, thermophilic fungi, *Legionella* sp. in unusually high concentrations, and the free-living amoebae of the genera *Naegleria* and *Acanthomoeba.* Of greatest concern is the *Naegleria (N.)* sp., four species of which have been isolated. To date, only one species, *N. fowleri*, has been determined to be pathogenic in humans. *N. fowleri*, has been determined to cause primary amebic meningoencephalitis (PAM) in humans.

The genus *Naegleria* is composed of a group of free-living amoeboflagellates that are distributed worldwide. Although several species have been identified, only one, *Naegleria fowleri*, has been associated with human disease. *N. fowleri* has been isolated from a variety of water sources, including domestic water supplies, recreational water facilities, and thermally polluted water from industrial sources. The presence of *N. fowleri* in environmental water has been linked to temperature, pH, coliforms, and the amount of organic matter present. Iron and iron-containing compounds in water favor growth of *N. fowleri*. (Marciano-Cabral, 2003).

As described in the NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437) in Section 4.3.6 Human Health, page 28, "the magnitude of the potential public health impacts associated with thermal enhancement of *N. fowleri* cannot be determined generically." Hallenbeck and Brenniman (1989) estimated individual annual risks for primary amebic meningoencephalitis (PAM) caused by the free-living *N. fowleri* to swimmers in fresh water to be approximately 4×10^{-6}. The most certain way to prevent infections is to refrain from swimming in freshwater bodies of water (MMWR, 2008). As stated above, the Schuylkill River designated public uses are boating and fishing, but not swimming.

Extensive research of reports and studies published by the Centers for Disease Control (CDC, 2008), Morbidity and Mortality Weekly Reports (MMWR, 2011), MedicineNet.com (Medicinenet, 2011), and various other research sources revealed no reports of cases of PAM in the Northeastern US. Exelon Generation has identified no record of monitoring for *N. fowleri* in the Schuylkill River in the region of LGS.

The LGS NPDES permit (Permit No. PA0051926) requires that the temperature in the thermal discharge be monitored at least once per week for compliance with an instantaneous maximum limit of 43.3 °C (110 °F) for the protection of human health. Based on several years of Discharge Monitoring Report (DMR) data, maximum summer discharge temperatures range from 32.2 to 35.0 °C (90 °F to 95 °F). Part C of the NPDES Permit, Other Requirements, Item No. 8 on page 30 further stipulates that: "*The following requirements apply with respect to the thermal impact of the discharge from Outfall 001 upon Schuylkill River: No rise when ambient temperature is 87°F or above; not more than a 5°F rise above ambient temperature until stream temperature reaches 87°F; not to be changed by more than 2°F during any one-hour period."* The NRC Final Environmental Statement (FES) for the operation of Limerick states that the predicted downstream temperature rise is normally less than 2.8 °C (5 °F). The cooling tower blowdown water from each unit's cooling tower is combined and discharged into the Schuylkill River through a submerged multi-port diffuser pipe, which is designed to rapidly diffuse the heat and limit the mixing zone size.

The DRBC-designated uses to be maintained in the Schuylkill River in the vicinity of LGS include secondary contact recreation, in which body contact is either incidental or accidental, and in which the probability of ingesting appreciable quantities of water, particularly through nasal passages, is minimal.

The LGS facility currently discharges sanitary sewage to the local publicly-owned treatment works (POTW) for treatment, which further reduces the potential for the facility's discharge to introduce pathogenic microorganisms that could present a threat to recreational users of the Schuylkill River.

Because thermophilic organisms are not known in the Schuylkill River or the region, there is no record of the associated disease in the northeast, LGS's temperature effect on the Schuylkill River is limited by its NPDES Permit, the river is not intended for primary contact, and Limerick discharges no treated sanitary wastewater, the impact of the cooling towers' effluent upon the river's natural dynamics of thermophilic organisms is expected to be SMALL.

Exelon Generation has requested the Pennsylvania Department of Environmental Protection (PADEP) to provide comments or concerns regarding whether LGS contributes to potential health effects resulting from *N. fowleri* or other thermophilic organisms. Exelon Generation requested PADEP to alternatively confirm Exelon's conclusion that operation of LGS during the period of extended operation would not enhance growth of thermophilic pathogens. In response, PADEP identified that they do not have any data associated with *N. fowleri* in the Schuylkill River nor have they conducted any investigations on the impact or potential impact of the LGS discharge on thermophilic organisms in the river. As a result, PADEP is unable to make any conclusions regarding the effect on public health from *N. fowleri* or any other thermophilic organisms in the Schuylkill River. A copy of Exelon Generation's correspondence with PADEP and the agency's response are provided in Appendix E.

4.13 Electric Shock from Transmission Line – Induced Currents

NRC

The environmental report must contain an assessment of the impact of the proposed action on the potential shock hazard from transmission lines "...[i]f the applicant's transmission lines that were constructed for the specific purpose of connecting the plant to the transmission system do not meet the recommendations of the National Electric Safety Code for preventing electric shock from induced currents…" 10 CFR 51.53(c)(3)(ii)(H)

"…Electrical shock resulting from direct access to energized conductors or from induced charges in metallic structures have not been found to be a problem at most operating plants and generally are not expected to be a problem during the license renewal term. However, site-specific review is required to determine the significance of the electric shock potential at the site.…" 10 CFR 51, Subpart A, Table B 1, Issue 59

NRC made impacts of electric shock from transmission lines a Category 2 issue because, without a review of each plant's transmission line conformance with the National Electrical Safety Code (NESC) criteria (IEEE, 2006), NRC could not determine the significance of the electric shock potential. This section provides an analysis of the LGS transmission lines in conforming to the NESC standard.

4.13.1 Production of Induced Currents

Objects located near transmission lines can become electrically charged due to their immersion in the lines' electric field. This charge results in a current that flows through the object to the ground. The current is called "induced" because there is no direct connection between the line and the object. The induced current can also flow to the ground through the body of a person who touches the object. An object that is insulated from the ground can actually store an electrical charge, becoming what is called "capacitively" charged." A person standing on the ground and touching a vehicle or a fence receives an electrical shock due to the sudden discharge of the capacitive charge through the person's body to the ground. After the initial discharge, a steady-state current can develop, the magnitude of which depends on several factors, including the following:

- The strength of the electric field which, in turn, depends on the voltage of the transmission line as well as its height and geometry;
- The size of the object on the ground; and
- The extent to which the object is grounded.

In 1977, the NESC adopted a provision that describes how to establish minimum vertical clearances to the ground for electric lines having voltages exceeding 98-kilovolt alternating current-to-ground. The clearance must limit the induced current due to electrostatic effects to five milliamperes if the largest anticipated truck, vehicle, or equipment were short-circuited to ground.

By way of comparison, the setting of ground fault circuit interrupters used in residential wiring (special breakers for outside circuits or those with outlets around water pipes) is four to six milliamperes.

4.13.2 LGS Transmission Lines

As described in Section 3.1.3, the LGS transmission system includes four 230-kV lines and one 500-kV line specifically constructed to connect LGS to the regional electricity grid:

- One 230-kV line (Line 220-60) from Limerick 230-kV Substation to Cromby Substation and one 230-kV line (Line 220-62) from Cromby Substation to North Wales Substation;
- One 230-kV line (Line 220-61) from Limerick 230-kV Substation to Cromby Substation and one 230-kV line with two segments (Line 220-63 and Line 220-64) from Cromby Substation to Plymouth Meeting Substation; and
- One 500-kV line (Line 5031) from Limerick 500-kV Substation Unit 2 to Whitpain Substation.

4.13.2.1 Induced Current Analysis

Exelon Generation's analysis of the LGS transmission system lines is based on computer modeling of induced current under the line. The initial step of the analysis was identification of the line/road crossings to be analyzed. Only paved roads and highways were considered in the analysis; minor roads (i.e., "dirt" or service road crossings) were not included. The electric field strength and subsequently the induced current were then calculated for the transmission line at each location.

The electric field strength and induced current were calculated using the Electric Power Research Institute (EPRI) HERB 2.0 program included in the "EPRI AC Transmission Line Reference Book - 200 kV and Above." The input parameters include voltage, conductor/bundle size, height above ground, sag, conductor geometric configuration, and object size and location. The EPRI HERB 2.0 is a well-known and industry accepted program for calculating EHV transmission line electric effects published by EPRI.

The input parameters included design features of the limiting-case scenario and the NESC requirement that line sag be determined at a minimum conductor temperature of 48.9°C (120°F). The conductor sag measurements were taken from plan-and-profile drawings for the five lines, which represent the design sag dimensions. The analysis took into account transmission lines that run in the same corridor with the LGS lines. For analysis purposes, the maximum vehicle size under the lines is considered to be a tractor-trailer of 2.6 meters (8.5 feet) wide, 4.1 meters (13.5 feet) maximum height, and 19.8 meters (65 feet) long.

4.13.2.2 Analysis Results

The analytical results for each line are summarized in Table 4.13-1. The analysis determined that the maximum values for the five transmission lines are in compliance with the NESC limit and below the NESC limit of 5 milliamperes. As shown in the table, the highest induced current was calculated to be 4.60 milliamperes for Line 220-63.

PECO, a subsidiary of Exelon Corporation and owners and operators of the transmission lines, conduct surveillance and maintenance activities to verify that design ground clearances will not change. These procedures include routine inspection by aircraft on a periodic basis. The aerial patrols of all corridors include checks for encroachments, broken conductors, broken or leaning structures, and signs of burnt trees, any of which would be evidence of clearance problems. Ground inspections are conducted yearly and include examination for clearance at questionable locations, integrity of structures, and surveillance for dead or diseased trees that might fall on the transmission line. Problems noted during any inspection are brought to the attention of the appropriate organizations for planning corrective maintenance.

As a result of this analysis performed in accordance with the requirements of 10 CFR Part 51, Exelon Generation concludes that electric shock is of SMALL significance for the LGS transmission lines because the magnitude of the induced currents does not exceed the NESC standard. Mitigation measures are not warranted because there is adequate clearance between energized conductors and the ground. The conclusions on this issue will remain valid because there are no changes in line use, voltage, or maintenance practices and no changes in land use under the line are expected.

4.14 Housing Impacts

4.14.1 Housing – Refurbishment

NRC

The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)

"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development…." 10 CFR 51, Subpart A, Table B-1, Issue 63

"The impacts on housing are considered to be of small significance when a small and not easily discernible change in housing availability occurs, generally as a result of a very small demand increase or a very large housing market. Increases in rental rates or housing values in these areas would be expected to equal or slightly exceed the statewide inflation rate. No extraordinary construction or conversion of housing would occur where small impacts are foreseen." (NRC, 1996a)

The issue of housing impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.14.2 Housing – License Renewal Term

NRC

The environmental report must contain "...[a]n assessment of the impact of the proposed action on housing availability…" 10 CFR 51.53(c)(3)(ii)(I)

"…Housing impacts are expected to be of small significance at plants located in a medium or high population area and not in an area where growth control measures that limit housing development are in effect. Moderate or large housing impacts of the workforce associated with refurbishment may be associated with plants located in sparsely populated areas or areas with growth control measures that limit housing development.…" 10 CFR 51, Subpart A, Table B-1, Issue 63

"...[S]mall impacts result when no discernible change in housing availability occurs, changes in rental rates and housing values are similar to those occurring statewide, and no housing construction or conversion occurs.…" (NRC, 1996a)

NRC made housing impacts a Category 2 issue because impact magnitude depends on local conditions that NRC could not predict for all plants at the time of GEIS publication (NRC, 1996a). Local conditions that need to be ascertained are: (1) population categorization as small, medium, or high and (2) applicability of growth control measures.

In 10 CFR Part 51, Subpart A, Appendix B, Table B-1, NRC concluded that impacts to housing are expected to be of small significance at plants located in high population areas where growth control measures are not in effect.

The maximum impact to area housing was calculated using the following assumptions:

- All direct jobs would be filled by in-migrating residents;
- The residential distribution of new residents would be similar to current operations worker distribution; and
- Each new direct job created would represent one housing unit.

As Section 3.4 indicates, although Exelon Generation estimates no additional jobs will be created to implement aging management programs during the period of extended operation, it is conservatively assumed for the purpose of analyzing environmental impacts in this report that 60 new employees would be added, and that the 60 additional employees could generate the demand for 60 housing units.

As described in Section 2.6, LGS is located in a high population area. As noted in Section 2.8, Montgomery, Berks, and Chester Counties, where most existing employees reside, are not subject to growth control measures that limit housing development. Additionally, in an area which has a population within the two adjacent counties of over one million people and a state average of 2.48 persons per household (USCB, 2002), suggesting the existence of over 400,000 housing units, it is reasonable to conclude that a demand for 60 housing units would not create a discernible change in housing availability, rental rates or housing values, or spur housing construction or conversion. Exelon Generation concludes that impacts to housing availability resulting from plant-related population growth would be SMALL and would not warrant mitigation.

4.15 Public Water Supply

4.15.1 Public Water Supply – Refurbishment

NRC

The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)

"…An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 65

"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC, 1996a)

The issue of public water supply impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.15.2 Public Water Supply – License Renewal Term

NRC

The environmental report must contain "…an assessment of the impact of population increases attributable to the proposed project on the public water supply." 10 CFR 51.53(c)(3)(ii)(I)

"…An increased problem with water shortages at some sites may lead to impacts of moderate significance on public water supply availability…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 65

"Impacts on public utility services are considered small if little or no change occurs in the ability to respond to the level of demand and thus there is no need to add capital facilities. Impacts are considered moderate if overtaxing of facilities during peak demand periods occurs. Impacts are considered large if existing service levels (such as quality of water and sewage treatment) are substantially degraded and additional capacity is needed to meet ongoing demands for services." (NRC, 1996a)

NRC made public utility impacts a Category 2 issue because an increased problem with water availability, resulting from pre-existing water shortages, could occur in conjunction with plant demand and plant-related population growth (NRC, 1996a). Local information needed would include: (1) a description of water shortages experienced in the area, and (2) an assessment of the public water supply system's available capacity.

NRC's analysis of impacts to the public water supply system considered both plant demand and plant-related population growth demands on local water resources. As stated in Section 2.3, the plant does not use water from a public water system. Therefore, there would be no plant demand-related impacts to the public water supply. As such, the following discussion focuses on impacts of continued operations on local public utilities and the assumption that LGS would add up to 60 additional employees during the period of extended operation for license renewal activities. As Section 3.4 indicates, Exelon Generation analyzed a hypothetical 60-person increase in LGS employment attributable to license renewal. Section 2.6 describes the LGS regional demography. Section 2.9 describes the public water supply systems in the area, their permitted capacities, and current demands.

The maximum impact to local water supply systems was assessed using the following assumptions: (1) all direct jobs would be filled by in-migrating residents; and (2) the residential distribution of the workers would resemble that of the current operations workforce. The impact can be determined by calculating the amount of water that would be required by these individuals. The average American uses about 340.6 liters per day (90 gallons per day or gpd) for personal use (EPA, 2003). As described in Section 3.4, LGS estimates an additional 60 employees, which could result in a population increase of 149 in the area (60 jobs multiplied by 2.48, which is the average number of persons per household in Pennsylvania [USCB, 2002]). Using this consumption rate, the plant-related population increase could require an approximate additional 50,755 liters per day (13,410 gpd) (149 people multiplied by use per day) in an area where the public water supply capacity is approximately 125 million gallons per day from the Aqua Pennsylvania Main System alone (see Table 2.9.1). There are no major water suppliers in Montgomery, Berks, and Chester Counties for which a surplus capacity of 13,410 gpd is not available. If it is assumed that this increase in population would be consistent with current employee trends (i.e., 84 percent in Montgomery, Berks, and Chester Counties), the increase in water demand would not create shortages in capacity of the water supply systems in these communities. Exelon Generation concludes that impacts resulting from plant-related population growth to public water supplies would be SMALL, requiring no additional capacity and not warranting mitigation.

Similarly, the maximum impact to local sewer systems was assessed for the assumed population increases and additional water usage in the three county areas. In accordance with the Pennsylvania Sewage Facilities Act of 1966 (Act 537, as amended), municipalities are required to develop and implement comprehensive official plans that provide for the resolution of existing sewage disposal problems, provide for the future sewage disposal needs of new land development; and provide for future sewage disposal needs of the municipality (PADEP, 2011b). Therefore, Exelon Generation concludes that impacts resulting from plant-related population growth to public sewer systems would be SMALL, requiring no capacity beyond that already planned for and not warranting mitigation.

4.16 Education

4.16.1 Education – Refurbishment

NRC

The environmental report must contain "…[a]n assessment of the impact of the proposed action on…public schools (impacts from refurbishment activities only) within the vicinity of the plant…." 10 CFR 51.53(c)(3)(ii)(I)

"…Most sites would experience impacts of small significance but larger impacts are possible depending on site- and project-specific factors…." 10 CFR 51, Subpart A, Table B-1, Issue 66

"…[S]mall impacts are associated with project-related enrollment increases of 3 percent or less. Impacts are considered small if there is no change in the school systems' abilities to provide educational services and if no additional teaching staff or classroom space is needed. Moderate impacts are generally associated with 4 to 8 percent increases in enrollment. Impacts are considered moderate if a school system must increase its teaching staff or classroom space even slightly to preserve its pre-project level of service….Large impacts are associated with project-related enrollment increases above 8 percent…." (NRC, 1996a)

The issue of educational impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.17 Offsite Land Use

4.17.1 Offsite Land Use – Refurbishment

NRC

The environmental report must contain "…an assessment of the impact of the proposed action on... land-use... (impacts from refurbishment activities only) within the vicinity of the plant…." 10 CFR 51.53(c)(3)(ii)(I)

"…Impacts may be of moderate significance at plants in low population areas…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 68

"…[I]f plant-related population growth is less than 5 percent of the study area's total population, off-site land-use changes would be small, especially if the study area has established patterns of residential and commercial development, a population density of at least 60 persons per square mile, and at least one urban area with a population of 100,000 or more within 50 miles…." (NRC, 1996a)

The issue of offsite land use impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.17.2 Offsite Land Use – License Renewal Term

NRC

The environmental report must contain "…[a]n assessment of the impact of the proposed action on…land-use…." 10 CFR 51.53(c)(3)(ii)(I)

"Significant changes in land use may be associated with population and tax revenue changes resulting from license renewal." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 69

"…[I]f plant-related population growth is less than five percent of the study area's total population, off-site land-use changes would be small…." (NRC, 1996a, Section 3.7.5)

"…[I]f the plant's tax payments are projected to be small relative to the community's total revenue, new tax-driven land-use changes during the plant's license renewal term would be small, especially where the community has preestablished patterns of development and has provided adequate public services to support and guide development." (NRC, 1996a, Section 4.7.4.1)

NRC made impacts to offsite land use during the license renewal term a Category 2 issue, because land-use changes may be perceived as beneficial by some community members and detrimental by others. Therefore, NRC could not assess the potential significance of site-specific offsite land-use impacts (GEIS Section 4.7.4.2). Site-specific factors to consider in an assessment of land-use impacts include: (1) the size of plant-related population growth compared to the area's total population, (2) the size of the plant's tax payments relative to the community's total revenue, (3) the nature of the community's existing land-use pattern, and (4) the extent to which the community already has public services in place to support and guide development.

The GEIS presents an analysis of offsite land use for the renewal term that is characterized by two components: population-driven and tax-driven impacts (GEIS Section 4.7.4.1).

4.17.2.1 Population-Related Impacts

Based on the GEIS case-study analysis, NRC concluded that all new population driven land-use changes during the license renewal term at all nuclear plants would be SMALL. Population growth caused by license renewal would represent a much smaller percentage of the local area's total population than the percent change represented by operations-related growth (GEIS Section 3.7.3).

4.17.2.2 Tax-Revenue-Related Impacts

Determining tax-revenue-related land use impacts is a two-step process. First, the significance of the plant's tax payments on taxing jurisdictions' tax revenues is evaluated. Then, the impact of the tax contribution on land use within the taxing jurisdiction's boundaries is assessed.

Tax Payment Significance

NRC has determined that the significance of tax payments as a source of local government revenue would be LARGE if the payments are greater than 20 percent of revenue, MODERATE if the payments are between 10 and 20 percent of revenue, and SMALL if the payments are less than 10 percent of revenue (NRC, 1996a).

Land Use Significance

In the GEIS, the NRC defined the magnitude of land-use changes as follows:

SMALL - very little new development and minimal changes to an area's land-use pattern.

MODERATE - considerable new development and some changes to land use pattern.

LARGE - large-scale new development and major changes in land-use pattern.

NRC further determined that,

> "…[I]f the plant's tax payments are projected to be medium to large relative to the community's total revenue, new tax-driven land-use changes would be moderate. This is most likely to be true where the community has no pre-established patterns of development (i.e., land use plans or controls) or has not provided adequate public services to support and guide development in the past, especially infrastructure that would allow industrial development (NRC, 1996a).

Tax Impacts

Table 2.7-1 provides a comparison of the 2006 through 2010 tax payments made by Exelon Generation to each of the official taxing authorities. Exelon Generation periodically discusses the assessed value of LGS for taxation purposes with taxing authorities to ensure consistency and stability for Exelon Generation and the taxing authority. The most recent discussion (in 2008) with Spring-Ford Area School District and the local taxing jurisdictions determined that the assessed value of LGS would be $20,000,000 and would remain in effect through 2013.

Limerick Township and Lower Pottsgrove Township provide a portion of the taxes paid by Exelon Generation to Montgomery County to support county services. Plumstead Township and Bedminster Township provide a portion of the taxes paid by Exelon Generation to Bucks County to support county services. Table 2.7-2 shows the percentage of tax revenue provided by Exelon Generation for each taxing authority. For purposes of analysis of tax payment significance, it is assumed that the total tax revenue provided to the Townships is provided directly to the County, providing a conservative analysis of potential impacts. The only taxing authorities where the Exelon Generation tax revenue is greater than one percent of the budget are:

- Limerick Township - 3.1 percent, and,
- Spring-Ford Area School District - 2.2 percent.

Tax payments made by Exelon Generation to each of the official taxing authorities during the period of extended operation would be expected to remain a similar percentage of the annual budget for the taxing authorities. Since the tax revenues from Exelon Generation are less than 10 percent of the budget of any taxing authority, tax payment significance is SMALL.

Land Use Impacts

As stated in Sections 2.6, 2.8, and 2.9, Montgomery County, Chester County, Berks County, and Limerick Township experienced significant population growth over the last several decades. Although Pennsylvania only increased in population by 4.4 percent between 1990 and 2010, Montgomery County population increased 18 percent, Chester County population increased 34 percent, Berks County population increased 18 percent, and Limerick Township population increased 168 percent. It is projected that these areas will grow in population at a rate of 4.4 percent to 6.8 percent in the future. Population growth in these counties and the Township can be attributed to some extent to the development of suburban areas surrounding the City of Philadelphia.

Although the three counties where most LGS employees reside have experienced growth over the last three decades, the majority of land use is specific to the county, and may be related to transportation quality from the metropolitan Philadelphia area.

Montgomery County uses comprehensive land use plans and zoning and subdivision ordinances to guide development. These plans and ordinances have been in place for several decades. The ordinances promote the public health, safety, and general welfare of residents; protect agricultural land from urban sprawl; and provide a basis for the orderly development. The ordinances require building permits, conditional use permits, plat development, zoning district controls, variance requests, and wellhead protection. In the early 1990s, the county adopted formal growth control measures to promote growth in areas with existing infrastructure and development. Most of the residential development in recent years has been in designated growth areas. Over 60 percent of the land use in Montgomery County is dedicated to single-family detached housing.

The CCPC is responsible for developing and implementing the county's comprehensive plan. Each municipality also has its own municipal planning division. The county and individual municipalities coordinate their planning activities through a partnership known as the Vision Partnership Program and the overall planning guidelines found within their plan, referred to as *Landscapes2*. Land use in Chester County is dominated by agriculture land uses with 36.7 percent of total land area located within the county used for agriculture. This represents roughly twice the area that is taken up by single-family land uses, which is the third highest user of land in the county, with wooded area representing the second highest land use in the county.

The Berks County Comprehensive Plan, maintained by the Berks County Planning Commission, provides a roadmap for the county planners to coordinate and efficiently manage development within Berks County. Berks County generally maintains rural characteristics, with 29 percent of land use dedicated to agricultural uses, 27 percent of the land use designated as rural, and only 23 percent of the land considered developed.

Hence, LGS license renewal would not impact these well-developed land use plans for the local counties because there would be no new construction activities or significant increases in operating jobs that would alter housing demand or change tax payments.

4.17.2.3 Property Value Impacts

Montgomery County has experienced significant increase in population over the past several decades (Simone Collins Landscape Architecture, 2009). Until 1980, Limerick Township was relatively in line with Montgomery County growth trends. In the 1980s its population grew dramatically (26 percent compared to 5 percent). In the 1990s, Limerick Township's population doubled and its growth rate was roughly ten times the county's rate. Limerick Township was the sixth fastest growing municipality in the Delaware Valley in the 1990s and ranked eighth in the gain of new residents. The pace of growth has continued in the first few years of the 21st century (Simone Collins Landscape Architecture, 2009). There is room for growth; however, with no new construction activities or significant increases in operational jobs as a result of license renewal, there would be no increased housing demand.

Exelon considered whether the presence of LGS has had a depressing effect on property values that would be continued during the license-renewal term. NRC considered this question for seven nuclear plants in its GEIS and found no depressed property values resulting from construction and operation or license renewal of these plants. Published literature on the subject comes to varying conclusions. Of the studies claiming to show a depressing effect, the geographic extent of the claimed effect ranges from less than 3.2 kilometers (2 miles) to as many as 96.5 kilometers (60 miles) (Blomquist, 1974; Clark and Nieves, 1994; Folland and Hough, 2000; Sheppard, 2007). Some studies demonstrate no effects (Gamble and Downing, 1982; Nelson, 1981; Rephann, Undated). The Nuclear Energy Institute (NEI) has studied economic benefits of several nuclear plants (NEI, 2006a), and found that property (housing) values are enhanced by the presence of nuclear plants, a conclusion that aligns with the GEIS and other studies (Bezdek and Wendling, 2006; Clark et al., 1997; Farrell and Hall, 2004; Metz et al., 1997; NEI, 2003, 2004a, 2004b, 2004c, 2004d, 2005a, 2005b and 2006b).

Sheppard (2007), which concludes that property values are depressed within 3.2 kilometers (2 miles) of a nuclear plant, is based on the Blomquist (1974) study of a single fossil-fueled plant located in a residential area. Blomquist (1974) noted that "[T]he findings of this study are based on a rather special instance…where the community is composed of primarily single-family residences…." The Blomquist proposition does not apply to LGS because the area is multi-use, as indicated by the expansion of shopping facilities and other service-related businesses in the area. Hence, given the developmental growth in Montgomery County and especially in Limerick Township, depression of housing is not indicated nor would it be expected to occur during the period of extended operation.

Exelon also notes that the plant that Blomquist (1974) studied was small, about 27 megawatts, burned oil and coal, and began commercial operation in 1949 (Blomquist, 1974, page 97). The workforce at such a facility would likely be much smaller than one at a large nuclear plant such as LGS. Accordingly, the multiplier effect of the LGS workforce would be larger for tax contributions than the comparable multiplier effect for a 27-MW fossil-fueled facility. This could demonstrably increase, rather than decrease, property values. For this reason, Exelon Generation believes the Blomquist (1974) methodology should not be applied to evaluate impacts of nuclear plants such as LGS, on property values as was done in Sheppard (2007).

4.17.2.4 Conclusion

Since Exelon Generation's payments to taxing authorities are less than 10 percent of their revenues, the significance of tax payments to each of these taxing authorities is SMALL. The renewal of Exelon's license would have a continued SMALL but financially beneficial impact on land use in the counties and townships. Therefore, mitigation would not be warranted.

Population growth has been attributed to the larger influence of the surrounding metropolitan areas and advancements in the transportation network. The counties where most LGS employees reside have an established pattern of development with controls for future development and have been able to provide the infrastructure needed to accommodate this growth. The continued presence of LGS is not expected to directly attract support industries and commercial development or to encourage or deter residential development.

Because population growth related to the license renewal of LGS (i.e., an assumption of 60 additional plant personnel) is expected to be less than 5 percent of the current and projected population for the study area, off-site land use changes would be SMALL.

Because the Sheppard (2007) assumptions do not apply to LGS, Exelon concludes, consistent with the GEIS, NEI, and the other studies cited above, that impacts on property values from LGS, if any, are positive, and that license renewal would not alter this status.

4.18 Transportation

4.18.1 Transportation – Refurbishment

NRC

The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)

"…Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 70

Small impacts would be associated with U.S. Transportation Research Board Level of Service A, having the following condition: "…Free flow of the traffic stream; users are unaffected by the presence of others." and Level of Service B, having the following condition: "…Stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished…." (NRC, 1996a)

The issue of transportation impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.18.2 Transportation – License Renewal Term

NRC

The environmental report must "...assess the impact of highway traffic generated by the proposed project on the level of service of local highways during periods of license renewal refurbishment activities and during the term of the renewed license." 10 CFR 51.53(c)(3)(ii)(J)

"…Transportation impacts…are generally expected to be of small significance. However, the increase in traffic associated with additional workers and the local road and traffic control conditions may lead to impacts of moderate or large significance at some sites…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 70

Small impacts would be associated with U.S. Transportation Research Board Level of Service A, having the following condition: "…Free flow of the traffic stream; users are unaffected by the presence of others." and Level of Service B, having the following condition: "…Stable flow in which the freedom to select speed is unaffected but the freedom to maneuver is slightly diminished…." (NRC, 1996a)

NRC made impacts to transportation a Category 2 issue, because impact significance is determined primarily by road conditions existing at the time of license renewal, which NRC could not forecast for all facilities (NRC, 1996a). Local road conditions to be ascertained are: (1) level of service conditions and (2) incremental increases in traffic associated with license renewal.

The following discussion focuses on impacts of continued operations on transportation and the assumption that LGS would hire 60 additional employees during the period of extended operations. Because Exelon Generation expects to maintain a stable workforce who would use the existing transportation networks to commute to and from work, the assumption of a 60-person increase is conservative for assessing impacts on the transportation system.

In the GEIS, NRC used the Transportation Research Board's Level of Service (LOS) definitions (see Section 2.9.2) to assess significance levels of transportation impacts. LOS is a qualitative measure describing operational conditions within a traffic stream and their perception by motorists (NRC, 1996a). Exelon Generation employed the same definitions to analyze transportation impacts. According to NRC criteria, LOS A and B are associated with small impacts because the operation of individual users is not substantially affected by the presence of other users (GEIS Section 3.7.4.2). LOS data are available for roads in Montgomery County, specifically US-442 and Evergreen Road (see Table 2.9-4, Roadway Information and Table 2.9-5, Highway Levels of Service). The LOS determinations for US-442 on either side of the LGS site entrances are dependent on the particular day of the week, road segment and direction of travel as noted in Table 2.9-5. The Sanatoga Interchange Study projected LOS for local roads after the new Sanatoga development has been constructed and businesses are operational. The predicted increased traffic flow discussed in the report is mainly a function of the new retail developments adjacent to US-422. The governing body of Limerick Township is planning to address the periodic congestion on these roads (Simone Collins Landscape Architecture, 2009).

Assuming all additional employees travel at the same time, the 60 additional employees could increase the traffic on Evergreen Road by approximately 2 percent and on US-422 by approximately 0.1 percent. These are insignificant increases within the current traffic average daily trips (refer to Table 2.9-4). Hence, Exelon Generation concludes that impacts to transportation from renewal of the LGS license would be SMALL and mitigation measures would not be warranted.

4.19 Historic and Archaeological Resources

4.19.1 Historic and Archeological Resources – Refurbishment

NRC

The environmental report must contain an assessment of "…whether any historic or archaeological properties will be affected by the proposed project." 10 CFR 51.53(c)(3)(ii)(K)

"Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archaeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 71

"Sites are considered to have small impacts to historic and archaeological resources if (1) the State Historic Preservation Officer (SHPO) identifies no significant resources on or near the site; or (2) the SHPO identifies (or has previously identified) significant historic resources but determines they would not be affected by plant refurbishment, transmission lines, and license-renewal term operations and there are no complaints from the affected public about altered historic character; and (3) if the conditions associated with moderate impacts do not occur." (NRC, 1996a)

The issue of historic and archeological resource impacts associated with refurbishment activities does not apply to LGS because, as Section 3.2 describes, Exelon Generation has no plans for refurbishment activities at LGS.

4.19.2 Historic and Archaeological Resources – License Renewal Term

NRC

The environmental report must contain an assessment of "…whether any historic or archaeological properties will be affected by the proposed project." 10 CFR 51.53(c)(3)(ii)(K)

"Generally, plant refurbishment and continued operation are expected to have no more than small adverse impacts on historic and archaeological resources. However, the National Historic Preservation Act requires the Federal agency to consult with the State Historic Preservation Officer to determine whether there are properties present that require protection." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 71

"Sites are considered to have small impacts to historic and archaeological resources if (1) the State Historic Preservation Officer (SHPO) identifies no significant resources on or near the site; or (2) the SHPO identifies (or has previously identified) significant historic resources but determines they would not be affected by plant refurbishment, transmission lines, and license-renewal term operations and there are no complaints from the affected public about altered historic character; and (3) if the conditions associated with moderate impacts do not occur." (NRC, 1996a)

NRC made impacts to historic and archaeological resources a Category 2 issue, because determinations of impacts to historic and archaeological resources are site-specific in nature and the National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Officer (NRC, 1996a).

In the context of the National Historic Preservation Act, NRC has determined that the area of potential effects (APE) for a license renewal action is the area at the power plant site and its immediate environs which may be impacted by post-license renewal land-disturbing activities specifically related to license renewal, regardless of ownership or control of the land of interest. For LGS, the APE is assumed to also include the Perkiomen Pumphouse and five transmission lines that were constructed for the purpose of connecting the main plant substations to the grid and are currently in service. PECO now owns the transmission lines beyond the two LGS substations and their continued future operation by PECO is not directly related to whether or not the NRC renews the licenses for LGS Units 1 and 2.

The LGS FES-OL included a letter from the Pennsylvania Historical and Museum Commission, Bureau of Historic Preservation, dated October 5, 1983, which indicated that the operations of the LGS would have no effect on significant historic or archaeological resources provided that archaeological surveys/mitigation were undertaken for the proposed transmission lines and provided measures were taken to mitigate visual impacts to historic sites. As is reported in Section 2.11.2, the archaeological surveys of the transmission lines and mitigation were completed. Consideration of effects to cultural resources is part of PECO's planning process for work to be done along the transmission lines.

The LGS license renewal will not affect the operation and maintenance practices in the transmission line corridors. Therefore, license renewal will have no adverse effect on significant archaeological and historic resources in the transmission line rights-of-way. Exelon Generation assumes that PECO will continue to protect such resources in the future, regardless of whether or not the NRC renews the licenses for LGS Units 1 and 2. Hence, the impacts of license renewal on archaeological and historic resources in the transmission line rights-of-way will be SMALL.

Historic and archaeological resources located within a 10-kilometer (6-mile) radius of the power plant site that are currently listed on the National Register of Historic Places, as well as those determined eligible for listing, are identified in Section 2.11 (see Tables 2.11-1, 2.11-2, and 2.11-3). In addition, Exelon Generation is implementing specific procedures for protecting cultural resources from activities related to operation and maintenance of the LGS, including a Cultural Resources Management Plan (CRMP) for the LGS plant site property and Exelon Generation-owned properties associated with the LGS makeup water supply system (refer to Section 2.1). Future land-disturbing activities on the properties would be done in a manner consistent with the provisions in the CRMP. The purpose of the CRMP is to manage known, potentially existing, or discovered archaeologically or historically significant cultural resources within LGS and adjacent Exelon Generation land. The CRMP addresses possible impacts from land-disturbing or other activities that could introduce new noise, air, or visual element impacts to known cultural resources. A proposed activity that introduces a new noise, air, or visual element, which potentially could impact a culturally sensitive area is evaluated prior to disturbance. Appropriate measures are defined and implemented, including contact with SHPO if appropriate, to protect the resource. Additional direction is provided to personnel performing a land-disturbing activity defining actions in the event that apparent cultural resources are discovered. Special protection measures are employed if there is a potential impact to any recorded archaeological site, following the consultation with SHPO. Therefore, Exelon Generation concludes that the impacts of license renewal on archaeological and historic resources would be SMALL, and no additional mitigation would be warranted.

Exelon Generation has consulted with the Pennsylvania Bureau of Historic Preservation, which serves as the State Historic Preservation Officer, regarding the effect of license renewal on historic and archaeological resources. Copies of the correspondence are presented in Appendix D. In its response to Exelon Generation, the bureau stated that, in its opinion, there will be no effect on historic buildings, structures, districts, or objects eligible for the National Register of Historic Places located in the project area, and that no archaeological investigations are necessary in the project area.

4.20 Severe Accident Mitigation Alternatives (SAMA)

NRC

The environmental report must contain a consideration of alternatives to mitigate severe accidents "…if the staff has not previously considered severe accident mitigation alternatives for the applicant's plant in an environmental impact statement or related supplement or in an environment assessment..." 10 CFR 51.53(c)(3)(ii)(L)

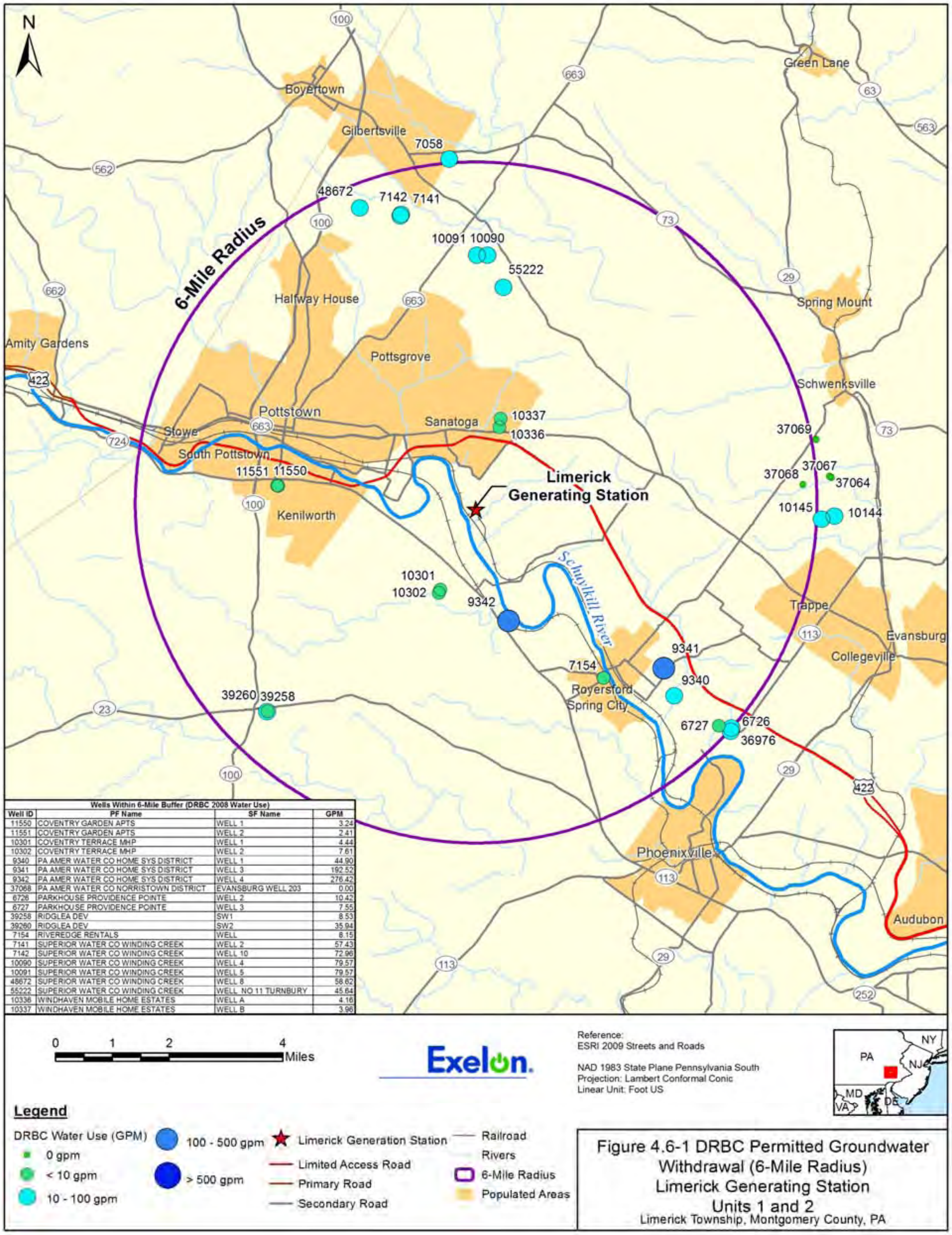
"…The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives…." 10 CFR 51, Subpart A, Appendix B, Table B-1, Issue 76

NRC characterizes consideration of alternatives to mitigate severe accidents as a Category 2 issue because the NRC's regulatory programs related to assessing severe accident mitigation (i.e., individual plant examination/individual plant examination of external events and Accident Management) have not established a record deemed adequate to support classifying the issue as Category 1 (NRC, 1996a; NRC, 2004). Notwithstanding, NRC has explained that Severe Accident Mitigation Alternatives (SAMAs) for LGS do not need to be analyzed at the license renewal stage because NRC previously completed such a site-specific analysis in a supplement to the Final Environmental Impact Statement Related to the Operation of LGS Units 1 and 2 (NRC, 1996a; NRC, 1989). The regulatory text codified in 10 CFR 51.53(c)(3)(ii)(L) also supports this conclusion. Accordingly, no analysis of SAMAs for LGS is provided in this License Renewal Environmental Report as none is required as a matter of law.

Nevertheless, in an abundance of caution, Section 5.3 discusses Exelon Generation's evaluation, which concludes that there is no new and significant information relevant to the conclusions codified in 10 CFR 51.53(c)(3)(ii)(L)***.***

Table 4.13-1 Results of Induced Current Analysis

Transmission Line	Voltage (kV)	Maximum Induced Current (Milliamperes)
Line 220-60	230	1.56
Line 220-61	230	3.44
Line 220-62	230	4.03
Line 220-63/64	230	4.60
Line 5031	500	4.55



Wells Within 6-Mile Buffer (DRBC 2008 Water Use)

Well ID	PF Name	SF Name	GPM
11550	COVENTRY GARDEN APTS	WELL 1	3.24
11551	COVENTRY GARDEN APTS	WELL 2	2.41
10301	COVENTRY TERRACE MHP	WELL 1	4.44
10302	COVENTRY TERRACE MHP	WELL 2	7.61
9340	PA AMER WATER CO HOME SYS DISTRICT	WELL 1	44.90
9341	PA AMER WATER CO HOME SYS DISTRICT	WELL 3	192.52
9342	PA AMER WATER CO HOME SYS DISTRICT	WELL 4	276.42
37068	PA AMER WATER CO NORRISTOWN DISTRICT	EVANSBURG WELL 203	0.00
6726	PARKHOUSE PROVIDENCE POINTE	WELL 2	10.42
6727	PARKHOUSE PROVIDENCE POINTE	WELL 3	7.55
39258	RIDGLEA DEV	SW1	8.53
39260	RIDGLEA DEV	SW2	35.94
7154	RIVEREDGE RENTALS	WELL	8.15
7141	SUPERIOR WATER CO WINDING CREEK	WELL 2	57.43
7142	SUPERIOR WATER CO WINDING CREEK	WELL 10	72.96
10090	SUPERIOR WATER CO WINDING CREEK	WELL 4	79.57
10091	SUPERIOR WATER CO WINDING CREEK	WELL 5	79.57
48672	SUPERIOR WATER CO WINDING CREEK	WELL 8	58.62
55222	SUPERIOR WATER CO WINDING CREEK	WELL NO 11 TURNBURY	45.64
10336	WINDHAVEN MOBILE HOME ESTATES	WELL A	4.16
10337	WINDHAVEN MOBILE HOME ESTATES	WELL B	3.96

Figure 4.6-1 DRBC Permitted Groundwater Withdrawal (6-Mile Radius)
Limerick Generating Station
Units 1 and 2
Limerick Township, Montgomery County, PA

5.0 ASSESSMENT OF NEW AND SIGNIFICANT INFORMATION

5.1 Discussion

NRC

"…The environmental report must contain any new and significant information regarding the environmental impacts of license renewal of which the applicant is aware." 10 CFR 51.53(c)(3)(iv)

The U.S. Nuclear Regulatory Commission (NRC) licenses the operation of domestic nuclear power plants and provides for license renewal, requiring a license renewal application that includes an environmental report (10 Code of Federal Regulations (CFR) 54.23). NRC regulations, 10 CFR Part 51, prescribe the environmental report content and identify the specific analyses the applicant must perform. In an effort to streamline the environmental review, NRC has resolved most of the environmental issues generically and only requires an applicant's analysis of the remaining issues.

While NRC regulations do not require an applicant's environmental report to contain analyses of the impacts of those Category 1 environmental issues that have been generically resolved [10 CFR 51.53(c)(3)(i)], the regulations do require that an applicant identify any new and significant information of which the applicant is aware [10 CFR 51.53(c)(3)(iv)]. The purpose of this requirement is to alert NRC staff to such information, so the staff can determine whether to seek the Commission's approval to waive or suspend application of the rule with respect to the affected generic analysis. NRC has explicitly indicated, however, that an applicant is not required to perform a site-specific validation of Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) conclusions regarding Category 1 issues (NRC, 1996a).

Exelon Generation Company, LLC (Exelon Generation) expects that new and significant information for Limerick Generating Station, Units 1 and 2 (LGS) would include:

- Information that identifies a significant environmental issue not covered in the GEIS and codified in the regulation, or
- Information that was not covered in the GEIS analyses and that leads to an impact finding different from that codified in the regulation.

NRC does not specifically define the term significant. For the purpose of its review, Exelon Generation used guidance available in Council on Environmental Quality (CEQ) regulations. The National Environmental Policy Act (NEPA) authorizes CEQ to establish implementing regulations for federal agency use. NRC requires license renewal applicants to provide NRC with input, in the form of an environmental report, that NRC will use to meet NEPA requirements as they apply to license renewal (10 CFR 51.10).

CEQ guidance provides that federal agencies should prepare environmental impact statements for actions that would significantly affect the environment (40 CFR 1502.3), focus on significant environmental issues (40 CFR 1502.1), and eliminate from detailed study issues that are not significant [40 CFR 1501.7(a)(3)]. The CEQ guidance includes a lengthy definition of significantly that requires consideration of the context of the action and the intensity or severity of the impact(s) (40 CFR 1508.27). Exelon Generation considered that MODERATE or LARGE impacts, as defined by NRC, would be significant. Section 4.0 presents the NRC definitions of SMALL, MODERATE, and LARGE impacts.

The new and significant assessment that Exelon Generation conducted during preparation of this license renewal application included: (1) interviews with Exelon Generation subject matter experts on the validity of the conclusions in the GEIS as they relate to LGS, (2) an extensive review of documents related to environmental issues at LGS, (3) a review of correspondence with state and federal agencies to determine if the agencies had concerns relevant to their resource areas that had not been addressed in the GEIS, (4) a review of the results of LGS environmental monitoring and reporting, as required by regulations and oversight of plant facilities and operations by state and federal regulatory agencies (i.e., the results of ongoing routine activities that could bring significant issues to Exelon Generation's attention), (5) a review for issues relevant to the LGS application of certain license renewal applications that have previously been submitted to the NRC by the operators of other nuclear plants, and (6) a review of information related to severe accident mitigation.

5.2 Radiological Groundwater Protection

As part of the assessment for new and significant information described in Section 5.1, Exelon Generation evaluated information about tritium and plant-related gamma-emitting isotopes in groundwater at LGS (Section 2.3). Based on that evaluation, Exelon Generation has concluded for the following reasons that LGS is not contributing to changes in groundwater quality that would preclude current or future uses of the groundwater:

- As discussed in Section 2.3.1, there are no glacial deposits capable of maintaining alluvial aquifers along the Schuylkill River or upland of the Schuylkill River in the vicinity of LGS.
- Tritium concentrations in groundwater are monitored within the Radiological Groundwater Protection Program (RGPP) and have not exceeded 2,000 pCi/L (see Section 2.3.3).
- Neither Sr-90 nor plant-related gamma emitters have been detected in samples of groundwater and surface water from LGS.
- The RGPP at LGS has been shown to provide an effective detection monitoring system for inadvertent releases of tritium to groundwater from Station operations.
- The Exelon Generation response to issues documented under the RGPP illustrates that timely corrective action is effective to remediate and control inadvertent tritium releases to groundwater.

The identification of tritium in groundwater is new information, but based on the monitoring results discussed in Section 2.3.3, it is not significant. There has been no identification of plant-related gamma-emitting radioisotopes in groundwater at LGS. A Buried and Underground Piping and Tanks aging management program consistent with NEI Guideline for the Management of Buried Piping Integrity (NEI 09-14, January 2010) will be implemented at LGS. Therefore, the contribution of LGS operations during the license renewal period to the cumulative impacts of major activities on groundwater quality would be SMALL.

5.3 Severe Accident Mitigation

In the 1996 GEIS, NRC evaluated whether Severe Accident Mitigation Design Alternatives (SAMDAs) could be adequately addressed generically for all plants (NRC, 1996a, Sec. 5.4). This evaluation found that ongoing regulatory programs related to severe accident mitigation (i.e., individual plant examination/individual plant examination of external events and Accident Management) had not been completed for all plants. Therefore, NRC decided that consideration of severe accident mitigation alternatives should be included in site-specific environmental impact statements (EISs) for license renewal of nuclear plants (NRC, 1996a, Sec. 5.4.1.5). Notwithstanding, the NRC explicitly exempted plants for which an evaluation of alternatives to mitigate severe accidents was completed and included in a prior EIS or EIS supplement from this requirement (NRC, 1996a, Sec. 5.4.1.5). LGS is a plant that qualifies for this exemption because, as discussed in Section 4.20, an evaluation of severe accident mitigation design alternatives was completed in the "Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2" (NRC, 1989).

The assessment described in Section 5.1 found no new and significant information that would change the small impact determination for severe accidents set forth in the GEIS (NRC, 1996a, Sec. 5.5.2). Also, no new and significant information has been found that would change the generic conclusion codified by the NRC that LGS need not reassess severe accident mitigation alternatives for license renewal [10 CFR 51.53(c)(3)(ii)(L)]. The following subsections report the results of the assessment components for this latter issue.

5.3.1 Process to Identify New Information

The process developed by Exelon Generation to identify new information related to environmental impacts of postulated severe accidents focused on the following steps:

- Review of the NRC's Supplement to NUREG-0974 (NRC, 1989)
- Review of the June 1989 PRA Update (PECO, 1989), and
- Review of the LGS probabilistic risk assessment (PRA) model and updates to that model since publication of the Supplement to NUREG-0974 in 1989.

For purposes of this review, new information is defined as information indicating a potential change in the consequences of severe accidents from those considered by the NRC in the GEIS. The process for identifying new information, which is further explained below, considers information related to plant functions (e.g., plant changes or new severe accident challenges) that contribute to the consequences of a severe accident. The significance and materiality of the new information identified through this process is discussed further in Section 5.3.2, "Significance of New Information."

To facilitate the review for new information, the key severe accident issues addressed in the NRC's Supplement to NUREG-0974 were identified. Each of the Severe Accident Mitigation Design Alternatives (SAMDAs) previously considered by the NRC staff for Limerick addresses at least one specific severe accident function the interruption of which can jeopardize core cooling and/or threaten containment integrity. For several of the SAMDAs, the function is associated with prevention of core damage and, for others, mitigation of a core damage event. Exelon Generation conducted the review to assess whether new information that would suggest the need to evaluate additional severe accident mitigation alternatives has become known concerning any of these functions since the assessment was performed in the Supplement to

NUREG-0974. Exelon Generation concludes that, overall, the strategies identified in the Supplement to NUREG-0974 for preventing and mitigating core damage remain appropriate and adequate to address each of the accident functions, and no new information exists that would significantly and materially change the accident sequence progression from postulated severe accidents.

The change in population in the area surrounding LGS could impact the consequences of any severe accident. Therefore, the population change is identified as new information.

In June 1989, Philadelphia Electric Company updated the LGS PRA. The June 1989 Update, which provided the foundation for NRC's Supplement to NUREG-0974, based the SAMDA cost benefit analysis solely on off-site exposure cost by estimating the person-rem averted for each of the candidate SAMDAs. In comparison, current license renewal analyses of severe accident mitigation alternatives consider additional costs which include; on-site exposure and economic costs, off-site economic costs, on-site cleanup costs, and replacement power costs. The off-site exposure cost and the off-site economic cost tend to dominate the overall cost assessment. Accordingly, the evaluation of the off-site economic cost is considered here to be new information that could change the outcome of the SAMDA cost/benefit analysis presented in the Supplement to NUREG-0974.

The screening cost/benefit analysis in the Supplement to NUREG-0974 assigned $1,000 to each person-rem averted by a SAMDA. However, subsequent guidance provided in *Regulatory Analysis Technical Evaluation Handbook*, NUREG/BR-0184 (1997) assigns $2,000 to each person-rem averted. This has the potential to increase the benefit assigned to a proposed SAMDA and is considered to be new information.

Since its inception, the LGS PRA model has been regularly updated to reflect as-built and as-operated conditions. The current LGS PRA model was reviewed to identify new information relative to the quantification of risk (measured in core damage events per year) in comparison to information provided in the Supplement to NUREG-0974. A comparison of the internal-events core damage frequency (CDF) is a useful indication of significant changes to the PRA. Table 5.3-1 lists the estimated internal-events CDF beginning with the results provided in NUREG-1068, *Review Insights on the Probabilistic Risk Assessment for the Limerick Generating Station* (August 1984), and continuing through LG108A/LG208A, *Limerick Generating Station Probabilistic Risk Assessment, Summary Notebook, LG108A and LG208A Models, LG-PRA-013, Revision 2,* (September 18, 2009).

Table 5.3-1 – History of Internal-Events CDF

PRA Model	Date	CDF (per yr)
NUREG-1068	1984	1.5E-5
June 1989 Update	1989	5.9E-6
Individual Plant Examination (IPE)	1992	4.3E-6
LGS93	1993	5.3E-6
LGS95	1995	4.4E-6 (Unit 1) 4.4E-6 (Unit 2)
LGS197/LGS297	1998	3.2E-6 (Unit 1) 3.2E-6 (Unit 2)
LGS101/LGS201	2002	4.5E-6 (Unit 1) 4.5E-6 (Unit 2)
LGS104B/LGS204B	2005	3.7E-6 (Unit 1) 3.7E-6 (Unit 2)
LGS104C/LGS204C	2007	3.9E-6 (Unit 1) 3.9E-6 (Unit 2)
LG108A/LG208A	2009	3.2E-6 (Unit 1) 3.2E-6 (Unit 2)

The reduction in CDF reflects improvements in reliability data, improvements in procedural guidance and plant capabilities, and a reduction in the number of reactor trips. The reduction in CDF can also be linked to Exelon Generation's implementation over the years of the following industry programs, which NRC identified in the Supplement to NUREG-0974 as components of a systematic program described in SECY-88-147 ("Integration Plan for Closure of Severe Accident Issues," May 25, 1988) that provides the proper vehicle for further review of severe accidents at nuclear power plants, including LGS:

- Containment Performance Improvement (CPI)
- Accident Management (AM)
- Individual Plant Examination (IPE)

None of the contributors to the reduction in CDF qualifies as new information relative to the quantification of risk at LGS.

New information has become available as described in Generic Issue 199 (GI-199), *Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern United States on Existing Plants* (August 2010). Through GI-199, NRC is investigating proposed changes to seismic hazards at many nuclear power plant sites, both with respect to Ground Motion Response Spectra (GMRS) used in design analyses and probabilistic seismic hazard curves used in seismic probabilistic risk assessments.

Relative to estimates of core damage from fire induced contributors, the industry is currently working on the development of fire PRAs following the guidance provided in NUREG/CR-6850, *EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities* (September 2005). However, because NUREG/CR-6850 describes primarily the <u>process</u> for fire PRA development, it does not itself provide new information relative to fire risk at LGS.

In summary, Exelon Generation has identified the following four items of new information that could affect the analysis of severe accident mitigation alternatives for LGS:

1. Population increase
2. Consideration of offsite economic cost risk
3. Changed criterion for assigning cost per person-rem averted
4. Changed seismic hazard proposed in GI-199

5.3.2 Significance of New Information

In the context of the NRC's License Renewal environmental review, new information would be considered significant if it would cause a materially different result in the assessment of impacts than were determined in prior environmental assessments conducted consistent with the National Environmental Policy Act (NEPA). The pertinent NEPA environmental assessments for the LGS License Renewal are the 1996 GEIS and the associated site-specific supplemental EIS, for which the LGS License Renewal Environmental Report serves as a basis.

5.3.2.1 Population Increase

The SAMDA evaluation as documented in the Supplement to NUREG-0974 calculated the consequences of postulated severe accidents out to a radius of 50 miles from the LGS site boundary. Population information was provided in the *Environmental Report Operating License Stage, Limerick Generating Station, Units 1 & 2.* Rev. 1, September 1981 (updated through Rev. 20, September 1984), Vol. 1, Section 2.1, "Geography and Demography". The 50-mile population values for 1980 were 6,819,505.

Population estimates for 2030 obtained from Delaware, Pennsylvania, New Jersey, and Maryland state population data centers for counties within a 50-mile radius of LGS yield a 50-mile population of 9,499,925. This represents an increase in population of approximately 39% between the time the Supplement to NUREG-0974 was prepared and a time several years into the proposed period of extended operation for LGS. The year 2030 was chosen for population projections because this was the farthest future year to which population data for most counties within the 50-mile radius were projected.

The relationship between the population surrounding a nuclear plant and the estimated dose following a severe accident is approximately linear. Applying this relationship to the estimated 39% increase in population within 50 miles of the LGS site would yield an approximate 39% increase in dose values over those calculated in the LGS June 1989 Update. An increase in the person-rem averted values by 39% would reduce the cost per person-rem averted by 28%. Hence, even assuming 2030 population numbers, the SAMDA in the LGS June 1989 Update with the highest benefit/cost ratio (ATWS Vent), based on cost per person-rem averted, would still have a ratio of approximately $10,000 per person-rem averted, which is well above the $1,000 per person-rem averted criterion used in 1989.

Since none of the SAMDAs in the LGS June 1989 Update would become cost beneficial if 2030 population numbers were assumed, the new information concerning population increase is not judged to be significant. Furthermore, this conclusion would remain true even if the cost/benefit criterion was increased to $2,000 per person-rem averted, as is discussed in a separate evaluation below.

5.3.2.2 Consideration of Off-site Economic Cost Risk

The SAMDA evaluation for LGS as documented in the Supplement to NUREG-0974 calculated the benefit of each proposed SAMDA based on a reduction of the estimated person-rem. The resulting benefit value did not account for possible reduction in land contamination from a severe accident or the associated economic cost reduction. The economic cost of a severe accident at LGS can be estimated using information from other license renewal applications. In particular, a review of the Three Mile Island Nuclear Station Unit 1 Environmental Report for License Renewal (Docket No. 50-289), Section E.4.2 indicates that the off-site economic cost risk is approximately 70% larger than the off-site exposure cost risk. Therefore, as applied to the cost/benefit result in Table 2-3 of the June 1989 Update, a factor of 3 increase in the person-rem averted value for each SAMDA would provide an approximation for the impact due to economic cost. This increase in the averted person-rem would result in a factor of 3 reduction in the estimated cost per person-rem averted values. Applying a factor of 3 reduction to the most beneficial SAMDA (ATWS Vent) would result in an adjusted cost per person-rem averted of $5,000, which remains well above both the $1,000 per person-rem averted threshold used in 1989 and the currently used $2,000 per person-rem averted threshold.

5.3.2.3 Changed Criterion For Assigning Cost Per Person-Rem Averted

The SAMDA evaluation as documented in the Supplement to NUREG-0974 calculated the benefit of each proposed SAMDA based on a criterion of $1,000 per person-rem averted. Using a value of $2,000 per person-rem averted would increase the threshold and potentially result in new cost beneficial SAMDAs. As described in the Supplement to NUREG-0974, where several of the proposed SAMDAs fell below the $1,000 per person-rem averted benefit threshold, the June 1989 Update presents significantly lower risk estimates. To be specific, the cost/benefit results reported in the June 1989 Update show a cost per person-rem averted value of $15,100 for the ATWS Vent plant modification. This is the lowest cost/benefit ratio for the set, and it represents the SAMDA with the largest benefit potential. Even for this limiting SAMDA, changing the cost/benefit threshold to $2,000 per person-rem averted would still not result in this or any other of the SAMDAs becoming cost beneficial. Therefore, Exelon Generation concludes that changing the criterion for assigning benefit (i.e., cost per person-rem averted) from $1,000 per person-rem averted to $2,000 per person-rem averted would not change the conclusions in the Supplement to NUREG-0974. Hence, the new information represented by the changed criterion for assigning cost per person-rem averted is judged not to be significant.

5.3.2.4 Changed Seismic Hazard Proposed in GI-199

GI-199 issues will not result in postulated accident scenarios not already considered for LGS. Seismologists are refining methodologies, which may increase the estimated frequency of seismic events with very low probability. However, any change in risk that may be postulated from such low probability events would be very small from a societal (human health) risk perspective. Results from the June 1989 Update indicate that the contribution from seismic risk to the total CDF is approximately 25%, with fire risk contributing 31% to the total. Therefore, based on the June 1989 Update, the major risk contributors for external hazards are approximately equal to the CDF computed for internal events only. Based on this, total CDF for internal and external events can generally be approximated by multiplying the CDF for internal events by a factor of 2.

With a multiplication factor of 2 applied to the CDF estimated by the current model of record (CDF=3.2E-6), the revised CDF that accounts for both internal and external hazards (CDF=6.4E-6) would still be a factor of 6.5 below the value used in 1989 to assess the SAMDAs in Supplement to NUREG-0974 (CDF=4.2E-5). This demonstrates the excess margin in the SAMDA evaluation documented in the Supplement to NUREG-0974. A possible increase in risk beyond this assumption due to an even larger seismic CDF would be more than offset by the factor of 6.5 reduction in the current CDF. Therefore, Exelon Generation concludes that the new information represented by the changed seismic hazard proposed in GI-199 is not significant because it would not materially alter the SAMDA conclusions in the Supplement to NUREG-0974.

5.3.3 Summary of Findings

Exelon Generation has performed an evaluation to identify new information and to judge the significance of any such new information. For the purpose of this evaluation, Exelon Generation defined new information as information indicating a potential change in the consequences of severe accidents from those considered by NRC in the GEIS. For LGS, the consequences of severe accidents considered by NRC in the GEIS are reported in the NRC's Supplement to NUREG-0974, which was published in 1989. The following four (4) items of new information were identified by comparing assumptions for the SAMDA assessment reported in that document with assumptions used for current-day assessments of severe accident mitigation alternatives:

1. Population increase
2. Consideration of offsite economic cost risk
3. Changed criteria for assigning cost per person-rem averted
4. Changed seismic hazard proposed by GI-199

Each item of new information was reviewed to determine whether it would materially alter the NRC's conclusions, as documented in the Supplement to NUREG-0974. None of the items of new information was found to be significant. Hence, no new and significant information has been found that would change the generic conclusion codified by the NRC that LGS need not reassess severe accident mitigation alternatives for license renewal [10 CFR 51.53(c)(3)(ii)(L)].

5.4 Conclusion

In its entirety, Exelon Generation's assessment did not identify any new and significant information regarding the plant's environment or operations that would make any generic conclusion codified by the NRC for Category 1 issues not applicable to LGS, that would alter regulatory or GEIS statements regarding Category 2 issues, or that would suggest any other measure of license renewal environmental impact.

6.0 SUMMARY OF LICENSE RENEWAL IMPACTS AND MITIGATING ACTIONS

6.1 License Renewal Impacts

Exelon Generation Company, LLC (Exelon Generation) has reviewed the environmental impacts of renewing the Limerick Generating Station, Units 1 and 2 (LGS) operating licenses and has concluded that impacts would be SMALL and would not require mitigation. This environmental report documents the basis for Exelon Generation's conclusion. Section 4.0 incorporates by reference U.S. Nuclear Regulatory Commission (NRC) findings for the 69 Category 1 issues that apply to LGS, all of which have impacts that are SMALL (Appendix A, Table A-1). The rest of Section 4.0 analyzes Category 2 issues, all of which are either not applicable or have impacts that are SMALL. Table 6.1-1 identifies the impacts that LGS license renewal would have on resources associated with Category 2 issues.

6.2 Mitigation

NRC

"The report must contain a consideration of alternatives for reducing adverse impacts…for all Category 2 license renewal issues…" 10 CFR 51.53(c)(3)(iii)

"The environmental report shall include an analysis that considers and balances…alternatives available for reducing or avoiding adverse environmental effects…" 10 CFR 51.45(c) as incorporated by 10 CFR 51.53(c)(2) and 10 CFR 51.45(c)

Impacts of license renewal activities have been predicted as SMALL and do not warrant additional mitigation. Current operations include monitoring activities that would continue during the license renewal term. Exelon Generation performs routine monitoring to ensure the safety of workers, the public, and the environment. These activities include gaseous and liquid radiological environmental monitoring in accordance with the LGS operating license technical specifications issued by the NRC, non-radiological air emissions monitoring in accordance with air quality permits issued by the Pennsylvania Department of Environmental Protection (PADEP), groundwater monitoring in accordance with the Limerick Radiological Groundwater Protection Program (RGPP), surface water withdrawals and consumption in accordance with the DRBC Docket, and water effluent monitoring in accordance with the National Pollutant Discharge Elimination System (NPDES) permits issued by PADEP. These monitoring programs assure that the plant's emissions and effluents are within regulatory limits, that water use conflicts are minimized, and that unusual or off-normal emissions/discharges are quickly detected, thus mitigating potential impacts. Accordingly, Exelon Generation has concluded that additional mitigation measures are not warranted.

6.3 Unavoidable Adverse Impacts

NRC

The environmental report shall discuss any "...adverse environmental effects which cannot be avoided should the proposal be implemented..." 10 CFR 51.45(b)(2) as adopted by 10 CFR 51.53(c)(2)

This environmental report adopts by reference NRC findings for applicable Category 1 issues, including discussions of any unavoidable adverse impacts (Table A-1). In addition, Exelon Generation identified the following site-specific unavoidable adverse impacts of license renewal and refurbishment activities:

- The cooling towers and their vapor plumes are visible from offsite. This visual impact will continue during the license renewal term.
- Procedures for the disposal of radioactive and nonradioactive wastes are intended to reduce adverse impacts from these sources to acceptably low levels. A SMALL impact will occur as long as the plant is in operation. Solid wastes are a product of plant operations and permanent disposal of such materials is required.
- Operation of LGS results in a very small increase in radioactivity in the air and water. However, fluctuations in natural background radiation are expected to exceed the small incremental increase in dose to the local population. Operation of LGS also creates a very low probability of accidental radiation exposure to inhabitants of the area.
- Operations of LGS results in consumptive use of Schuylkill River water. Exelon Generation is required to have operating plans to mitigate consumptive use makeup (i.e., water diverted from the Delaware River), including low-flow augmentation during drought conditions through participation in the Merrill Creek Reservoir storage project.

6.4 Irreversible and Irretrievable Resource Commitments

NRC

The environmental report shall discuss any "...irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented…" 10 CFR 51.45(b)(5) as adopted by 10 CFR 51.53(c)(2)

Continued operation of LGS for the license renewal term will result in irreversible and irretrievable resource commitments, including the following:

- Nuclear fuel, which is used in the reactor and is converted to radioactive waste;
- Land required to permanently store or dispose of spent nuclear fuel, low-level radioactive wastes generated as a result of plant operations, and nonradioactive industrial wastes;
- Elemental materials that will become radioactive; and
- Materials used for the normal industrial operations of the plant that cannot be recovered or recycled or that are consumed or reduced to unrecoverable forms.

6.5 Short-Term Use Versus Long-Term Productivity of the Environment

NRC

The environmental report shall discuss the "...relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity..." 10 CFR 51.45(b)(4) as adopted by 10 CFR 51.53(c)(2)

The LGS plant site contains a total of 261.0 hectares (645 acres), including 198.7 hectares (491 acres) in Montgomery County and 62.3 hectares (154 acres) in Chester County. The current balance between short-term use and long-term productivity at LGS was established with the decision to convert approximately 261.0 hectares (645 acres) of farmland and woodland to industrial use. The Final Environmental Statement evaluated the impacts of constructing and operating LGS (AEC, 1973; NRC, 1984). Natural resources that would be subjected to short-term use include land and water. As discussed in Section 2.8, the land use around LGS has developed differently in Montgomery County and Chester County. Montgomery County and, especially, Limerick Township are primarily single-family homes and the infrastructure, such as retail and professional establishments, to support that land use. The population increases are supported by the availability of clean electric energy. Chester County remains primarily agricultural, which is unchanged from the area land use during construction of LGS.

Although LGS consumes water from the Schuylkill River, the impacts are SMALL and would cease once the reactors cease operation. Exelon Generation's mitigation and low-flow augmentation programs maintain any impact from water use as SMALL.

There is no evidence that the productivity of the aquatic community in the Schuylkill River in the vicinity of LGS is significantly impacted by its water use.

After decommissioning, most environmental disturbances would cease and restoration of the natural habitat could occur. Thus, the "trade-off" between the production of electricity and changes in the local environment is reversible to some extent.

Experience with other experimental, developmental, and commercial nuclear plants has demonstrated the feasibility of decommissioning and dismantling such plants sufficiently to restore a site to its former use. The degree of dismantlement will take into account the intended new use of the site and a balance among health and safety considerations, salvage values, and environmental impact. However, decisions on the ultimate disposition of these lands have not yet been made. Continued operation for an additional 20 years would not increase the short-term productivity impacts described here.

Table 6.1-1 Environmental Impacts Related to License Renewal at LGS

NO.	Category 2 Issue	Environmental Impact
Surface Water Quality, Hydrology and Use (for all plants)		
13	Water use conflicts (plants with cooling ponds or cooling towers using makeup water from a small river with low flow)	**SMALL.** Maximum LGS consumptive water use is less than 3.3% of Schuylkill River annual average flow. Both the DRBC and PADEP have regulations, plans, and processes in place to mitigate water usage conflicts and control the discharge of pollutants. Impacts on in-stream and riparian ecological communities relating to water use would be minimal.
Aquatic Ecology (for plants with once-through or cooling pond heat dissipation systems)		
25	Entrainment of fish and shellfish in early life stages	**NONE.** This issue does not apply because LGS does not use a once-through or cooling pond heat dissipation system.
26	Impingement of fish and shellfish	**NONE.** This issue does not apply because LGS does not use a once-through or cooling pond heat dissipation system.
27	Heat shock	**NONE.** This issue does not apply because LGS does not use a once-through or cooling pond heat dissipation system.
Groundwater Use and Quality		
33	Groundwater use conflicts (potable and service water, and dewatering; plants that use > 100 gpm)	**NONE.** This issue does not apply because LGS uses less than 100 gpm of groundwater annually.
34	Groundwater use conflicts (plants using cooling towers or cooling ponds and withdrawing makeup water from a small river)	**SMALL.** Maximum LGS consumptive water use is less than 3.3 %of Schuylkill River annual average flow. Because highly permeable or extensive alluvial or glacial deposits in the vicinity of the LGS and along the lower Schuylkill watershed are absent, variations in the stream flow of the Schuylkill River do not affect long-term groundwater availability. Therefore, withdrawal of water from the Schuylkill River has small, if any, impacts on groundwater availability and no impacts on recharge to alluvial aquifers.
35	Groundwater use conflicts (Ranney wells)	**NONE.** This issue does not apply because LGS does not use Ranney wells.
39	Groundwater quality degradation (cooling ponds at inland sites)	**NONE.** This issue does not apply because LGS does not use cooling ponds.
Terrestrial Resources		
40	Refurbishment impacts	**NONE.** This issue does not apply because Exelon Generation has no plans for refurbishment activities at LGS.
Threatened or Endangered Species		
49	Threatened or endangered species	**SMALL**. No species listed as threatened or endangered by a state or federal agency has been encountered during surveys and reviews conducted at the LGS site and in the Schuylkill River. None of the agencies responsible for natural resource protection identified any listed species or critical habitat that would likely be affected by LGS license renewal.

Air Quality		
50	Air quality during refurbishment (nonattainment and maintenance areas)	**NONE.** This issue does not apply because Exelon Generation has no plans for refurbishment activities at LGS.
Human Health		
57	Microbiological organisms (public health) (plants using lakes or canals, or cooling towers or cooling ponds that discharge to a small river)	**SMALL.** Thermophilic organisms are not known in the Schuylkill River; LGS's temperature effect on the Schuylkill River is limited by its NPDES Permit; the river is not intended for primary contact; and LGS does not discharge treated sanitary wastewater. Therefore, the impact of the LGS cooling tower effluent on the natural dynamics of thermophilic organisms in the Schuylkill River is expected to be small.
59	Electromagnetic fields, acute effects (electric shock)	**SMALL.** The largest modeled induced current under the LGS transmission lines is 4.6 milliamperes, which is less than the 5-milliampere criterion established by the National Electrical Safety Code. Therefore, the LGS transmission lines all conform to the National Electrical Safety Code provisions for preventing electric shock from induced current.
Socioeconomics		
63	Housing impacts	**SMALL.** The hypothetical addition of 60 permanent workers during the license renewal term would not noticeably affect a housing market that serves a population of more than one million people in the three counties where most LGS employees reside. Due to the absence of refurbishment for LGS license renewal, there would be no impacts associated with refurbishment.
65	Public water supply: public utilities	**SMALL.** Water suppliers in the three counties where most LGS employees reside have excess capacity. The addition of as many as 60 permanent workers during the license renewal term would not adversely affect the available water supply. Since refurbishment is not planned for LGS license renewal, there would be no impacts associated with refurbishment.
66	Public services: education (refurbishment)	**NONE.** This issue does not apply because Exelon Generation has no plans for refurbishment activities at LGS.
68	Offsite land use (refurbishment)	**NONE.** This issue does not apply because Exelon Generation has no plans for refurbishment activities at LGS.
69	Offsite land use (license renewal term)	**SMALL.** Plant-induced changes to offsite land use from license renewal are expected to be financially beneficial but small because LGS real estate tax payments represent less than 10% of total revenues for any county, municipality, or school district. In addition, the well-developed land use plans for the local counties and municipalities as well as the small number of added plant personnel assumed for the period of extended operation would keep off-site land-use changes small.
70	Public services: transportation	**SMALL.** The addition of as many as 60 permanent workers would increase traffic on the main roads that access the plant—Evergreen Road and US-422—by no more than two percent, which is insignificant in comparison with current traffic average daily trips on these roads. Since refurbishment is not planned for LGS, there would be no transportation impacts associated with refurbishment.

71	Historic and archaeological resources	**SMALL.** The use of plant configuration change review procedures, an LGS cultural resources management plan, and an agreement for stabilization and rehabilitation of the Fricks Lock Historic District will prevent adverse impacts to cultural resources from land disturbance activities, if any, during the license renewal term.
Postulated Accidents		
76	Severe Accidents	**SMALL.** The NRC's GEIS concluded that the probability-weighted consequences of severe accidents are of small significance for all nuclear power plants. An analysis of severe accident mitigation design alternatives (SAMDA) completed for LGS in 1989 (prior to construction), as reported in a supplement to the Final Environmental Statement Related to the Operation of Limerick Units 1 and 2, reached a consistent LGS-specific conclusion; therefore, 10 CFR 51.53(c)(3)(ii)(L) requires no further site-specific consideration of severe accident mitigation for LGS license renewal.

7.0 ALTERNATIVES TO THE PROPOSED ACTION

NRC

The environmental report shall discuss "Alternatives to the proposed action…" 10 CFR 51.45(b)(3), as adopted by reference at 10 CFR 51.53(c)(2).

"...The report is not required to include discussion of need for power or economic costs and benefits of ... alternatives to the proposed action except insofar as such costs and benefits are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation...." 10 CFR 51.53(c)(2).

"While many methods are available for generating electricity, and a huge number of combinations or mixes can be assimilated to meet a defined generating requirement, such expansive consideration would be too unwieldy to perform given the purposes of this analysis. Therefore, NRC has determined that a reasonable set of alternatives should be limited to analysis of single, discrete electric generation sources and only electric generation sources that are technically feasible and commercially viable…" (NRC, 1996a).

"…The consideration of alternative energy sources in individual license renewal reviews will consider those alternatives that are reasonable for the region, including power purchases from outside the applicant's service area...." (NRC, 1996a)

Section 7.0 evaluates alternatives to Limerick Generating Station, Units 1 and 2 (LGS) license renewal. The section identifies actions that Exelon Generation Company, LLC (Exelon Generation) might take, and associated environmental impacts, if the U.S. Nuclear Regulatory Commission (NRC) does not renew the LGS operating licenses. The section also addresses actions that Exelon Generation has considered, but would not take, and discusses the bases for determining that such actions would be unreasonable.

In considering the level of detail and analysis that it should provide for each alternative, Exelon Generation relied on the NRC decision-making standard for license renewal: "…the NRC staff, adjudicatory officers, and Commission shall determine whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decision makers would be unreasonable." [10 Code of Federal Regulations (CFR) 51.95(c)(4)]

Exelon Generation has determined that the environmental report would support NRC decision-making as long as the document provides sufficient information to clearly indicate whether an alternative would have a smaller, comparable, or greater environmental impact than the proposed action. Providing additional detail or analysis serves no function if it only brings to light additional adverse impacts of alternatives to license renewal. This approach is consistent with regulations of the Council on Environmental Quality (CEQ), which provide that the consideration of alternatives (including the proposed action) should enable reviewers to evaluate their comparative merits (40 CFR 1500-1508). Exelon Generation believes that Section 7.0 provides sufficient detail about alternatives to establish the basis for necessary comparisons to the Section 4.0 discussion of impacts from the proposed action. In characterizing environmental impacts from alternatives, this section uses the same definitions of "SMALL," "MODERATE," and "LARGE" as those presented in the introduction to Section 4.0.

7.1 No-Action Alternative

The “no-action alternative” refers to a scenario in which NRC does not renew the LGS operating licenses. Unlike the proposed action, denying license renewal does not expressly provide a means of meeting future electric system needs. Therefore, unless replacement generating capacity is provided as part of the no-action alternative, a large amount of base-load generation would no longer be available, and the alternative would not equivalently satisfy the purpose and need for the proposed action. For this reason, the no-action alternative is defined as having two components—replacing the generating capacity of LGS and decommissioning the LGS facility, as described below.

LGS annually provides approximately 19 terawatt-hours of electricity (EIA, 2010f) as base-load electrical capacity (Exelon Corporation, 2010b) to residents and other consumers in the mid-Atlantic region. Replacement could be accomplished by (1) building new base-load generating capacity using energy from coal, gas, nuclear, wind, solar, other sources, or some combination of these, (2) purchasing power from the wholesale market, or (3) reducing power requirements through demand side reduction. Section 7.2.1 describes each of these possibilities in detail, and Section 7.2.2 describes environmental impacts from alternatives deemed reasonable.

The Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC, 1996a) defines decommissioning as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits release of the property for unrestricted use and termination of the license. NRC-evaluated decommissioning options include immediate decontamination and dismantlement and safe storage of the stabilized and defueled facility for a period of time, followed by additional decontamination and dismantlement. Regardless of the option chosen, decommissioning must be completed within the 60-year period following permanent cessation of operations and permanent removal of fuel. Under the no-action alternative, Exelon Generation would continue operating LGS until the existing licenses expire, and then initiate decommissioning activities for both units in accordance with NRC requirements. The GEIS describes decommissioning activities based on an evaluation of the equivalently sized 1,155 megawatt-electric (MWe) Washington Public Power Supply System Nuclear Project 2 (the “reference” boiling-water reactor). As each LGS unit operates at an approximate average net output of 1,170 MWe, this description is applicable to decommissioning activities that Exelon Generation would conduct at LGS for each unit.

As the GEIS notes, NRC has evaluated environmental impacts from decommissioning. NRC-evaluated impacts include impacts of occupational and public radiation dose, impacts of waste management, impacts to air and water quality, and ecological, economic, and socioeconomic impacts. NRC indicated in the Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities; Supplement 1 (NRC, 2002a) that the environmental effects of greatest concern (i.e., radiation dose and releases to the environment) are substantially less than the same effects resulting from reactor operations. Exelon Generation adopts by reference the NRC conclusions regarding environmental impacts of decommissioning for both units.

Exelon Generation notes that decommissioning activities and their impacts are not discriminators between the proposed action and the no-action alternative. LGS will have to be decommissioned regardless of the NRC decision on license renewal; license renewal would only postpone decommissioning for another 20 years. NRC has established in the GEIS that the timing of decommissioning operations does not substantially influence the environmental impacts of decommissioning. Exelon Generation adopts by reference the NRC findings (10

CFR Part 51, Subpart A, Appendix B, Table B-1) to the effect that delaying decommissioning until after the renewal term would have small environmental impacts. The discriminators between the proposed action and the no-action alternative lie within the choice of generation replacement options to be part of the no-action alternative. Section 7.2.2 analyzes the impacts from these options.

Exelon Generation concludes that the decommissioning impacts under the no-action alternative would not be substantially different from those occurring following license renewal, as identified in the GEIS (NRC, 1996a) and in the decommissioning generic environmental impact statement (NRC, 2002a). These impacts would be temporary and would occur at the same time as the impacts from meeting system generating needs.

7.2 Alternatives that Meet System Generating Needs

Limerick Units 1 and 2 have a nominal maximum net capacity of 1,170 MWe each, and generated approximately 9.3 and 9.7 terawatt-hours of base-load electricity, respectively, in 2008 (EIA, 2008), and 10.0 and 9.3 terawatt-hours of base-load electricity, respectively, in 2009 (EIA, 2009). This base-load power is sufficient to supply the electricity used by over 2,000,000 homes (Exelon Corporation, 2010b), and would be unavailable to customers in the event the LGS operating licenses are not renewed.

The power consumed in Pennsylvania is not limited to electricity generated within the Commonwealth. Pennsylvania relies on electricity drawn from the PJM Interconnection, a regional network that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. One consequence of the network is that electric power consumers in Pennsylvania are not dependent on electricity generated within the Commonwealth. The current mix of power generation options within the PJM Interconnection is one indicator of what Exelon Generation considers to be feasible alternatives. In 2009, electric generators connected to the PJM Interconnection had a total generating capacity of 167,326 MWe (PJM, 2009a). This capacity included units fueled by coal (40.7 percent), natural gas (29.2 percent), nuclear (18.4 percent), oil (6.4 percent), hydroelectric (4.7 percent), solid waste (0.4 percent), and wind (0.2 percent) (PJM, 2009b). In 2009, electricity generators provided 682 terawatt-hours of electricity to the PJM Interconnection. The fuel sources used to produce this electricity were dominated by coal (50.5 percent), followed by nuclear (36 percent), natural gas (9.7 percent), hydroelectric (2 percent), solid waste (0.8 percent), wind (0.8 percent), and oil (0.2 percent) (PJM, 2009b). Figure 7.2-1 and Figure 7.2-2 respectively illustrate the distribution of fuel types contributing to the 2009 installed generating capacity and the electricity production of the PJM Interconnection.

Comparing the fuel types of generating capacity with the fuel types actually utilized for electricity production indicates that generating units fueled by coal and nuclear are used by PJM substantially more relative to their installed capacity than either oil-fired or gas-fired generation. This condition reflects the relatively low fuel cost and base-load suitability for nuclear and coal-fired power plants, and the relatively higher use of gas- and oil-fired units to meet peak loads. Comparison of installed capacity and energy production for petroleum and gas-fired facilities indicates a strong preference for gas firing over oil firing, indicative of the higher cost and greater air pollutant emissions associated with oil firing. Energy production from hydroelectric sources is preferred from a cost standpoint over production from plants fueled by nuclear and all three fossil fuels, but hydroelectric capacity is limited and utilization can vary substantially depending on water availability.

7.2.1 Alternatives Considered

Technology Choices

For the purposes of this environmental report, alternative generating technologies were evaluated to identify candidate technologies that would be capable of replacing the LGS nominal total net base-load capacity of 2,340 MWe at the time the LGS Unit 1 license expires in 2024. Exelon Generation accounted for the fact that LGS is a base-load generator and that any reasonable alternative to LGS would also need to be able to generate base-load power. Exelon Generation assumed that the region of interest (ROI) for purposes of this alternatives analysis includes the states of Delaware, Maryland, and New Jersey, and the Commonwealth of Pennsylvania, which are the states within the PJM Interconnection’s network that are geographically closest to LGS.

For the purposes of the LGS license renewal environmental report, Exelon Generation has limited analysis of impacts from new generating plant technology alternatives to the technologies it deems reasonable or potentially reasonable by 2024: new nuclear generation, pulverized coal- and gas-fired generation, wind generation, solar generation, and combinations of these technologies. The generation information presented above, which identifies coal as the most heavily used non-nuclear generating fuel type in the PJM Interconnection, supports consideration of a coal-fired alternative. The gas-fired technology alternative that Exelon Generation has chosen to evaluate is the combined-cycle (combustion and steam) turbine rather than the simple-cycle (combustion-only) turbine. The combined-cycle option is more efficient and economical to operate since it uses the heated exhaust of the combustion turbines to produce steam in Heat Recovery Steam Generators (HRSGs), which is then used in the steam turbines to generate additional power. The benefits of lower operating costs for the combined-cycle option outweigh its higher capital costs. Exelon Generation assumes the use of natural gas as the primary fuel in combined-cycle combustion turbines because of the economic and environmental advantages of natural gas over oil and other types of gas. Manufacturers now have large standard sizes of combined-cycle turbines that are economically attractive and suitable for high-capacity base-load operation.

Recently, members of both industry and government have expressed interest in the development of nuclear power plants to provide new base-load generating capacity. Beginning in 2007, several utilities submitted applications for combined construction and operating licenses (COLs) for new nuclear generating units. Although processing by NRC is not yet complete for any, Exelon Generation believes construction of new nuclear capacity may become a reasonable base-load generation alternative to license renewal for the LGS units, considering that the existing LGS operating licenses expire in 2024 and 2029.

For wind generation, Exelon Generation assumes that development of plants in the ROI is likely to include both land-based and offshore plants. For solar generation, two technologies have emerged as possible candidates for centralized electricity generation—photovoltaic (PV) and concentrating solar power (CSP) systems. While obstacles now exist to the use of wind and solar energy technologies for base-load electrical capacity in the amount that would be needed to replace the LGS units, Exelon Generation assumes that future technological advances may occur such that pure wind generation and pure solar generation could, by 2024, become reasonable base-load generation alternatives to LGS license renewal.

Currently, however, the intermittent nature of both wind and solar generation creates grid-reliability issues that make both energy sources unsuitable for base-load generation unless they are combined with some method of capacity firming. For this reason, Exelon Generation assumes that wind or solar generation facilities in combination with capacity-firming methods would also be reasonable alternatives to LGS license renewal. Methods for providing firming capacity involve combining wind or solar energy with another electrical power source capable of providing electrical output when the wind or solar energy source is not available. Thereby, reliability of the electrical grid system is maintained. Suggested firming capacity sources include compressed air energy storage (CAES), high energy batteries, pumped hydro storage (PHS), and interconnected wind farms. These sources of firming capacity are described below along with discussions of whether or not Exelon Generation considers them reasonable capacity firming methods for purposes of LGS license renewal.

Firming Capacity Methods

Compressed Air Energy Storage

CAES is a hybrid generation/storage technology with potential for use in balancing the electrical output from renewable energy power generators to improve their suitability for providing base-load capability. CAES systems are based on conventional gas turbine technology and use the elastic potential energy of compressed air. Energy would be stored by using wind-generated power to compress air in an airtight underground storage cavern. To extract the stored energy, compressed air would be drawn from the storage vessel, heated, and then expanded through a high-pressure turbine that captures some of the energy in the compressed air. The air would then be mixed with fuel and combusted, with the exhaust expanded through a low-pressure gas turbine. The turbines would be connected to an electrical generator. As part of a base-load renewable energy generation system, CAES would be used to enable a nearly constant output by smoothing the highly variable output from the renewable energy generator. CAES is considered a hybrid generation/storage system because it requires combustion in the gas turbine. The primary disadvantages of CAES are the need for an underground cavern and its reliance on fossil fuels. Assessments of this concept by the National Renewable Energy Laboratory (NREL) included a combination of 2,000 MW of wind generation with 900 MW of CAES generation to produce a nearly constant 900 MWe output (NREL, 2006). The largest commercial CAES that has been proposed is the 800 MW (with a potential expansion to 2,700 MW) plant that is planned for construction in Norton, Ohio. This nine-unit plant will compress air to 1,500 pounds per square inch (psi) in an existing limestone mine some 2,200 feet underground. The current estimated cost of such a facility is in the range of $700/kW with energy conversion efficiency in the range of 80 percent (Xcel Energy, 2007). Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this environmental report that, if costs are ignored, a suitable geologic formation would be available; thus, a combination of wind generation combined with CAES would be a reasonable alternative to renewal of the LGS operating licenses.

High-Energy Batteries

High-Energy Batteries can generally provide rapid response, which means that batteries "designed" for energy management can potentially provide services over all the durations required. Several battery technologies have been demonstrated or deployed for energy management applications. The commercially available batteries targeted to energy management include two general types: high-temperature batteries and liquid electrolyte flow batteries. The most mature high-temperature battery as of 2009 is the sodium-sulfur battery, which has worldwide installations that exceed 270 MW. Alternative high-temperature chemistries have been proposed and are in various stages of development and commercialization. One example is the sodium-nickel chloride ("ZEBRA") battery. The second class of high-energy batteries is the liquid electrolyte "flow" battery. This battery uses a liquid electrolyte that flows across a membrane. As of 2009, there has been limited deployment of two types of flow batteries: vanadium redox and zinc-bromine. Other combinations such as polysulfide-bromine have been pursued, and new chemistries are under development. In the United States, a primary application of energy management batteries has been transmission and distribution deferral. Demonstration projects have been deployed for varying other applications, but, there are no current applications or demonstration studies of battery storage systems that approach the reserve capacity required for balancing the output from a wind or solar generation power plant of the size necessary to replace the LGS approximate annual average net base-load generating capacity of 2,340 MWe (NREL, 2010a). Because this method for balancing intermittent output from wind and solar generation facilities has not been demonstrated, Exelon Generation does not consider it to be a reasonable firming capacity method and, thus, impacts of combining it with wind or solar generation are not evaluated further.

Pumped Hydro Storage

PHS is the only energy storage technology deployed on a gigawatt scale in the United States and worldwide. In the United States, about 20 GW is deployed at 39 sites, and installations range in capacity from less than 50 MW to 2,100 MW. Many of the sites store sufficient water for 10 hours or more of discharge, making the technology useful for replacing the wind or solar energy. PHS uses conventional pumps and turbines and requires a significant amount of land and water for the upper and lower reservoirs. PHS plants can achieve round-trip efficiencies that exceed 75 percent and may have discharge capacities that exceed 20 hours. Environmental regulations may limit large-scale above-ground PHS development. However, given the high round-trip efficiencies, proven technology, and low cost compared to most alternatives, conventional PHS is still being pursued in a number of locations (NREL, 2010a). A PHS station costs in excess of $1,000/kW and the overall losses are about 25 percent. Most PHS stations store sufficient water for 6 to 10 hours of operation. The ideal operating head is between 457 and 671 meters (1,500 and 2,200 feet) of elevation (NWW, 2009). The environmental impact of large-scale PHS facilities is becoming more of an issue, especially where pre-existing reservoirs are not available and sites with large, naturally occurring reservoirs at sufficiently large differential elevations where environmentally benign, inexpensive PHS facilities can be built are increasingly rare (PEI, 2008). The feasibility of implementing PHS in the ROI would depend on availability of a suitable water reservoir, which would require detailed site-specific investigation. Because this method for balancing intermittent output from wind and solar generation facilities would be very resource and capital intensive, involving construction of a reservoir at an as-yet unidentified location in proximity to a site suitable for wind or solar generation, Exelon Generation does not consider PHS to be a reasonable firming capacity method in comparison to other available methods. Accordingly, impacts of combining it with wind or solar generation are not evaluated further.

Interconnecting Wind Farms

The concept of developing base-load wind energy by interconnecting wind farms through the transmission grid postulates that, if wind farms are interconnected in an array, wind speed correlation among sites decreases and so does the probability that all sites experience the same wind regime at the same time. The array consequently behaves more and more similarly to a single wind farm with steady wind speed and, thus, steady deliverable wind power (JAMC, 2007).

The Cape Wind project, a proposed 420 MW facility off the coast of Massachusetts, is anticipated to be the first offshore wind generation facility completed on the Atlantic coast. The Cape Wind project filed its application in 2001 and has not received final approval for construction because public opposition on aesthetic and environmental grounds has slowed the approval process. Although other offshore wind projects in the Atlantic have also been proposed and may be developed faster, the availability of enough other wind farms that could be interconnected to provide base-load capacity adequate to replace the base-load capability of LGS in the ROI before the existing LGS Unit 1 operating license expires in 2024 cannot be accurately predicted given current information.

Even if it were assumed that Exelon Generation could itself construct multiple offshore wind generation facilities with adequate combined capacity (if interconnected) to replace the base-load LGS generating capacity by 2024, the transmission line infrastructure would also have to be in place. Installation of added transmission infrastructure along the Atlantic coast has already been announced by investors (Washington Post, 2010). This project may eliminate the need for transmission lines dedicated to interconnecting the wind generation facilities to be constructed. The proposed grid would be designed to transmit 6,000 megawatts of offshore wind energy between northern New Jersey and Virginia and is projected for completion by 2020. Notwithstanding, because construction of multiple offshore wind generation facilities would be capital and resource intensive, and because completion of the proposed transmission system lacks certainty, Exelon Generation does not consider interconnecting wind farms to be a reasonable firming capacity method for wind generation in comparison to other available methods. Accordingly, impacts of combining it with wind generation are not evaluated further.

Effects of Restructuring

Nationally, the electric power industry has been undergoing a transition from a regulated industry to a competitive market environment. Efforts to deregulate the electric utility industry began with passage of the National Energy Policy Act of 1992. Provisions of this act required electric utilities to allow open access to their transmission lines and encouraged development of a competitive wholesale market for electricity. The Act did not mandate competition in the retail market, leaving that decision to the states (EAI, 2010a; NEI, 2007b). Over the past few years, states within the ROI have transitioned to competitive wholesale and retail markets.

In 1996, Pennsylvania enacted the “Electricity Generation Customer Choice and Competition Act.” Provisions opened Pennsylvania’s retail electric power market to competition. The Pennsylvania Public Utility Commission (PPUC) provides strategic direction and policy guidance for oversight of the electric power industry in the Commonwealth, including the restructuring initiative (Pennsylvania General Assembly, 2010). In 1999, New Jersey passed legislation to restructure the electric power industry in New Jersey. Under the “Electric Discount and Energy Competition Act” (EDECA) the law allowed all consumers to shop for their electric supplier, reduced current rates, and allowed recovery of utilities' stranded costs through a wires charge paid by consumers. In 1999 Maryland passed the “Maryland Customer Choice and Competition Act. The legislation included a rate reduction for residential consumers, funding for low-income programs, stranded cost recovery to be determined by the Maryland Public Service Commission (MPSC), disclosure of fuel sources by electric suppliers, recovery of stranded costs through a non-bypassable wires charge, and a 3-year phase-in for competition. In 2006, Delaware passed the Electric Utilities Retail Customer Supply Act of 2006 which provides that all electric distribution companies subject to the jurisdiction of the Delaware Public Service Commission (DPSC) would be designated as the standard offer service supplier and returning customer service supplier in their respective territories. Provisions provide further opportunity for distribution companies to enter into long and short-term supply contracts, own and operate generation facilities, build generation and transmission facilities, make investments in demand-side resources and take any other DPSC approved action to diversify their retail load supply (EIA, 2010a).

In 2004, Pennsylvania enacted the Alternative Energy Portfolio Standard (AEPS), requiring that qualified power sources provide 18.5 percent of Pennsylvania’s electricity by 2020. There are two tiers of qualified sources that may be used to meet the standard. Tier 1 sources must make up 8 percent of the portfolio, and include wind, solar, coal mine methane, small hydropower, geothermal, and biomass. Solar sources must provide 0.5 percent of generation by 2020. Tier 2 sources make up the remaining 10 percent of the portfolio, and include waste coal, demand side management, large hydropower, municipal solid waste, and coal integrated gasification combined cycle. In 2006, the New Jersey Board of Public Utilities (NJBPU) approved new regulations that expanded the state’s renewable portfolio standard (RPS). The NJBPU decision requires utilities to produce 22.5 percent of their electricity from renewable sources, at least two percent of which must come from solar sources. Sources of energy that count toward the remainder of the standard include solar, wind, wave, tidal, geothermal, methane gas captured from a landfill, fuel cells powered by renewable fuels, electricity generated by the combustion of gas from the anaerobic digestion of food waste and sewage sludge at a biomass generating facility, and hydropower. In 2007, Delaware enacted Senate Bill 19, which expanded the state’s previous renewable portfolio standard to require that two percent of the state’s electricity supply come from solar photovoltaics by 2019, in addition to 18 percent from other renewable sources by the same date. Sources of energy that count toward the standard include wind, ocean tidal, ocean thermal, fuel cells powered by renewable fuels, hydroelectric facilities with a maximum capacity of 30 megawatts, sustainable biomass, anaerobic digestion, and landfill gas. In 2008, Maryland enacted Senate Bill 209, which accelerates Maryland’s existing renewable portfolio standard to require that 20 percent of the state’s electricity supply come from renewable sources by 2022, and that retained the requirement that two percent of electricity come from solar power. Sources of energy that count toward the standard include wind, qualifying biomass, methane from the anaerobic decomposition of organic materials in a landfill or wastewater treatment plant, geothermal, ocean, including energy from waves, tides, currents, and thermal differences, a fuel cell that produces electricity from qualifying biomass or methane, and small hydroelectric power plants (Pew, 2010).

Descriptions of Alternatives

The following sections present fossil-fuel-fired (coal or natural gas) generation capacity (Section 7.2.1.1), purchased power (Section 7.2.1.2), new nuclear generation capacity (Section 7.2.1.3), wind energy (Section 7.2.1.4), solar energy (Section 7.2.1.5), and combinations of various energy supplies (Section 7.2.1.6) as reasonable alternatives to license renewal for supplying base-load electricity. Section 7.2.1.7 discusses additional alternatives that Exelon Generation has determined are not reasonable and the bases for these determinations.

Construction of a hypothetical new power station at the present LGS site or another existing power station would be preferable to construction at a new greenfield site. This approach would minimize environmental impacts by building on previously disturbed land and by making the most use possible of existing facilities, such as transmission lines, roads and parking areas, office buildings, and components of the cooling system. However, there is insufficient area at the existing LGS site to construct a new nuclear, coal- or gas-fired unit of adequate capacity without impacting the ongoing operations; thus, a new plant would have to be located elsewhere. Accordingly, except for the wind and solar generation alternatives, it is assumed that space would be found at another existing power plant site within the ROI in order to benefit from the existing infrastructure and minimize the environmental impact that would occur in comparison to a new greenfield location. This approach avoids overstating the environmental impacts of these alternatives in comparison to the proposed action. Because of the large land use demands of new wind and solar generation facilities, Exelon Generation assumes that even if the LGS plant site or another existing plant site were used, doing so would not significantly reduce the total greenfield acreage that would be affected.

To compare the environmental impacts of alternative electricity supplies with LGS license renewal on an equal basis, Exelon Generation set the existing approximate net average annual generating capacity of LGS (2,340 MWe) as the approximate net electrical generating capacity that any reasonable alternative would need to supply. However, because some alternative technologies are manufactured in standard unit sizes, it was not always possible to aggregate such technologies to exactly match the LGS capacity. In such cases, generation capacity below the LGS net average annual generating capacity has been used to conservatively evaluate impacts in cases of new facility construction.

It must be emphasized, however, that all scenarios are hypothetical. Exelon Generation has no current plans for new facility construction to replace LGS.

7.2.1.1 Construct and Operate New Natural Gas-Fired or Coal-Fired Generation Capacity

Gas-Fired Generation

For purposes of this analysis, Exelon Generation assumed development of a modern natural gas-fired combined-cycle plant with design characteristics similar to those being developed elsewhere in the PJM region, and with a net generating capacity comparable to that of LGS. The hypothetical plant would be composed of four pre-engineered natural gas-fired combined-cycle units producing 530 MWe each of net plant power for a total of 2,120 MWe (Chase and Kehoe, 2000). The characteristics of this plant and other relevant resources were used to define the gas-fired alternative. Table 7.2-1 presents the basic characteristics for the gas-fired alternative, and impacts are described in Section 7.2.2.1.

Coal-Fired Generation

NRC has routinely evaluated coal-fired generation alternatives for nuclear plant license renewal. In defining the coal-fired alternative to LGS, site- and Pennsylvania-specific input has been applied for direct comparison with a gas-fired plant producing 2,120 MWe (net).

Table 7.2-2 presents the basic coal-fired alternative emission control characteristics, and impacts are described in Section 7.2.2.2. The emissions control assumptions are based on the technologies recognized by the U.S. Environmental Protection Agency (EPA) for minimizing emissions and calculated emissions based upon the EPA published removal efficiencies (EPA, 1998a).

7.2.1.2 Purchased Power

Exelon Generation has evaluated conventional and prospective power supply options that could be reasonably implemented before the existing LGS licenses expire. As noted in Section 7.2.1, electric industry restructuring initiatives in the ROI are designed to promote competition in energy supply markets by facilitating participation by non-utility suppliers. PJM has implemented market rules to appropriately anticipate and meet electricity demands in the wholesale electricity market that has resulted from restructuring. However, because retail customers in the ROI now may choose among multiple companies to supply their electricity needs, future load obligations of such companies are uncertain. For the purposes of this analysis, Exelon Generation assumes that the PJM member companies will install electricity generation capacity beyond that necessary to meet future demand, although delayed retirement of existing units is not considered available. Thus, it is assumed that purchased power would be available as a reasonable alternative for meeting load obligations in the event the existing operating licenses for LGS are not renewed.

The technologies that would be used to generate purchased power are unknown. Even so, Exelon Generation believes it is likely that the generating technologies analyzed by the NRC in the GEIS would be the primary sources of purchased power. For this reason, Exelon Generation is adopting by reference the GEIS description of the alternative generating technologies to represent the purchased power alternative. Of these technologies, facilities fueled by coal and combined-cycle facilities fueled by natural gas are the most cost effective for providing base-load capacity. Impacts are described in Section 7.2.2.3.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace LGS capacity. From a local perspective, loss of LGS could require construction of new transmission lines to ensure local system stability. From a regional perspective, PJM's inter-connected transmission system is highly reliable.

7.2.1.3 Construct and Operate New Nuclear Generating Capacity

Since 1997, the NRC has certified four new standard designs for nuclear power plants under 10 CFR Part 52, Subpart B. Additional designs are undergoing precertification and certification reviews. All of the plants currently certified or undergoing certification reviews are light-water reactors; several of the designs in precertification review are not, including the Pebble Bed Modular Reactor and the Advanced CANDU Reactor, ACR-700 (NRC, 2009a).

The NRC staff considered new nuclear generating capacity as an alternative to license renewal for the Beaver Valley Power Station (NRC, 2009b). In its analysis, the NRC staff assumed that

1,900 MWe of new nuclear generation would be installed in the form of either one or two units having a certified design. Impact analyses did not reference a particular design, and impacts generally applicable to all certified designs were assumed. Exelon Generation has reviewed the NRC analysis of new nuclear capacity for Beaver Valley, believes it to be sound, and notes that it addresses less capacity than the approximately 2,340 MWe discussed in this analysis; however, for comparison with LGS license renewal, that provides a conservative estimate of potential impacts. Exelon Generation has assumed construction at an existing plant site of two new nuclear units having a certified design. Impacts are described in Section 7.2.2.4.

7.2.1.4 Wind Energy

Energy potential in wind is expressed by wind generation classes, ranging from 1 (least energetic) to 7 (most energetic). Current wind technology can operate economically on Class 4 sites with the support of the Federal production tax credit of 1.9 cent per kWh (DOE, 2008a), while Class 3 wind regimes would require further technical development for utility scale application. In the PJM region, areas of highest wind energy potential (Class 5 and 6) are the outer coastal areas of New Jersey, offshore areas of Lake Erie, and the higher mountain summits of the Appalachians. PJM Interconnection has reported installed wind generating capacity in the PJM region totaling 512 MW as of September 30, 2010, with additional wind projects totaling approximately 34 GW proposed as of January 4, 2011 (PJM, 2011). Due to the intermittent nature of wind, wind power plants are not considered dispatchable (i.e. they cannot reliably be turned on quickly to a desired level of output) and PJM Interconnection grants new wind facilities only a 13 percent capacity credit (PJM, 2010), calculated as the production capability of a wind plant during the highest-load hours of June through August. Accordingly, to replace the LGS approximate annual average net base-load generating capacity of 2,340 MWe, assuming the current-day capacity credit for wind generation, approximately 18,000 MW of new wind capability would be required ([new wind capability] x 0.13 = 2,340 MWe). However, by 2025 (one year after the LGS Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors (the ratio of actual energy output over the highest-load period and its hypothetical maximum energy output capability over that same period) as high as 52 percent and 55 percent, respectively, as a result of technology improvements and operating experience (DOE, 2008a, Tables B-10 and B-11, pp. 182-183). Therefore, assuming a future capacity credit for wind generation based on an average of the projected capacity factors for land-based and offshore projects, approximately 4,400 MW of new wind capability would be required to replace the base-load generating capacity of LGS.

The intermittent nature of wind causes fluctuations that can change power frequency and lead to grid-reliability issues when wind energy is used to supply electricity to the transmission grid. For this reason, methods to mitigate grid-reliability issues of generating electricity with intermittent wind energy (see Section 7.2.1) must be applied in order to suit current-day wind energy facilities to provide base-load generation capacity (NREL 2010a). Even so, for the purposes of this environmental report, it is assumed that a wind plant with no firming capacity could be a reasonable alternative in the future. Hence, impacts from a purely wind energy alternative are described in Section 7.2.2.5. Section 7.2.2.7 discusses impacts from wind energy combined with solar energy and gas-fired combined-cycle firming capacity. Section 7.2.2.8 discusses impacts from wind energy combined with CAES firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate wind energy generation into the regional electricity grid if this alternative is used to replace LGS's base-load generating capacity.

7.2.1.5 Solar Energy

Like wind energy, solar energy is intermittent by its nature, which causes fluctuations that can change power frequency and lead to grid-reliability issues when solar energy is used to supply electricity to the transmission grid. For this reason, some type of firming capacity method must be applied in order for current-day solar energy facilities to provide base-load generation capacity. Two solar generation technologies have emerged as possible candidates for centralized electricity generation—photovoltaic (PV) and concentrating solar power (CSP) systems. Solar photovoltaic systems are semiconductor devices that convert sunlight directly into electricity. CSP systems use the thermal energy of sunlight to generate electricity.

Two common designs of CSP plants are parabolic troughs and power towers. Both of these designs concentrate sunlight onto a heat-transfer fluid (HTF), which is used to generate steam that drives a steam turbine. Cooling towers or once-through cooling would be used to condense the spent steam back to water for reuse. CSP systems can provide base-load capacity without external balancing systems because their designs incorporate integral thermal energy storage (TES) to shift generation to periods without solar resource and to provide backup energy during periods with reduced sunlight caused by cloud cover. The storage medium is typically a molten salt, which has extremely high storage efficiencies in demonstration systems. Current designs provide a maximum TES of six hours (NREL, 2010e).

Unlike CSP systems, PV generation does not provide all of the characteristics necessary for stable grid operation. For example, PV provides the most electricity during midday on sunny days, but none during evenings or at night (NREL, 2010f). PV output can increase and fall rapidly during cloudy weather, making it difficult to maintain balance on a grid with a large penetration of PV (NREL, 2010f). Therefore, the use of a PV system would require backup generation or another external balancing system, such as those described in Section 7.2.1. Notwithstanding, photovoltaics can take advantage of direct and indirect (diffuse) exposure to sunlight, whereas CSP is designed to use only direct exposure. As a result, PV modules need not directly face and track incident radiation as CSP systems must do. This has enabled PV systems to have broader geographical application than CSP (NREL 2010g). Hence, for the purposes of this environmental report, it is assumed that a solar plant using PV generation with no firming capacity could be a reasonable alternative for base-load generating capacity. Impacts of a purely solar energy alternative using either CSP generation or PV generation without firming capacity are described in Section 7.2.2.6. Section 7.2.2.7 discusses impacts from solar energy combined with wind energy and gas-fired combined-cycle firming capacity.

Exelon Generation anticipates that additional transmission infrastructure would be needed to integrate solar energy generation into the regional electricity grid if this alternative is used to replace LGS's base-load generating capacity.

7.2.1.6 Combinations of Alternatives

NRC indicated in the GEIS that, while many methods are available for generating electricity and a huge number of combinations or mixes can be assimilated to meet system needs, such expansive consideration would be too unwieldy, given the purposes of the alternatives analysis. Therefore, NRC determined that a reasonable set of alternatives should be limited to the analysis of single discrete electrical generation sources and only those electric generation technologies that are technically reasonable and commercially viable. Nevertheless, for the purpose of comparison, Exelon Generation has crafted alternatives that combine generation alternatives to replace LGS's approximate annual average net base-load generating capacity. Two combinations are considered: (1) wind generation combined with PV solar generation and firming capacity in the form of gas-fired combined-cycle generation, and (2) wind generation combined with CAES.

Exelon Generation assumes that the envisioned scenarios are combinations of generation alternatives that could adequately balance the electrical output from intermittent wind and solar energy sources to allow these sources to replace LGS's base-load generating capacity by 2024.

Wind Generation, PV Solar Generation, and Gas-fired Combined-Cycle Generation

Wind and solar generation appear to be appropriate components of this combination alternative because renewable energy sources, including wind and solar energy as well as other renewable energy sources, are projected to be a growing source of electricity through 2035 (EIA, 2011a). Additionally, PJM Interconnection reports that, as of January 1, 2011, about 34 GW of wind generation has been proposed for construction in the PJM region, and about 4 GW of solar generation has been proposed. Since most new power plants added to the U.S. electricity grid since 1990 have been powered by gas-fired combined-cycle plants, it is also appropriate to assume that the method by which firming capacity for wind and solar power would be provided is a new gas-fired combined-cycle generation plant. Furthermore, the Energy Information Administration's Annual Energy Outlook forecasts continued growth in the use of gas-fired combined-cycle plants as a new electricity source through 2035 (EIA, 2011a). Hence, gas-fired combined-cycle electricity generation is a proven technology with demonstrated operating characteristics and well defined resource and capital requirements.

For this combination of alternatives, Exelon Generation assumed that 1,200 MWe of LGS's net base-load capacity of 2,340 MWe would be replaced by one land-based wind farm, with the balance (1,140 MWe) replaced by three PV solar facilities. However, since wind and PV solar energy are intermittent, for the purpose of this alternative, the wind farm capacity credit is assumed to be 52 percent (based on the DOE projected capacity factor for land-based wind energy in 2025) (Section 7.1.2.4), while the PV solar facility capacity credit is assumed to be 38 percent (the current-day PJM Interconnection capacity credit for solar [Section 7.2.2.6]). As a result, the total capacity assumed to be required for the wind farm is 2,308 MWe and the total capacity assumed to be required for each of the three PV solar facilities is 1,000 MWe, for a total PV solar generating capacity of 3,000 MWe.

Gas-fired combined-cycle generation has been successfully used to balance intermittent renewable power and thereby maintain electrical grid system reliability. Based on the NREL evaluation in its recent Eastern Wind Integration and Transmission Study (NREL, 2011b), approximately 6 percent of land-based and 4 percent of offshore wind energy capability would be needed in gas-fired combined-cycle backup to support the regulation and operating reserve requirements imposed by wind energy. Assuming 2,308 MWe of land-based wind generation capability, approximately 140 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

Comparable estimates of the amount of gas-fired combined-cycle backup needed to support the regulation and operating reserve requirements imposed by solar generation were not found in the literature. Therefore, for the purposes of this evaluation, Exelon Generation has assumed that approximately 10 percent of PV solar energy capability would be needed in gas-fired combined-cycle backup. Accordingly, for 3,000 MWe of PV solar energy capability (assuming the current PJM Interconnection capacity credit for solar of 38 percent), approximately 300 MWe of gas-fired combined-cycle generation would be required as reserve capacity.

In summary, for this combination of alternatives, Exelon Generation assumed that the LGS base-load capacity of 2,340 MWe would be replaced by one 2,308 MWe wind farm (with a 140 MWe gas-fired combined-cycle backup unit) and three 1,000 MWe PV solar facilities (each with a 100 MWe gas-fired combined-cycle backup unit). Also, for the purposes of this environmental report, it is assumed that, by 2024, this combination of alternatives would be a reasonable alternative to renewal of the LGS operating licenses. Impacts of this alternative are discussed in Section 7.2.2.7.

Wind Generation Combined With Compressed Air Energy Storage

As was previously explained, wind generation appears to be an appropriate component of a combination of alternatives because renewable energy sources, including wind energy as well as other renewable energy sources, are projected to be a growing source of electricity through 2035 (EIA, 2011a). Furthermore, by 2025 (one year after the LGS Unit 1 license expires), new land-based and offshore wind projects may have achieved capacity factors as high as 52 percent and 55 percent, respectively, as a result of technology improvements and operating experience (DOE, 2008a, Table B-11, p. 183). Even so, if wind energy is used to supply electricity to the transmission grid, its intermittent nature causes fluctuations that can change power frequency and lead to grid-reliability issues. For this reason, some method to mitigate grid-reliability issues associated with generating electricity using intermittent wind energy is likely to also be necessary (NREL 2010a). Although site-specific investigations would be needed to determine whether a suitable geologic formation is available to accommodate CAES in the ROI, it is assumed for the purposes of this environmental report that, if costs are ignored, a suitable geologic formation would be available; thus, a combination of wind generation combined with CAES would be a reasonable alternative to renewal of the LGS operating licenses.

The combination of alternatives is assumed to include one land-based wind farm and one offshore wind farm coupled with one CAES facility. Using PJM Interconnection capacity credits for land-based and offshore wind generation equal to the DOE-projected capacity factors for 2025 (52 percent for land-based projects and 55 percent for offshore projects), approximately 4,400 MWe of new wind capability (approximately 2,300 MWe land-based and 2,100 MWe off-shore) would be required to replace LGS's base-load generating capacity. Additionally, based on the NREL assessment of the amount of CAES needed in combination with a wind farm in order to provide a nearly constant energy output (Section 7.2.1), a 4,400 MWe wind farm combined with a 1,980 MWe CAES facility would be capable of providing approximately 1,980 MWe as a nearly constant output. An additional 360 MWe of CAES would be required to provide a nearly constant output of 2,340 MWe from the combined wind and CAES facilities. Impacts of this alternative are discussed in Section 7.2.2.8.

7.2.1.7 Other Alternatives

This section identifies alternatives that Exelon Generation has evaluated and determined are not reasonable for replacing LGS and the bases for these determinations. Exelon Generation accounted for the fact that LGS is a base-load generator and that any feasible alternative to LGS would also need to be able to generate base-load power. Except for the discussion of demand-side management, Exelon Generation relied heavily upon NRC's GEIS in performing this evaluation (NRC, 1996a).

Demand Side Management

Demand side management (DSM) programs include energy conservation and load management measures. As discussed in the GEIS (NRC, 1996a; NRC, 2009a), the DSM alternative does not fulfill the stated purpose and need of the proposed action because it does not "provide power generation capability."

Historically, state regulatory bodies required regulated utilities to institute programs designed to reduce demand for electricity. In a deregulated market, however, electric power generators may not be able to offer competitively priced power if they must retain an extensive conservation and load-modification incentive program. In addition, a private company engaged in generating energy for the wholesale market, such as Exelon Generation, has no business connection to the end users of its electricity and, therefore, no ability to implement DSM. Because a company whose sole business is that of generating electricity and selling energy at wholesale has no ability to implement DSM, the NRC determined that NEPA does not require that an alternative involving electricity demand reduction through DSM be considered when the project purpose is to authorize a power plant to supply existing and future electricity demand (NRC, 2005). The NRC determination was upheld by the U.S. Court of Appeals for the Seventh Circuit (2006). Nevertheless DSM is considered here because energy conservation and peak load management are important tools for meeting projected demand.

In 2008, the Center for Energy, Economic and Environmental Policy (CEEEP) compared actual New Jersey electricity savings data for the years 2004 to 2007 to the estimates under both the Business-as-Usual case and the Advanced Efficiency case presented in the 2004 study. Between 2004 and 2007, conservation programs achieved approximately 939 GWh per year of avoided electricity use. This represents over 78 percent of the 2004 to 2007 Business-as-Usual savings potential of 1,205 GWh and almost 44 percent of the Advanced Efficiency scenario of 2,116 GWh (CEEEP, 2008). Overall, the New Jersey Clean Energy Program reduced peak electric demand by a total of 87 MWe in 2007 (NJBPU, 2009). It is evident that the New Jersey energy efficiency programs captured significantly less electricity savings than estimated by the 2004 study. However, CEEEP estimates that continuing the programs "as-is" would likely result in New Jersey meeting the Business-as-Usual case; however the savings estimated under the Advanced Efficiency case are not likely to be attained (CEEEP, 2008).

In 2008, electricity providers reported total peak-load reductions of 32,741 MW resulting from demand-side management (DSM) programs, an 8.2 percent increase from the amount reported in 2007. Reported DSM costs increased $1.2 billion, up 47.4 percent from the $2.5 billion reported in 2007. DSM costs can vary significantly from year to year because of business cycle fluctuations and regulatory changes. Since costs are reported as they occur, while program effects may appear in future years, DSM costs and effects may not always show a direct relationship. In the five years since 2003, nominal DSM expenditures have increased at a 22.9-percent average annual growth rate nationally. During the same period, actual peak load reductions have grown at a 6.17 percent average annual rate, from 22,904 MW to 32,741 MW nationally. The divergence between the growth rates of load reduction and expenditures is driven in large measure by 2008 expenditures, which are in response to higher overall energy prices (EIA, 2010c).

Because Exelon Generation sells power into the wholesale electricity market through PJM Interconnection, LLC (PJM), DSM measures are not within the Company's control. However, PJM has instituted measures to capture energy conservation potential and load management in its resource planning. As a practical matter, it would be highly unlikely that energy savings from demand reductions could be increased by an additional 2,340 MWe by 2024 to replace the LGS base-load capacity.

The DSM alternative would produce different impacts than the other alternatives addressed. Unlike the discrete generation options, there would be no major generating facility construction and few ongoing operational impacts. However, the loss of LGS generating capacity could require construction of new transmission lines to ensure local system stability. The most significant effects would likely occur during installation or implementation of conservation measures, when old appliances may be replaced, building climate control systems may be retrofitted, or new control devices may be installed. In some cases, increases in efficiency may come from better management of existing control systems. While replaced or removed items may be recycled, volumes of landfilled trash could still increase.

The GEIS generally indicates that impacts from a DSM alternative are small and that some postulated effects (like increases in mercury, polychlorinated biphenyls (PCBs), or chlorofluorocarbon (CFC) releases as fluorescent bulbs, old transformers, or old refrigerators are replaced) may not prove to be significant because effective disposal methods can prevent health effects, and because more environmentally-benign alternatives are available (NRC, 1996a).

In conclusion, although DSM is an important tool for meeting projected electricity demand and the impacts from the DSM alternative are generally small, DSM does not fulfill the stated purpose and need for license renewal of nuclear power plants, which is to "provide power generation capability" (NRC, 1996a). DSM measures are already captured in state and regional load projections and additional DSM measures would offset only a fraction of the energy supply lost by the shutdown of LGS. In addition, the purpose for LGS license renewal is to allow Exelon Generation to sell wholesale power generated by LGS to meet future demand. Because Exelon Generation engages solely in the sale of wholesale electric power, the Company has no business connection to end users of its electricity and, therefore, no ability to implement DSM. For these reasons, Exelon Generation does not consider DSM to be a viable supply of replacement base-load electricity. Hence, DSM does not represent a reasonable alternative to renewal of the LGS operating licenses.

Hydropower

About 7,768 MWe of utility generating capacity in the PJM region is hydroelectric (PJM, 2009b). As the GEIS points out in Section 8.3.4, hydropower's percentage of United States generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern over flooding, destruction of natural habitat, and alteration of natural river courses. A small number of hydropower projects, the largest of which is 190 MWe, are being considered in the PJM region (FERC, 2010). These small hydropower projects could not replace the 2,340 MWe generated at LGS. According to the U.S. Hydropower Resource Assessment (INEEL, 1998), there are no remaining sites in the PJM region that would be environmentally suitable for a large hydroelectric facility.

The GEIS estimates land use of 4,142 square kilometers (1,600 square miles) per 1,000 MWe for hydroelectric power. Based on this estimate, replacement of LGS generating capacity would require flooding approximately 9,320 square kilometers (3,600 square miles), resulting in a large impact on land use. Further, operation of a hydroelectric facility would alter aquatic habitats above and below the dam, which would impact existing aquatic communities.

Exelon Generation has concluded that, due to the lack of suitable sites in the ROI for a large hydroelectric facility and the amount of land needed (approximately 9,320 square kilometers) (3,600 square miles), hydropower is not a reasonable alternative to LGS license renewal.

Geothermal

Geothermal energy is a proven resource for power generation. Geothermal power plants use naturally heated fluids as an energy source for electricity production. To produce electric power, underground high temperature reservoirs of steam or hot water are tapped by wells and the steam rotates turbines that generate electricity. Typically, water is then returned to the ground to recharge the reservoir (PJM, 2009b).

Geothermal energy can achieve average capacity factors of 90 percent and can be used for base-load power where this type of energy source is available (MIT, 2006). Widespread application of geothermal energy is constrained by the geographic availability of the resource (NREL, 2009). In the United States, high-temperature hydrothermal reservoirs are located in the western continental U.S., Alaska, and Hawaii. There are no known high-temperature geothermal sites in the ROI (NREL, 2007). The ROI has low to moderate temperature resources that can be tapped for direct heat or geothermal heat pumps, but electricity generation is not feasible with these resources (INEEL, 1998; NREL, 2007; NREL, 2011a).

Exelon Generation has concluded that, due to the lack of high temperature geothermal sites in the ROI, geothermal power is not a reasonable alternative to LGS license renewal.

Tidal, Ocean Thermal, and Wave

Technologies to harness electrical power from the ocean are tidal power, ocean thermal energy, and wave power conversion. These technologies are still in the early stages of development and are not commercially available to replace a large base-load generator such as LGS.

Tidal power technologies extract energy from the diurnal flow of tidal currents caused by the gravitational pull of the moon. Unlike wind and wave power, tidal streams offer entirely predictable output. All coastal areas consistently experience two high tides and two low tides over a period of approximately 25 hours. However, because the lunar cycle is longer than a 24-hour day, the peak outputs differ by about an hour each day, and so tidal energy cannot be guaranteed at times of peak demand (Feller, 2003).

Tidal power technologies consist of tidal turbines and barrages. Tidal turbines are similar in appearance to wind turbines that are mounted on the seabed. They are designed to exploit the higher energy density, but lower velocity, of tidal flows compared to wind. Tidal barrages are similar to hydropower dams in that they are dams with gates and turbines installed along the dam. When the tides produce an adequate difference in the level of the water on opposite sides of the dam, the gates are opened and water is forced through turbines, which turns a generator. For those tidal differences to be harnessed into electricity, the difference in water height between the high and low tides must be at least 4.9 meters (16 feet). There are only about 20 sites on Earth with tidal ranges of this magnitude (DOE, 2009). The only sites with adequate tidal differences within the United States are in Maine and Alaska (CEC, 2009). Therefore, tidal resources off the coast of the ROI do not provide a viable tidal energy resource.

Ocean thermal energy conversion (OTEC) technology capitalizes on the fact that the water temperatures decrease with depth. As long as the temperature between the warm surface water and the cold deep water differs by about 20°C (36°F), an OTEC system can produce a significant amount of power. The temperature gradient off of the coast of the ROI is less than 18°C (32°F) and not a good resource for OTEC technology (NREL, 2008).

Wave energy conversion takes advantage of the kinetic energy in the ocean waves (which are mainly caused by interaction of wind with the surface of the ocean). Wave energy offers an irregular, oscillatory, low frequency energy source that must be converted to a 60-Hertz frequency before it can be added to the power grid (CEC, 2009). Wave energy resources are best between 30 and 60 degrees latitude in both hemispheres and the potential tends to be greatest on western coasts (RNP, 2007). Ocean Power Technologies, Inc. deployed a 40-kilowatt PowerBuoy wave energy converter off the coast of New Jersey in November 2005 (DOE, 2005).

Offshore technologies that harness the energy of ocean waves and current are in their infancy, and have not been used at utility scale (NREL, 2008). Since the late 1990s, new technologies have been introduced to harness the energy of the ocean's waves, currents, and tides. Nearly 100 companies worldwide have joined this effort but most companies struggle to deploy their first prototypes and not all can be funded from the public sector. A viable strategy to help mature the marine renewable energy industry does not exist (NREL, 2008). Hence, although some technologies may be available in the future, none has yet been demonstrated to be capable of providing the electrical generating capacity needed to replace LGS's base-load generating capacity.

Exelon Generation believes that tidal, ocean thermal, and wave technologies have not matured sufficiently to provide a viable supply of replacement base-load electricity for LGS. As a result, Exelon Generation has concluded that, due to cost and production limitations, these technologies are not reasonable alternatives to LGS license renewal.

Wood Energy

As discussed in the GEIS, the use of wood waste to generate electricity is largely limited to those states with significant wood resources. The pulp, paper, and paperboard industries in states with adequate wood resources generate electric power by consuming wood and wood waste for energy, benefiting from the use of waste materials that could otherwise represent a disposal problem. It takes roughly one ton per hour of wood waste to produce one MWe of electricity. Generally, the largest wood waste power plants are 40 to 50 MWe in size.

Further, as discussed in Section 8.3.6 of the GEIS, construction of a wood-fired plant would have an environmental impact that would be similar to that for a coal-fired plant, although facilities using wood waste for fuel would be built on smaller scales. Like coal-fired plants, wood waste plants require large areas for fuel storage, processing, and waste (i.e., ash) disposal. Additionally, operation of wood-fired plants has environmental impacts, including impacts on the aquatic environment and air. Wood has a low heat content that makes it unattractive for base-load applications. It is also difficult to handle and has high transportation costs.

While some wood resources are available in the ROI, Exelon Generation believes that, due to the lack of an environmental advantage, low heat content, handling difficulties, and high transportation costs, wood energy cannot provide a viable supply of replacement base-load electricity for LGS. Hence, Exelon Generation has concluded that wood energy is not a reasonable alternative to LGS license renewal.

Municipal Solid Waste

As discussed in Section 8.3.7 of the GEIS, the initial capital costs for municipal solid waste plants are greater than for comparable steam turbine technology at wood-waste facilities. This is due to the need for specialized waste separation and handling equipment.

The decision to burn municipal solid waste to generate energy is usually driven by the need for an alternative to landfills, rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of unfavorable economics. Estimates in the GEIS suggest that the overall level of construction impacts from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate, but still larger than the environmental effects of LGS license renewal.

Exelon Generation believes that, due to the high costs and lack of environmental advantages, burning municipal solid waste to generate electricity cannot provide a viable supply of replacement base-load electricity for LGS. Hence, Exelon Generation has concluded that burning municipal solid waste is not a reasonable alternative to LGS license renewal.

Other Biomass-Derived Fuels

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning energy crops, converting crops to a liquid fuel such as ethanol (ethanol is primarily used as a gasoline additive), and gasifying energy crops (including wood waste) (Walsh et al., 2000). As discussed in the GEIS, none of these technologies has progressed to the point of providing a competitive and reliable boiler fuel for large-scale use to replace a base-load plant such as LGS (NREL, 2005).

Further, estimates in the GEIS suggest that the overall level of construction impacts from a crop-fired plant should be approximately the same as that for a wood-fired plant. Additionally, crop-fired plants would have similar operational impacts (including impacts on the aquatic environment and air). These systems also have large impacts on land use, due to the acreage needed to grow energy crops (NREL, 2005).

Exelon Generation believes that, due to the high costs and lack of environmental advantage, burning other biomass-derived fuels to generate electricity cannot provide a viable supply of replacement base-load electricity for LGS. Hence Exelon Generation has concluded that burning other biomass-derived fuels is not a reasonable alternative to LGS license renewal.

Petroleum

The PJM region has several petroleum (oil)-fired power plants; however, they produce less than one percent of the total power generated in the region (PJM, 2009b). From 2002 to 2009, utilities reduced the proportion of power produced by oil-fired generating plants by 78 percent (EIA, 2010c, Table 1.1). Oil-fired operation is more costly than nuclear or coal-fired operation, and future increases in petroleum prices are expected to make oil-fired generation increasingly more costly. Also, construction and operation of an oil-fired plant would have significant environmental impacts. For example, Section 8.3.11 of the GEIS estimates that construction of a 1,000-MWe oil-fired plant would require about 48.6 hectares (120 acres). Additionally, operation of oil-fired plants would have significant environmental impacts (including impacts on the aquatic environment and air) that would be comparable to those from a coal-fired plant.

Exelon Generation has concluded that, due to the high costs and lack of obvious environmental advantage, burning oil to generate electricity is not a reasonable alternative to LGS license renewal.

Fuel Cells

Fuel cell power plants are in the initial stages of commercialization. While more than 900 large stationary fuel cell systems have been built and operated worldwide, the global stationary fuel cell electricity generating capacity in 2008 was only 175 MWe. In addition, the nominal stationary fuel cell power plant is only one MWe (Fuel Cell Today, 2008). Recent estimates demonstrate a price of $2,500 per kilowatt (Fuel Cell Today, 2008). However, the production capability of the largest stationary fuel cell is 2.4 MWe.

Exelon Generation believes that fuel cell technology has not matured sufficiently to provide a viable supply of replacement base-load electricity for LGS. As a result, Exelon Generation has concluded that, due to cost and production limitations, fuel cell technology is not a reasonable alternative to LGS license renewal.

Next Generation Nuclear Power

Increased interest in the development of next generation nuclear plants (NGNP) has been expressed by members of both industry and government (DOE, 2008c). These technologies are referred to as Generation IV reactors, and include such technologies as the very-high-temperature gas-cooled reactor (VHTR) technology (DOE, 2008b). The Energy Policy Act of 2005 requires that research, development, design, construction, and operation of a prototype NGNP plant be completed by 2021 (DOE, 2008c). With this schedule for development of a prototype, Exelon Generation considers it unlikely that a commercially viable replacement for LGS using NGNP technology could be sited, planned, licensed, constructed, and brought online by the time the existing LGS operating licenses expire in 2024 and 2029.

Delayed Retirement

As the NRC noted in the GEIS, extending the lives of existing non-nuclear generating plants beyond the time they were originally scheduled to be retired represents another potential alternative to license renewal. Exelon Generation currently has plans to retire three coal-fired units and one oil-fired unit that are no longer economically suitable to operate. However, the combined generating capacity of the two units at Cromby Generating Station and the two units at Eddystone Generating Station is only 946 MWe (Exelon Corporation, 2010c; Exelon

Corporation, 2010e). Thus, delayed retirement of the above generation sources could not replace the 2,340 MWe generated at LGS.

Power generating utilities within the PJM region have retired non-nuclear generating facilities totaling 5,945 MWe from 2003 to 2009, and this has resulted in multiple reliability criteria violations. The problem has been magnified by steady load growth and sluggish generation additions (PJM, 2009b). Some potential reliability issues have been forestalled through a combination of short lead-time transmission upgrades, voluntary deactivation deferrals, and implementation of a process that compensates generators that remain online beyond announced retirement dates. However, the Federal Energy Regulatory Commission has determined that PJM cannot compel the owners of units scheduled for retirement to keep such units in service (PJM, 2009b). For these reasons, Exelon Generation does not consider the delayed retirement of non-nuclear generating units to be a reasonable alternative to LGS license renewal.

7.2.2 Environmental Impacts of Alternatives

This section evaluates the environmental impacts of alternatives that Exelon Generation has determined to be reasonable alternatives to LGS license renewal: gas-fired generation, coal-fired generation, purchased power, new nuclear generation, wind energy, solar energy, and combination alternatives.

7.2.2.1 Gas Fired Generation

NRC evaluated environmental impacts from gas-fired generation alternatives in the GEIS, focusing on combined-cycle plants. Section 7.2.1.1 presents Exelon Generation's reasons for defining the gas-fired generation alternative as a four-unit combined-cycle plant on an existing fossil plant site. Construction of a gas-fired unit would have impacts on land-use and could impact ecological, aesthetic, and cultural resources. Human health effects associated with air emissions would be of concern. Aquatic biota losses due to cooling water withdrawals would be offset by the concurrent shutdown of the nuclear generator.

Air Quality

Natural gas is a relatively clean-burning fossil fuel that primarily emits nitrogen oxides (NOx), a regulated pollutant, during combustion. A natural gas-fired plant would also emit small quantities of sulfur oxides [presented as sulfur dioxide (SO_2)][7], particulate matter (PM), and carbon monoxide (CO), all of which are regulated pollutants. In addition, a natural-gas-fired plant would produce CO_2, a greenhouse gas.

Control technology for gas-fired turbines focuses on NOx emissions. From data published by EPA, the emissions from the natural gas-fired plant are calculated to be:

SO_2 = 153.3 metric tons (169 tons) per year

NOx = 404.6 metric tons (446 tons) per year

CO = 2,698.9 metric tons (2,975 tons) per year

[7] For gas-fired generation, EPA assumes all sulfur in fuel is converted to sulfur dioxide (SO_2) upon combustion; therefore, the terms SOx and SO_2 can be used interchangeably (EPA, 2000).

Filterable Particulates = 85.3 metric tons (94 tons) per year [all particulates are particulates with diameters of 2.5 microns or less ($PM_{2.5}$)]

CO_2 = 4,948,052.0 metric tons (5,454,202 tons) per year

Recently, Pennsylvania was ranked first nationally in sulfur dioxide (SO_2) emissions (EIA, 2010e), second nationally in CO_2 emissions (EIA, 2010d), and fourth nationally in NOx emissions from electric power plants (EIA, 2010e). The ranking was based on quantity emitted. For example, no state's power plants emitted more SO_2 than Pennsylvania's. The acid rain requirements of the 1990 Clean Air Act (CAA) amendments capped the nation's SO_2 emissions from power plants. Each company with fossil-fuel-fired units was allocated SO_2 allowances. To be in compliance with the CAA, the companies must hold enough allowances to cover their annual SO_2 emissions. Exelon Generation would need to obtain SO_2 credits to operate a fossil-fuel-fired plant. In 1998, the EPA promulgated the NOx SIP (State Implementation Plan) Call regulation that required 22 states, including Pennsylvania, to reduce their NOx emissions by over 30 percent to address regional transport of ground-level ozone across state lines (EPA, 1998b). In 2005, EPA issued the Clean Air Interstate Rule (CAIR), which required 28 states and the District of Columbia to revise their SIPs to include control measures to reduce emission of SO_2 and/or NOx. Further, the CAIR gave the states an option to comply through adoption of model rules implementing an EPA-administered SO_2 and NOx emissions trading program. Subsequently, the CAIR was remanded by the federal DC Circuit Court of Appeals, and in August 2010, EPA published the draft Transport Rule, which when finalized, will replace the CAIR. The draft Transport Rule would require 31 states and the District of Columbia to significantly reduce SO_2 and NOx emissions that cross state lines. The draft Transport Rule would set pollution limits for each state and, under EPA's preferred option, would allow emissions trading. Hence, to operate a new fossil-fuel-fired plant, Exelon Generation would need to obtain enough NOx credits and SO_2 allowances to cover annual emissions. Additionally, because most of the ROI is treated as a non-attainment area for ozone, a fossil-fuel-fired plant would need to obtain NOx emission reduction credits in the amount of 1.04 metric tons (1.15 tons) of NOx for every ton of NOx emitted. EPA is currently scheduled to issue the final Transport Rule during 2011.

NOx effects on ozone levels, SO_2 allowances, and NOx credits could all be issues of concern for gas-fired combustion. While gas-fired turbine emissions are less than coal-fired boiler emissions, the emissions are still substantial. Exelon Generation concludes that emissions from the gas-fired alternative would noticeably alter local air quality, but would not cause or contribute to violations of National Ambient Air Quality Standards in the region. Based on these emissions, Exelon Generation believes human health impacts would be SMALL to MODERATE. Air quality impacts would, therefore, be MODERATE.

Waste Management

The solid waste generated from this type of facility would be minimal. The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NOx control. The SCR process for a 2,120 MWe plant would generate only a small amount of spent catalyst per year (NRC, 2002b). Exelon Generation concludes that gas-fired generation waste management impacts would be SMALL.

Water Resources

Impacts to aquatic resources and water quality would be smaller than the impacts of LGS due to the replacement plant's use of the cooling water withdrawals from and discharges to the Schuylkill River or other naturally occurring body of water. These impacts would be offset by the concurrent shutdown of LGS. Exelon Generation concludes that gas-fired generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Construction of the gas-fired alternative on an existing plant site would impact the construction site and the supporting utility corridors. A new gas pipeline would likely be required for the gas turbine generators in this alternative. To the extent practicable, Exelon Generation would route the pipeline along existing, previously disturbed, rights-of-way to minimize impacts. Two new pipelines, each approximately 40.64 centimeters (16 inches) in diameter, would require a 30.5-meter-wide (100-foot-wide) corridor. This new construction may also necessitate an upgrade of the statewide pipeline network. Exelon Generation estimates that 14.2 hectares (35 acres) would be needed for a plant site, but the location on an existing plant site would minimize any impacts. Therefore, land use impacts would be SMALL. Erosion and sedimentation, fugitive dust, and construction debris impacts would be noticeable but SMALL with appropriate controls. Compliance with the Endangered Species Act would minimize any impacts on Threatened or Endangered species, ensuring a SMALL impact. The resultant loss in terrestrial habitat would be mitigated by location on an existing site, thus the impact to ecological resources would be SMALL. The National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Officer, where any cultural and historic impacts of construction of the facility or transmission lines would be addressed. Impacts to cultural resources would be possible, but if surveys for archaeological and cultural resources were not already done at the time the existing plant at the selected site was constructed, site surveys would be conducted to identify these resources and mitigate any impacts. Therefore, impacts to cultural resources would remain SMALL. Exelon Generation estimates a peak construction workforce of 800; thus, socioeconomic impacts of construction would be SMALL. However, Exelon Generation estimates a significantly reduced workforce of 45 for gas operations, resulting in adverse socioeconomic impacts due to the loss of approximately 700 personnel responsible for operational activities at LGS and the approximately 1,400 additional personnel employed during each LGS refueling outage (Exelon Corporation, 2010d). Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, offsite land use, economic structure, and public services. Exelon Generation believes these impacts would be MODERATE.

The stacks and boilers of the new gas-fired unit may add visual impacts at the existing power plant site where it is constructed; but these should be minimal because of the presence of existing plant structures and the impact on aesthetic resources would be SMALL.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace LGS capacity. From a local perspective, loss of LGS's generating capacity could require construction of new transmission lines to ensure local system stability. From a regional perspective, PJM's inter-connected transmission system is highly reliable.

7.2.2.2 Coal-Fired Generation

NRC evaluated environmental impacts from coal-fired generation alternatives in the GEIS. NRC concluded that construction impacts could be substantial, due in part to the large land area required (which can result in natural habitat loss) and the large workforce needed. NRC identified major adverse impacts from operations as human health concerns associated with air emissions, waste generation, and losses of aquatic biota due to cooling water withdrawals and discharges.

The coal-fired alternative that Exelon Generation has defined in Section 7.2.1.1 would be located at an existing plant site.

Air Quality

A coal-fired plant would emit sulfur oxides[8] (SOx), NOx, PM, mercury, and CO, all of which are regulated pollutants. A coal-fired plant would also emit CO_2, which is a greenhouse gas. As Section 7.2.1.1 indicates, Exelon Generation has assumed a plant design that would minimize air emissions through a combination of boiler technology and post combustion pollutant removal. Using data published by the Energy Information Administration (EIA, 2010a; EIA, 2011a) and the EPA (EPA, 1998a) the coal-fired alternative emissions are calculated to be as follows:

SOx = 13,100.9 metric tons (14,441 tons) per year

NOx = 1,665.6 metric tons (1,836 tons) per year

CO = 1,665.6 metric tons (1,836 tons) per year

Mercury = 0.272 metric tons (0.30 tons) per year

PM:

PM_{10} (particulates having a diameter of greater than 2.5 microns to 10 microns) = 125.2 metric tons (138 tons) per year

$PM_{2.5}$ (particulates having a diameter 2.5 microns or less) = 32.7 metric tons (36 tons) per year

CO_2 = 18,353,912 metric tons (20,231,385 tons) per year

The discussion in Section 7.2.2.1 of regional air quality is applicable to the coal-fired generation alternative. In addition, NRC noted in the GEIS that adverse human health effects from coal combustion have led to important federal legislation in recent years and that public health risks, such as cancer and emphysema, have been associated with coal combustion. NRC also mentioned global warming and acid rain as potential impacts. Exelon Generation concludes that federal legislation and large-scale concerns, such as global warming and acid rain, are indications of concerns about destabilizing important attributes of air resources. However, SOx emission allowances, NOx credits, low NOx burners, over-fire air, fabric filters or electrostatic precipitators, and scrubbers are imposed mitigation measures by regulation. As such, Exelon Generation concludes that the coal-fired alternative would have MODERATE impacts on air quality; the impacts would be noticeable and greater than those of the gas-fired alternative, but would not destabilize air quality in the area. The impacts on human health would likewise be MODERATE.

---

[8] For coal-fired generation, SOx includes sulfur dioxide (SO_2), sulfur trioxide (SO_3), and other compounds of sulfur generated by coal combustion (EPA, 1998a).

Waste Management

Exelon Generation concurs with the GEIS assessment that the coal-fired alternative would generate substantial solid waste. The coal-fired plant would annually consume approximately 6,658,848 metric tons (7,340,000 tons) of coal having an ash content of 16.29 percent. After combustion, 45 percent of this ash (ACAA, 2011), approximately 539,109 metric tons (538,059 tons) per year, would be marketed for beneficial reuse. The remaining ash, approximately 724,911 metric tons per year (657,627 tons per year), would be collected and disposed of onsite, if space were available. In addition, if space were available, approximately 507,125 metric tons (559,000 tons) of scrubber sludge would be disposed of onsite each year (based on annual limestone usage of about 425,477 metric tons or 469,000 tons). Exelon Generation estimates that ash and scrubber waste disposal over a 20-year period would require approximately 187 hectares (464 acres). If this acreage is not available at the existing power plant site where the new coal-fired unit would be sited, offsite disposal may be necessary, which would increase disposal impacts.

Exelon Generation believes that proper siting, current waste management practices, and current waste monitoring practices would prevent waste disposal from destabilizing any resources. After closure of the waste site and revegetation, the land would be available for other uses. For these reasons, Exelon Generation believes that waste disposal for the coal-fired alternative would have MODERATE impacts; the impacts of increased waste disposal would be noticeable, but would not destabilize any important resource.

Water Resources

Impacts to aquatic resources and water quality would be similar to impacts of LGS, due to the new plant's use of the cooling water from and discharge to the Schuylkill River or other natural water body, and the use of cooling towers, and would be offset by the concurrent shutdown of LGS. These impacts would be offset by the concurrent shutdown of LGS. Exelon Generation concludes that coal-fired generation aquatic resources and water quality impacts would be SMALL.

Other Impacts

Exelon Generation estimates that construction of the power block and coal storage area would affect 113.3 hectares (280 acres) of land and associated terrestrial habitat. Because much of this construction would be on previously disturbed land, impacts would be SMALL to MODERATE. Installation of a new rail spur or expansion of an existing spur would likely be required for coal and limestone deliveries under this alternative. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of onsite. The resultant loss in terrestrial habitat would be mitigated by location on an existing site, but the waste would require dedication of 187 hectares (464 acres), thus the impact to ecological resources would be SMALL to MODERATE. Compliance with the Endangered Species Act would minimize any impacts on Threatened or Endangered species, ensuring a SMALL impact. The National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Officer, where any cultural and historic impacts of construction of the facility or transmission lines would be addressed and, therefore, would remain SMALL. Impacts to cultural resources would be possible, but if surveys for archaeological and cultural resources were not already done at the time the existing plant at the selected site was constructed, site surveys would be conducted to identify these resources and mitigate any impacts; therefore, impacts to cultural resources would remain SMALL. Exelon Generation estimates a peak construction work force of 2,500 people. Socioeconomic impacts from the construction workforce would be minimal, if worker relocation is not required with a site located near a large metropolitan area. Exelon Generation estimates an operational workforce of 141 people for the coal-fired alternative. This is a sizable reduction in operating personnel compared to LGS's approximately 700 personnel and the approximately 1,400 additional personnel employed during each LGS refueling outage (Exelon Corporation, 2010d). Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, offsite land use, and public services, which could be significant. Thus, reduction in workforce would result in adverse socioeconomic impacts characterized as MODERATE.

Visual impacts would be consistent with the industrial nature of the site. The stacks, boilers, and rail deliveries would change the visual impact to the site, but the impacts should be minimal because of the presence of existing plant structures. Impacts to cultural resources would also be possible, but site surveys would be conducted to identify these resources and mitigate any impacts. Thus, aesthetic impacts would be characterized as SMALL.

7.2.2.3 Purchased Power

As discussed in Section 7.2.1.2, Exelon Generation assumes that the generating technology used under the purchased power alternative would be one of those that NRC analyzed in the GEIS. Exelon Generation is also adopting by reference the NRC analysis of the environmental impacts from those technologies. Under the purchased power alternative, therefore, environmental impacts would still occur, but they would likely originate from a power plant located elsewhere in the PJM region. Exelon Generation believes that imports from outside the PJM region would not be required.

Impacts would occur in areas where purchased power is produced. Impact magnitude would be incremental and reflective of the increased amount of power being produced. The impact to threatened and endangered species, aesthetics, socioeconomics, and cultural resources are anticipated to be SMALL based on there being no new construction required. The impact to all other resources could be SMALL to MODERATE, depending on the type of fuel used, waste management practices, and locations of the facilities.

Exelon Generation anticipates that additional transmission infrastructure would be needed in the event purchased power must replace LGS capacity. From a local perspective, loss of LGS capacity could require construction of new transmission lines to ensure local system stability. From a regional perspective, PJM's inter-connected transmission system is highly reliable.

7.2.2.4 New Nuclear Capacity

As discussed in Section 7.2.1.3, under the new nuclear capacity alternative, Exelon Generation would construct new nuclear generating units of comparable sizes using an NRC-certified standard design. Although Exelon Generation has not identified a location for a new nuclear plant at or near the LGS plant site, Exelon Generation is assuming the new nuclear plant would be sited on the LGS plant site.

Air Quality

Air quality impacts would be minimal. Air emissions, primarily from facility equipment (e.g., diesel generators, auxiliary boilers) and non-facility equipment (e.g., vehicular traffic), would be comparable to those associated with the continued operation of LGS. Overall, such emissions and associated impacts are characterized as SMALL.

Waste Management

Management of radioactive and nonradioactive wastes would be similar to that associated with the continued operation of LGS. Quantities of low-level radioactive wastes (LLRW) would be higher due to clean up of the old units. The overall impacts are characterized as SMALL.

Water Resources

Impacts to aquatic resources and water quality would be similar to impacts of LGS, due to use by the new unit(s) of the existing cooling water intake and discharge structures and water supplies, and the cooling towers. The overall impacts are characterized as SMALL.

Other Impacts

Exelon Generation estimates that construction of the reactor units and auxiliary facilities would affect 255 to 510 hectares (630 to 1,260 acres) of land and associated terrestrial habitat. Because most of this construction would be on previously disturbed land, impacts at the LGS site would be SMALL to MODERATE. For the purposes of analysis, Exelon Generation has assumed that the existing roadway infrastructure would be used for reactor vessel and other deliveries under this alternative. Visual impacts would be consistent with the industrial nature of the site, thus aesthetic impacts would be SMALL. As with any large construction project, some erosion and sedimentation and fugitive dust emissions could be anticipated, but would be minimized by using best management practices. Debris from clearing and grubbing could be disposed of onsite. Compliance with the Endangered Species Act would minimize any impacts on Threatened or Endangered species, ensuring a SMALL impact. The National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Officer, where any cultural and historic impacts of construction of the facility or transmission lines would be addressed and, therefore, would remain SMALL.

Exelon Generation estimates a peak construction work force of approximately 3,650 workers. The surrounding communities would experience moderate demands on housing, public services, and transportation during construction. Long-term job opportunities would be comparable to continued operation of LGS. Therefore, Exelon Generation concludes that socioeconomic impacts during construction would be SMALL TO MODERATE and during operation would continue to be SMALL.

Exelon Generation estimates that other construction and operation impacts would be SMALL. In most cases, the impacts would be detectable, but they would not destabilize any important attribute of the resource involved. Due to the minor nature of these other impacts, mitigation would not be warranted.

7.2.2.5 Wind Energy

As discussed in Section 7.2.1.4, between 4,400 MW and 18,000 MW of new wind capability could be required to replace LGS's base-load generating capacity depending on whether the present-day or projected future capacity factors are applied. Each wind turbine needed to provide utility-scale wind generation capability would have a small footprint but would be tall structures (up to about 121 meters or 400 feet to tip of rotor) with large rotors (up to about 82-meter or 230-foot rotor diameter), requiring an otherwise undisturbed airspace around it. Hence, development of wind energy projects to replace LGS's capacity would requires large commitments of land and, although land-based wind projects may be able to coexist with land uses such as farming, ranching, and forestry, wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes (DOE, 2008a). Also, construction and operation of wind turbines could affect ecological, aesthetic, and cultural resources.

Air Quality

Potential benefits of using wind-generated electricity include reduction (compared with fossil-fueled generation) in the levels emitted into the atmosphere of carbon dioxide (CO_2), which is believed to be the major cause of global climate change (DOE, 2008a). In addition, compared with fossil-fueled generation, levels emitted into the atmosphere of regulated pollutants such as nitrogen oxides, sulfur dioxide, and mercury, which can cause human health effects, would be reduced (DOE, 2008a). Hence, air quality impacts from wind generation would be minimal. Some air emissions from portable diesel generators and vehicular traffic during construction and operation would be comparable to or less than those associated with the continued operation of LGS. Overall, pollutant emissions to air and associated impacts are characterized as SMALL. The impacts on human health would likewise be SMALL.

Waste Management

Minor quantities of construction-related wastes would be generated. During operation, maintenance activities could generate dielectric fluids at the wind turbine locations and substations. Overall, non-radioactive waste produced at wind generation facilities would be minimal and associated impacts are characterized as SMALL. Radioactive wastes are not produced at wind generation facilities.

Water Resources

No water would be consumed during construction or operation of wind generation facilities, and no water would be diverted for non-consumptive cooling use. Hence, impacts to aquatic resources would be minimal. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel, but such impacts are also expected to be minimal. Overall, impacts on aquatic resources and water quality from wind generation facilities are characterized as SMALL.

Other Impacts

Denholm et al. (2009) reports that there is no uniformly accepted single metric of land use for wind power plants. However, two primary indices of land use do exist – the infrastructure/direct impact area (land temporarily or permanently disturbed by wind power plant development) and the total impact area (overall area of the power plant as a whole) (Denholm et al., 2009).

Permanent direct impact caused by road development, turbine pads and electrical support equipment was found to average between zero and 0.3 hectares/MW of capability, while temporary direct impact was found to average between 0.1 and 1.3 hectares/MW of capability, for a combined direct impact area (both temporary and permanently disturbed land) of between 0.3 and 1.7 hectares/MW (Denholm et al., 2009). The average value for the total area occupied by a land-based wind power plant was found to be between 12 and 56 hectares/MW (Denholm et al., 2009). Using the lower end of the ranges of these estimates (to provide a conservative impacts comparison), new wind generating plants to replace the LGS approximate annual average net base-load generating capacity of 2,340 MWe may have a total direct impact area ranging from 1,312 hectares (based on estimated 2025 PJM capacity credit) to 5,400 hectares (based on current-day PJM capacity credit) (3,242 acres to 13,343 acres). Meanwhile, the overall area occupied by such wind power plants may range from 52,486 hectares (based on estimated 2025 PJM capacity credit) to 216,000 hectares (based on current-day PJM capacity credit) (129,691 acres to 533,729 acres). Furthermore, it is unlikely that siting wind generation projects at existing power plant sites to reduce new land development impacts would be possible. In comparison, the LGS plant site occupies approximately 261 hectares (645 acres), and no new land development would occur as a result of license renewal. Overall, land use impacts from wind energy development are characterized as LARGE.

In addition to relatively high land requirements, development of land-based wind power projects may cause other direct and indirect environmental impacts that are predominately local, but can concern individuals in the affected communities and landscapes (DOE, 2008a). For example, indirect impacts can include trees being removed around turbines, edges in a forest being detrimental to some species, and the presence of turbines causing some species or individuals to avoid previously viable habitats. Indirect habitat impacts on grassland species are a particular concern, because extensive wind energy development could take place in grassy regions of the country (DOE, 2008a). Direct impacts can include bird and bat mortality from collisions with turbines. This is a particular worry with bats because they are relatively long-lived mammals with low reproduction rates, which means that species populations could be impacted. Within the PJM region, New Jersey has evaluated the land in its coastal zone and prepared the Large Scale Wind Turbine Siting Map, which identifies specific areas where wind turbines 61 meters (200 feet) in height or taller or having a cumulative rotor swept area of greater than 372 square meters (4,000 square feet) are unacceptable due to the operational impacts of the turbines on birds and bats (NJDEP, 2009). In comparison, no new land development would occur as a result of LGS license renewal. Overall, the direct and indirect environmental impacts of wind energy development on ecological resources are characterized as SMALL to MODERATE.

Compliance with the Endangered Species Act would minimize any impacts on Threatened or Endangered species, ensuring a SMALL impact.

The National Historic Preservation Act, applicable to land-based facilities, mandates that impacts must be determined through consultation with the State Historic Preservation Officer, where any cultural and historic impacts of construction of the wind generation facilities or transmission lines would be addressed and, therefore, would remain SMALL. Impacts to cultural resources would be possible, but if surveys for archaeological and cultural resources were not already done in the area, site surveys would be conducted to identify these resources and mitigate any impacts prior to construction; therefore, impacts to cultural resources would remain SMALL.

Visual impacts would be considerable due to the number and size of wind turbines that would be required to provide between 4,400 MW and 18,000 MW of new wind capability, and because they would be prominent from afar in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a construction workforce of 200 and a permanent maintenance and operational workforce of 50 for the wind alternative, which could be larger based on the selected wind capability requirement. This is a sizable reduction in operating personnel compared to LGS's approximately 700 personnel and the approximately 1,400 additional personnel employed during each LGS refueling outage (Exelon Corporation, 2010d). Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, offsite land use, and public services, which could be significant. However, the communities and land-owners where the wind facilities would be located would benefit via royalties on land leases, property tax payments, and direct and indirect jobs. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

Offshore Facility Impacts

Offshore wind generation projects would create fewer land use conflicts than land-based wind projects, but the costs of offshore wind projects are higher than land-based projects by about 400 percent, which can be attributed to the added complexity of siting wind turbines in a marine (and potentially harsher) environment, higher foundation and infrastructure costs, and higher operations and maintenance costs because of accessibility issues and the corrosive nature of the marine environment (DOE, 2010). NREL's Regional Energy Deployment System (ReEDS) model shows nationwide offshore wind potential penetration of between 54 gigawatts (GW) and 89 GW by 2030, but only when economic scenarios favoring offshore wind are applied, including combinations of cost reductions (resulting from technology improvements and experience), rising natural gas prices (3 percent annually), heavy constraints on conventional power and new transmission development in congested coastal regions, and national incentive policies including grants and favorable loan policies (NREL, 2010b; NREL,2010c). Further, little information is available regarding other potential impacts of developing offshore wind generation plants in the eastern United States, including impacts on marine and avian life, tourism, and commercial and recreational fishing (NJ, 2006). As a result, the New Jersey Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters recommended the exercise of sound planning and caution when moving forward with the development of renewable technologies, including offshore wind (NJ, 2006). Hence, while future development of wind generation plants in the ROI is likely to include both land-based and offshore plants, comparisons of LGS license renewal impacts with offshore wind generation plant impacts is difficult. However, because LGS license renewal involves no new construction, impacts from LGS license renewal would be in all respects equivalent to or less than impacts from construction of a new offshore wind generation plant.

7.2.2.6 Solar Energy

As discussed in Section 7.2.1.5, replacement of the LGS approximate annual average net base-load generating capacity of 2,340 MWe, assuming the current-day capacity credit for solar generating capacity would require dedication of about 40,000 hectares (98,900 acres) of land for PV and about 62,200 hectares (154,000 acres) of land for CSP.

Air Quality

Potential benefits of using solar-generated electricity include reduction (compared to fossil-fueled generation) in the levels emitted into the atmosphere of carbon dioxide (CO_2), which is believed to be the major cause of global climate change (BLM/DOE, 2010). However, any solar technology will have emissions during operations of fugitive dust and engine exhaust from onsite maintenance and repair activities as well as from commuter/delivery/support vehicles. These emissions would include a small amount of regulated pollutants (e.g., nitrogen oxides, sulfur dioxide, and mercury), volatile organic compounds, carbon dioxide, and hazardous air pollutants (BLM/DOE, 2010). Such emissions would be intermittent and would have minor impacts on ambient air quality. Power block emissions at CSP generation facilities would include those from small-scale boilers that maintain heat transfer fluid temperatures and from wet-cooling towers (BLM/DOE, 2010). Since PV generation facilities have no power block, potential impacts on ambient air quality associated with operation of a PV facility would be negligible (BLM/DOE, 2010). Overall, air pollutant emissions from a CSP facility are characterized as MODERATE, while those from a PV facility are characterized as SMALL. The impacts on human health would be SMALL in either case.

Waste Management

Minor quantities of construction-related wastes would be generated for both CSP and PV facilities. Such wastes would be similar in character and quantity to wastes generated during construction of any large industrial facility (BLM/DOE, 2010).

During operation of any solar power facility, industrial wastes, domestic wastes, and wastewaters would be produced similar to any large industrial facility. Industrial wastes would include discarded materials and equipment, and general maintenance wastes such as spent solvents, used oil and filters, oily rags, used hydraulic and transmission fluids, spent glycol-based coolants, spent battery electrolyte, and spent lead-acid batteries (BLM/DOE, 2010). While some of these wastes could be toxic, the quantities of toxic wastes are expected to be small and would be managed in accordance with applicable environmental regulations (BLM/DOE, 2010). At PV facilities, high-performance solar cell materials would contain small amounts of toxic metals such as cadmium, selenium, and arsenic. Under normal conditions, these metals are secured within sealed solar panels and represent no hazard to workers or the public. When removed from service, legitimate recycling opportunities would be sought for these panels, but if such opportunities are not available, discarded solar panels containing toxic metals would be characterized, and they might need to be managed as hazardous waste (BLM/DOE, 2010). On an annual basis, malfunctions or damage sustained in accidents or as a result of weather extremes may result in some panels needing to be replaced (BLM/DOE, 2010). Although critical fluids at CSP facilities such as heat transfer fluids (typically a mix of synthetic organic oils, TES media (e.g., molten salts), and dielectric fluids would be present in substantial quantities, they are expected to last the life of the facility or the component in which they are installed. Thus, wastes consisting of these fluids would be routinely generated only in small amounts as a result of repairs and replacements of system components, as well as spills and leaks (BLM/DOE, 2010).

Domestic wastes would include wastes associated with workforce support such as discarded paper, beverage containers, food scraps, cardboard, glass, and plastic containers, and other non-hazardous trash (BLM/DOE, 2010).

Wastewaters would include wastes from industrial activities (spent aqueous cleaning/washing solutions, cooling system and steam cycle blowdowns, brines from water treatment, and spent glycol coolants), sanitary wastewaters from support of the workforce, and stormwater runoff from industrial areas (BLM/DOE, 2010). Industrial wastewaters generated at a CSP generation facility would also include blowdown from steam cycles and cooling systems and brines from water softening, which may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities (BLM/DOE, 2010). In comparison, PV facilities would not generate any wastes associated with the operation and maintenance of a steam cycle or cooling water systems (BLM/DOE, 2010).

Overall, non-radioactive waste types and volumes produced at a solar power generation facility would be comparable to or less than those associated with the continued operation of LGS, and associated impacts are characterized as SMALL. Radioactive wastes are not produced at solar power generation facilities.

Water Resources

Water use during construction of a solar power facility would be comparable to water use during construction of any large industrial facility.

During facility operation, a new CSP generation facility would likely use closed-loop cooling towers for removal of heat from the steam cycle, considering applicable environmental regulations. Water use associated with this activity would depend on the size of the facility (BLM/DOE, 2010). For a facility with electrical output equivalent to LGS, consumptive water use and quantities of water diverted for non-consumptive cooling use would be comparable to or less than those associated with the continued operation of LGS. Impacts to water quality could occur from accidental spills of petroleum lubricants and fuel or from spills during washing of reflective panels, but such impacts are also expected to be comparable to those associated with the continued operation of LGS. Overall, impacts on aquatic resources and water quality from CSP generation facilities are characterized as SMALL.

Operation of PV facilities would have minimal water consumption impacts because steam cooling is not needed. Impacts to water quality from operation of a PV facility would be comparable to or less than those associated with operation of a CSP facility or continued operation of LGS. Overall, impacts on aquatic resources and water quality from PV facilities are characterized as SMALL.

Other Impacts

Land requirements for solar plants are high. Estimates based on existing installations indicate that utility-scale plants would occupy about 1.5 hectares (3.8 acres) per MWe for PV and 3.2 hectares (8 acres) per MWe for solar thermal systems, such as CSP (Denholm, 2008). Utility-scale solar plants have only been used in regions, such as the western United States, that receive high concentrations of solar radiation (5 to 7.2 kilowatt hours per square meter per day). Considering that a utility-scale solar plant located in the PJM region receives only 2.8 to 3.9 kilowatt hours of solar radiation per square meter per day (NREL, 2010d), Exelon Generation estimates that a solar plant located in the PJM region would occupy about 6.5 hectares (16 acres) per MWe for PV and 10.1 hectares (25 acres) per MWe for CSP. However, the PJM Interconnection currently grants new solar facilities only 38 percent capacity credit (PJM, 2010). Therefore, replacement of the LGS approximate annual average net base-load generating capacity of 2,340 MWe, assuming the current-day capacity credit for solar generating capacity would require dedication of about 40,000 hectares (98,900 acres) of land for PV and about 62,200 hectares (154,000 acres) of land for CSP. In comparison, the LGS plant site occupies approximately 261 hectares (645 acres), and no new land development would occur as a result of license renewal.

No existing power plant sites in the ROI are large enough to accommodate either type solar plant of the generating capacity needed to replace the LGS base-load generation capacity. Accordingly, any solar plant constructed to replace LGS would have to be located on a greenfield site. Assuming that sufficient land could be acquired for a solar generation facility, development of the greenfield site would cause much larger land use impacts in comparison to renewal of the existing LGS operating licenses. Overall, land use impacts from both CSP and PV solar energy development is characterized LARGE.

Much of the land area occupied by either a CSP or PV generation facility would be cleared and maintained as an unvegetated or sparsely vegetated surface throughout the life of the facility. This would create an extensive loss of habitat for terrestrial, avian and plant communities. Adjacent plant communities could be affected by such factors as increased runoff, altered hydrology, sedimentation, reduced water quality, and erosion (BLM/DOE, 2010).

Habitat disturbance from the construction of a solar generation project could impact wildlife, and the presence of the solar generation facilities would create a physical hazard to some wildlife. In particular, birds could collide with certain components of solar generation facilities (e.g., towers and mirrors at CSP facilities), while mammals could collide with project fencing. However, ground-level collisions at solar plant sites would be infrequent, since the human activity, noise, and limited quantity and quality of habitat within the project site would discourage the presence of most wildlife in the immediate project area (BLM/DOE, 2010). In comparison, no new land development would occur as a result of LGS license renewal. Overall, the direct and indirect environmental impacts on ecological resources of both CSP and PV solar power projects occupying between 40,000 hectares (98,900 acres) and 62,200 hectares (154,000 acres) are characterized as LARGE.

If a CSP generation facility site is in the proximity of a military or civilian airport or a common aircraft flight path, the potential for glint and glare from reflective surfaces to adversely affect pilot control of aircraft would have to be considered as potential aircraft hazards (BLM/DOE, 2010).

Compliance with the Endangered Species Act would minimize any impacts on Threatened or Endangered species, ensuring a SMALL impact.

The National Historic Preservation Act mandates that impacts must be determined through consultation with the State Historic Preservation Officer, where any cultural resource impacts of construction of the solar generation facilities or transmission lines would be addressed and, therefore, would remain SMALL. Impacts to cultural resources would be possible, but if surveys for archaeological and historic resources were not already done in the area, site surveys would be conducted to identify these resources and mitigate any impacts prior to construction; therefore, impacts to cultural resources would remain SMALL.

Visual impacts would be considerable due to the number and size of either solar towers (approximately 91 meters or 300 feet in height) with arrays of sun-tracking heliostats (mirrors), or arrays of parabolic solar troughs together with ancillary systems that would be required to provide approximately 6,200 MWe of new solar capability (equivalent to LGS's base-load generating capacity, based on PJM's 38 percent capacity credit). These components would be prominent in the open landscape and over a large area. Thus, aesthetic impacts would be characterized as MODERATE to LARGE.

Socioeconomic impacts from the construction workforce could be significant, if worker relocation is required to sites located away from large metropolitan areas. Exelon Generation estimates a construction workforce of 200 and a permanent maintenance and operational workforce of 50 for the solar alternative, which could be larger based on the selected solar capability requirement. This is a sizable reduction in operating personnel compared to LGS's approximately 700 personnel and the approximately 1,400 additional personnel employed during each LGS refueling outage (Exelon Corporation, 2010d). Loss of the operational and temporary personnel would impact various aspects of the local community including employment, taxes, housing, offsite land use, and public services, which could be significant. However, the communities and land-owners where the wind facilities would be located would benefit via royalties on land leases, property tax payments, and direct and indirect jobs. Thus, the net socioeconomic impact is characterized as SMALL to MODERATE.

7.2.2.7 Wind Generation, PV Solar Generation and Gas-fired Combined-cycle Generation

Construction of the wind farm and the gas-fired combined-cycle plants would have relatively larger environmental impacts in comparison to LGS license renewal, which would involve no new construction activities. Operating impacts associated with the wind and PV solar portions of this alternative are described in Sections 7.2.2.5 and 7.2.2.6, respectively. Additional impacts from the backup gas-fired combined-cycle plants would be similar to those described in Section 7.2.2.1. As a whole, the combination of alternatives would have relatively greater impacts than from any of its three components. Furthermore, those impacts would also be greater than the impacts from renewal of the LGS operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of fossil-fuel-fired and renewable energy alternatives would be comparable to the small level of impacts associated with renewal of the LGS operating licenses because most alternatives would require construction activities.

7.2.2.8 Wind Generation Combined With Compressed Air Energy Storage

Construction of the land-based and off-shore wind farms and the CAES facility would have relatively larger environmental impacts in comparison to LGS license renewal, which would involve no new construction activities. Operating impacts associated with the wind portion of this alternative are described in Section 7.2.2.5. Impacts from the gas-fired portion of the energy recovery process associated with the CAES component would be similar to the impacts described in Section 7.2.2.1 for a gas-fired combined-cycle plant. As a whole, construction and operation of both a land-based wind generation facility and an off-shore wind generation facility combined with construction and operation of a CAES facility would have relatively greater impacts than the wind generation facilities alone. Furthermore, those impacts would also be greater than the impacts from renewal of the LGS operating licenses.

Exelon Generation concludes that it is very unlikely that the environmental impacts of this or any combination of renewable energy alternatives would be comparable to the small level of impacts associated with renewal of the LGS operating license because most alternatives would require construction activities.

Table 7.2-1 Gas-Fired Alternative

Characteristic	Basis
Plant size = 2,120 MWe ISO rating net consisting of four 530-MWe combined-cycle units	Manufacturer's standard size gas-fired combined-cycle units (total rating ≤ LGS net capacity of 2,340 MWe)
Plant size = 2,205 MWe ISO rating gross	Based on four percent onsite power usage
Number of plants/combined-cycle units = 1 / 4	Assumed
Fuel Type = natural gas	Assumed
Fuel heating value = 1,027 Btu/ft^3	2008 value for gas (EIA, 2010c)
Fuel SO_2 emission = 0.0034 lb/MMBtu	(EPA, 2000)
NOx control = selective catalytic reduction (SCR) with steam/water injection	Best available for minimizing NOx emissions (EPA, 2000)
Fuel NOx emission = 0.0090 lb/MMBtu	Typical for large SCR controlled gas fired units with water injection (EPA, 2000)
Fuel CO emission = 0.0600 lb/MMBtu	Typical for large SCR controlled gas fired units. (EPA, 2000)
Fuel PM_{10} emission = 0.0019 lb/MMBtu	(EPA, 2000)
Fuel CO_2 emission = 110 lb/MMBtu	(EPA, 2000)
Heat rate = 6,040 Btu/kWh	(Chase and Kehoe, 2000)
Capacity factor = 0.85	Assumed based on conservative performance of modern plants (EIA, 2010c)

Note: The difference between "net" and "gross" is electricity consumed onsite.
Note: The heat recovery steam generators (HRSGs) do not contribute to air emissions.
Btu = British thermal unit
ft^3 = cubic foot
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
MM = million
MWe = megawatt electrical
NOx = nitrogen oxides
PM_{10} = particulates having diameter of >2.5 microns to 10 microns
CO_2 = carbon dioxide
SO_2 = sulfur dioxide
≤ = less than or equal to

Table 7.2-2 Coal-Fired Alternative

Characteristic	**Basis**
Plant size = 2,120 MWe ISO rating net	Size set = to gas-fired alternative (≤ LGS net capacity of 2,340 MWe)
Plant size = 2,247 MWe ISO rating gross	Based on 6 percent onsite power usage
Number of plants = 1	Assumed
Boiler type = tangentially fired, dry-bottom	Minimizes nitrogen oxides emissions. (EPA, 1998a)
Fuel Type = bituminous, pulverized coal	Typical for coal used in Pennsylvania and the ROI (EIA, 2010c)
Fuel heating value = 11,549 Btu/lb	2008 value for coal used in Pennsylvania (EIA, 2010c)
Fuel ash content by weight = 16.29 percent	2008 value for coal used in Pennsylvania (EIA, 2010c)
Fuel sulfur content by weight = 2.07 percent	2008 value for coal used in Pennsylvania (EIA, 2010c)
Uncontrolled NOx emission = 10 lb/ton	Typical for pulverized coal, tangentially fired, dry-bottom, NSPS (EPA, 1998a)
Uncontrolled CO emission = 0.5 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA, 1998a)
Uncontrolled CO_2 emission = 5,510 lb/ton	Typical for pulverized coal, tangentially fired, dry bottom, NSPS (EPA, 1998a)
Heat rate = 10,138 Btu/kWh	Typical for coal-fired boilers (EIA, 2010c)
Capacity factor = 0.85	Typical for large coal-fired units
NOx control=low NOx burners, over-fire air and selective catalytic reduction (95 percent reduction)	Best available and widely demonstrated for minimizing NOx emissions (EPA, 1998a)
Particulate control = fabric filters (baghouse 99.9 percent removal efficiency)	Best available for minimizing particulate emissions (EPA, 1998a)
SOx control = Wet scrubber - limestone (95 percent removal efficiency)	Best available for minimizing SOx emissions (EPA, 1998a)

Note: The difference between “net” and “gross” is electricity consumed onsite.
Btu = British thermal unit
ISO rating = International Standards Organization rating at standard atmospheric conditions of 59 °F, 60 percent relative humidity, and 14.696 pounds of atmospheric pressure per square inch
kWh = kilowatt hour
NSPS = New Source Performance Standard
lb = pound
MWe = megawatt electrical
NOx = nitrogen oxides
SOx = sulfur oxides
CO_2 = carbon dioxide
≤ = less than or equal to

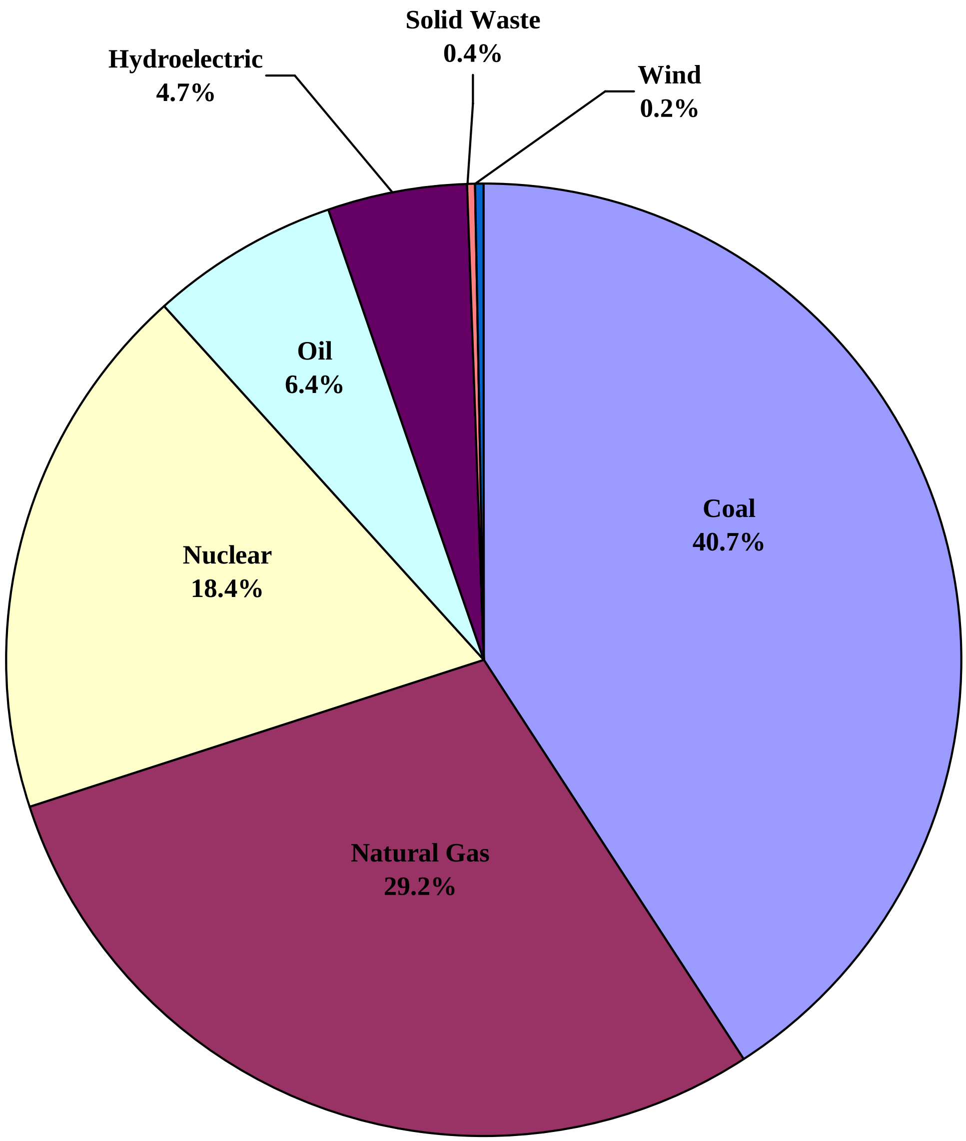


Figure 7.2-1 PJM Regional Generating Capacity by Fuel Type 2009

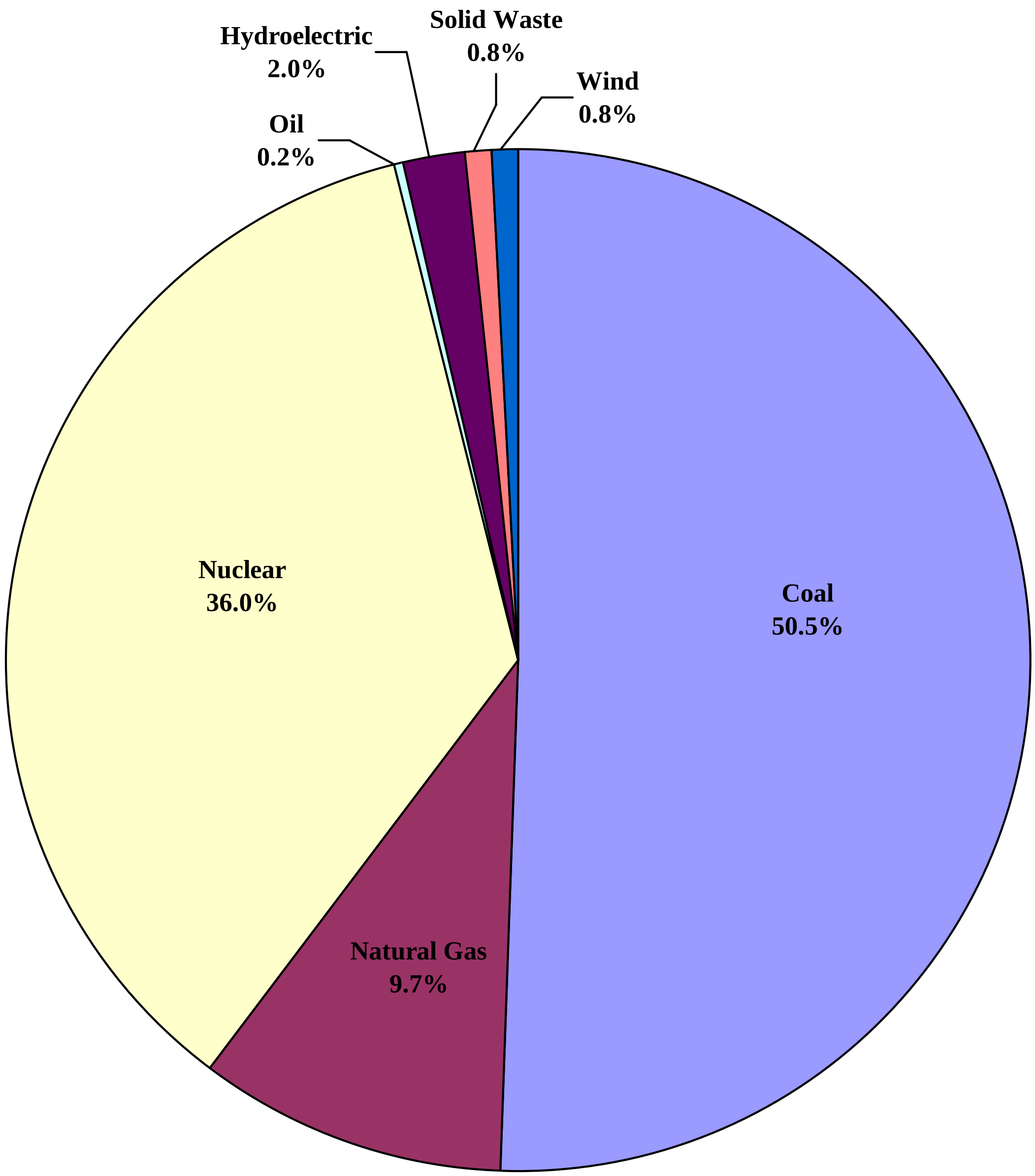


Figure 7.2-2 PJM Regional Energy Output by Fuel Type 2009

8.0 COMPARISON OF ENVIRONMENTAL IMPACT OF LICENSE RENEWAL WITH THE ALTERNATIVES

NRC

“To the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form...” 10 CFR 51.45(b)(3) as adopted by 51.53(c)(2)

8.1 Comparison of Impacts

Section 4.0 analyzes environmental impacts of the Limerick Generating Station Units 1 and 2 (LGS) license renewal and Section 7.0 describes potential alternatives to renewal and analyzes impacts from the alternatives deemed to be reasonable.

Table 8.0-1 summarizes environmental impacts of the proposed action (license renewal) and the alternatives deemed to be reasonable, for comparison purposes. The environmental impacts compared in Table 8.0-1 are those that are either Category 2 issues that apply to the proposed action or are issues that the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS) (NRC, 1996a) identified as major considerations in an alternatives analysis. For example, although the U.S. Nuclear Regulatory Commission (NRC) concluded that air quality impacts from the proposed action would be small (Category 1), the GEIS identified major human health concerns associated with air emissions from alternatives (Section 7.2.2). Therefore, Table 8.0-1 includes a comparison of the air impacts from the proposed action to those of the alternatives. Table 8.0-2 is a more detailed comparison of the alternatives.

As shown in Table 8.0-1 and Table 8.0-2, environmental impacts of the proposed action (LGS license renewal) are expected to be SMALL for all impact categories evaluated. In contrast, Exelon Generation expects that environmental impacts in some impact categories would be MODERATE or MODERATE to LARGE for the no-action alternative (NRC decision not to renew LGS operating licenses), considered with or without development of replacement generation facilities.

As a result, Exelon Generation concludes that the environmental impacts of the continued operation of LGS, providing approximately 2,340 MWe of base-load power generation through 2044, are superior to impacts associated with the best case among reasonable alternatives. LGS continued operation would create significantly less environmental impact than the construction and operation of new base-load generation capacity. Additionally, LGS continued operation will have a significant positive economic impact on the communities surrounding the station.

Table 8.0-1 Impacts Comparison Summary

Impact	Proposed Action (License Renewal)	No Action Alternative								
		Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Power	With Wind Energy Generation	With Solar Power Generation	With Combined Wind Energy, Solar Power, & Gas-Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Air Quality	SMALL	SMALL	MODERATE	MODERATE	SMALL TO MODERATE	SMALL	SMALL	SMALL TO MODERATE	SMALL TO MODERATE	SMALL TO MODERATE
Land Use	SMALL	SMALL	SMALL	SMALL TO MODERATE	SMALL TO MODERATE	SMALL TO MODERATE	LARGE	LARGE	LARGE	LARGE
Water Quality	SMALL	SMALL	SMALL	SMALL	SMALL TO MODERATE	SMALL	SMALL	SMALL	SMALL TO MODERATE	SMALL
Ecological Resources	SMALL	SMALL	SMALL	SMALL TO MODERATE	SMALL TO MODERATE	SMALL TO MODERATE	SMALL TO MODERATE	LARGE	SMALL TO MODERATE	SMALL TO MODERATE
Threatened or Endangered Species	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL TO MODERATE	MODERATE	SMALL TO MODERATE	SMALL	SMALL	SMALL	SMALL TO MODERATE	SMALL TO MODERATE
Socioeconomics	SMALL	SMALL	MODERATE	MODERATE	SMALL	SMALL TO MODERATE	SMALL TO MODERATE	SMALL TO MODERATE	MODERATE	MODERATE
Waste Management	SMALL	SMALL	SMALL	MODERATE	SMALL TO MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL
Aesthetics	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	MODERATE TO LARGE	MODERATE TO LARGE	MODERATE TO LARGE	MODERATE TO LARGE
Cultural Resources	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.
(10 CFR 51, Subpart A, Appendix B, Table B-1, Footnote 3)

Table 8.0-2 Impacts Comparison Detail

	No Action Alternative								
Proposed Action (License Renewal)	**Base (Decommissioning)**	**With Gas-Fired Generation**	**With Coal-Fired Generation**	**With Purchased Power**	**With New Nuclear Power**	**With Wind Energy Generation**	**With Solar Energy Generation**	**With Combined Wind Energy, PV Solar Energy, & Gas-Fired Generation**	**With Combined Wind Energy & Compressed Air Energy Storage**
Alternative Descriptions									
Renewal of LGS Units 1 and 2 licenses for 20 years each, followed by decommissioning	Decommissioning following expiration of current LGS Units 1 and 2 licenses. Adopting by reference, as bounding for LGS decommissioning, GEIS description (Section 7.1)	New construction at an existing power plant site (Section 7.2.2.1)	New construction at an existing power plant site (Section 7.2.2.2)	Would involve construction of new generation capacity in the PJM region. Adopting by reference GEIS description of alternate technologies (Section 7.2.2.3)	New construction at an existing power plant site, assumed to be LGS (Section 7.2.2.4)	Would involve construction of wind energy turbine capacity (Section 7.2.2.5)	Would involve construction of solar collector capacity (CSP or PV) (Section 7.2.2.6)	Would involve construction of wind energy turbines, solar energy collectors, and gas-fired firming capacity (Section 7.2.2.7)	Would involve construction of wind energy turbines and CAES firming capacity (Section 7.2.2.8)
		Four pre-engineered 530-MWe gas-fired combined-cycle systems with heat recovery steam generators, producing combined total of 2,120 MWe (net); capacity factor: 0.85	One 2,120-MWe (net) tangentially fired, dry bottom unit; capacity factor 0.85		Two units using a NRC-certified standard design producing 2,340 MWe net, capacity factor 0.90	2011 capacity factor: 0.13 -- 18,000 MWe wind turbine capacity; 2025 capacity factor: 0.52 -- 4,400 MW wind turbine capacity; Assume no firming capacity	2011 capacity factor: 0.38 -- 2,340 Mwe solar energy generation; Assume no firming capacity	Wind turbine -- 2,308 MWe (capacity factor: 0.52), plus Solar -- 3,000 MWe (capacity factor: 0.38), plus Firming capacity from gas-fired combined cycle generation -- 740 Mwe	4,500 MWe of wind turbine power (capacity factor: 0.52), with 2,100 MWe of firming capacity from CAES generation
		Construct two-16-inch diameter gas pipelines in an existing 100-ft wide corridor. May require upgrades to existing pipelines		Construct new transmission lines to assure local transmission system stability		Construct new transmission lines	Construct new transmission lines	Construct new transmission lines	Construct new transmission lines
		Construct intake/discharge system	Construct/modify cooling tower(s) and construct/modify intake/discharge system		Construct/modify cooling tower(s) and construct/modify intake/discharge system		For CSP plant, construct small gas-fired industrial boiler and cooling towers for TES system support		
		Natural gas, 1,027 Btu/ft^3; 6,040 Btu/kWh; 0.0034 lb SO_2/MMBtu; 0.009 lb NOx/MMBtu; 9.66 x 10^{10} ft^3 gas/yr	Pulverized bituminous coal, 11,549 Btu/lb; 10,138 Btu/kWh; 16.29% ash; 2.07% sulfur; 10 lb NOx/ton coal; 7.34 x 10^6 tons coal/yr				For CSP plant, small amounts of pollutants from boiler; For PV plants, negligible		
		Selective catalytic reduction with water injection	Low NOx burners, over-fire air and selective catalytic reduction (95% NOx reduction efficiency)						
			Wet scrubber – limestone desulfurization system (95% SOx removal efficiency); 469,000 tons limestone/yr; Fabric filters (99.9% particulate removal efficiency)						
Approximately 821 full time employees		45 workers (Section 7.2.2.1)	141 workers (Section 7.2.2.2)		Comparable to present LGS workforce (Section 7.2.2.4)				

Table 8.0-2 Impacts Comparison Detail

Proposed Action (License Renewal)	No Action Alternative								
	Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Power	With Wind Energy Generation	With Solar Energy Generation	With Combined Wind Energy, PV Solar Energy, & Gas-Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Land Use Impacts									
SMALL – Adopting by reference Category 1 issue findings (Appendix A, Table A-1, Issues 52, 53)	SMALL – Not an impact evaluated by GEIS (NRC, 1996a)	SMALL– 35 acres for facility at existing power plant location. New gas pipeline would be built within existing transmission ROW to connect with existing gas pipeline corridor (Section 7.2.2.1)	SMALL to MODERATE – 280 acres on existing site required for the power block and associated facilities; 927 acres for ash disposal (Section 7.2.2.2)	SMALL to MODERATE – Most transmission facilities could be constructed along existing transmission corridors (Section 7.2.2.3). Adopting by reference GEIS description of land use impacts from alternate technologies (NRC, 1996a)	SMALL to MODERATE - 630 to 1,260 acres required for the power block and associated facilities at LGS location (Section 7.2.2.4)	LARGE - Acreage estimates at 2011 capacity factor -- Direct impact area:13,343 acres; Total affected area: 533,729 acres. Acreage estimates at 2025 capacity factor -- Direct impact area: 3,242 acres; Total affected area: 129,691 acres (Section 7.2.2.5)	LARGE - Requires 98,900 acres for PV and 154,000 acres for CSP (Section 7.2.2.6)	LARGE - Large land mass required for wind and solar power generation (Section 7.2.2.7)	LARGE - Large land mass required for wind power generation and large caverns required for CAES (Section 7.2.2.8)
Water Quality Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 3, 6-11, and 32). One Category 2 surface water issue applies – Compliance with DRBC and PADEP requirements mitigates water usage conflicts and controls pollutant discharges (Section 4.1, Issue 13); one Category 2 groundwater issue applies – Absence of alluvial or glacial deposits in the vicinity of the Schuylkill River eliminates impacts on alluvial aquifers from river water withdrawals (Section 4.6, Issue 34); and three Category 2 groundwater issues do not apply (Section 4.5, Issue 33; Section 4.7, Issue 35; and Section 4.8, Issue 39).	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 89).	SMALL – Reduced cooling water demands, inherent in combined-cycle design (Section 7.2.2.1)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to LGS by using cooling tower and discharging to the Schuylkill River. (Section 7.2.2.2)	SMALL TO MODERATE – Adopting by reference GEIS description of water quality impacts from alternate technologies (NRC, 1996a)	SMALL – Construction impacts minimized by use of best management practices. Operational impacts similar to LGS by using cooling towers and discharging to the Schuylkill River. (Section 7.2.2.4)	SMALL - No consumptive water use required (Section 7.2.2.5)	SMALL – No consumptive water use for a PV facility; Cooling towers and heat transfer systems in CSP facility consumptively use water; Runoff can be controlled with engineered features (Section 7.2.2.6)	SMALL TO MODERATE – CSP facility cooling towers and heat transfer systems would consume water and discharge blowdown in amounts similar to LGS (Section 7.2.2.7)	SMALL - CAES and wind turbines consume minimal water (Section 7.2.2.8)

Table 8.0-2 Impacts Comparison Detail

Proposed Action (License Renewal)	No Action Alternative: Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Power	With Wind Energy Generation	With Solar Energy Generation	With Combined Wind Energy, PV Solar Energy, & Gas-Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Air Quality Impacts									
SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 51). One Category 2 issue does not apply (Section 4.11, Issue 50).	SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issue 88)	MODERATE – 169 tons SO_2/yr 446 tons NOx/yr 2,975 tons CO/yr 94 tons $PM_{2.5}$/yr 5,454,202 tons CO_2 /yr (Section 7.2.2.1)	MODERATE – 14,441 tons SOx/yr 1,836 tons NOx/yr 1,836 tons CO/yr 36 tons $PM_{2.5}$/yr 138 tons PM_{10}/yr 600 lb mercury/yr 20,231,385 tons CO_2 /yr (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of air quality impacts from alternate technologies (NRC, 1996a)	SMALL – Air emissions are primarily from non-generation equipment and diesel generators and are comparable to those associated with the continued operation of LGS (Section 7.2.2.4)	SMALL - Minimal air emissions during operation (Section 7.2.2.5)	SMALL to MODERATE- Air emissions during operation are from small-scale boilers and wet cooling towers (CSP only); Negligible emissions from PV (Section 7.2.2.6)	SMALL TO MODERATE - Gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but at approximately 1/3 the amounts (Section 7.2.2.7)	SMALL TO MODERATE - Compression and thermal expansion gas-fired combustion turbine emits air pollutants similar to gas-fired alternative, but in reduced amounts (Section 7.2.2.8)
Ecological Resource Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 15-24, 28-30, 43, and 45- 48). Four Category 2 issues do not apply (Section 4.9, Issue 40; (Section 4.2, Issue 25; Section 4.3, Issue 26; and Section 4.4, Issue 27)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 90)	SMALL – Construction of pipeline could alter the terrestrial habitat. (Section 7.2.2.1)	SMALL to MODERATE – 464 acres of the existing site could be required for ash/sludge disposal over a 20-year period. (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of ecological resource impacts from alternate technologies (NRC, 1996a)	SMALL to MODERATE – Impacts would be comparable to those associated with continued operation of LGS, except for the additional land disturbance (Section 7.2.2.4)	SMALL TO MODERATE – Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality (Section 7.2.2.5)	LARGE – Potential for extensive loss of grasslands and habitat area beneath solar collectors due to clearing and maintenance as unvegetated or sparsely vegetated surface during operation (Section 7.2.2.6)	SMALL TO MODERATE – Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality, as wells as solar impacts to habitat (Section 7.2.2.7)	SMALL TO MODERATE – Potential for impact to grasslands, habitat avoidance by mammals, and bird and bat mortality (Section 7.2.2.8)
Threatened or Endangered Species Impacts									
SMALL – One Category 2 issue applies – No Federally threatened or endangered species are known residents at the site or along transmission corridors (Section 4.10, Issue 49)	SMALL – Not an impact evaluated by GEIS (NRC, 1996a)	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats	SMALL – Federal and state laws prohibit destroying or adversely affecting protected species and their habitats

Table 8.0-2 Impacts Comparison Detail

	No Action Alternative								
Proposed Action (License Renewal)	**Base (Decommissioning)**	**With Gas-Fired Generation**	**With Coal-Fired Generation**	**With Purchased Power**	**With New Nuclear Power**	**With Wind Energy Generation**	**With Solar Energy Generation**	**With Combined Wind Energy, PV Solar Energy, & Gas-Fired Generation**	**With Combined Wind Energy & Compressed Air Energy Storage**
Human Health Impacts									
SMALL – Adopting by reference Category 1 issues (Table A-1, Issues 56, 58, 61, 62). Two Category 2 issues apply – (1) Impacts from thermophilic organisms are not expected because such organisms are not known to occur in the Schuylkill River, the temperature of the LGS effluent is limited by the NPDES permit, and primary contact recreation is restricted (Section 4.12, Issue 57) ; and (2) Risk due to transmission-line induced currents is minimal due to conformance with consensus code (Section 4.13, Issue 59)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 86)	SMALL TO MODERATE– Adopting by reference GEIS conclusion that some risk of cancer and emphysema exists from emissions (NRC, 1996a)	MODERATE – Adopting by reference GEIS conclusion that risks such as cancer and emphysema from emissions are likely (NRC, 1996a)	SMALL to MODERATE – Adopting by reference GEIS description of human health impacts from alternate technologies (NRC, 1996a)	SMALL – Impacts would be comparable to continued operation of LGS (Section 7.2.2.4)	SMALL - Adequate siting distances can minimze souind and vibration impacts (Section 7.2.2.5)	SMALL - Potential for glint and glare from reflective surfaces of CSP system, which could adversely affect pilot control of aircraft (Section 7.2.2.6)	SMALL to MODERATE – Air emissions from combustion turbines (Section 7.2.2.7)	SMALL to MODERATE – Air emissions from combustion turbines / heaters / compressors (Section 7.2.2.8)
Socioeconomic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 64, 67). Two Category 2 issues do not apply (Section 4.16.1, Issue 66; and Section 4.17.1, Issue 68). Four Category 2 issues apply – (1) Location in high population area with no growth controls minimizes potential for housing impacts (Section 4.14, Issue 63); (2) Plant property tax payment represents less than 1 percent of county's total tax revenues (Section 4.17.2, Issue 69); and (3) Capacity of public water supply and transportation infrastructure minimizes potential for related impacts (Section 4.15, Issue 65 and Section 4.18, Issue 70)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 91)	MODERATE – Reduction in permanent work force at LGS could adversely affect surrounding counties. (Section 7.2.2.1)	MODERATE – Reduction in permanent work force at LGS could adversely affect surrounding counties (Section 7.2.2.2)	SMALL – Adopting by reference GEIS description of socioeconomic impacts from alternate technologies (NRC, 1996a)	Construction: SMALL to MODERATE – Peak construction workforce of 3,650 could affect housing and public services in surrounding counties but would be mitigated by LGS' proximity to several metropolitan areas. Operation: SMALL – Impacts would be comparable to those associated with the continued operation of LGS (Section 7.2.2.4)	SMALL to MODERATE – Wind energy development might not be compatible with land uses such as housing developments, airport approaches, some radar installations, and low-level military flight training routes; reduction in permanent work force at LGS could adversely affect surrounding counties (Section 7.2.2.5)	SMALL to MODERATE – Large land use precludes availability of land for use appropriate for job generation or development of ratables, reduction in permanent work force at LGS could adversely affect surrounding counties (Section 7.2.2.6)	MODERATE - Reduction in permanent work force at LGS could adversely affect surrounding counties combined with other impacts of each technology (Section 7.2.2.7)	MODERATE - Reduction in permanent work force at LGS could adversely affect surrounding counties combined with other impacts of each technology (Section 7.2.2.8)

Table 8.0-2 Impacts Comparison Detail

Proposed Action (License Renewal)	No Action Alternative: Base (Decommissioning)	With Gas-Fired Generation	With Coal-Fired Generation	With Purchased Power	With New Nuclear Power	With Wind Energy Generation	With Solar Energy Generation	With Combined Wind Energy, PV Solar Energy, & Gas-Fired Generation	With Combined Wind Energy & Compressed Air Energy Storage
Waste Management Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 77 85)	SMALL – Adopting by reference Category 1 issue finding (Table A-1, Issue 87)	SMALL – The only noteworthy waste would be from spent selective catalytic reduction (SCR) used for NOx control. (Section 7.2.2.1)	MODERATE – 657,627 tons of non-recycled coal ash and 559,000 tons of scrubber sludge annually would require 464 acres over a 20-year period. (Section 7.2.2.2)	SMALL to MODERATE – Adopting by reference GEIS description of waste management impacts from alternate technologies (NRC, 1996a)	SMALL – Non-radioactive and radioactive wastes would be similar to those associated with the continued operation of LGS (Section 7.2.2.4)	SMALL - Waste generation in minor quantities during operation (Section 7.2.2.5)	SMALL - Waste generation in minor quantities during operation (Section 7.2.2.6)	SMALL - Minimal waste generation during operation (Section 7.2.2.7)	SMALL - Minimal waste generation during operation (Section 7.2.2.8)
Aesthetic Impacts									
SMALL – Adopting by reference Category 1 issue findings (Table A-1, Issues 73 and 74)	SMALL – Not an impact evaluated by GEIS (NRC, 1996a)	SMALL – Steam turbines and stacks would create visual impacts comparable to those from existing LGS facilities (Section 7.2.2.1)	SMALL – Visual impacts would be consistent with the industrial nature of the site (Section 7.2.2.2)	SMALL – Adopting by reference GEIS description of aesthetic impacts from alternate technologies (NRC, 1996a)	SMALL – Visual impacts would be comparable to those from existing LGS facilities (Section 7.2.2.4)	MODERATE to LARGE - 18,000 Mwe required with each wind turbine generating aproximately 3MW requires 6,000 wind turbines (Section 7.2.2.5)	MODERATE to LARGE - Large land mass occupied by solar collectors with impacted vegetation and mammal habitat reduction (Section 7.2.2.6)	MODERATE to LARGE - 750 wind turbines, thousands of acres of solar collectors, and a gas-fired generation unit (Section 7.2.2.7)	MODERATE to LARGE - 1,500 wind turbines and the compression / expansion / heating faciltiy for 2,100 MW CAES (Section 7.2.2.8)
Cultural Resource Impacts									
SMALL – One Category 2 issue applies – SHPO consultation minimizes potential for impact (Section 4.19, Issue 71).	SMALL – Not an impact evaluated by GEIS (NRC, 1996a)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site and SHPO consultation minimizes potential for impact. (Section 7.2.2.1)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site and SHPO consultation minimizes potential for impact. (Section 7.2.2.2)	SMALL – Adopting by reference GEIS description of cultural resource impacts from alternate technologies (NRC, 1996a)	SMALL – Impacts to cultural resources would be unlikely due to developed nature of the site and SHPO consultation minimizes potential for impact. (Section 7.2.2.4)	SMALL – Impacts to cultural resources would be unlikely due to SHPO consultation minimizing potential for impact. (Section 7.2.2.5)	SMALL – Impacts to cultural resources would be unlikely due to SHPO consultation minimizing potential for impact. (Section 7.2.2.6)	SMALL – Impacts to cultural resources would be unlikely due to SHPO consultation minimizing potential for impact. (Section 7.2.2.7)	SMALL – Impacts to cultural resources would be unlikely due to SHPO consultation minimizing potential for impact. (Section 7.2.2.8)

SMALL - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
MODERATE - Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.
LARGE - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource. (10 CFR Part 51, Subpart A, Appendix B, Table B 1, Footnote 3)

[a] All TSP for gas-fired alternative is PM2.5.

Btu = British thermal unit
ft^3 = cubic foot
gal = gallon
GEIS = Generic Environmental Impact Statement (NRC, 1996a)
kWh = kilowatt-hour
lb = pound
m^3 = cubic meter
MM = million
MW = megawatt
NOx = nitrogen oxide
PJM = regional electric distribution network
$PM_{2.5}$ = particulates having diameter of 2.5 microns or less
PM_{10} = particulates having diameter > 2.5 microns to 10 microns
SHPO = State Historic Preservation Officer
SO2 = sulfur dioxide
SOx = sulfur oxides
TSP = total suspended particulates
yr = year

9.0 STATUS OF COMPLIANCE

9.1 Proposed Action

NRC

"The environmental report shall list all federal permits, licenses, approvals and other entitlements which must be obtained in connection with the proposed action and shall describe the status of compliance with these requirements. The environmental report shall also include a discussion of the status of compliance with applicable environmental quality standards and requirements including, but not limited to, applicable zoning and land-use regulations, and thermal and other water pollution limitations or requirements which have been imposed by Federal, State, regional, and local agencies having responsibility for environmental protection." 10 CFR 51.45(d), as adopted by 10 CFR 51.53(c)(2)

9.1.1 General

Table 9.1-1 lists environmental authorizations that Exelon Generation Company, LLC (Exelon Generation) has obtained for current Limerick Generating Station, Units 1 and 2 (LGS) operations. In this context, Exelon Generation uses "authorizations" to include permits, licenses, approvals, or other entitlements. Exelon Generation expects to continue renewing these authorizations during the current license period and throughout the period of extended operation under the renewed U.S. Nuclear Regulatory Commission (NRC) license, as required. Because the NRC regulatory focus is prospective, Table 9.1-1 does not include authorizations that Exelon Generation obtained for past activities that did not include continuing obligations.

To support its application for renewal of the LGS licenses to operate, Exelon Generation assessed (see Section 5) whether new and significant environmental information exists relative to the information considered by the NRC in preparing the Generic Environmental Impact Statement (GEIS) for license renewal (NRC, 1996a). The assessment included interviews with subject matter experts at LGS, a review of LGS environmental documentation, and communications with state and federal environmental protection agencies. Responses from contacted agencies are summarized below. Based on this assessment, Exelon Generation concludes that LGS is in compliance with applicable environmental standards and requirements.

Table 9.1-2 lists additional environmental authorizations and consultations related specifically to renewal by the NRC of the Limerick Units 1 and 2 licenses to operate. As indicated, Exelon Generation anticipates needing relatively few such authorizations and consultations. Sections 9.1.2 through 9.1.4 discuss some of these items in more detail.

9.1.2 Threatened or Endangered Species

Section 7 of the Endangered Species Act (16 USC 1531 et seq.) requires federal agencies to ensure that agency action is not likely to jeopardize any species that is listed, or proposed for listing, as endangered or threatened. Depending on the agency action involved, the Act requires consultation either with the U.S. Fish and Wildlife Service (FWS) (regarding effects on non-marine species), or the National Marine Fisheries Service (NMFS) (regarding effects on marine species), or both. FWS and NMFS have issued joint procedural regulations at 50 CFR 402, Subpart B, that address consultation, and FWS maintains the joint list of threatened and endangered species at 50 CFR 17.

Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment from federal and state agencies regarding potential effects that renewal of the Limerick Units 1 and 2 licenses might have. Appendix C includes copies of Exelon Generation correspondence with FWS, Pennsylvania Department of Conservation and Natural Resources (DCNR), the Pennsylvania Game Commission (PGC), and the Pennsylvania Fish and Boat Commission (PFBC). Appendix C also contains copies of the agency responses.

In general, the contacted agencies commented that, even though there may be species or resources of concern under agency of jurisdiction located in the vicinity of the project, the proposed license renewal of LGS is not likely to adversely impact these species, predicated on the project involving no new construction, earth disturbance, or changes to existing land use.

9.1.3 Historic Preservation

Section 106 of the National Historic Preservation Act (16 USC 470 et seq.) requires federal agencies having the authority to license any undertaking to, prior to issuing the license, take into account the effect of the undertaking on historic properties and to afford the Advisory Council on Historic Preservation an opportunity to comment on the undertaking. Council regulations provide for the State Historic Preservation Office (SHPO) to have a consulting role (35 CFR 800.2).

Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comment by the PA Bureau for Historic Preservation (the SHPO). Appendix D contains a copy of Exelon Generation's letter to SHPO.

Also in Appendix D is a copy of the SHPO’s response letter to Exelon Generation, in which the SHPO stated that, based upon its review of the project’s potential effect upon both historic and archaeological resources:

- There will be no effect on historic buildings/structures/districts/objects eligible for the National Register of Historic Places located in the project area; and
- No archaeological investigations are necessary in the project area.

9.1.4 Water Quality (401) Certification

Federal Clean Water Act Section 401 requires an applicant seeking a federal license for an activity that may result in a discharge to navigable waters to provide the licensing agency with a certification by the state where the discharge would originate indicating that applicable state water quality standards will not be violated as a result of the discharge (33 USC 1341). The Pennsylvania Department of Environmental Resources [now the Pennsylvania Department of Environmental Protection (PADEP)] issued a Section 401 State Water Quality Management Permit on July 16, 1976 for LGS prior to its initial operation. The permit transmittal letter states that the facilities, if operated properly, will meet the water quality standards for the Schuylkill River.

Now, Exelon Generation is applying for NRC approval to extend Limerick Units 1 and 2 operations under renewed licenses. The NRC has indicated in Section 4.2.1.1 of the GEIS for nuclear plant license renewal (NRC, 1996a) that issuance of a National Pollutant Discharge Elimination System (NPDES) permit by a state implies continued Section 401 certification by the state. PADEP has U.S. Environmental Protection Agency (EPA) authorization to implement the NPDES permitting program. In addition, guidance published by PADEP states that water quality certifications have been integrated with other required permits and that individual water quality certifications will be issued only for activities that are not regulated by other water quality approvals or permits. Accordingly, as evidence of continued Section 401 certification by Pennsylvania, Exelon Generation is providing copies of the current LGS and Bradshaw Reservoir NPDES permits (PA0051926 and PA0052221, respectively) in Appendix B.

Although not required of an applicant by federal law or NRC regulation, Exelon Generation has chosen to invite comments or concerns by PADEP regarding *N. fowleri* or any other thermophilic organisms and potential public health effects over the license renewal term. Exelon Generation alternatively requested PADEP to confirm Exelon Generation's conclusion that operation of LGS over the license renewal term would not enhance growth of thermophilic pathogens (see Section 4.12). A copy of Exelon Generation's correspondence with PADEP and the agency's response are provided in Appendix E. In its response, PADEP identified that it does not have any data associated with *N. fowleri* in the Schuylkill River nor has it conducted any investigations on the impact or potential impact of the LGS discharge on thermophilic organisms in the river. As a result, PADEP is unable to make any conclusions regarding the effect on public health from *N. fowleri* or any other thermophilic organisms in the Schuylkill River.

9.2 Alternatives

NRC

"The discussion of alternatives in the report shall include a discussion of whether the alternatives will comply with such applicable environmental quality standards and requirements." 10 CFR 51.45(d), as required by 10 CFR 51.53(c)(2)

The coal, gas, new nuclear, purchased power, and other alternatives discussed in Section 7.2 probably could be constructed and operated to comply with applicable environmental quality standards and requirements. Exelon Generation notes that increasingly stringent air quality protection requirements could make the construction of a large fossil-fueled power plant infeasible in many locations.

Table 9.1-1 Existing Environmental Authorizations for LGS Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011, et seq.), 10 CFR 50.10	License to operate	Dockets 50-352 and 50-353	Docket 50-352 Issued: 8/8/1985 Expires: 10/26/2024 Docket 50-353 Issued: 08/25/1989 Expires: 06/22/2029	Operation of Limerick Units 1 and 2
Delaware River Basin Commission	Delaware River Basin Compact, P.L. 87-328, Section 3.8; DRBC Rules of Practice and Procedure, Article 3, Section 2.3.4	Submission of project for DRBC approval and determination as to whether the project impairs or conflicts with the Delaware River Basin Commission Comprehensive Plan	Docket D-69-210 CP (Final), as revised through Revision 12	Issued: 11/07/1975 (Rev. 12 - 11/02/2004) Expires: No expiration date indicated	Project approval of LGS operation and its multiple release, withdrawal, and discharge components; addition to the Comprehensive Plan; monitoring/other conditions, operating conditions for withdrawals for consumptive and non-consumptive use; conduct demonstration project
Delaware River Basin Commission	Delaware River Basin Compact, P.L. 87-328, Section 3.8; DRBC Rules of Practice and Procedure, Article 3, Section 2.3.4	Submission of project for DRBC approval and determination as to whether the project impairs or conflicts with the Delaware River Basin Commission Comprehensive Plan	Docket D-79-52 CP	Issued: 02/18/1981 Expires: No expiration date indicated	Project approval of operation of Bradshaw Reservoir, Bradshaw Pumphouse, and transmission main to East Branch Perkiomen Creek for consumptive use makeup at LGS
Delaware River Basin Commission	Delaware River Basin Compact, P.L. 87-328, Section 3.8; DRBC Rules of Practice and Procedure, Article 3, Section 2.3.4	Submission of project for DRBC approval and determination as to whether the project impairs or conflicts with the Delaware River Basin Commission Comprehensive Plan	Docket D-77-110 CP	Issued: 10/24/1984 Expires: No expiration date indicated	Project approval of operation of Merrill Creek Reservoir, pumping station, and transmission main to Delaware River for consumptive use makeup at LGS

Table 9.1-1 Existing Environmental Authorizations for LGS Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
Delaware River Basin Commission	Delaware River Basin Compact, P.L. 87-328, Section 3.8; DRBC Rules of Practice and Procedure, Article 3, Section 2.3.4	Submission of project for DRBC approval and determination as to whether the project impairs or conflicts with the Delaware River Basin Commission Comprehensive Plan	Docket D-65-76 CP (8)	Issued: 02/18/1981 Expires: No expiration date indicated	Project approval of operation by Forest Park Water Authority of Point Pleasant intake and transmission main to the Bradshaw Reservoir for LGS consumptive use makeup
Pennsylvania Department of Environmental Protection	Air Pollution Control Act, P.L. 2119, as amended, and 25 Pa. Code Chapter 127	Title V Operating Permit	TVOP-46-00038	Issued: 12/07/2009 Expires: 12/07/2014	Operation of the air emission sources described in permit at LGS
Pennsylvania Department of Environmental Protection	Clean Water Act, 33 U.S.C. Section 1251 et seq. and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 et seq.	Authorization to discharge under the National Pollutant Discharge Elimination System (NPDES)	PA0051926	Issued: 03/31/2006 Expires: 03/31/2011 Note: Exelon Generation submitted an LGS NPDES Permit Renewal Application at least 180 days prior to permit expiration, as required; PADEP deemed the Application administratively complete; the current permit is administratively extended since PADEP did not issue the renewed permit by the expiration date.	Authorization to discharge from LGS into the Schuylkill River, Possum Hollow Run, and Sanatoga Creek in accordance with effluent limitations, monitoring requirements, and other permit conditions

Table 9.1-1 Existing Environmental Authorizations for LGS Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
Pennsylvania Department of Environmental Protection	Clean Water Act, 33 U.S.C. Section 1251 et seq. and Pennsylvania's Clean Streams Law, as amended, 35 P.S. Section 691.1 et seq.	Authorization to discharge under the National Pollutant Discharge Elimination System (NPDES)	PA0052221	Issued: 07/01/2009 Expires: 06/30/2014	Authorization to discharge from Bradshaw Reservoir into East Branch Perkiomen Creek in accordance with effluent limitations, monitoring requirements, and other permit conditions
Pennsylvania Department of Environmental Protection	Dam Safety and Encroachments Act, P.L. 1375, as amended, and 25 Pa. Code Chapter 105	Approval of design modifications, operation and maintenance of Bradshaw Reservoir dam	D09-181A	Issued: 12/30/1986 Expires: 12/30/2036	Operate and maintain dam in accordance with state-approved manual; maintain Emergency Action Plan in event of failure of dam; inspect dam every three months; pay annual fee
Pennsylvania Department of Environmental Protection	P.L. 555, as amended, and 25 Pa. Code Chapter 105	Maintenance dredging permit	19616	Issued: 07/16/1976 Expires: No Date Listed on Permit	Maintenance dredging of the intake area and discharge diffuser in the Schuylkill River after notification to PFBC; siltation control during dredging, and sediment placement outside 100-yr floodplain and wetlands
Pennsylvania Department of Environmental Protection	P.L. 555, as amended, and 25 Pa. Code Chapter 105	Maintenance dredging permit	19615	Issued: 07/16/1976 Expires: No Date Listed on Permit	Maintenance dredging of the intake area in the Perkiomen Creek after notification to PFBC; siltation control during dredging, and sediment placement outside 100-yr floodplain and wetlands
Pennsylvania Department of Environmental Protection	25 PA 105 and CWA Section 404	General Permit No. 11 for Maintenance Dredging	044610317	Issued: 12/07/2010 Expires: No expiration date indicated	Maintenance dredging at Perkiomen Pumphouse Intake

Table 9.1-1 Existing Environmental Authorizations for LGS Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
Pennsylvania Department of Environmental Protection	Pennsylvania Safe Drinking Water Act (P.L. 206, No. 43) and 25 PA Code 109	Permit to operate a public water system or a substantially modified facility	1. 4696508 2. 4606501 3. 4609503	Issued: 03/25/1997 Issued: 06/30/2006 Issued: 11/20/2009 Expires: No Date Listed on Permits	Operation of corrosion control system Operation of arsenic reduction system Operation of additional filter tank on existing arsenic removal system
U.S. Environmental Protection Agency	RCRA Section 310; 40 CFR Part 262 and 25 PA Code 262a.10	Notification of regulated waste activity to obtain an EPA identification number for hazardous waste	PAD000797951	Issued: 01/01/2001 Expires: N/A	Small quantity generation of hazardous or mixed waste at LGS and off-specification used oil burner
Pennsylvania Department of Environmental Protection	Pennsylvania Storage Tank and Spill Prevention Act and 25 PA Code 245	Certificate of registration/ permit to operate storage tanks	None	Issued: 02/04/2011 Expires: Renewed Annually	Registration and operation of 18 above-ground storage tanks at LGS
U.S. Department of Transportation	49 CFR Part 107, Subpart G and 49 U.S.C. 5108	Hazardous Materials Certificate of Registration	040810 750 001SU	Issued: 06/09/2010 Expires: 06/30/2013	Hazardous materials transportation
Pennsylvania Department of Labor and Industry, Boiler Section	37 PA Code 11	Fire Marshall approval for storage and handling of flammable and combustible liquid	172,943	Issued: 02/25/1972 Expires: No Date Listed on Approval	Storage and handling of flammable and combustible liquids in two 10,000-gallon capacity underground gasoline and diesel fuel tanks at LGS
Pennsylvania Department of Labor and Industry, Boiler Section	37 PA Code 11	Fire Marshall approval for storage and handling of flammable and combustible liquid	186,609	Issued: 08/15/1977 Expires: No Date Listed on Approval	Storage and handling of flammable and combustible liquids in eight 37,500-gallon capacity underground fuel oil tanks at LGS

Table 9.1-1 Existing Environmental Authorizations for LGS Operations

Agency	Authority	Requirement	Number	Issue or Expiration Date	Activity Covered
Federal and State Requirements					
Pennsylvania Department of Labor and Industry, Boiler Section	37 PA Code 11	Fire Marshall approval for storage and handling of flammable and combustible liquid	186,610	Issued: 08/15/1977 Expires: No Date Listed on Approval	Storage and handling of flammable and combustible liquids in one 10,000-gallon capacity and one 200,000-gallon capacity aboveground fuel oil tanks.
Pennsylvania Department of Labor and Industry, Boiler Section	37 PA Code 11	Fire Marshall approval for storage and handling of flammable and combustible liquid	187,162	Issued: 11/17/1977 Expires: No Date Listed on Approval	Storage and handling of flammable and combustible liquids in one 12,500-gallon capacity aboveground fuel oil tank.
Pennsylvania Department of Environmental Protection	25 PA Code 109.801	Environmental laboratory certificate of accreditation under 25 PA Code 252	PA Lab ID No. 46-01028,Cert. 003	Issued: 08/31/2010 Expires: Renewed Annually	Perform accredited analyses NPDES categories as approved
Pennsylvania Department of Environmental Protection	25 PA Code 105.11	Permit to operate an encroachment	E 09-77A	Issued: 02/12/1988 Expires: 02/11/2038	Pumping and releases to the East Branch Perkiomen Creek; regular ecological monitoring of the East Branch Perkiomen Creek and reporting every two years
U.S. Nuclear Regulatory Commission	10 CFR 20.2002	Approval for disposal of licensed material generated in licensee's activities	N/A (NRC and PADEP Letters of approval)	Issued: 07/10/1996 (NRC) Issued: 03/23/1998 (PADEP) Expires: No Date Listed on Approvals	Onsite disposal of slightly-contaminated flowable solids from cooling tower basins, emergency spray pond, and hold pond within the LGS site restricted area

Table 9.1-2 Environmental Authorizations Needed to Continue Limerick Operation During the Period of License Renewal

Agency	Authority	Requirement	Remarks
U.S. Nuclear Regulatory Commission	Atomic Energy Act (42 USC 2011 et seq.)	License renewal	Environmental Report submitted as Appendix E in license renewal application
Pennsylvania Department of Environmental Protection	Clean Water Act Section 401 (33 USC 1341)	Certification	State issuance of NPDES permit constitutes 401 certification (Appendix B)
U.S. Fish and Wildlife Service (FWS)	Endangered Species Act Section 7 (16 USC 1536)	Consultation	Requires federal agency issuing a license to consult with the FWS (Appendix C)
Pennsylvania Historical and Museum Commission	National Historic Preservation Act Section 106 (16 USC 470f)	Consultation	Requires federal agency issuing a license to consider effects on historic properties and consult with State Historic Preservation Office (SHPO). (Appendix D)
Note: No renewal-related requirements identified for local or other agencies.			

10.0 REFERENCES

Note to reader: Some web pages cited in this document are no longer available, or are no longer available through the original URL addresses. Hard copies of cited web pages are available in Exelon Generation Company, LLC (Exelon Generation) files. Some sites, for example the census data, cannot be accessed through their given URLs. The only way to access these pages is to follow queries on previous web pages. The complete URLs used by Exelon Generation have been given for these pages, even though they may not be directly accessible.

Abplanalp, K. M. 2010. *Historical and Architectural Survey of Frick's Lock Historic District, East Coventry Township, Pennsylvania*. Report prepared for Exelon Generation Company, LLC.

ACAA (American Coal Ash Association). 2011. Corrected 2009 Coal Combustion Product (CCP) Production & Use Survey. February. Available at: http://acaa.affiniscape.com/associations/8003/files/2009_CCP_Production_Use_Survey_Corrected_020811.pdf. Accessed March 22, 2011.

AEC (U.S. Atomic Energy Commission). 1973. Final Environmental Statement Related to the Proposed Limerick Generating Station, Units 1 and 2. Philadelphia Electric Company. Docket Nos. 50-352 and 50-353. Directorate of Licensing. November.

AMO (AMO Environmental Decisions). 2007. Spring 2007 Routine Groundwater and Surface Water Monitoring Round, Summary of Results, Conclusions, and Recommendations for Future Monitoring Rounds. September 24, 2007 letter from AMO to Mr. Tom Basso.

AMO (AMO Environmental Decisions). 2008. Fall 2007 Routine Groundwater and Surface Water Monitoring Round, Summary of Results, Conclusions, and Recommendations for Future Monitoring Rounds. February 22, 2008 letter from AMO to Mr. Douglas Wahl.

Amtrak. 2011. Catch the Keystone | Welcome to the Keystone Line. Available on-line at: http://catchthekeystone.com/. Accessed April 7, 2011.

Bailey, R.G., P.E. Avers, T. King, and W.H. McNab, eds. 1994. Ecoregions and Subregions of the United States (map). Washington, D.C.: U.S. Geological Survey. Scale 1:7,500,000; colored. Accompanied by a supplementary table of map unit descriptions compiled and edited by McNab, W.H. and Bailey, R.G. Prepared for the U.S. Department of Agriculture, Forest Service.

BCPC (Berks County Planning Commission). 2005. 2005 Berks County Data Book. Thirty-Fourth Revision — April, 2005 with revisions through March 12, 2008. Available on-line at: http://www.co.berks.pa.us/Dept/Planning/Pages/BerksCountyDataBook.aspx.

Bedminster Township. Undated. Revenues. 2010 General Fund Budget available on-line at: http://www.bedminsterpa.com/twpgov.html. Accessed January 16, 2011.

Berks County. 2003. Berks Vision 2020, A Comprehensive Plan for the County of Berks. Available on-line at: http://test3.pacounties.org/Dept/Planning/Pages/BerksCountyComprehensivePlan.aspx. Accessed January 12, 2011.

Berks County. 2011. Joint Comprehensive Planning Program. Available on-line at: http://www.co.berks.pa.us/Dept/Planning/Pages/JointComprehensivePlanningProgram.aspx. Accessed April 7, 2011.

Bezdek, R.H. and R.M. Wendling. 2006. The Impacts of Nuclear Facilities on Property Values and Other Factors in the Surrounding Communities. Int. J. Nuclear Governance, Economy and Ecology 1(1): 122–144.

BLM/DOE (Bureau of Land Management/U.S. Department of Energy), 2010. *Draft Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States.* DES 10-59; DOE/EIS-0403). Volume 1 and Volume 8. December. Available on-line at: http://solareis.anl.gov/documents/dpeis/index.cfm. Accessed May 2, 2011.

Blomquist, G. 1974. The Effect of Electric Utility Power Plant Location on Area Property Value. Land Economics 50(1): 97–100. Publication date: February 1974.

Brundage, H.M. III and R.E. Meadows. 1982. The Atlantic Sturgeon, Acipenser oxyrhynchus, in the Delaware River Estuary. Fishery Bulletin. Vol. 80, No. 2. pp. 337-343.

Bucks County. 2010. County of Bucks 2011 Final Budget. 2011 Final Budget – Summary available on-line at: http://www.buckscounty.org/government/departments/finance/index.aspx. Accessed January 16, 2011.

CCPC (Chester County Planning Commission). 2008. 2007 Daily Traffic Volume Estimates. Available on-line at: http://www.chesco.org/planning/cwp/view.asp?a=1676&Q=646922&planningNav=|. Accessed April 7, 2011.

CCPC (Chester County Planning Commission). 2009. Chester County Planning Commission Annual Report.

CCPC (Chester County Planning Commission). 2010a. Facts About Chester County. Available on-line at: http://dsf.chesco.org/planning/cwp/view.asp?a=3&q=604992. Content last modified on August 16, 2010.

CCPC (Chester County Planning Commission). 2010b. Chester County Comprehensive Policy Plan. Available on-line at: http://www.landscapes2.org/ls2online/index.html. Accessed January 15, 2011.

CDC (Centers for Disease Control and Prevention). 2008. Primary Amebic Meningoencephalitis --- Arizona, Florida, and Texas, 2007. Morbidity and Mortality Weekly Report (MMWR), May 30, 2008; 57(21); 573-577. Available on-line at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5721a1.htm. Accessed January 4, 2011.

CEC (California Energy Commission). 2011. Ocean Energy. Available on-line at: http://www.energy.ca.gov/oceanenergy/index.html. Site last updated February 17, 2011.

CEEEP (Center for Energy, Economic & Environmental Policy). 2008. Draft Review and Update of Energy Efficiency Market Assessment for the State of New Jersey, Center for Energy, Economic and Environmental Policy. Retrieved December 15, 2010, from http://policy.rutgers.edu/ceeep/publications/2008/energyassessment.pdf . Publication date: June 2008.

Central Bucks School District. 2010. Budget for the 2010-2011 School Year. Executive Summary. Available on-line at: http://www.cbsd.org/schoolboard/Pages/budget.aspx. Accessed January 16, 2011.

Chase, D.L. and P.T. Kehoe. 2000. GE Combined-Cycle Product Line and Performance. GER-3574G. GE Power Systems, Schenectady, NY. October. Available on-line at: http://www.gepower.com/prod_serv/products/tech_docs/en/downloads/ger3574g.pdf. Accessed December 15, 2010.

Chester County. 2009a. Parks and Recreation: Schuylkill River Trail. Available on-line at: http://dsf.chesco.org/ccparks/cwp/view.asp?a=1552&q=621925&ccparksNav=|34759|. Accessed January 10, 2011. Content last modified on August 28, 2009.

Chester County. 2009b. County of Chester, Pennsylvania 2010 Budget. Available on-line at: http://dsf.chesco.org/chesco/cwp/view.asp?a=1413&Q=575242. Accessed January 16, 2011.

Clark, D. and L. Nieves. 1994. An Interregional Hedonic Analysis of Noxious Facility Impacts on Local Wages and Property Values. Journal of Environmental Economics and Management 27: 235–253.

Clark, D., L. Michelbrink, T. Allison, and W. Metz. 1997. Nuclear Power Plants and Residential Housing Prices. Growth and Change 28 (Fall): 496–519.

Conestoga-Rovers (Conestoga-Rovers & Associates). 2006. Hydrogeologic Investigation Report. Fleetwide Assessment, Limerick Generating Station, Pottstown, Pennsylvania. Revision 1. September.

DCNR (Pennsylvania Department of Conservation and Natural Resources). undated. Schuylkill River National & State Heritage Area. Available on-line at: http://www.dcnr.state.pa.us/brc/heritageparks/schuylkillriver.aspx. Accessed January 10, 2011.

DCNR (Pennsylvania Department of Conservation and Natural Resources). 2010. Pennsylvania Scenic Rivers Program, Schuylkill River, Map 7 http://www.dcnr.state.pa.us/brc/rivers/scenicrivers/schuylkillhome.htm Accessed June 9, 2010.

DCNR (Pennsylvania Department of Conservation and Natural Resources). 2011. PA Topographic & Geologic Survey, PaGWIS Groundwater Records Data. MS Access 2000 database downloaded from http://www.dcnr.state.pa.us/topogeo/groundwater/PaGWIS/PaGWISMenu.asp?c=t on March 29, 2011.

Denholm, P. 2008. Land-use requirements and the per-capita solar footprint for photovoltaic generation in the United States. Journal of Energy Policy, Vol. 36, Issue 9, pp. 3531-3543. Available on-line at: http://www.sciencedirect.com/science/article/B6V2W-4T0NGHH-1/2/72735acd2e4fd791e0c841b9ba03067b. Accessed December 15, 2010.

Denholm, P., M. Hand, M. Jackson, and S. Ong. 2009. Land-Use Requirements of Modern Wind Power Plants in the United States, Technical Report NREL/TP-6A2-45834. August.

DOE (U.S. Department of Energy). 2005. New Wave Energy Prototypes Deployed in Hawaii and New Jersey, EERE News, November 23, 2005. Available on-line at: http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=9551. Accessed April 15, 2011.

DOE (U.S. Department of Energy). 2008a. 20% Wind Energy by 2030, Increasing Wind Energy's Contribution to U.S. Electricity Supply. Energy Efficiency and Renewable Energy. DOE/GO-102008-2567. July.

DOE (U.S. Department of Energy). 2008b. Facilities for the Future of Nuclear Energy Research: A Twenty-year Outlook. Draft Revision 4. November.

DOE (U.S. Department of Energy). 2008c. Next Generation Nuclear Plant Licensing Strategy A Report to Congress. Submitted to Congress in conjunction with the Chairman of the Nuclear Regulatory Commission. August.

DOE (U.S. Department of Energy). 2009. Ocean Energy Technology Overview. Prepared for the DOE, Office of Energy Efficiency and Renewable Energy, Federal Energy Management Program, OE/GO-102009-2823. July.

DOE (U.S. Department of Energy). 2010. 2009 Wind Technologies Market Report. Energy Efficiency and Renewable Energy. August.

DRBC (Delaware River Basin Commission). Undated. Basin Facts. Available on-line at http:www.state.nj.us/drbc/thedrb.htm. Accessed January 17, 2011.

DRBC (Delaware River Basin Commission). 1999. Delaware River Rooted Aquatic-Plant Biomass Study from Port Jervis, N.Y. (Route 84 Bridge) to Milford, PA (Route 206 Bridge). Report No. 22, August.

DRBC (Delaware River Basin Commission). 2001. Comprehensive Plan. July. Available on-line at: http://www.state.nj.us/drbc/cp_wo_2.pdf. Accessed April 6, 2011.

DRBC (Delaware River Basin Commission). 2004. Water Resources Plan for the Delaware River Basin. September. Available on-line at: http://www.state.nj.us/drbc/BPSept04/index.htm. Accessed April 6, 2011.

DRBC (Delaware River Basin Commission). 2008a. Administrative Manual – Part III. Water Quality Regulations with Amendments through July 16, 2008. 18 CFR Part 410. September.

DRBC (Delaware River Basin Commission). 2008b. Delaware River State of the Basin Report 2008. Available on-line at: http://www.state.nj.us/drbc/SOTB/index.htm.

DVRPC (Delaware Valley Regional Planning Commission). 2011. Municipal Data Navigator. Chester County 2005 Land Use by Acres. Available on-line at: http://www.dvrpc.org/asp/mcddatanavigator/default.aspx. Accessed January 17, 2011.

East Coventry Township. undated. 2010 Capital Reserve Fund Final Budget 2010. Available on-line at: http://www.eastcoventry-pa.gov/. Accessed January 16, 2011.

EIA (Energy Information Administration). 2008. EIA-923 Monthly Time Series File 2008. (Excerpt) Full document available on-line at: http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html. Accessed May 16, 2011.

EIA (Energy Information Administration). 2009. EIA-923 Monthly Time Series File 2009. (Excerpt) Full document available on-line at: http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html. Accessed May 16, 2011.

EIA (Energy Information Administration). 2010a. Electric Power Annual 2009. Available on-line at: http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html. Accessed December 15, 2010.

EIA (Energy Information Administration). 2010b. Status of Electricity Restructuring by State. November. Available on-line at: http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html. Accessed December 21, 2010.

EIA (Energy Information Administration). 2010c. DOE/EIA-0348(2009). Electric Power Annual 2008. Available on-line at: http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf. Accessed December 15, 2010.

EIA (Energy Information Administration). 2010d. State Ranking, Carbon Dioxide Emissions by the Electric Power Industry, 2009. Available on-line at: http://www.eia.doe.gov/state/state_energy_rankings.cfm?keyid=86&orderid=1. Accessed December 15, 2010.

EIA (Energy Information Administration). 2010e. U.S. Electric Power Industry Estimated Emissions. Available on-line at: http://www.eia.doe.gov/state/SEP_MoreEnviron.cfm. U.S. Electric Power Industry Estimated Emissions (EIA-767 and EIA-906). Accessed December 15, 2010.

EIA (Energy Information Administration). 2010f. EIA-923 Monthly Time Series File 2010. (Excerpt) Full document available on-line at: http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html. Accessed May 16, 2011.

EIA (Energy Information Administration). 2011a. Annual Energy Outlook Early Release. Table A8, Electricity Supply, Disposition, Prices, and Emissions. Available on-line at: http://www.eia.gov/forecasts/aeo/excel/aeotab_8.xls. Accessed January 14, 2011.

EIA (Energy Information Administration). 2011b. Average Capacity Factors by Energy Source. Available at: http://www.eia.gov/cneaf/electricity/epa/epat5p2.html. Last viewed March 21, 2011.

EPA (U.S. Environmental Protection Agency). 1998a. Air Pollutant Emission Factors. Vol. 1, Stationary Point Sources and Area Sources. Section 1.1, “Bituminous and Subbituminous Coal Combustion” and Table 3.1-2a. AP-42. September. Available http://www.epa.gov/ttn/chief/ap42/. Accessed December 15, 2010.

EPA (U.S. Environmental Protection Agency). 1998b. Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone. Washington, DC, Environmental Protection Agency. Federal Register 63 (207): 57356–57404. Publication date: October 27, 1998.

EPA (U.S. Environmental Protection Agency). 2000. Air Pollutant Emission Factors. Vol. 1, Stationary Point Sources and Area Sources. Section 3.1, “Stationary Gas Turbines.” AP-42. April. Available on-line atL http://www.epa.gov/ttn/chief/ap42/ch03/index.html. Accessed December 15, 2010.

EPA (U.S. Environmental Protection Agency). 2003. Water on Tap, What You Need to Know. Office of Water. EPA 816-K-03-007. October.

EPA (U.S. Environmental Protection Agency). 2007. Letter from Jon M. Capacasa, Director, Water Protection Division regarding a Total Maximum Daily Load (TMDL) for PCBs. Dated April 7, 2007, sent to Ms. Cathy Curran Myers, Deputy Secretary for Water Management, Pennsylvania Department of Environmental Protection.

EPA (U.S. Environmental Protection Agency). 2010. National Ambient Air Quality Standards (NAAQS). Available on-line at: http://www.epa.gov/air/criteria.html#5 updated on June 3, 2010. Accessed April 5, 2011.

EPA (U.S. Environmental Protection Agency). 2011a. Safe Drinking Water Information System Query, Montgomery, Chester, and Berks Counties. Available on-line at: http://oaspub.epa.gov/enviro/sdw_form_v2.create_page?state_abbr=PA. Accessed January 17, 2011.

EPA (U.S. Environmental Protection Agency). 2011b. Superfund Site Progress Profile, OCCIDENTAL CHEMICAL CORP./FIRESTONE TIRE & RUBBER CO. (EPA ID: PAD980229298) Available on-line at: http://cfpub2.epa.gov/supercpad/cursites/csitinfo.cfm?id=0301183 updated on January 14, 2011. Accessed January 14, 2011.

EPA (U.S. Environmental Protection Agency). 2011c. Status of SIP Requirements for Designated Areas. Pennsylvania Areas by Pollutant. Available on-line at: http://www.epa.gov/air/urbanair/sipstatus/reports/pa_areabypoll.html as of April 3, 2011. Accessed April 5, 2011.

Exelon Corporation. 2010a. About Us. Available on-line at: http//www.exeloncorp.com/aboutus.aspx. Site accessed on December 7, 2010.

Exelon Corporation. 2010b. Generation. Available on-line at: http//www.exeloncorp.com/energy/generation/Pages/generation.aspx. Site accessed on December 7, 2010.

Exelon Corporation. 2010c. Cromby Generating Station. Available on-line at: http://www.exeloncorp.com/PowerPlants/cromby/Pages/profile.aspx
Accessed December 15, 2010.

Exelon Corporation. 2010d. Limerick Generating Station. Available on-line at: http://www.exeloncorp.com/PowerPlants/limerick/Pages/profile.aspx
Accessed December 15, 2010.

Exelon Corporation. 2010e. Eddystone Generating Station. Available on-line at: http://www.exeloncorp.com/PowerPlants/eddystone/Pages/profile.aspx
Accessed December 15, 2010.

Exelon Generation. 2001. Letter to U.S. Nuclear Regulatory Commission. 2000 Annual Environmental Operating Report (Non-Radiological). April.

Exelon Generation. 2002. Letter to U.S. Nuclear Regulatory Commission. 2001 Annual Environmental Operating Report (Non-Radiological). April.

Exelon Generation. 2003. Letter to U.S. Nuclear Regulatory Commission. 2002 Annual Environmental Operating Report (Non-Radiological). April.

Exelon Generation. 2004. Letter to U.S. Nuclear Regulatory Commission. 2003 Annual Environmental Operating Report (Non-Radiological). April.

Exelon Generation. 2005. Letter to U.S. Nuclear Regulatory Commission. 2004 Annual Environmental Operating Report (Non-Radiological). April.

Exelon Generation. 2007. Letter to U.S. Nuclear Regulatory Commission. 2006 Annual Radiological Environmental Operating Report. April.

Exelon Generation. 2008a. Updated Final Safety Analysis Report, Revision 14. September.

Exelon Generation. 2008b. Letter to U.S. Nuclear Regulatory Commission. 2007 Annual Radiological Environmental Operating Report. April.

Exelon Generation. 2009a. Letter to U.S. Nuclear Regulatory Commission. 2008 Annual Radiological Environmental Operating Report. April.

Exelon Generation. 2009b. Limerick Generating Station Independent Spent Fuel Storage Installation 10 CFR 72.212 Evaluation. July.

Exelon Generation. 2009c. Limerick Generating Station, Units 1 and 2, Facility Operating License Nos. NPF-39 and NPF-85, NRC Docket Nos. 50-352 and 50-353, Notice of Intent to Pursue License Renewal. Letter from Michael P. Gallagher, Exelon, to USRC Document Control Desk. April 29.

Exelon Generation. 2010a. Letter to U.S. Nuclear Regulatory Commission. Request for License Amendment to Allow Receipt and Storage of Low-Level Radioactive Waste at Peach Bottom Atomic Power Station, Units 1, 2, and 3. January.

Exelon Generation. 2010b. Letter to U.S. Nuclear Regulatory Commission. 2009 Annual Radiological Environmental Operating Report. April.

Exelon Generation. 2010c. Limerick Generating Station Wildlife Management Plan.

Exelon Generation. 2010d. Form 10-K. Annual Report Pursuant to Section 13 or 15d of the Securities Exchange Act of 1934. Available on-line at: http://www.sec.gov/Archives/edgar/data/22606/0001193125110300543/d10k.htm. Accessed March 21, 2011.

Farrell, C. and W.W. Hall, Jr. 2004. Economic Impact Study of the Progress Energy, Inc., Brunswick Nuclear Power Facility on North Carolina State Planning Region O. Washington, DC, Nuclear Energy Institute (NEI). Publication date: October 2004.

Feller, G. 2003. Winds, Waves, Tides – Ocean Energy. Posted on Aug 9, 2003 on EcoWorld website. Available on-line at: http://www.ecoworld.com/other/winds-waves-tides-ocean-energy.html.

FERC (Federal Energy Regulatory Commission). 2010. “Issued Preliminary Permits.” Available on-line at: http://www.ferc.gov/industries/hydropower.asp. Accessed December 15, 2010.

FHWA (U.S. Department of Transportation Federal Highway Administration). 2004. Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE 8-hour Ozone Nonattainment Map. Available on-line at: http://www.fhwa.dot.gov/environment/air_quality/conformity/reference/maps.ozone_1997/panjmdde_philadelphia_wilmington_atlanticcity.cfm. Accessed January 17, 2011.

FHWA (U.S. Department of Transportation Federal Highway Administration). 2010. Philadelphia-Wilmington, PA-NJ-DE 2006 PM2.5 Nonattainment Map. Available on-line at: http://www.fhwa.dot.gov/environment/air_quality/conformity/reference/maps.pm2.5_2006/pa_nj_de_philadelphia-wilmington.cfm. Accessed January 17, 2011.

Folland, S. and R. Hough. 2000. Externalities of Nuclear Plants: Further Evidence. Journal of Regional Science 40(4): 735–753. Publication date: April 2000.

Fuel Cell Today. 2008. “Fuel Cells Market Survey: Large Stationary Applications.” Available on-line at: http://www.fuelcelltoday.com/media/pdf/surveys/2008-LS-Free.pdf. Accessed on December 15, 2010.

FWS (U.S. Fish and Wildlife Service). 2010. Species Reports- Environmental Conservation Online System. “Species Listed in Pennsylvania based on Published Population Data.” http://ecos.fws.gov/tess_public/pub/stateListingIndividual.jsp?state=PA&status=listed. Accessed February 12, 2010.

Gamble, H.B. and R.H. Downing. 1982. Effects of Nuclear Power Plants on Residential Property Values. Journal of Regional Science 22(4): 457–478.

H&K Group. 2011. Pottstown Trap Rock - Sanatoga Quarry. Available on-line at: http://www.hkgroup.com/companies/pottstown-trap-rock-sanatoga-quarry/index.aspx. Accessed January 15, 2011.

Hallenbeck, W.H. and G.R. Brenniman. 1989. Risk of fatal amebic meningoencephalitis from waterborne Naegleria fowleri. Environmental Management, Volume 13, Number 2, 227-232. March. Available on-line at: http://www.springerlink.com/content/wnmp73u556mv1511. Accessed January 4, 2011.

Holzinger, C.H. and J.A. Humpreville. 1972. Archaeological Report, Limerick Generating Station Site, Montgomery and Chester Counties, PA. Report submitted to the Philadelphia Electric Company, Philadelphia, PA.

IEEE (Institute of Electrical and Electronics Engineers). Published 2006. National Electrical Safety Code, 2007 Edition. Report C2-2007. New York. Approved April (IEEE) and June (American National Standards Institute).

INEEL (Idaho National Engineering and Environmental Laboratory). 1998. U.S. Hydropower Resource Assessment Final Report. DOE/ID-10430.2. December.

JAMC (Journal of Applied Meteorology and Climatology). 2007. Supplying Baseload Power and Reducing Transmission Requirements by Interconnecting Wind Farms Volume 46 November.

Kingsley, R.B., J.A. Robertson, and D.G. Roberts. 1990. The Archaeology of the Lower Schuylkill River Valley in Southeastern Pennsylvania. Report submitted to the Philadelphia Electric Company, Philadelphia, PA.

Kuhn, R.K. and W.B. Shrope. 1857. Map of Bucks and Montgomery Counties and the Consolidated City of Philadelphia. [Inset of Port Kennedy] R.K. Kuhn & Wm. B. Shrope, Philadelphia, PA.

Limbeck, R. and G. Smith. 2007. Pilot Study: Implementation of a Periphyton Monitoring Network for the Non-Tidal Delaware River. Delaware River Biomonitoring Program Delaware River Basin Commission West Trenton, NJ. March 2007.

Limerick Township. undated. Limerick Township 2010 Final Budget. Available on-line at: http://www.limerickpa.org/Departments_Finance.htm. Accessed January 16, 2011.

Limerick Township. 2011. Limerick Township Sewer Department. Available on-line at: http://www.limerickpa.org/Departments_Sewer.htm. Accessed April 4, 2011.

Longwill, S.M. and C.R. Wood. 1965. Ground-Water Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania. Ground Water Report W22. 59 pp.

Lower Pottsgrove Township. 2008. 2009 Budget. Available on-line at: http://www.lowerpottsgrove.org/. Accessed January 16, 2011.

Marciano-Cabral, F, R. MacLean, A. Mensah, and L. LaPat-Polasko. 2003. Identification of Naegleria fowleri in Domestic Water Sources by Nested PCR. Applied and Environmental Microbiology, October 2003; 69(10): 5864-5869.

MCPC (Montgomery County Planning Commission). 2005a. Montgomery County Comprehensive Plan. Available on-line at: http://planning.montcopa.org/planning/cwp/view,a,1407,q,40433.asp. Accessed January 11, 2011.

MCPC (Montgomery County Planning Commission). 2005b. The Pottstown Metropolitan Region Intergovernmental Cooperative Implementation Agreement for Regional Planning. October, 2005. Available on-line at: http://www2.montcopa.org/planning/cwp/view,A,3,Q,2059.asp.

MCPC (Montgomery County Planning Commission). 2005c. Pottstown Metropolitan Regional Comprehensive Plan. Available on-line at: http://www2.montcopa.org/planning/cwp/view,A,3,Q,2059.asp.

MCPC (Montgomery County Planning Commission). 2009. 2009 Annual Summary; Subdivision, Land Development, and Zoning Activity. Available on-line at: http://planning.montcopa.org/planning/cwp/view.asp?a=1462&q=41420&planningnav=|.

Medicinenet.com. 2011. Search for current Naeglaria citations. Available on-line at: http://www.medicinenet.com/naegleria_infection/article.htm. Accessed January 4, 2011.

Metz, W.C., T. Allison, and D.E. Clark. 1997. Does Utility Spent Nuclear Fuel Storage Affect Local Property Values? Radwaste Magazine 4:27–33. Publication date: May 1997.

Michalski, A. 1990. Hydrogeology of the Brunswick (Passaic) Formation and Implications for Groundwater Monitoring Practice, Groundwater Monitoring Review. Fall. pp. 134-143.

Milner (John Milner Associates, Inc.). 1984a. A Descriptive Report of an Archaeological Investigation for the 220-60 Transmission Line Right-of-Way in Association With the Limerick Nuclear Generating Station, Montgomery and Chester Counties, Pennsylvania. Report submitted to the Philadelphia Electric Company.

Milner (John Milner Associates, Inc.). 1984b. A Descriptive Report of an Archaeological Investigation for the 220-61 Transmission Line Right-of-Way in Association With the Limerick Nuclear Generating Station, Chester and Montgomery Counties, Pennsylvania. Report submitted to the Philadelphia Electric Company.

Milner (John Milner Associates, Inc.). 1984c. A Descriptive Report of an Archaeological Investigation for the 220-62 Transmission Line Right-of-Way in Association with the Limerick Nuclear Generating Station, Montgomery and Chester Counties, Pennsylvania. Report submitted to the Philadelphia Electric Company.

Milner (John Milner Associates, Inc.). 1985. A Descriptive Report of an Archaeological Investigation for the 220-63 Transmission Line Right-of-Way in Association With the Limerick Nuclear Generating Station, Chester and Montgomery Counties, Pennsylvania. Report submitted to the Philadelphia Electric Company.

Milner (John Milner Associates, Inc.). 1989. A Descriptive Report of an Archaeological Investigation for the 5031 Transmission Line Right-of-Way in Association With the Limerick Nuclear Generating Station, Montgomery County, Pennsylvania. Report submitted to the Philadelphia Electric Company.

MIT (Massachusetts Institute of Technology). 2006. The Future of Geothermal Energy Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st Century. Prepared for U.S. Department of Energy, Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Geothermal Technologies. Report INL/EXT-06-11746.

MMWR (Morbidity and Mortality Weekly Report). 2008. Surveillance for Waterborne Disease and Outbreaks Associated with Recreational Water Use and Other Aquatic Facility-Associated Health Events --- United States, 2005--2006. MMWR Vol. 57, 1-29. September 12.

MMWR (Morbidity and Mortality Weekly Report). 2011. Search for current *Naeglaria* citations. Available on-line at: http://www.cdc.gov/search.do?subset=mmwr&queryText=naegleria&action=search. Accessed January 4, 2011.

Montgomery County. Undated. Montgomery County: Septa Map. Available on-line at: http://www2.montcopa.org/montco/cwp/view,a,3,Q,5307.asp. Accessed January 15, 2011.

Montgomery County. 2009. Montgomery County Commissioners Adopt No Tax Increase Budget for 2010. News Release December 21, 2009. Available on-line at: http://www2.montcopa.org/montco/CWP/View.asp?a=11&q=79073. Accessed January 16, 2011.

Montgomery County. 2010. R6 Norristown Line Service Extension Study. Available on-line at: http://planning.montcopa.org/planning/cwp/view,a,1677,q,67495.asp. Accessed January 15, 2011.

NAI (Normandeau Associates, Inc.). 2005. East Branch Perkiomen Creek Aquatic Biology Assessment VIII, 2001-2003 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. August.

NAI (Normandeau Associates, Inc.). 2007. East Branch Perkiomen Creek Aquatic Biology Assessment IX, 2004 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. July 2007.

NAI (Normandeau Associates, Inc.). 2008a. East Branch Perkiomen Creek Aquatic Biology Assessment X, 2005 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. March.

NAI (Normandeau Associates, Inc.). 2008b. East Branch Perkiomen Creek Aquatic Biology Assessment XI, 2006 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. September 2008.

NAI (Normandeau Associates, Inc.). 2009. East Branch Perkiomen Creek Aquatic Biology Assessment XII, 2007 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. March 2009.

NAI (Normandeau Associates, Inc.). 2010a. East Branch Perkiomen Creek Aquatic Biology Assessment XIII, 2008 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. May.

NAI (Normandeau Associates, Inc.). 2010b. East Branch Perkiomen Creek Aquatic Biology Assessment XIV, 2009 Monitoring Period. Prepared for Exelon Nuclear, Limerick Generating Station. July.

NAI (Normandeau Associates, Inc.). 2010c. Fish and Benthic Macroinvertebrate Community Composition in the Schuylkill River in the Vicinity of Limerick Generating Station During 2009. February 2010.

NAI (Normandeau Associates, Inc.). 2010d. Letter from Normandeau Associates, Inc. to Exelon Nuclear via email. Zebra mussel/Asiatic clam Survey. November.

NEFSC (Northeast Fisheries Science Center). 2010. EFH Source Documents: Life History and Habitat Characteristics. Available on-line at: http://www.nefsc.noaa.gov/nefsc/habitat/efh/. File modified July 27, 2010.

NEI (Nuclear Energy Institute). 2003. Economic Benefits of Millstone Power Station. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/millstone. Publication date: July 2003.

NEI (Nuclear Energy Institute). 2004a. Economic Benefits of Diablo Canyon Power Station. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/diablo canyon. Publication date: February 2004.

NEI (Nuclear Energy Institute). 2004b. Economic Benefits of Indian Point Energy Center. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/indianpoint. Publication date: April 2004.

NEI (Nuclear Energy Institute). 2004c. Economic Benefits of Palo Verde Nuclear Generation Station. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/palo verde. Publication date: November 2004.

NEI (Nuclear Energy Institute). 2004d. Economic Benefits of the Duke Power-Operated Nuclear Power Plants. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/dukepower. Publication date: December 2004.

NEI (Nuclear Energy Institute). 2005a. Economic Benefits of Wolf Creek Generating Station. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/wolfcreek. Publication date: July 2005.

NEI (Nuclear Energy Institute). 2005b. Economic Benefits of Three Mile Island Unit 1. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/threemileisland1. Publication date: November 2005.

NEI (Nuclear Energy Institute). 2006a. Economic Benefits of Salem and Hope Creek Nuclear Generating Stations. Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/salemhopecreek/. Publication date: September 2006.

NEI (Nuclear Energy Institute). 2006b. Economic Benefits of The Exelon Pennsylvania Nuclear Fleet. Washington, DC, Nuclear Energy Institute. Retrieved February 9, 2009, from http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/exelonpennsylvania. Publication date: August 2006.

NEI (Nuclear Energy Institute). 2007a. NEI Groundwater Protection Initiative 07-07—Final Guidance. Washington, DC, Nuclear Energy Institute. Publication date: August, 2007.

NEI (Nuclear Energy Institute). 2007b. “Overview of Status of Restructuring the U.S. Electric Power Industry.” Available on-line at: http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/graphicsandcharts/stateelectricindustryrestructuringoverview.
Accessed December 15, 2010.

Nelson, J.P. 1981. Three Mile Island and Residential Property Values: Empirical Analysis and Policy Implications. Land Economics, 57(3):364–372. Publication date: August.

NJ (State of New Jersey). 2006. Blue Ribbon Panel on Development of Wind Turbine Facilities in Coastal Waters, Final Report. April.

NJBPU (New Jersey Board of Public Utilities). 2009. New Jersey’s Clean Energy Program: 2008 Annual Report. Retrieved on December 15, 2010 from: http://www.njcleanenergy.com/files/file/Library/CLEAN%20ENERGY%202008%20Annual%20Report%20final%281%29.pdf.

NJDEP (New Jersey Department of Environmental Protection). 2009. Large Scale Wind Turbine Siting Map Report. September 8.

NJDEP (New Jersey Department of Environmental Protection). 2010. Studying the Delaware River - 2009 Report. Division of Fish & Wildlife. June. Available on-line at: http://www.njfishandwildlife.com/artdelstudy10.htm. Retrieved March 7, 2011.

NOAA (National Oceanic and Atmospheric Administration. 2010. NOAA Habitat Conservation, Habitat Protection, Essential Fish Habitat Mapper v2.0. Available on-line at: http://www.habitat.noaa.gov/protection/efh/habitatmapper.html. Retrieved October 13, 2010.

NOAA (National Oceanic and Atmospheric Administration. 2011. National Weather Service. National Hurricane Center Archive of Hurricane Seasons. Available on-line at: http://www.nhc.noaa.gov/pastall.shtml. Accessed January 15, 2011.

NRC (U.S. Nuclear Regulatory Commission). 1984. Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2. Philadelphia Electric Company. Docket Nos. 50-352 and 50-353. Office of Nuclear Reactor Regulation. NUREG-0974. Washington, DC. April.

NRC (U.S. Nuclear Regulatory Commission). 1989. Final Environmental Statement Related to the Operation of Limerick Generating Station, Units 1 and 2. Philadelphia Electric Company. Docket Nos. 50-352 and 50-353. Office of Nuclear Reactor Regulation. NUREG-0974 Supplement. August.

NRC (U.S. Nuclear Regulatory Commission). 1994. Environmental Assessment Relating to the Increase in Spent Fuel Storage Capacity Limerick Generating Station Units 1 and 2, Sec. 1.2. November 16.

NRC (U.S. Nuclear Regulatory Commission). 1996a. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Volumes 1 and 2. Office of Nuclear Regulatory Research. NUREG-1437. Washington, DC. May.

NRC (U.S. Nuclear Regulatory Commission). 1996b. Regulatory Analysis for Amendments to Regulations for the Environmental Review for Renewal of Nuclear Power Plant Operating Licenses. Office of Nuclear Regulatory Research. NUREG-1440. Washington, DC. May.

NRC (U.S. Nuclear Regulatory Commission). 1999. Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS). Volume 1, Addendum 1. NUREG-1437. Washington, DC,

NRC (U.S. Nuclear Regulatory Commission). 2000. Preparation of Supplemental Environmental Reports for Applications to Renew Nuclear Power Plant Operating Licenses; Supplement 1 to Regulatory Guide 4.2. Office of Nuclear Regulatory Research. Washington, DC. September.

NRC (U.S. Nuclear Regulatory Commission). 2002a. Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities. Supplement 1; Regarding the Decommissioning of Nuclear Power Reactors. NUREG-0586, Supplement 1. Washington, DC. November.

NRC (U.S. Nuclear Regulatory Commission). 2002b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants Regarding McGuire Nuclear Station, Units 1 and 2. NUREG-1437, Supplement 8, Final. Office of Nuclear Reactor Regulation. Washington, DC. December.

NRC (U.S. Nuclear Regulatory Commission). 2004. Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues. Change Notice. Office Instruction No. LIC-203, Rev. 1. Effective May 24, 2004.

NRC (U.S. Nuclear Regulatory Commission). 2005. Memorandum and Order in the Matter of Exelon Generation Company, LLC (Early Site Permit for Clinton ESP Site). Docket No. 52-007-ESP, ASLB No. 04-821-01-ESP. Washington, DC, U.S. Nuclear Regulatory Commission, Atomic Safety and Licensing Board. Ruling Date: July 28, 2005.

NRC (U.S. Nuclear Regulatory Commission). 2006. Limerick Generating Station, Units 1 And 2 - Issuance Of Amendment Re: Revision Of The Appendix B, Environmental Protection Plan (Non-Radiological). Letter from Richard V. Guzman, Project Manager to Mr. Christopher M. Crane, Exelon. February 17.

NRC (U.S. Nuclear Regulatory Commission). 2008. Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste. Draft Regulatory Guide DG-1186 (proposed revision 2 of regulatory guide 1.21). October.

NRC (U.S. Nuclear Regulatory Commission). 2009a. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Draft Report for Comment. NUREG-1437 (Revision 1). July.

NRC (U.S. Nuclear Regulatory Commission). 2009b. Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Supplement 36 Regarding Beaver Valley Power Station, Units 1 and 2, Final Report. NUREG-1437, Supplement 36. Office of Nuclear Reactor Regulation. Washington, D.C. May.

NRC (U.S. Nuclear Regulatory Commission). 2011. Limerick Generating Station, Units 1 and 2 - Issuance of Amendments Re: Measurement Uncertainty Recapture Power Uprate and Standby Liquid Control System Changes (TAC Nos. ME3589, ME3590, ME3591, and ME3592). April 8.

NREL (National Renewable Energy Laboratory). 2005. A Geographic Perspective on the Current Biomass Resource Availability in the United States. Technical Report NREL/TP-560-39181. December.

NREL (National Renewable Energy Laboratory). 2006. Creating Baseload Wind Power Systems Using Advanced Compressed Air Energy Storage Concepts. NREL/PO-640-40674. October.

NREL (National Renewable Energy Laboratory). 2007. “Updated U.S. Geothermal Supply Characterization.” NREL/CP-640-41073. March.

NREL (National Renewable Energy Laboratory). 2008. Status of Wave and Tidal Power Technologies for the United States. Technical Report NREL/TP-500-43240. August.

NREL (National Renewable Energy Laboratory). 2009. “Geothermal Electricity Production.” Available on-line at: http://www.nrel.gov/learning/re_geo_elec_production.html. Accessed December 15, 2010.

NREL (National Renewable Energy Laboratory). 2010a. The Role of Energy Storage with Renewable Electricity Generation. Technical Report NREL/TP-6A2-47187. January.

NREL (National Renewable Energy Laboratory). 2010b. Large-Scale Offshore Wind Power in the United States. NREL/TP-500-49229. September.

NREL (National Renewable Energy Laboratory). 2010c. 80 and 100 Meter Wind Energy Resource Potential for the United States. NREL/PO-550-48036. May.

NREL (National Renewable Energy Laboratory). 2010d. Interactive Solar maps. Available on line at: http://www.nrel.gov/gis/solar.html. Accessed March 18, 2011.

NREL (National Renewable Energy Laboratory). 2010e. The Value of Concentrating Solar Power and Thermal Energy Storage. Technical Report NREL-TP-6A2-45833. February.

NREL (National Renewable Energy Laboratory). 2010f. Solar Power and the Electric Grid. REL/FS-6A2-45653. March.

NREL (National Renewable Energy Laboratory). 2010g. 2008 Solar Technologies Market Report. DOE/GO-102010-2867. January.

NREL (National Renewable Energy Laboratory). 2011a. Policymakers’ Guidebook for Geothermal Electricity Generation. Technical Report NREL/BR-6A20-49476. February.

NREL (National Renewable Energy Laboratory). 2011b. Eastern Wind Integration And Transmission Study. Revised February.

NWW (National Wind Watch). 2009. Cost of pumped hydro storage. Available at: http://www.wind-watch.org/documents/cost-of-pumped-hydro-storage/. Accessed March 22, 2011.

NYSDEC (New York State Department of Environmental Protection). 2009. Delaware River American Shad Stock Status, Status of American Shad in the Delaware River. Updated August 2009. Available on-line at: http://www.dec.ny.gov/animals/57679.html. Accessed September 2, 2010.

O’Bannon, P. 1987. Architectural and Historical Documentation of the Frick’s Lock District, East Coventry Township, Chester County, Pennsylvania. Report prepared for the Philadelphia Electric Company. John Milner Associates, Inc.

Owen J Roberts School District. 2010. Annual Budget Fiscal Year 2010-2011. Available on-line at: http://ojrsd.com/modules/cms/pages.phtml?sessionid=9fe6d82757b0bbd856f6033e43ba4053&pageid=192505&sessionid=9fe6d82757b0bbd856f6033e43ba4053. Accessed January 16, 2011.

PABTGS (Pennsylvania Bureau of Topographic and Geologic Survey). 1997. Pennsylvania Geologic Survey Map 59, Glacial Deposits in Pennsylvania, by W.D. Sevon and D.D. Brown, 2nd edition.

PADEP (Pennsylvania Department of Environmental Protection). 2004. Environmental Justice Public Participation Policy. Document ID: 012-0501-002. Effective date: April 24, 2004.

PADEP (Pennsylvania Department of Environmental Protection). 2005. Environmental Justice Areas. Vector Digital Data Form. Publisher: U.S. Census Bureau. July. Available on-line at: http://www.dep.state.pa.us/external_gis/gis_home.htm. Accessed January 17, 2011.

PADEP (Pennsylvania Department of Environmental Protection). 2007. Letter to U.S. Environmental Protection Agency, Region III. Attainment Demonstration for Eight-hour Ozone Nonattainment Area. August.

PADEP (Pennsylvania Department of Environmental Protection). 2010. Letter to U.S. Environmental Protection Agency, Region III. Attainment Demonstration for Fine Particulate (PM2.5) Nonattainment Area. April.

PADEP (Pennsylvania Department of Environmental Protection). 2011a. Drinking Water Reporting System. Available on-line at: http://www.drinkingwater.state.pa.us/dwrs/htm/welcome.html. Accessed January 17, 2011.

PADEP (Pennsylvania Department of Environmental Protection). 2011b. Act 537 Sewage Facilities. Planning Authorizations. Available on-line at: http://www.dep.state.pa.us/dep/deputate/watermgt/wqp/Forms/Act537/Forms_537Plan.html. Accessed April 4, 2011.

PADEP (Pennsylvania Department of Environmental Protection). 2011c. State Water Plan, Water Use Data Download. Available on-line at: http://www.pawaterplan.dep.state.pa.us/StateWaterPlan/WaterDataExportTool/WaterExportTool.aspx.

PaGWIS (Pennsylvania Groundwater Information System). 2010. Pennsylvania Groundwater Information System. Available on-line at: http://www.dcnr.state.pa.us/topogeo/groundwater/PaGWIS/PaGWISMenu.asp?c=t.

PDE (Pennsylvania Department of Education). 2011. Pennsylvania Information Management System. Available on-line at: http://www.portal.state.pa.us/portal/server.pt/community/pims_-_pennsylvania_information_management_system/8959. Data downloaded April 14, 2011.

PECO (Philadelphia Electric Company). 1984. Environmental Report – Operating License Stage. Limerick Generating Station Units 1&2. 5 vols.

PECO (Philadelphia Electric Company). 1989. Letter to U.S. Nuclear Regulatory Commission regarding “Response to Request for Additional Information Regarding Consideration of Severe Accident Mitigation Design Alternatives.” June 23.

PECO (PECO Nuclear). 1990. Letter to U.S. Nuclear Regulatory Commission. 1989 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1991. Letter to U.S. Nuclear Regulatory Commission. 1990 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1992. Letter to U.S. Nuclear Regulatory Commission. 1991 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1993. Letter to U.S. Nuclear Regulatory Commission. 1992 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1994. Letter to U.S. Nuclear Regulatory Commission. 1993 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1995. Letter to U.S. Nuclear Regulatory Commission. 1994 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1996. Letter to U.S. Nuclear Regulatory Commission. 1995 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1997. Letter to U.S. Nuclear Regulatory Commission. 1996 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1998. Letter to U.S. Nuclear Regulatory Commission. 1997 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 1999. Letter to U.S. Nuclear Regulatory Commission. 1998 Annual Environmental Operating Report (Non-Radiological). April.

PECO (PECO Nuclear). 2000. Letter to U.S. Nuclear Regulatory Commission. 1999 Annual Environmental Operating Report (Non-Radiological). April.

PEI (Princeton Environmental Institute). 2008. Compressed Air Energy Storage: Theory, Resources, And Applications For Wind Power. Princeton University Energy Systems Analysis Group, Samir Succar and Robert H. Williams. April.

PennDOT (Pennsylvania Department of Transportation). 2009a. Federal Functional Class Map Montgomery County. Updated January 14, 2009. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Functional_Class/Gisc ty46.PDF. Accessed June 30, 2010.

PennDOT (Pennsylvania Department of Transportation). 2009b. Federal Functional Class Map Chester County. Updated January 14, 2009. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Functional_Class/Gisc ty15.PDF.

PennDOT (Pennsylvania Department of Transportation). 2009c. Federal Functional Class Map Berks County. Updated January 14, 2009. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Functional_Class/Gisc ty06.PDF.

PennDOT (Pennsylvania Department of Transportation). 2010a. 2009 Traffic Volume Map, Chester County, Pennsylvania. Published December. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Traffic_Volume/2009/Chester_2009_tv.pdf. Accessed April 6, 2010.

PennDOT (Pennsylvania Department of Transportation). 2010b. 2009 Traffic Volume Map, Berks County, Pennsylvania. Published December. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Traffic_Volume/2009/Berks_2009_tv.pdf. Accessed April 6, 2010.

PennDOT (Pennsylvania Department of Transportation). 2011a. Bureau of Aviation. PA Commercial Service Airports. Public Airports. Available on-line at: http://www.dot.pa.us/internet/bureaus/pdBOA.nsf/aviationhomepage?openframeset. Accessed January 14, 2011.

PennDOT (Pennsylvania Department of Transportation). 2011b. 2009 Traffic Volume Map, Montgomery County, Pennsylvania. Published February. Available at: ftp://ftp.dot.state.pa.us/public/pdf/BPR_PDF_FILES/MAPS/Traffic/Traffic_Volume/2009/Montgomery_2009_tv.pdf. Accessed April 6, 2010.

Pennridge School District. 2010. Pennridge School District 2010-2011 Budget. May 27, 2010. Available on-line at: http://www.pennridge.org/psd/psd.htm. Accessed January 16, 2011.

Pennsylvania General Assembly. 2010. Pennsylvania Code, Title 66 Pa. C.S.A. Public Utilities. Section 2801. Available on-line at: http://www.legis.state.pa.us/WU01/LI/LI/CT/PDF/66/66.PDF. Accessed December 15, 2010.

Pew (Pew Center on Global Climate Change). 2010. Renewable and Alternative Energy Portfolio Standards. November. Available on-line at: http://www.pewclimate.org/what_s_being_done/in_the_states/rps.cfm. Accessed January 4, 2011.

PFBC (Pennsylvania Fish and Boat Commission). 2009. Biologists Reports. Schuylkill River, Montgomery County. June 2, 2009 Adult American Shad Survey. Available on-line at: http://www.fish.state.pa.us/images/fisheries/afm/2009/6x06_18schuylkill.htm. Site accessed September 2, 2010.

PFBC (Pennsylvania Fish and Boat Commission). 2010a. Schuylkill River American Shad. Available on-line at: http://www.fish.state.pa.us/shad_schu.htm. Site accessed August 31, 2010.

PFBC (Pennsylvania Fish and Boat Commission). 2010b. 2004 & 2005 Fairmount Fish Ladder Passage Data Compared to Historical Counts. Available on-line at: http://www.fish.state.pa.us/pafish/shad/schuylkill/fairmount2005.htm. Site accessed August 31, 2010.

PFBC (Pennsylvania Fish and Boat Commission). 2010c. 2010 Adult Trout Stocking by County. Trout Stocking Events in Montgomery County from 2/1/2010 to 2/28/2011. Available on-line at: http://pfbc.state.pa.us/pfbc_webgis/TroutStockingDetails.aspx. Site accessed September 1, 2010.

PFBC (Pennsylvania Fish and Boat Commission). 2010d. 2010 Adult Trout Stocking by County. Trout Stocking Events in Berks County from 2/1/2010 to 2/28/2011. Available on-line at: http://pfbc.state.pa.us/pfbc_webgis/TroutStockingDetails.aspx. Site accessed September 30, 2010.

PFBC (Pennsylvania Fish and Boat Commission). 2010e. 2010 Adult Trout Stocking by County. Trout Stocking Events in Bucks County from 2/1/2010 to 2/28/2011. Available on-line at: http://pfbc.state.pa.us/pfbc_webgis/TroutStockingDetails.aspx. Site accessed September 1, 2010.

PHMC/PennDOT (Pennsylvania Historical and Museum Commission/ Pennsylvania Department of Transportation). 2011. CRGIS Spatial Summary. Available on-line at: https://dot7.state.pa.us/ce/NET/Reports/SpatialSummary.aspx. Site accessed March 23, 2011.

PJM (PJM Interconnection, LLC). 2009a. PJM Statistics Fact Sheet. Available on-line at: http://www.pjm.org/about-pjm/newsroom/~/media/about-pjm/newsroom/downloads/pjm-statistics.ashx . Accessed December 15, 2010.

PJM (PJM Interconnection, LLC). 2009b. State of the Market Report for PJM. Prepared by Monitoring Analytics, LLC. Available on-line at: http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2009/2009-som-pjm-volume1.pdf . Accessed December 15, 2010.

PJM (PJM Interconnection, LLC). 2010. PJM Manual 21, Rules and Procedures for Determination of Generating Capability. Revision: 09. May.

PJM, (PJM Interconnection, LLC). 2011. Renewable Energy Dashboard.

Plumstead Township. Undated. 2011 Adopted Budget - General Fund (Revenues). Available on-line at: http://www.plumstead.org/. Accessed January 16, 2011.

PNHP (Pennsylvania Natural Heritage Program). 2011a. State Species List Database – Bucks, Chester, and Montgomery Counties. Available on-line at: http://www.naturalheritage.state.pa.us. Accessed January 5, 2011.

PNHP (Pennsylvania Natural Heritage Program). 2011b. Species Fact Sheet. Bridle Shiner (*Notropis bifrenatus*). Available on-line at: http://www.naturalheritage.state.pa.us/Factsheets.aspx. Accessed February 23, 2011.

PNHP (Pennsylvania Natural Heritage Program). 2011c. Species Fact Sheet. Banded sunfish (*Enneacanthus obesus*). Available on-line at: http://www.naturalheritage.state.pa.us/Factsheets.aspx. Accessed January 11, 2011.

PNHP (Pennsylvania Natural Heritage Program). 2011d. Species Fact Sheet. Longear sunfish (*Lepomis megalotis*). Available on-line at: http://www.naturalheritage.state.pa.us/Factsheets.aspx. Accessed January 11, 2011.

Pottsgrove School District. 2010. Pottsgrove School District Expenditures. May 11, 2010. Available on-line at: http://www.pgsd.org/District/BoardofSchoolDirectors/Budget/tabid/172/Default.aspx. Accessed January 16, 2011.

Pottstown Borough Water Authority. 2011. Public Summary. Available on-line at: http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-59612/RS1460037001%20Pottstown.pdf. Accessed January 12, 2011.

Rephann, T.J. undated (circa 1997). The Economic Impacts of LULUs. Revised version published in Environment and Planning C: Government and Policy 2000 18(4): 393–407. Retrieved February 9, 2009 from http://www.equotient.net/papers/lulu.pdf.

Rhoads, A.F. and T.A. Block. 2008. Montgomery County, Pennsylvania, Natural Areas Inventory Update. Morris Arboretum of the University of Pennsylvania, 100 Northwestern Avenue, Philadelphia, PA. Submitted to the Montgomery County Planning Commission.

RMC (RMC Environmental Services). 1984. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1979-1983. Prepared for Philadelphia Electric Company. October.

RMC (RMC Environmental Services). 1985. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1984. Prepared for Philadelphia Electric Company. December.

RMC (RMC Environmental Services). 1986. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1985. Prepared for Philadelphia Electric Company. September.

RMC (RMC Environmental Services). 1987. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1986. Prepared for Philadelphia Electric Company. November.

RMC (RMC Environmental Services). 1988. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1987. Prepared for Philadelphia Electric Company. September.

RMC (RMC Environmental Services). 1989. Progress Report, Non-Radiological Environmental Monitoring for Limerick Generating Station 1988. Prepared for Philadelphia Electric Company. December.

RNP (Renewable Northwest Project). 2007. Wave and Tidal Fact Sheet. Available on-line at: http://www.rnp.org/node/wave-tidal-energy-technology. Revised March and April.

Sanatoga Post. 2010. Five Years of Lower Pottsgrove Budgets at a Glance. Posted on November 29, 2010. Available on-line at: http://sanatogapost.com/2010/11/29/five-years-of-lower-pottsgrove-budgets-at-a-glance/. Accessed January 16, 2011.

Schuylkill River Trail Association. 2009. The Schuylkill River Trail. Available on-line at: http://www.schuylkillrivertrail.com/index.php?. Accessed January 10, 2011. Copyright 2009.

Sea Grant Pennsylvania. 2011. Hydrilla (*Hydrilla verticillata*). Available on-line at: http://seagrant.psu.edu/publications/fs/Hydrilla.pdf. Accessed April 1, 2011.

SEPTA. 2010. SEPTA Regional Rail & Rail Transit Map. Available on-line at: http://www.septa.org/maps/system/index.html. Accessed April 7, 2011.

Sheppard, S.C. 2007. Declaration of Stephen C. Sheppard. New York State Notice of Intention to Participate and Petition to Intervene and Supporting Declarations and Exhibits, Volume II of II, filed on November 30, 2007, pp 23-38 of 274. United States Nuclear Regulatory Commission; In re: License Renewal Application Submitted by Entergy Nuclear Indian Point 2, LLC, et al., Docket No. 50-247-LR and 50-286-LR, ASLBP No. 07-858-03-LR-BD01. Retrieved February 9, 2009, from http://ehd.nrc.gov/EHD_Proceeding/doccontent.dll?library=EHD2_ADAMS^HQ2KAD108&id=080950018:1.

Shultz, C.H. 1999. The Geology of Pennsylvania, Pennsylvania Geological Survey and Pittsburgh Geological Society, Harrisburg, PA. 888 pp.

Simone Collins Landscape Architecture. 2008. Sanatoga Interchange Study, Draft, March 2008. Prepared for Lower Pottsgrove Township, Montgomery Township, Pennsylvania. Available on-line at: http://www.lowerpottsgrove.org/economic/422study.htm.

Simone Collins Landscape Architecture. 2009. Limerick Comprehensive Plan. March 26, 2009.

Simpson, P.C. and D.A. Fox. undated. Atlantic sturgeon in the Delaware River: contemporary population status and identification of spawning areas. Completion Report: Award NA05NMF4051093.

Spring-Ford Area School District. 2010. Spring-Ford Area School District Final Budget 2010/2011. Adopted: June 21, 2010. Available on-line at: http://www.spring-ford.net/Administration/business/business.htm. Accessed January 16, 2011.

Steiner, L. 2002. Pennsylvania Fishes. Pennsylvania Fish and Boat Commission, Harrisburg, PA. 170 pp. Also available on-line at: http://www.fish.state.pa.us/pafish/fishhtms/chapindx.htm.

Stroud (Stroud Water Research Center). 2011. Schuylkill Project. Available on-line at: http://www.stroudcenter.org/schuylkill/index.htm. Accessed April 1, 2011.

Thompson, A. and B.N. Taylor. 2008. Guide for the Use of the International System of Units. NIST Special Publication 811, 2008 Edition. Gaithersburg, MD, U.S. Department of Commerce, National Institute of Standards and Technology. Retrieved February 12, 2008, from http://physics.nist.gov/cuu/pdf/sp811.pdf.

U.S. Court of Appeals for the Seventh Circuit. 2006. Environmental Law and Policy Center et. al. v. U.S. Nuclear Regulatory Commission and Exelon Generation Company, LLC. No. 06-1442 (7th Cir. 2006). Decision date: December 5, 2006.

USCB (U.S. Census Bureau). 2002. Pennsylvania: 2000: Census 2000 Profile. Report C2KPROF/00-PA. U.S. Department of Commerce, Economics and Statistics Administration. August.

USCB (U.S. Census Bureau). 2003. Population in Metropolitan and Micropolitan Statistical Areas in Alphabetical Order and Numerical and Percent Change for the United States and Puerto Rico: 1990 and 2000. Census 2000 PHC-T-29. Ranking Tables for Population of Metropolitan Statistical Areas, Micropolitan Statistical Areas, Combined Statistical Areas, New England City and Town Areas, and Combined New England City and Town Areas: 1990 and 2000. Available on-line at: http://www.census.gov/population/www/cen2000/briefs/phc-t29/index.html. Internet Release date: December 30, 2003.

USCB (U.S. Census Bureau). 2010a. American Fact Finder, Race, Hispanic or Latino, Age, and Housing Occupancy: 2010 2010 Census Redistricting Data (Public Law 94-171) Summary File. Available on-line at: http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed April 7, 2011.

USCB (U.S. Census Bureau). 2010b. Current Population Survey, 2010 Annual Social and Economic (ASEC) Supplement. Available on-line at: http://www.census.gov/cps/. Data downloaded April 14, 2011.

USCB (U.S. Census Bureau). 2010c. How We Count America. Available on-line at: http://2010.census.gov/2010census/about/how-we-count.php. Accessed April 11, 2011.

USCB (U.S. Census Bureau). 2011. 2009 Data Release, American Community Survey. Available on-line at: http://www.census.gov/acs/www/data_documentation/2009_release/. Accessed April 7, 2011.

USDA (U.S. Department of Agriculture). 1967. Soil Survey of Montgomery County, Pennsylvania, Soil Conservation Service. April 1967.

USGS (U.S. Geological Survey). 2002. Geohydrology of Southeastern Pennsylvania. Water-Resources Investigations Report 00-4166. In cooperation with the Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey.

USGS (U.S. Geological Survey). 2009. NAS - Nonindigenous Aquatic Species, Mapped collection data for *Dreissena polymorpha*. Collection Data for Dreissena polymorpha in HUC 2040105. Available on-line at: http://nas2.er.usgs.gov/ARCIMS/interactive/interactive.asp?speciesID=5&InterstatesON=&MajorC. Accessed September 1, 2010.

USGS (U.S. Geological Survey). 2010a. USGS Surface-Water Annual Statistics for the Nation, USGS 01472000 Schuylkill River at Pottstown, PA. Available on-line at: http://waterdata.usgs.gov/nwis/annual/?referred_module=sw&site_no=01472000&por_01472000_1=1820177,00060,1,1928,2010&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed October 21, 2010.

USGS (U.S. Geological Survey). 2010b. USGS Surface-Water Annual Statistics for the Nation, USGS 01473000 Perkiomen Creek at Graterford, PA. Available on-line at: http://waterdata.usgs.gov/nwis/annual?referred_module=sw&site_no=01473000&por_01473000_1=1820279,00060,1,1915,2010&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Access August 25, 2010.

USGS (U.S. Geological Survey). 2010c. USGS Surface-Water Annual Statistics for the Nation, USGS 01472620 East Branch Perkiomen Creek near Dublin, PA. Available on-line at: http://waterdata.usgs.gov/nwis/annual?referred_module=sw&site_no=01472620&por_01472620_4=1820271,00060,4,1984,2010&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed October 21, 2010.

USGS (U.S. Geological Survey). 2010d. USGS Surface-Water Annual Statistics for the Nation, USGS 01463500 Delaware River at Trenton NJ. Available on-line at: http://waterdata.usgs.gov/nwis/annual?referred_module=sw&site_no=01463500&por_01463500_5=147753,00060,5,1913,2010&year_type=W&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list. Accessed October 21, 2010.

Versar, Inc. 2003. The Delaware River Creel Survey 2002. Prepared for Pennsylvania Fish & Boat Commission, May.

Walsh M.E., R.L. Perlack, A. Turhollow, D. de la Torre Ugarte, D.A. Becker, R.L. Graham, S.E. Slinsky, and D.E. Ray. 2000. “Biomass Feedstock Availability in the United States: 1999 State Level Analysis.” Oak Ridge National Laboratory. Oak Ridge, TN. April 30, 1999. Updated January, 2000. Available on-line at: http://bioenergy.ornl.gov/resourcedata/index.html. Accessed December 15, 2010.

Washington Post. 2010. Google helps finance 'superhighway' for wind power. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2010/10/12/AR2010101202271.html?hpid=talkbox1. Last viewed March 21, 2011.

WHC (Wildlife Habitat Council). 2006. Site Assessment and Wildlife Management Opportunities prepared for Exelon Corporation’s Limerick Generating Station. 100 pp. Illustrated. August.

Xcel Energy 2007. 2007 Resource Plan, Appendix E. Xcel Energy. Available at: http://www.xcelenergy.com/SiteCollectionDocuments/AppendixE.pdf. Accessed March 22, 2011.